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Dear friends and colleagues,
dear delegates,

welcome to the **9th International Conference on Cochlear Implants and Related Sciences.**
It is an honour to host this meeting in Vienna, where cochlear implantation has a long tradition since 1977.

The conference venue located in the unique Hofburg emperor palace, in the historic heart of imperial Vienna, gives us the right forum for more than 1000 participants.

Thanks to your contributions of more than 600 lectures, from all over the globe, in the main program, more than additional 100 company presentations and a lot of round tables and special sessions, making this meeting to the biggest scientific event in the field of otologic implants and related sciences, ever.

For the first time we selected an international publisher (Springer Publishers) to print all the abstracts beforehand the conference in an indexed journal supplement, giving everybody the opportunity to present his/her scientific data in a cited format. I hope that this innovation can be continued for the next conferences as well.

I wish You a successful and prosperous conference, pulsating and vibrating discussions about the latest research in the field, enjoy this supplement which indicates the event horizon in our scientific world and have a very nice time in Vienna.

Sincerely Yours

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Opening Lecture

Cochlear implants: A remarkable past and a brilliant future

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Just 30 years ago cochlear implants provided little more than a sensation of sound and sound cadences. They were useful as an aid to lip reading. Now, a majority of implant users enjoy high levels of speech recognition using hearing alone; indeed, many can use the telephone without difficulty. This is a long trip in a short time, and cochlear implants are widely and correctly regarded as one of the true miracles of modern medicine.

Although great progress has been made, much remains to be done. Patients with the best results still do not hear as well as listeners with normal hearing, particularly in demanding situations such as speech presented in competition with noise or other talkers. Users of standard unilateral implants do not have much access to music and other sounds that are more complex than speech. Most importantly, speech reception scores still vary widely across patients for relatively difficult tests, such as recognition of monosyllabic words, with any of the implant systems now in widespread use.

Fortunately, major steps forward have been made recently and many other possibilities for further improvements in implant design and function are on the horizon.

In this talk, I will recount briefly the progress made during the past three decades and then present my view of the future, which could not be more positive.

Basic Research (F1)

F1 – O1

Auditory nerve electrode with acoustic and electric stimulation and recording of nerve and evoked brain potentials in cats

WF Thumfart[1], P Finkenzeller[2]

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Objectives: Report of the historic first permanent auditory nerve implants in cats during the years 1975 till 1977. In addition brain electrodes overlying the auditory cortex were also permanently implanted to record the acoustic potentials after auditory stimulation.

Methods: Copper wire electrodes as bipolar implants were implanted into the acoustic nerve of cats. Cortical electrodes were placed over the acoustic cortex and could get direct access at the parietal skull of the cat, where it was fixed with titanium screws. Connecting this with a stimulation unit and a recording unit enabled the collection of evoked potentials.

Results: The dynamic range of electrically evoked potentials after stimulation of the auditory nerve differed remarkably from those after acoustic stimulation. On the other hand the resulting cortical evoked response potentials were very similar to each other.

Conclusions: After electrical as well as acoustic stimulation of the auditory nerve in cats with hooked wire electrodes cortical evoked potentials of chronic implanted 12 cats showed a very similar result to each other. Only the dynamic range of an acoustic evoked potential could never be compared with those after electric stimulation with rectangular stimuli. Over a time course of about one year after implantation also the stimulation intensity had to be increase from 8 μA to more than 120 μA because of the scar formation in the auditory nerve around the wire electrodes. Therefore an electrode placement for chronic electrical stimulation should be better placed outside the nerve in order to prevent changes onto the intensity over the course of time.

F1 – O2

Insights on auditory prosthesis design from animal models

PA Leake

University of California San Francisco, USA

Objectives: Studies in animals have shown significant neurotrophic effects of electrical stimulation via a cochlear implant (CI) in partially preventing spiral ganglion (SG) degeneration and other changes after deafness. Our objective is to elucidate the factors that promote anatomical and functional integrity of the auditory system after early deafness.

Methods: Cats deafened at birth or at 30 days of age model congenital and early acquired deafness. Anatomical changes in the SG and cochlear nucleus (CN) are examined and functional consequences of electrical stimulation are assessed in the inferior colliculus.

Results: Neurotrophins promote neural survival, but must be delivered for prolonged periods in conjunction with an implant for long-term efficacy. The cochleotopic organization of the SG to cochlear nucleus (CN) projections is intact even in neonatally deafened animals, but due to severe shrinkage of the CN, the spatial selectivity and inferred frequency resolution is significantly poorer than normal. Electrophysiological results also show that the fundamental tonotopic organization

of the central auditory system develops normally even in subjects deafened at birth. Following severe SG degeneration, electrical stimulation from an implant can improve degraded temporal resolution, but does not reverse the marked reduction in spatial selectivity and dynamic range associated with severe pathology.

Conclusions: Synchronized neural activity elicited by a CI can profoundly alter central auditory processing in the deafened auditory system. With very severe cochlear pathology, a CI subject might have to rely more on temporal cues that are still available to the central auditory system. *(Research supported by NIDCD Contract N01-DC-3–1006)*

F1 – O3

Estimating frequencies for cochlear implant electrodes

PA Leake, O Stakhovskaya

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Objectives: Frequencies of cochlear implant (CI) electrodes are usually estimated using Greenwood's equation for frequency vs. percent of organ of Corti (OC) length. However, there is often no accurate way to estimate OC length in temporal bone studies or imaging studies of living CI recipients. Further, many CIs target the spiral ganglion (SG), whose map may be different from that of the OC. Our objective was to develop better methods for estimating cochlear-place frequency.

Methods: Cadaver cochleae (n = 9) were fixed < 24 hrs post mortem, stained with osmium tetroxide, microdissected, decalcified briefly, embedded in epoxy resin and examined in surface preparations. In digital images, the OC and SG were measured and radial nerve fibers were traced to define frequency-matched points along the OC and SG.

Results: Expressed as percent of length, the data sets were highly correlated and best fit by a cubic function, allowing derivation of SG frequency from Greenwood's equation. The mean OC length was 33.13 mm; the mean length of the SG measured along the modiolar wall (optimum position of CI electrode) was only15.49 mm. Both OC and SG lengths were correlated (r^2=0.78, 0.88 respectively; $p < 0.005$) with cochlear size (basal coil diameter). Data suggest that frequency vs. angular position is relatively constant across specimens, whereas insertion distance correlates with cochlear size.

Conclusions: These data provide a means of estimating OC and SG length and thus more accurate frequency-place maps in imaging studies, allowing better matching of CI processor filter bands to stimulation sites. *(Supported by NIDCD Contract N01-DC-3–1006)*

F1 – O4

Innervation of the apical turn of the human cochlea – Implication for cochlear implantation

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Depts of Otosurgery and Otolaryngology, Uppsala University Hospital, Sweden

Objective: Innervation pattern of the human cochlea needs further characterization. The apical turn is not readily accessible for electrode insertion due to its small dimension. In addition, the benefits with such a deep insertion is not fully apprehended.

Methods: A light microscopic (LM) and transmission electron microscopy (TEM) investigation was performed on the apical turn of freshly fixed human cochlea, removed during petroclival meningioma surgery. The cochlea was serially sectioned perpendicularly to its long axis and at regular distances semi-thin sections were re-embedded and prepared for TEM. Nerve fibres/fascicles were traced from the area of the spiral ganglion to the level of the inner hair cells (IHC). The tonotopic organization of the cochlear nerve was assessed.

Results: The apical turn was innervated by 3694 myelinated nerve fibres (MNF), representing ten percent of the total number of fibres innervating the cochlea. The total number of unmyelinated nerve fibres (uMNF) was 513. A majority were efferent olivo-cochlear fibres of the intra-ganglionic spiral bundle but also single fibres representing type II afferent neurons, innervating outer hair cells (OHC).

Discussion: The significance of the anatomical findings in relation to cochlear implantation (CI) is discussed.

F1 – O5

Ultrastructure, innervation and organisation of the human cochlea

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[2]Department of Otolaryngology, Uppsala University Hospital, Sweden
[3]Department of Histology and Molecular Cell Biology, Institute of Anatomy and Histology; Medical University of Innsbruck, Austria

We compared morphological findings with electron microscopy and light microscopy of well preserved human and animal subjects. The characteristics of neural innervation, the pathways of the nerves through the organ of Corti and the intimate relation of nerves to supporting cells along their route with an emphasis on the apical turn of cochlea could be studied in detail.

Innervation density of the human cochlea varies from base to apex. It is highest in its mid-portion reaching a maximum in the lower second turn with 1400 fibers/mm. The rich interaction between neurons could explain the relatively slow retrograde degeneration noted in humans especially at the mid- and low frequency region.

We suggest that the concentration and high density of spiral ganglion cells, and the close physical interaction between neural elements, may explain the slow retrograde degeneration

found in human after loss of peripheral receptors with the typical base to apex gradient.

Possible sites for electrical stimulation in the very apex align with peripheral axons, since there are no ganglion cells present at that level. More apical located electrodes may result in lower pitched speech and better speech perception. More data on the tonotopical organization of the human spiral ganglion, especially in the middle turn and apex with densely packed spiral ganglion neurons, is required to better match electrical pitch with the place-equivalent acoustic pitch.

F1 – O6

Representation of acoustic signals in the human cochlea in presence of a cochlear implant electrode

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Objectives: In subjects with remaining low frequency hearing, combined electric-acoustic stimulation (EAS) of the auditory system is a new therapeutic perspective. Intracochlear introduction of a cochlear implant electrode may alter mechanical properties.

Methods: two hypothesis were evaluated in a 3D-computational finite element model of the inner ear: the effects of basilar membrane (BM) stiffening in the ascending basal and middle turns of the cochlea due to close contact of the BM with the electrode, and the effect of increased round window impedance following formation of fibrous tissue in this region. To verify our hypothesis, pre- and postoperative pure-tone audiograms of 13 subjects with substantial residual hearing, who underwent cochlear implantation, were evaluated.

Results: for partial BM-fixation, acoustic energy of middle (2kHz) and high (6kHz) frequencies was focused basally and apically to the fixed section, increasing BM displacement amplitudes up to 6 dB. Lower frequencies were not affected. Simulating an increase in the impedance ensued a 5 dB decrease in amplitude, predominantly in the low frequency area. In implanted subjects, a small but significant decrease of thresholds was observed at 1.5 kHz, a place in tonotopy adjacent to the tip region of the implanted electrode.

Conclusion: Our model suggests, that stiffening of the basilar membrane adjacent to an implanted electrode into the basal and middle cochlear turn did not affect BM movement in the low frequency area. Observations in implanted subjects were concordant with our model predictions. High frequencies, however, should not be amplified in patients using EAS to avoid disturbances due to tonotopically incorrect frequency representation. Fibrosis in the basal parts of the cochlea should only results in a minor decrease in low frequency perception.

F1 – O7

Electrical frequency-place map in subjects with no or minor hearing loss

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[2]Med-El GmbH, Innsbruck, Austria

Objectives: In actual cochlear implant systems the signal is filtered into different frequency bands and transmitted to electrodes along the cochlea which elicit different pitch perceptions. The study is investigating the frequency-place map for electric hearing in order to improve current speech coding strategies by delivering the spectral information of the incoming signal to the appropriate cochlear place.

Methods: Subjects with sufficient remaining hearing at the contra-lateral ear to make use of a hearing aid have been provided with a MED-EL cochlear implant in order to reduce their annoyance caused by tinnitus sounds. These subjects are unique in a way that they can directly compare acoustic and electric hearing. First the acoustic and electric stimuli are compared regarding their perceptual dissimilarities in a multidimensional scaling task. The stimuli consist of 5 electric stimuli between E2 and E10 and five acoustic stimuli (sinusoids logarithmically spaced between 150 and 3790 Hz). Second a pitch scaling is performed with each of 12 electrodes and 12 acoustic stimuli (sinusoids logarithmically spaced between 100 and 8500 Hz).

Results: The frequency-place map is calculated according to the exact electrode position in the cochlea obtained by multi-slice CT scans and will be compared to the Greenwood mapping.

Conclusions: The results of the presented study are important for future speech coding strategies because they indicate a frequency-electrode allocation which delivers each frequency component of a signal to the place where its pitch is elicited by electrical stimulation of the cochlea.

F1 – O8

Cortical tonotopic reorganization over time

J Guiraud[1], J Besle[2], L Arnold[3], P Boyle[3], E Truy[1], L Collet[1]

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[3]Advanced Bionics Europe, United Kingdom

Objectives: The tonotopic organization of the human auditory cortex has been shown to be changed in subjects both objectively (Dietrich et al., 2001) and subjectively (Thai-Van et al., 2002). However, there is no evidence that injury-induced reorganization after a long period of deafness is reversible (Irvine, 2000). Our objective was to follow up the tonotopy in cochlear implant users to see whether their cortical structures get reorganized after hearing rehabilitation.

Methods: The tonotopic organization was investigated in ten subjects using current density mapping, scalp potential mapping and dipole modelling at first day of cochlear implant use, and one and five months later. Subjects' ability to discriminate pitch was also studied using psycho-acoustical tests.

Results: The evolution of each tonotopic map is described with regard to subjects ability to discriminate pitch over time. Most of the subjects showed a dependence of dipole orientation to stimulated electrode after one month of cochlear implant use. In those subjects, individual responses revealed important inter-subject variabilities in N1 latencies and topographic changes with stimulus frequency. An inter-subject grand-average response, computed for each frequency at each session, is also compared with tonotopy in normal hearing subjects.

Conclusion: A cortical tonotopy could be shown in cochlear implantees. This organization changes over time and is the same as in normal hearing subjects for subjects who can discriminate pitch.

References

Dietrich V, Nieschalk M, Stoll W, Rajan R, Pantev C (2001) Cortical reorganization in patients with high frequency cochlear hearing los. Hearing Research 158(1–2): 95–101

F1 – O9

Preservation of hearing following long-term cochlear implantation

R Shepherd[1,2], A Coco[1], S Epp[1], J Fallon[1], J Xu[1], R Millard[2]

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Objectives: Maintenance of acoustic hearing following cochlear implantation (CI) is important as combined electric acoustic stimulation (EAS) to the one ear provides improved speech perception over electrical stimulation (ES) alone. We have previously demonstrated preservation of hearing following CI in normal hearing animals, here we examine whether hearing can be preserved following CI in partially deafened animals as hair cells that have survived one insult may be more susceptible to a second.

Methods: Five cats were partially deafened neonatally with aminoglycosides, received bilateral CIs at 2 months of age and were unilaterally ES for 6 months; three animals served as deafened controls. Compound action potentials (CAPs) and auditory brainstem responses (ABRs) were periodically recorded to evaluate hearing status and the cochleae were then examined histologically.

Results: CAP thresholds recorded from the implanted ear at frequencies of 0.5–4.0 KHz, showed no significant change over implantation time ($p = 0.63$). Moreover there was no significant increase in ABR thresholds over time and importantly, chronic ES did not affect the animal's hearing status. Histological examination of the cochleae was consistent with these physiological results, moreover these cochleae showed no evidence of infection or significant electrode insertion trauma.

Conclusions: Long-term CI and ES does not adversely affect acoustic thresholds in partially deafened cochleae free of infection and subject to minimal electrode insertion trauma. Moreover hair cells that survive aminoglycoside deafening do not appear more susceptible to a second insult from CI. These findings support clinical research investigating improved speech perception using EAS.

F1 – O10

Voxel based statistical analysis method for animal PET studies to assess the cerebral glucose metabolism in cat deafness model

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Background and Objectives: Imaging research on the sensory-deprived cat brain using small animal PET scanner has gained interest, because this model allows closer examination of the brain than is possible in the mouse or rat. In this study, we established procedures for the 3D voxel-based statistical analysis of FDG PET images of cat brain.

Methods: FDG PET scans of 4 normal and 4 deaf cats were acquired for 30 minutes using a microPET R4 scanner, and 3D PET data were rebinned using FORE and reconstructed using the OSEM algorithm. A target brain with best image quality and symmetry was selected and smoothed by convolution using an isotropic Gaussian kernel with 2 mm FWHM. All images were then spatially normalized (voxel size of 0.3 mm) onto the target brain and smoothed using a 3 mm Gaussian kernel. Voxel-wise and ROI-based nonparametric permutation tests were finally performed to identify regions with significantly different FDG uptake in normal and deaf cats.

Results: Cat brains were spatially normalized well onto the target brain after removing background activity. In the voxel-wise statistical analysis, the glucose metabolisms in the temporal cortex, caudate head, and thalamus in both hemispheres of deaf cats were found to be significantly lower than those in controls ($P < 0.05$). These findings matched well those obtained by the ROI-analysis.

Conclusions: In this study, we established a method for the voxel-wise statistical analysis of animal PET data of cat brain. The devised method showed high localization accuracy and specificity.

F1 – O11

Developmental myelination of central auditory pathway in congenital profound sensorineural hearing loss revealed by MRI

M Sano, K Kaga, K Mima

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Objectives: Myelination is considered to be an important factor in the development of central auditory pathway. However, congenital sensorineural hearing loss may affect the myelination of auditory pathway had not been cleared. So we performed MR study in 8 congenital profound sensorineural hearing loss infants before the cochlear implants operation and

evaluated the myelination of central auditory pathway comparing with normal hearing infants group.

Setting: The university of Tokyo Hospital in Japan.

Subjectives and Methods: Control Group is 80 normal hearing infants (younger than 2 years) who are between 1999 and 2002, suspected of brain disorder and underwent MR (magnetic resonance) imaging. We exclude the MR imaging that we cannot evaluate auditory pathway because of their brain lesions. Sensorineural hearing loss is 8 patients (age range, 1.5- 3.5 years) with congenital profound sensorineural hearing loss. Case 1 is auditory nerve disease, Case 2 is congenital cytomegalovirus infection, Case 3 is hyperbilirubinemia. Cases 4, 5, and 6 are etiology unknown. Case 7 and 8 is inner ear abnormality.

Results: Compared with normal hearing group, congenital profound sensorineural hearing loss group have no evident difference of myelination in central auditory pathway.

Conclusion: Congenital sensorineural hearing loss infants have developed normal myelination of central auditory pathway. So cochlear implants is considered to be effective even more congenital profound sensorineural hearing loss infants.

Rehabilitation (F2)

F2 – O1

Monitoring early vocal development in infants and young children

DK Oller

The University of Memphis, USA

Objectives: A special theoretical structure is needed to interpret changes in early vocal development for infants and young children with cochlear implants, CI (Oller, 2000; Ertmer et al., 2002). The primary purpose of our work on vocal development is to develop the necessary theoretical and methodological infrastructure for monitoring early development of vocalizations (Nathani and Oller, 2001).

Methods: Our approach identifies "protophones" that emerge in the first months for normally hearing infants, before "canonical" syllables are produced. The methods are based on a primarily auditory/perceptual approach influenced by classical ethology (Lorenz, 1978), with direct observations of infants and questionnaire information from parents (Oller et al., 1996).

Results: Deaf infants are delayed in onset of canonical babbling (Eilers and Oller, 1994; Oller and Eilers, 1988; Koopmans-van Beinum et al., 1998, July; Vinter, 1994), and infants with CI make rapid progress in the development of canonical babbling (Ertmer et al., 2002; Gillis et al., 2003). Canonical babbling often begins within a very few months of implant activation, and word usage shortly thereafter. In deaf infants without cochlear implants canonical babbling is often delayed a year or more, and word usage may be delayed by an additional year or more.

Conclusions: Monitoring vocal development within our approach makes it possible to view changes that are opaque to traditional methods of phonetic transcription and unguided acoustic analysis (Oller, 2006). The infraphonological approach allows analysis of changes that provide foundations for speech, and thus effects of rehabilitiation for infants with CI can be systematically monitored.

F2 – O2

Language development with a cochlear implant for meningitic deafness

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Objectives: to evaluate the long term development of language with a cochlear implant in children and adults with profound deafness caused by bacterial meningitis with and without basal turn ossification, and to compare to age matched populations with progressive deafness and congenital deafness

Methods: From 226 implantees, 29 were deafened by bacterial meningitis and implanted between 6 months and 38 years later, 6 by anterior cochleotomy due to ossified basal turn. 23 subjects performed the Freiburg monosyllabic and number tests at 60 and 80 dB SPL, 5 children the german RDSL III (live voice), 1 toddler was evaluated by comparative observation.

Results: monosyllabic discrimination scores between 75 % and 0 %, on average 33–37 %, numbers between 100 % and 0 %, on average 66–70 %. RDLS shows steep increase along time in all individuals. Two adult late implantees are non-users, one regular user gains no speech discrimination.

Conclusions: Most implantees of the meningitic deafness population achieve speech discrimination scores as good as those from the progressive hearing loss population. Language development in children and infants is similar in the meningitic population as compared to age matched congenital deaf children. Duration of deafness and the extent of basal turn ossification does not correlate with low performance.

F2 – O3

Language development at one year post implantation in young children

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Objectives: As part of the Childhood Development after Cochlear Implantation (CDaCI) study, receptive and expressive language was assessed using a parental report (the Macarthur Communication Developmental Inventory-CDI) and a standardized language test administered by a speech-=language pathologist (Reynell Developmental Language Scales-RDLS). Language outcomes are reported for 45 implanted children (CI, mean age at baseline = 3.2 years) and 45 normal

hearing controls (NH, mean age at baseline = 3.1 years) reaching 12 months of follow-up.

Methods: Children were evaluated at baseline, 6-month and12-month follow-up intervals. Parental measures were given as questionnaires typically filled out at home and the RDLS was administered in the clinic. Total correct scores were calculated based on the total number of items reported by either the parents of clinicians.

Results: At baseline, language scores were higher for older children than younger children in both groups. Nearly 65 % of CI children and all NH children showed improvements in language performance during the first year. Greater gains were observed for the parental report measures relative to the clinician derived measures.

Conclusions: By 12 months, more than more than half of CI children were demonstrated small but steady gains in overall language skills; however, no CI children performed comparably to normally hearing peers. (Supported by NIH-NIDCD R01DC004797).

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F2 – O4

Assessment and rehabilitation of children with auditory neuropathy

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Objectives: Discuss the clinical paradigm and results for the evaluation and rehabilitation of children diagnosed with auditory neuropathy (AN) at a large tertiary care pediatric cochlear implant program.

Study Design: Retrospective chart review.

Results: Since universal newborn hearing screening was implemented in North Carolina in 2001, we have identified or evaluated seventy-five children with AN. Of these, 26 (35 %) are in the evaluation process or do not require amplification and 21 (28 %) are being rehabilitated with amplification. Twenty-eight children (37 %) have undergone cochlear implantation after an appropriate amplification trial.

Conclusion: Children with AN may represent more of a diverse clinical group than previously thought. The diagnosis and rehabilitation of these children is complex and challenging. We suggest that assessment by auditory brainstem response alone in these children is not a reliable indicator of cochlear implant candidacy and that continued behavioral audiometric assessment and an appropriate amplification trial combined with information obtained from diagnostic auditory therapy are required to determine the optimal rehabilitation mode for each individual.

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F2 – P5

Formulation of language structures of Filipino cochlear implanted children in a bilingual setting

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Objectives: In every therapy situation, parents and professionals are always faced with the choice of which language to use in teaching the child with hearing impairment. Most often, the choice is based on either 1) the language most comfortably used by the majority of the household or 2) medium of instruction used in the school system. In a bilingual setting, what influences the development of language structures of cochlear-implanted children undergoing Auditory-Verbal Therapy?

Conclusions: This presentation focuses on the probable factors that influence the development of language structures of Filipino cochlear-implanted children undergoing Auditory-Verbal Therapy at CLASP AV Center Manila as it relates to the general stages of early bilingual development. Specifically, the main outcome parameters for determining language structures will focus on the following: Mean Length of Utterance (MLU), sentence structure and complexity. Discussion arising from this presentation may lead both parents and professionals to re-think the methods used in teaching language to children with hearing impairment. Is it time for a paradigm shift?

F2 – O6

The effects of implantation age on theory of mind of cochlear implanted pre-lingually deaf children

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The term ‘theory of mind’ (ToM) refers to the ability to impute mental states to oneself and to others; it involves the knowledge that mental states of others can differ from one’s own and also from reality. Mental states include purpose, intention, knowledge, belief, thinking, doubt, guessing, pretending, and liking.

This paper aims to compare theory of mind ability among children who were cochlear implanted in three different age groups: 0–2, 2–4 and 4–6 years. The obtained results will be compared with that of peer non-implanted deaf children and hearing children. The subjects were matched based on socioeconomic status, residual hearing before cochlear implantation, the kinds of cochlear implant device, speech processing strategy, communication mode after implantation and primary language in family. All of them have used the device minimally for four years. All the subjects were tested with a range of false belief tasks; which, are traditionally used for assessment of theory of mind development. Results showed that the theory of mind ability in children who are implanted at 0–2 years of age is similar to peer hearing children.

F2 – P7

Learning speech with shifted frequency-to-place maps

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Objectives: Both, CI users and normal hearing listeners are able to learn to overcome some of the acute effects on speech perception of shifted mappings of acoustic frequency to cochlear place. Previous studies have shown this to occur for shifts that are approximately constant in basilar membrane (BM) distance such as arise with variations of electrode insertion depth. We have investigated whether such learning can also occur with more complex shifts of frequency-to-place mapping that may also arise with cochlear implants.

Methods: Both studies were simulations in normal listeners using vocoder-like speech processing. The first was a monaural processor in which the 6 medial analysis bands of a 12-channel processor were shifted around a simulated dead medial BM region. Three bands were shifted apically and three shifted basally. Listeners were trained for 3 hours and speech perception measured before, during and after training. A second study examined a 6-band binaural processor. Analysis bands were interleaved between the two ears. One ear received stimulation at places matching the analysis bands, while the opposite ear was stimulated at BM places shifted basally by 6 mm from the correct places. Again, listeners were trained, here for 5 hours, and speech perception measured before, during and after training.

Results: Listeners were readily able to learn to recognise speech through the monaural processor that shifted mid-frequencies both apically and basally. However, the binaural processor with a mismatch to one ear proved resistant to training, with scores not exceeding those found when only the 3 unshifted bands were presented.

Conclusions: While the ability to learn shifted frequency-to-place maps is not limited to constant shifts of basilar membrane position, maps that are in conflict between two ears may be more resistant to this plasticity. This may have important implications for bilateral CI and for the use of one CI with a contralateral hearing aid.

F2 – P8

Becoming bilingual: English and Spanish speech and language development following cochlear implantation

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Objectives: The purpose of this single-case study was to document the speech and language acquisition in Spanish and English in a child following cochlear implant activation at 20 months-of-age.

Method: Language data were obtained from both parents and school personnel. Speech data were obtained at monthly intervals in the home while the child was engaging in free play. The speech samples were transcribed and entered into the Logical International Phonetics Program or LIPP. Consonant and vowel repertoires and CV patterns were obtained up to 30 months post implant. Vocabulary development in Spanish and English were measured by the MacAurthur Child Development Inventory.

Results: Analysis of our participant's CV productions showed a pattern similar to children in an English language environment who have received cochlear implants. These patterns of syllable organization showed similarities to typically developing infants and to other children with CIs. Vocabulary development in both English and Spanish are proceeding at a steady pace. Some code mixing on specific words has been noted.

Conclusions: These results further support the notion that the patterns of serial organization of speech are different in children receiving cochlear implants. These results support the notion that ambient language exposure has little influence on the content of syllables in early speech. Language development data suggests children can develop simultaneous bilingual skills.

F2 – O9

The rate of development of phoneme accuracy in children following cochlear implantation as a function of age of implant

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Objectives: The goal of this study was to explore the rate of development of phoneme accuracy over time.

Method: Fifty-seven children who received their cochlear implant between 12 months of age and 14 years of age participated in the study. Yearly speech samples were obtained in both free play and through an elicited task. Speech samples were transcribed an entered into the Logical International Phonetics Program or LIPP. Phoneme accuracy was evaluated at each age interval. The children were grouped by age-of-implant. The data were analyzed using hierarchical linear modeling (HLM).

Results: Children implanted after age 5 had a slower rate of growth of phonemes and speech skills began to plateau after 7 years post implant. The younger implant group showed steeper growth functions and a longer period of growth prior to the plateau in speech skills beginning at 11 years post implant.

Conclusions: These data further demonstrate the positive speech outcomes in children who receive their implants at an earlier age.

F2 – O10

The development of consonant-vowel syllables in children following cochlear implantation

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Objectives: This study investigates the beginning stages of speech acquisition following cochlear implantation within the perspective of the Frame-Content Theory. Intrasyllabic consonant-vowel (CV) syllable shapes were evaluated at yearly intervals post-implant.

Methods: Fifty-seven children who received their cochlear implant between 12 months of age and 14 years of age participated in the study. Yearly speech samples were obtained in both free play and through an elicited task. The speech samples were transcribed an entered into the Logical International Phonetics Program or LIPP. The intrasyllabic patterns of consonant-vowel pairs (CV) in words and babbling were analyzed.

Results: Analysis of CV productions showed that children implanted prior to 30 months-of-age demonstrated patterns of syllable organization most like typically developing infants. However, they also showed a statistically significant preference for other CV syllable types not seen in typical infants. Children implanted after 30 months of age showed patterns of organization distinctly different from typical children. Subsequent analysis of the elicited task used to gather the data showed the children were very accurate in production of the elicited narrative task. The task did not control for the normal distribution of syllable shapes observed in English, therefore introduced a bias in the sample.

Conclusions: Intrasyllabic syllable organization is more typical when the child is implanted earlier. The results of the older children were biased by the task in which the data were gathered.

F2 – O11

Phonological distance measures for cochlear implant users

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Objectives: To examine formal measures of distance between phonological systems of pediatric cochlear implant users and the ambient language; to compare these measures to naïve human judgments.

Methods: Single-word speech production data were collected from children with at least 5 years of cochlear implant use. Data were then subjected to three measures of phonological distance. Specifically, the data were analyzed (1) with respect to corresponding dictionary pronunciations using (a) an existing deterministic dialect difference measure, Levenshtein distance (Levenshtein, 1965); (b) a novel probabilistic measure of dialect difference adapted from Dunning's (1994) maximum likelihood estimation for language classification, which compares multiple languages to a single test corpus; and (2) with respect to correctness judgments by naïve listeners. Finally, correlational analyses were applied to the three phonological distance measures.

Results: Both formal methods show promise in determining phonological distance with respect to cochlear implant users. The maximum likelihood estimation developed here produces results similar to the established Levenshtein distance measure on the same training, and both methods approximate naïve human judgments.

Conclusions: Dialect distance provides a useful quantitative summary of the phonological development of cochlear implant users. A formal algorithm provides a repeatable, understandable method that approximates human judgments. Both formal distance measures have this property, but the statistical, probabilistic algorithm is more flexible since it requires fewer assumptions about the input corpus.

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F2 – P12

Cochlear implantation improves developmental rate in children with global delay

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Objectives: The most common measure of success following pediatric cochlear implantation is language development. However, even with normal hearing, children with global developmental delays do not typically have normal language development. As an alternate measure of success, we sought to determine whether deaf children with such delays have improvements in quality of life and rate of development after cochlear implantation.

Methods: We studied a cohort of four pediatric patients with global developmental delays who underwent cochlear implantation. Standardized neuropsychological testing was performed pre-implant and approximately one-year post-implant. Additionally, notebooks maintained by parents and records from teachers and therapists were analyzed.

Results: Each child tested at or near the first percentile for age on neuropsychological testing pre-implantation. Post-implantation, these patients remained at or near the first percentile for age, but the average rate of development increased from 0.25 to 0.47 cognitive months per chronological month, representing an 88 % improvement versus the pre-operative rate of development. Additionally, all four children demonstrated improved self-confidence, communication skills, and social interactions after implantation. These improvements have manifested as longer attention spans and decreased timidity and anxiety as reported by family and caregivers. All children are calmed when their implant is turned on, enjoy listening to music, and have an increased connectedness with their family and caregivers.

Conclusions: Cochlear implantation can facilitate improvements in cognitive development and provide considerable quality of life improvements for deaf children with global developmental delays, even though normal speech is not expected to occur.

F2 – P13

Stability of vowel space and vowel placement

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Objectives: The Bark Scale is an innovative method for evaluating the speech perception of children with a cochlear implant. Vowel production and vowel space is directly affected by auditory perception. We examined the stability of vowel space in normal hearing adults over time and in adults with a cochlear implant.

Methods: Correlational study of lingual position of the cornerstone vowels /i/, /a/, and /u/ and vowel space over time. Speech samples of the three cornerstone vowels in 3 phonetic contexts were gathered using an imitative paradigm and analyzed spectrographically. The respective harmonic frequencies of the vowels were converted into Bark scale values. Correlational values were calculated between the F1-F0 and F3-F2 Bark differences and area of the vowel space. To study the stability in adult implant users, 3 adult cochlear implant users were also sampled. Their implants were turned off for 24 hours and vowel productions were sampled over time to measure the effect of short-term auditory deprivation on vowel production.

Results: 19 monolingual English-speaking adults were sampled in 3 phonetic contexts, the vowels in isolation, CVC, and sentence. Results indicate statistically significant correlation values for the /i/, /a/, and /u/ vowels in isolation. The test-retest reliability in adults with cochlear implants and change over 24 hours of auditory deprivation will be reported.

Conclusions: Bark scale difference values for the cornerstone vowels /i/, /a/, and /u/ indicate that vowels are stable measures in normal-hearing adults. The pilot data with cochlear implant adult users demonstrates the effects of short-term auditory deprivation.

F2 – P14

Benefit of language software for prelingual teen / adult CI users

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Objective: To determine if prelingually deafened adult and teen CI recipients benefit from home-based, self-paced, computerized language learning software.

Methods: A within-subjects balanced crossover design was used to compare speech perception and speech/language abilities of subjects prior to and following use of the Rosetta Stone Language Learning software program.

Subjects: 12 individuals who received a multichannel CI and were deafened prior to the age five.

Subjects participated in speech perception and speech-language testing on three separate occasions over a 6 month period: at the beginning, and three, and six months into the study. Six subjects utilized the software program daily for the first three months while the remaining six subjects utilized the program daily during months 4–6. Subjects completed questionnaires regarding their satisfaction and software use.

Results: Most subjects demonstrated improved speech-language scores following utilization of the software program. Preliminary results indicate these scores did not decrease once the subjects discontinued use of the software program.

Conclusions: The Rosetta Stone Language-learning software may facilitate improvements in speech perception and speech/language skills of prelingually deafened cochlear implant users. This approach to aural rehabilitation is attractive for this population as it is self-paced and provides the individual with a non-threatening learning partner. We recommend that patients consider using this software as part of their post-implant rehabilitation process.

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F2 – P15

Custom made computer program for hearing training of CI patients

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Objectives: The authors demonstrate a custom made computer programme for hearing training of CI-patiens.

Methods: A computer programme was written in Visual Basic language for hearing training. The database for practice contains sentences taken from a conversational dictionary sorted by different topics.

The database consists of sentences in text and of sound files with "wav" extension. The programme and the database are stored on CD. The CD can be used in group activities and for individual training too. The patients or the tutor can choose the topic, and the sentences are played randomly or in alphabetical order, according to the request. The patient has to repeat loudly the sentence. After adjustable delay comes the written solution. Pressing the correct or incorrect bottom the test will be continued with a new sentence and the screen shows the acquired points.

The database can be completed with new topics or difficult words individually. The CD can contain video-clips with original sound, or clips with synchronized sound preventing from lip reading. The database for children shows pictures instead of text. In case of difficult understanding the test can be repeated.

Results: The patients like to use the test at home, but most of them prefer the group activities.

Conclusions: The CD material is a very useful help for hearing training of CI-patients.

F2 – P16

Discrimination of spectrally rippled noise and speech understanding

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Objective: A major factor limiting speech performance and musical appreciation is the poor frequency resolution of CI users. Assessment of a subject's sensitivity to spectral changes may hold predictive value for program adjustments and recognition performance. Recently spectral ripple testing was proposed to assess the whole cochlea in a single broadband measurement [1]. The test subject has to discriminate between two ways of spectral modulation of a wideband noise signal while the number of ripples is gradually increased. In [1] this test showed a good correlation with vowel and consonant recognition. In this study we investigate the performance of CI and HA users on spectral ripple tests and correlate it with the performance on alternative frequency resolution tests and speech recognition tasks.

Methods: The AFDL and spectral ripple tests were implemented in PACTS, a psychoacoustic test package. The smallest noticeable differences were determined with an adaptive 3AFC procedure. Speech performance was assessed with phoneme discrimination, CVC words, and a Dutch vowel and consonant identification test. 18 adult CI users and 15 HA users participated in this study.

Results: Average spectral ripple performance for HA and CI users are respectively 2.7 and 1.5 ripples per octave. Spectral ripple performance is correlated with average AFDL. A smaller correlation frequency selectivity and speech understanding performances was found than in the Henry study.

Conclusions: Spectral ripple testing is a promising technique for frequency discrimination assessment.

References

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F2 – O17

Perception of emotion by cochlear implant users

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Objectives: To investigate the ability of adult CI users to identify suprasegmental aspects of speech conveying different emotions.

Methods: Pre-recorded speech examples expressing each of four emotions (happiness, sadness, anger, neutral) were played to thirteen subjects. A pilot study indicated that normally hearing listeners could identify these emotional types. Subjects used their usual cochlear implant setting and results were plotted on a confusion matrix. Twelve normally hearing listeners also performed the task listening via CI simulations that emulated three rates of stimulation. Correct identification scores (CIS) were compared with those of CI subjects.

Results: Results showed that the CI users have poorer average total CIS than the normally hearing listeners. However the pattern of least to most easily identifiable emotions was almost identical between the two groups. A significant negative correlation was found between the amount of confusion and the magnitude of F0 differences in the normally hearing group but not the CI group. Correlations between the confusion scores and absolute intensity differences in the CI group showed a significant negative relationship. The intermediate processing rate (1400pps/channel) was found to give the best CIS.

Conclusions: Ability to correctly identify emotion is limited in CI users. While normally hearing listeners can use F0 differences effectively, CI users are forced to rely on absolute intensity differences.

F2 – O18

The effects of training on timbre recognition

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Objectives: To examine 3 types of training on timbre recognition (musical instruments) presented to normal hearing (NH) adults through CI simulations. Prior research indicates that CI recipients are less accurate than NH adults on timbre recognition, but can improve as a result of direct instruction (Gfeller et al., 2001, 2002a, 2002b). This study using simulation testing compares rate as well as extent of improvement for different training approaches.

Methods: We are testing 99 NH adults assigned to 3 types of training (repeated exposure, repeated exposure with feedback, direct training) for recognition of CI simulations of 8 musical instruments. The condition of repeated exposure without feedback is similar to everyday music listening (e. g., the radio) where specific information about the musical content is absent. The stimuli presented in training contains CI simulations created from recordings of live instruments. The training is presented via computer over a 5-week period. Recognition testing is completed prior to training and at intervals during and after training.

Results: Data collected to date with 26 participants indicate that modest improvement in recognition can occur as a result of repeated exposure without feedback. The mean number of correct responses (closed set) prior to training is 42 % correct, with modest improvement of 53 % correct after repeated exposure without feedback. Results for the feedback and direct training conditions will be presented.

Conclusions: Only modest improvement in timbre recognition occurs as a result of repeated exposure without feedback. We hypothesize greater improvement as a result of feedback and direct training.

F2 – P19

Speech perception in noise in CI systems with different microphones

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Objectives: To compare speech perception in noise in recipients of the Nucleus CI24R(CA) implant system (Cochlear, Melbourne) and the Combi 40+ system (Med-el, Innsbruck).

Methods: One group of patients was provided with the CI24R(CA) implant the other with a C40+ implant. The loudspeaker set-up was S0N180 for the Hochmair-Schulz-Moser (HSM) sentence test and S0N0 for the Oldenburg test. Both tests were presented with a fixed speech level of 65 dB. The noise level was modified adaptively in the Oldenburg test, whereas the HSM test was carried out at four fixed signal to noise levels (15, 10, 5 and 0 dB).

Results: A significant difference between both implant groups was detected in the results of the HSM sentence test set-up ($p < 0.001$ at 0 and 5 dB SNR, $p < 0.05$ at 10 and 15 dB SNR), but not with the Oldenburg sentence test set-up. The cochlea system with the directional microphone feature shows a significant advantage in the specific hearing situation, where the signal is presented from the front and the noise from the back (S0N180).

Conclusions: In comparison to an omnidirectional microphone, a directional microphone does improve speech perception in situations, where a single noise source from behind is the masker. The selection of test method and loudspeaker set-up is essential to assess speech perception in noise.

F2 – P20

Fitting children with implants with personal FM systems

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Objectives: It is recognized that personal FM systems reduce the detrimental impact of noise and reverberation on speech recognition for individuals using conventional amplification (Anderson & Goldstein, 2004) and it is likely that the same benefit can be gained by children with cochlear implants. However, there are several factors that confound the use of personal FM systems with cochlear implants. These include the presence of a second FM signal used to transmit information from the speech processor to the internal implant and the inability of teachers to experience the same signal the cochlear implant user receives.

Methods: Twenty children with Nucleus ESPrit 3G speech processors were seen for their annual assessment. Personal FM systems and speech processors were checked and each child was administered the Word Identification Picture Index in quiet, in noise without the FM system and then in noise with the FM system.

Results: Problems with speech processors, FM systems and accessories are defined and comparisons among performance in quiet, noise and noise with FM are presented.

Conclusions: This study examines the problems that can occur when cochlear implants and personal FM systems are linked together and presents a process that ensures speech processors and cochlear implants are functioning effectively together.

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Surgery (F3)

F3 – O1

Protection against trauma induced hearing loss by mild hypothermia

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Objective: To demonstrate that systemic or localized hypothermia allows conservation of ABR and DPOAE following cochlear implantation of the rat.

Methods: In the first study, thirty rats underwent CI electrode insertion with rectal temperature maintained at 37° C or 34° C throughout the experiment. Controls included non-operated ears and cochleostomy only at 37° C. Multiple frequency auditory brainstem response (ABR) and distortion product otoacoustic emission (DPOAE) testing of all ears was performed immediately before and after surgery and on postoperative days 3, 5, and 7. In the second study, twenty-four ears of 12 rats were prepared by sealing a micro-temperature probe into the basal turn of the cochlea. Cochleae were then cooled by cold saline irrigation (11° or 14° C) of the external auditory canal (EAC) or bulla or by direct application of ice over the bulla. Cochlear temperature measurements were obtained every 30 seconds during the cooling period until stable. Cooling was then discontinued until temperature recordings spontaneously re-normalized. Rectal temperature was monitored continuously and maintained at 36° C.

Results: Mild systemic hypothermia prevented some of the initial HL and most progressive HL caused by electrode insertion. All localized hypothermia techniques resulted in cochlear hypothermia without a concomitant change in rectal temperature with no statistically significant differences between groups.

Conclusions: Systemic hypothermia protects the cochlea against electrode insertion induced loss of auditory function. Localized cochlear hypothermia was induced in a rat model demonstrating the feasibility and efficacy of modulating cochlear temperature to a targeted level without influencing the body's core temperature.

F3 – O2

Surgical considerations in cochlear implant in children with normal and anomalous ears

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Objective: To summarize and analyze the etiology, preoperative assessments, surgical techniques, surgical complications and outcomes of cochlear implantation in children with normal and anomalous ears at PUMC hospital, Beijing.

Methods: 667 children with severe and profound hearing loss received cochlear implant. Their ages at implant were from 10 moths to 14 years. 101 cases (about 15.1 %) were found the anomalous middle and inner ear malformations. That included Mondini in 36 cases, Common cavity in 10 cases and Large vestibule aqueduct syndrome in 37 cases. Preoperative hearing assessments were done for all children and speech evaluations were done only for some children with auditory verbal abilitis. The devices they used were Nucleus, Med El and Clarion.

Results: All the patients restored their useful hearing excepted 2 children without any auditory sensation. In the inner ear malformation cases, gushers happened in 28 of 36 cases in Mondini cases, but only happened in 2 cases in Common cavity cases. The surgical complications were mild. The average of open set sentences discrimination in postlingual deadness was 70 to 80 %. The satisfaction rate of questionnaire for prelingual deafness was 94.7 %.

Conclusions: Cochlear implant is an useful treatment to restore the hearing of children with severe and profound hearing loss. It is important for the better outcomes with appropriate preoperative assessment, patent selection, surgical techniques, switch-on and mapping, postsurgical auditory and verbal rehabilitations.

F3 – O3

"Deep" insertion of the electrode, up to the apex of the cochlea

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As neuronal structures in the apex region of the cochlea remain present in complete deafness it is advantageous to exitate them too with a cochlear implant. Prerequisits are an appropriate electrode and some micro surgical details. The electrode should be guided into the cochlea on a strait road without edges. The postoperative results are rewarding.

F3 – O4

Effects of electrode placement and place of stimulation on speech perception with cochlear implants in adults and children

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F3 – O5

Cochlear implantation in chroic otitis media and subfacial route

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Patients suffering from profound hearing loss as a result of chronic otitis media (COM) who had been implanted with a multichannel device were evaluated regarding surgical problems and modifications in surgical technique.

Between May 1998 – October 2005 419 cases were implanted at Ýzmir Teaching Hospital CI Center. Among them in 42 the etiology was COM. Sub facial route was used for implantation in 5 revision cochlear implantation (CI) cases and 12 primary cases in which a radical cavity exists. These 42 COM cases were evaluated regarding the surgical problems, technical modifications, complications and hearing results.

In all patients hearing results found to be satisfactory 1 to 5 years after implantation.

CI in COM patients necessitates technical modifications. In radical cavities sub facial implantation seems to be a good solution for prevention of complications.

F3 – O6

Management of chronic otitis and mastoiditis in children after cochlear implantation

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There is no doubt, that cochlear implants have been an effective treatment for deaf born children. Due to the results of an effective newborn hearing screening the advantages of cochlear implantation can be offered more and more to younger children. This leads on one hand to a decrease of the age at implantation. On the other side, cochlear implants are placed more and more in younger children, a population also will face with courses of middle ear effusions and acute otitis media.

A possible complication of every otitis media is mastoiditis. Having placed an implant, which is of course a sort of a foreign body, the question comes up, how to proceed in implanted children, if an otitis media or mastoiditis occurs. Usually it is recommended in cases of infection to remove foreign bodies. We report on three children of our population who underwent surgical treatment of mastoiditis with preservation of the implant inside too. Two of these three children were implanted because of their deafness following meningitis. The same pneumococcus caused the mastoiditis. In addition an early surgical intervention was able in all three cases not only to treat the disease and cure the infection but also preserve the implant intact. Surgical concepts in these revision cases were explained and also conclusions regarding primary cochlear implant surgery were drawn from these selected revision cases.

F3 – O7

Adjusting flap thickness over implant package

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Objectives: Flap thickness is an important criterion in the optimum function of the Cochlear Implant, the most practical method is to use the magnet in the coil to assess the thickness of the flap, and thinning it when needed, without comprmising the integrity and future viability of the flap.

Methods: Towards the end of the surgical procedure, after fixing the Implant Package in its bony bed, the flap is secured temporarily in its final position and the coil is placed on the flap to assess the adherence of the coil to the internal package through the skin. The surgical details of what and how much and what to re move are explained.

Results: Good contact is achieved between the Coil and the Implant Package, the skin is slightly indented in some cases but no other skin flap complications were seen.

Conclusions: Assessing and adjusting the thickness of the flap using the coil magnet as a guide is a safe and reliable technique, as well as being practical.

F3 – O8

Electrode lead fixation at posterior tympanotomy using sialastic wedge

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Objectives: Securing the fixation of the Electrode Lead as close as possible to the Cochlea by a technique which is easily applicable, easily available, non traumatic to the surrounding tissues or the Electrode lead.

Methods: Sialastic Wedge 1 mm. thickness, triangular in shape, the base of which is 3 mm. wide, the height of which is 4 mm.

This wedge is placed in the posterior tympanotomy, alongside the Electrode Lead, to act as a plug, fixing the Lead in place.

Results: This method of fixation has been used by the author in more than 200 cases over the past 6 years with no adverse effects. Around 10 cases needed reimplantation, where the site of posterior tympanotmy was well inspected, and compared to cases where different methods of fixation were used.

Conclusions: Fixation of Electrode Lead by Sialastic Wedge is a safe and secure method of fixation with no adverse side effects. The presence of the wedge may facilitate surgery at reimplantation.

F3 – O9

Surgical management to problems of cochlear implantation

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Background and Objectives: Management of implant failures and performance of revision surgery are becoming increasingly important in cochlear implant programs. We reviewed cases involving implant failure and revision surgery in a tertiary hospital.

Materials and Methods: Between 1988 and 2005, 540 cases received cochlear implantation at Seoul National University Hospital. We evaluated the cause of deafness, the intraoperative findings and the complication rate for all performed cochlear implantations. The series included 80 adults and 460 children.

Results: In 540 cases, additional surgery was performed to associated problems of implant in 24 cases (4.4 %). Device failure was detected in 12 patients (2.2 %), and they received revision surgery. In 5 cases (0.9 %), electrode array of internal device made problems. Magnet displacement was found in 2 cases. Other problems were flap necrosis, infection, facial nerve palsy, keratoma, and granuloma. In revision cases, preoperative and postoperative auditory performance showed no significant differences. There were no complications in revision surgery.

Conclusions: Cochlear implantation is a safe procedure, associated with a low rate of major complications. Nevertheless, patients should be informed about possible problems and especially about the risk of a reoperation due to device failure and other surgical problems.

F3 – O10

Revision cochlear implant surgery in children

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Objectives: 1. Evaluate the mechanisms that lead to revision cochlear implant surgery in children 2. Determine the impact of revision surgery on cochlear implant performance.

Methods: A retrospective chart review of children requiring revision cochlear implant surgery at two large pediatric cochlear implant centers was performed. Patient demographic, surgical findings, complications, device type, and performance data were collected. The presumed mechanism that led to revision surgery was classified. Post-explantation device analysis reports from the manufacturer were also reviewed.

Results: Of 972 pediatric cochlear implant patients followed at the two centers, 92 (9.5 %) required revision surgery related to the device. The reasons for revision surgery were: total device failure (50 %), symptoms or signs of suspected device malfunction (16 %), or a medical/surgical-related complication (34 %). Preceding trauma to the device was not uncommon. Performance was generally good after revision surgery although a period of acclimation to the new device was often needed. Complications related to revision surgery were uncommon.

Conclusions: The need for revision cochlear implant surgery in the pediatric population is not uncommon. Most patients undergo revision surgery for device failure or for medical/surgical issues. While uncommon, suspected device malfunction must be considered in children with worsening performance or when significant aversive symptoms arise. In most cases, good performance can be anticipated although a period of acclimation may be needed.

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F3 – O11

Cochlear reimplantation

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Aim: The goal of this study is to examine the cases of cochlear implant (CI) users who underwent reimplantation at ARC, Bauru.

Methodology: Since 1990, this center realized more than 460 surgeries. From this total number, twenty-six CI users were reimplanted. The thresholds from the free field audiometry and the results from the speech perception tests were compared before and after the reimplantation.

Results: Internal device failure (23), head trauma (2) and otitis media (1) originated the necessity for the reimplantation. The use of CI by the patients varied from 4 to 58 months. There was no significant difference between the audiometric thresholds and the speech perception tests before and after the reimplantation.

Conclusion: The results obtained with this study showed that the reimplantation did not significantly affect the auditory performance, related to the audiometric thresholds and the speech perception tests. The reimplantation should be done as soon as possible, especially with patients that acquired the hearing loss before the oral language acquisition. The stimulation generated from the CI users test will contribute effectively for the evolution of the auditory and language abilities.

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F3 – O12

Contralateral reimplantation – is there a problem?

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Objectives: Prospective monitoring of outcomes of patients who have received contralateral-implants who technically would have been out of clinical selection criteria.

Method: 4 patient study. 2 Children previously successfully implanted had to be explanted and unable to be reimplanted into the same ear. When assessed the dilemma to implant the opposite side was that they would be 12.5 and 9.5 years in the non-stimulated ear. 2 adults; both had profound hearing loss in one ear from birth / early childhood. ED lost the hearing in her only ear 1 month after middle fossa surgery at the age of 53. This ear was implanted but with no benefit. Mr K at 55 suffered immediate hearing loss following surgery for a facial tic. In both implantations were performed on their long term deafened ear.

Results: Both children continued to progress despite the contralateral ears being 'out off criteria'. LJ uses the phone CAP level 7; RW good open set CAP 6.

Mr K over a 5 year period developed open set hearing. Mrs ED has had her implant for 9 months and recognises sounds and basic phrases.

Conclusions: The auditory nerves are known to stimulate both sides of the brain. In all cases there has been appropriate initial auditory stimulation. It is suggested that the efferent nerves may well offer 'trophic' stimulation and maintain the integrity of the peripheral auditory pathways up to spiral ganglion cells thereby allowing successful implantation in what might be considered inappropriate ears.

F3 – O13

Paediatric cochlear reimplantation

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Experience on 15 paediatric cases who had reimplanted at Ýzmir Teaching Hospital Cochlear Implant Center will be presented and measures that are necessary for prevention of complications will be discussed. Although cochlear implantations are generally performed by experienced ear surgeons in some patients reimplantations may be necessary. As many other revision surgeries reimplantations may have special problems and experience on this topic should be shared.

Between May 1998- October 2005 419 cases were implanted at Ýzmir Teaching Hospital Cochlear Implant Center. 294 of them were paediatric ceses aged between 18 months to 14 years. In 15 cases a reimplantation was found to be necessary. Cases were analised retrospectively.

All reimplantations were done without any complications and implant performances have not changed after reimplantation. Surgical details of reimplantation, status of the implant body and electrodes and operative field were noted and audiological results were reviewed.

The rate of reimplantation for surgical or device related complications are dropping; nevertheless every case can give new information about how to avoid the complications. Implant trauma and migration of implant body may cause device related problems in small children. Although paediatric reimplantation was found to be safe and reliable, to avoid complications which necessitates reimplantation is essential.

Genetics (F4)

F4 – O1

How genetics can help cochlear implantation: the Otoferlin story

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The last ten years have witnessed the identification of over 40 genes involved in non-syndromic hearing impairment (NSHI). However, routine genetic diagnosis is provided only for mutations in the DFNB1 locus in most of countries. To expand genetic diagnosis, further knowledge is needed on the prevalence, mutational spectra and genotype-phenotype correlations of the different subtypes of NSHI. Progress in these fields is exemplified by studies on the otoferlin gene (OTOF, on 2p22).

OTOF expression in the adult cochlea is restricted to inner hair cells. Otoferlin, a membrane-anchored cytosolic protein with up to six C2 calcium-binding domains, is likely to be involved in membrane fusion of synaptic vesicles.

The p.Q829X mutation in OTOF was first identified in a Spanish consanguineous family. Subsequent general screenings of over 1,000 Spanish cases with autosomal recessive NSHI revealed p.Q829X in the homozygous state or in the heterozygous state with 14 other mutant alleles in 3.5 % of cases, and so it is one of the commonest NSHI-causing mutations in Spain, being also present in subjects of Hispanic ancestry in other countries.

Clinical studies of more than 50 subjects with mutations in OTOF showed a remarkably homogeneous phenotype: profound prelingual NSHI, auditory neuropathy, and no inner ear malformations. Interestingly, about 25 % of subjects had been provided with cochlear implants, successfully. Therefore, genetic screening of subjects with auditory neuropathy for OTOF mutations not only provides the basis for genetic counseling, but it also helps to decide whether cochlear implantation should be performed.

F4 – O2

Connexin deafness and speech perception outcome of cochlear implants

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Objectives: Performance in children with cochlear implants is likely to be affected by the etiology of deafness, and may be influenced by the presence or absence of a particular genetic mutation. Data on the correlation between mutations in connexins and cochlear implantation performance are still controversial. The purpose of this study was to compare performance after cochlear implantation in children with mutations in connexin 26 (GJB2) or connexin 30 (GJB6) and children with deafness of unknown etiology.

Methods: The study took place at Speech and Hearing and Genetic centers of a hospital in the central part of Israel and genetics departments. A total of 30 implanted children were selected for the study, with controls matched according to age of implantation, duration of implant use and mode of communication. There was no evidence for additional disabilities or handicaps in either group. Test material was selected according to the child's age, cognitive and language abilities. All cochlear implantees underwent genetic analysis. Speech perception performance was retrospectively analyzed 6, 12, 24, 36 and 48 months after implantation.

Results: Overall, the two groups showed significant improvement in speech perception results after implantation. Both groups achieved mean open-set speech perception scores at four years post-implantation of approximately 60 %, 75 % and 90 % for monosyllabic, two syllables and words in sentences tests, respectively.

Conclusions: (1) There are no apparent differences in speech perception performance between the two groups; (2) These data have important implications as a prognostic indicator when counseling candidates for cochlear implantation.

F4 – O3

Auditory neuropathy of genetic etiology caused by OTOF gene mutation

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Introduction: The Auditory Neuropathy (AN) is characterized by a hearing loss that presents an audiological study compatible with a disorder of the auditory portion in the VIII nerve.

Recently has been described OTOF gene mutation as a AN cause. OTOF gene encodes Otoferlin. The Otoferlin is a protein involved in the synapses of the inner ear hair cells.

The objective is to study the incidence of AN caused by OTOF gene mutation in our series of AN and to study the CI results.

Material and Methods: The study design was prospective and retrospective in 16 AN patients. Ten of them presented OTOF gene mutation. The diagnosis was audiological and/or genetic.

14 of the patients, with prelingual profound Bilateral Neurosensorial Hearing loss, have been implanted. The CI results were evaluated with speech tests adapted to the patients age.

Results: 66 % of the AN are caused by OTOF gene mutation in our group. The mutation was Q829X in homozygosis in most of the cases, the hearing loss was profound, bilateral and congenital with hereditary autosomal recessive mode.1 patient passed the TOAE neonatal hearing screening.

The CI performance was good in the OTOF patients and similar to the control group. 3 non OTOF patients were

implanted; performance was good for two of them and poor for the other.

Conclusions: The OTOF gene mutation is the most frequent AN aetiology in our series. The use of the CI in these cases is unquestionable. The TOAE neonatal screening could not detect the AN cases.

F4 – O4

IL4R polymorphism is associated with sudden deafness in Koreans

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Objectives: we hypothesized that *IL4R* polymorphism could be related to sudden deafness (SD). In the present study Q576R (rs 180275), a well known single nucleotide polymorphism (SNP) of *IL4R*, had been selected and investigated in SD patients and controls.

Methods: we investigated the possible relationship between SD and *IL4R* polymorphism Q576R in 97 Korean SD patients and 613 controls using pyrosequencing method.

Results: The odds ratio (OR) for SD associated with the G vs. A allele was 2.58 [$p < 0.0001$, 95 % confidence interval (CI) = 1.84–3.60]. We then sub-grouped SD into Tinnitus positive (+) and Tinnitus negative (-).G allele in Tinnitus (+) is significantly associated with the development of Tinnitus (+) [$\chi^2 = 32.02$, $p < 0.0001$, OR (95 % CI) = 2.74 (1.91–3.93)] but not with Tinnitus (-).

Conclusions: Taken together these results suggest that G allele could be a risk factor for SD.

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F4 – O5

Clinical spectrum of Cx26 caused hearing impaired in Austria

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Objectives: Hearing impairment (HI) has a high prevalence in Austria affecting approximately 1 in 1000 newborn children. Alterations in the gap junction protein Cx26 are associated with non-syndromic (NS) HI and have a significant impact on early diagnosis and cochlear implantation (CI). Since the presence of additional symptoms may exclude children from the benefits of genetic analysis, we therefore screened an expanded patient cohort for alterations in Cx26.

Methods: The prevalence of mutations in a NSHI patient group comprising 45 families and 57 sporadic cases was initially determined by sequencing. The role of Cx26 was then assessed in HI individuals (3 families and 20 sporadic cases) usually excluded from analysis due to the presence of additional symptoms or where a role for non-genetic factors could not be eliminated.

Results: Autosomal recessively inherited Cx26 mutations induced HI in 25.5 % of individuals in the NSHI group. Cx26 alterations were also seen in 17.4 % of individuals where additional symptoms or a role for non genetic involvement could not be excluded. In total, 15 different alterations in Cx26 were detected, including the previously unknown 154G>C, 557C>T and 682C>T mutations and these were correlated to clinical parameters.

Conclusions: Improved genetic counselling, prognosis following a possible CI therapy can be performed by screening for Cx26 alterations in HI patients even if exogenetic factors or further symptoms are present.

F4 – O6

Pathological effects of Cx26 alterations

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Objectives: Non syndromic hearing impairment (NSHI) due to coding mutations in the gap junction gene Connexin (Cx) 26 is common in Caucasian populations and cause up to 25 % of cases in Austria. Genetic alterations may be classified into truncating mutations such as 35delG which introduces a premature stop codon before the first trans-membrane domain and point mutations that may pathologically influence protein function.

Methods: The Cx26 mutational status was determined in a patient cohort by direct DNA sequencing of polymerase chain reaction amplified DNA and correlated to clinical parameters. By analysis of family trees, mutations were identified as autosomal recessive or dominant and correlated to the severity of HI within the families.

Results: All Cx26 caused hearing impaired patients had a normally developed bony cochlea regardless of mutation. Although the degree of Cx26 caused HI was stable in patients and tended to reflect the mutational classification, the severity of HI was found to vary even within the same family.

Conclusions: A variety of Cx26 gene mutations cause malfunctions of gap junctions in the cochlear sensory epithelium and induce HI. Inner ear structures important for cochlear implantation such as the cochlear nerve or the bony cochlear appear not to be affected in Cx26 caused HI.

F4 – O7

Connexin 26 caused hearing impaired patients – candidates for CI

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Objectives: Mutations in the gap junction protein beta 2 gene Connexin 26 (Cx26) have a high prevalence in Caucasian patients suffering from hearing impairment (HI). Depending on the screening parameters, genetic changes may be found in up to 50 % of cases of HI. In the Austrian population, a homogeneous clinical appearance of Cx26 caused HI with regard to autosomal recessive inheritance, prelingual onset of HI and non-progressive deterioration is seen.

Methods: The Cx26 mutational status is being determined in CI recipients (n>75) and collated to clinical parameters, magnetic resonance images, temporal bone computed tomography scans and the outcome of CI.

Results: Almost one third of screened CI recipients have a clear Cx26 associated HI. Preliminary data show no associated abnormalities concerning clinical parameters and a good outcome assessed by speech performance and the development of verbal communication skills.

Conclusions: Cx26 caused hearing impaired individuals benefit from CI. Clear advantages for the children, their parents and the surgeon support Cx26 genetic testing before CI.

F4 – O8

Genetic testing within the Austrian newborn screening program for hearing impairment

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Objectives: In Austria, a comprehensive newborn screening program for hearing loss (HL) has been recently introduced. Analysis of clinical data shows the importance of early identification for hearing-impaired children. In the first year of life, the majority of children suspected of HL can be detected. The present study was performed to evaluate the importance of Connexin 26 (Cx26) genetic testing within a national, neonate screening program for HL.

Methods: Neonatal cases of non-syndromic HL (n = 21) identified by postpartal otoacustic emissions (OAE) and brainstem electric response audiometry (BERA) analysis were screened for mutations in Cx26 by double stranded sequencing of the whole coding region.

Results: Mutations in Cx26 were found in 15 of 21 children (71.4 %). As a clear cause of HL, the 35delG mutation in Cx26 was homozygous in 10 cases (47.6 %) and compound heterozygous in 3 cases (14.3 %) as 35delG/del311–324, 35delG/L90P and L90P/R143Q. In 2 of 3 HL cases which were not identifiable during initial OAE testing, homozygous 35delG and 35delG/R184P defined the genetic basis for HL.

Conclusions: Our findings of the high mutation rate in the Austrian population, especially in neonates identified during the newborn screening program, confirm the importance of screening for mutations in the Cx26 gene. The earliest possible diagnosis of HL is important for early initiation of therapy and intervention in age-appropriate speech and language development.

F4 – O9

Good speech recognition and quality of life scores after CI in patients with DFNA9

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Objective: To compare audiometric and quality of life results in DFNA9 patients who received a cochlear implant with cochlear implant patients with adult-onset progressive sensorineural hearing loss.

Methods: 11 DFNA9-patients were included in the study as well as a comparative group of 39 postlingually deafened CI subjects with an adult-onset progressive sensorineural hearing loss. All patients received a cochlear implant. Subjects were implanted with either the Nucleus 24M/RCS or Med-El Combi 40+ CI systems implementing the SPEAK, ACE or CIS+ coding strategies. Speech recognition was determined by means of phonetically balanced monosyllabic word lists. The Hearing Handicap Inventory for Adults, the Glasgow Benefit Inventory and the Scale for the Prediction of Hearing Disability in Sensorineural Hearing Loss were used to quantify the quality of life.

Results: The results show that the speech perception and the quality of life of the DFNA9 patients don't differ significantly from the control group ($p = .179$; $p = .56$).

Conclusions: In spite of the fact that DFNA9 is a pathology that is known to involve cochlear dendrites, cochlear implantation is a good option for treatment of deafness in DFNA9.

F4 – O10

Speech and language disorder in deaf children – is this part of the phenotype?

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18 severely/profoundly deaf children were referred for specialist assessment because of unexpectedly poor development of language and speech.

We identified the nature of their speech and/or language difficulty in the context of the aetiology of their hearing loss and communication management.

Results showed predictable variety within the group except for those children with Waardenburg syndrome who formed both a disproportionate percentage of the group and demonstrated characteristic features of developmental verbal dyspraxia as part of their speech and language profile. This accounted for their slow rate of progress.

Further research is needed to determine whether developmental verbal dyspraxia is part of the phenotype of this syndrome.

Results in Cochlear Implantation (Z1)

Z1 – O1

Nucleus Freedom north american clinical crial

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Objectives: To evaluate the Nucleus Freedom cochlear implant; specifically the effects of stimulation rate and input processing on performance.

Methods: Randomized, prospective, single-blind clinical study of 73 severe-profound hearing impaired adults enrolled at 14 centers in the U. S. and Canada. Subjects received a Nucleus Freedom cochlear implant (CI) and were randomly programmed at two different sets of rate: standard ACE (500Hz, 900Hz, 1200Hz) and a higher rate ACE RE (1800Hz, 2400Hz, 3500Hz) using an ABAB study design. Subjects were blinded to the order and the speech processing rates they received. Auditory function was evaluated using the Hearing in Noise Test (HINT) sentences administered in quiet and in noise and the Consonant Nucleus Consonant (CNC) monosyllabic words/phonemes administered in quiet. Subjective outcomes were evaluated using the Abbreviated Profile of Hearing Aid Benefit (APHAB).

Results: Data will be reported on sixty of the seventy-three subjects who completed their six-month data point. Preliminary data suggest that speech perception scores with Nucleus Freedom are higher than with previous Nucleus devices. Subjective rate preferences of these sixty subjects varied substantially. Mean scores on the various speech perception measures will be presented and will include a comparison of intra-subject performance with their preferences for each rate set.

Conclusions: These data indicate that higher rates of stimulation do not necessarily correlate with improved performance or patient satisfaction. Input processing improved both subjective and objective measures of performance. Overall measures of performance are superior to the previous generation of implants by the same manufacturer at 6 months.

Z1 – O2

Comparison of performance between the Esprit 3G & the Freedom™ speech processor

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Objectives: To compare speech perception scores, in quiet and in noise, between the Esprit 3G and the Freedom™ speech processor.

Methods: 10 adults with the Freedom™ CI24RE implant were initially fitted with the Esprit 3G speech processor. After a minimum of 2 months use, they were fitted with the Freedom™ SP after a standard map-conversion. Stimulation rate was not changed. The Freedom™ processor has a wider input dynamic range than previous devices and the signal processing hardware/software used also differs. No pre-processing algorithms (ADRO, Whisper, BEAM) nor autosensitivity were activated on the Freedom™ processor for this study.

Speech perception tests in quiet (monosyllabic words) and in noise (sentences at S/N of +10 and +5 dB) were performed with both processors at the time of conversion, and 4 weeks later. Subjects used only the Freedom™ processor between test sessions. Before testing, subjects were allowed 1 hour of acclimatisation with the alternate processor. Subjective performance was evaluated using the APHAB questionnaire and a comparative questionnaire.

Results: Preliminary results (n = 7) show no significant differences in the group speech perception scores in quiet or in noise between the processors. 5 of 7 subjects preferred the Freedom™ processors in quiet listening conditions and 4 of 7 in noisy situations. The APHAB questionnaire shows no significant difference in difficulties of communication between the speech processors.

Conclusions: Preliminary results show that when using the same map parameters, performance between the Esprit 3G and Freedom™ speech processor appears equivocal. Subjectively, the majority of subjects preferred the Freedom™ processor.

Z1 – O3

Clinical validation of Nucleus® Freedom™ for N24 speech processor

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Objectives: The Nucleus® Freedom™ for N24 speech processor has been developed to replace the ESPrit and SPrint speech processors currently used with the Nucleus 24 cochlear implant system. Existing patients were fitted with the new processor to determine if there was speech perception equivalence or improvement using SPEAK, ACE and CIS speech coding strategies with the Nucleus® Freedom™ for N24 when compared to the recipients own speech processor. A secondary objective was to determine whether the SmartSound™ input processing available on the Nucleus® Freedom™ provides improved speech understanding of a range of listening environments.

Method: Subjects current processor MAPs were converted and loaded into the Nucleus® Freedom™ for N24 speech processor. Three weeks take home experience was given before the subjects returned for speech testing. Subjects were tested with both their existing speech processor and the Nucleus® Freedom™ at input dynamic ranges of 30dB and 40dB, on three measures: CNC words in quiet at 50dBSPL and 60dBSPL and CUNY sentences in noise at 65dBSPL. Standard, ADRO™, and Whisper™ maps were then loaded into the Nucleus® Freedom™ for N24 speech processor and after two weeks, testing performed in quiet. Then ASC, ADRO™, BEAM™ and Standard MAPs were loaded into the processor and after another two weeks testing performed in noise.

Results: Analysis of speech test and questionnaire results will be presented for 20 subjects.

Z1 – O4

Speech perception performance of double array Nucleus multi-channel cochlear Implant users with standard and duplicated maps in each of the arrays

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Objective: The present investigation evaluated the speech perception performance of adult patients with ossified cochleas implanted with the Nucleus 24M Double Array cochlear implant.

Methods: Speech perception performance with the two arrays was compared to the performance with the basal-array-duplicated and apical-array-duplicated maps. Twelve subjects received a Nucleus 24 Double array Cochlear implant in the last two years but only seven could participate in this study. Test battery was composed of vowels and closed set word and sentence recognition in quiet.

Results: The performance was similar in the four-choice word test for all the map situations, nevertheless the vowel recognition and closed set sentence recognition the standard map with both electrode arrays activated showed the highest scores. The present results suggest that the performance with two split electrode arrays is superior to the performance with one array, even with a duplication of channels.

Conclusions: Double array multichannel cochlear implant device is appropriate and broadens patients opportunity to perform better, even those with extensive or complete ossification of the cochlea.

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Z1 – O5

Nucleus Freedom performance and preferences for ACE and CIS strategies

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Objectives: Investigate subjective preference for ACE and CIS coding strategies for a range of stimulation rates.

Methods: 22 postlingually deaf adults received the Nucleus Freedom Implant. The first 3 months after initial fitting, 4 visits were planned in which recipients were fitted with MAPs based on ACE and CIS speech coding strategies using total stimulation rates from 6000–31500 pps. Initial MAPs were pseudo-randomized to avoid bias of the group towards a certain strategy. During consecutive visits a range of MAPs was programmed and adapted according to the preference of the recipient. Speech performance in quiet and noise was measured 3 and 6 months after switch-on.

Results: No single strategy and/or rate was subjectively preferred by all recipients. Subjective preference for ACE and CIS strategy at different rates was spread over the range of rates 6000–31500 pps. The table presents average speech scores at 6 months.

German n = 17, Dutch n = 4	6 months scores
Freiburger monosyllables in quiet (60dB)	56 %
Freiburger monosyllables in quiet (70dB)	74 %
Oldenburger sentences in quiet (65dB)	88 %
Oldenburger adaptive test in noise (SRT in dB)	–1.3 (n = 10)
NVA monosyllables in quiet (60dB)	70 %
NVA monosyllables in quiet (70dB)	87 %

Conclusions: Subjective preference for stimulation rate and coding strategy varied across the range of available rates and strategies. Freiburger monosyllabic word scores obtained with the Nucleus FreedomTM system at 6 months are better than scores obtained in a German study 6 months after bilateral implantation with the Nucleus 24 implant.

Z1 – O6

Frequency importance functions for adults with cochlear implants and normal hearing: Effect of background noise

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Objectives: Current research suggests that adult cochlear implant users are able to achieve high levels of speech understanding in quiet but have severe degradation in performance when listening in noise. The objectives of this study were to 1) determine which frequency regions are most important for understanding speech in quiet and in noise and (2) compare the shape of the frequency importance functions for adults with cochlear implants and normal hearing.

Methods: One group of adults, all of whom used the Med-El cochlear implant system listened to standard NST syllables. A second group of adults, all of whom had normal hearing, listened to NST syllables that had been synthesized through a processor similar to the Med-El device. During the experiment the pairs of channels were systematically turned off and performance was measured. Participants listened in quiet and in a 10 dB signal-to-noise ratio.

Results: Results demonstrated that, in general, that although performance dropped in the presence of background noise, the shape of the frequency importance function remained the same for both groups. That is, the frequency bands that carried the most weight in quiet were also the frequency bands that carried the most weight in background noise.

Conclusions: This study demonstrates that frequency importance functions for participants with normal hearing and cochlear implants listening to nonsense syllables have a similar shape in quiet and in a +10 dB SNR.

Z1 – O7

Effect of cochlear implant microphone location on speech intelligibility

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Objectives: The position of a cochlear-implant microphone can affect speech intelligibility in noise in listening conditions where the speech and noise originate from different directions. This study compared speech understanding in noise between the T-Mic, the Auria BTE microphone, and the Platinum Headpiece (PHP) microphone.

Methods: Head-related transfer functions (HRTFs) were measured for the ear canal and for sound processed through the PHP microphone, BTE microphone, and the T-Mic. Sentence reception thresholds (sSRTs) in noise were evaluated in 14 normal-hearing Mandarin-speaking listeners in free field and under headphones where sound direction and microphone position were simulated using HRTFs. Using the Mandarin HINT-adaptive test, sSRTs for speech coming from the front were measured in the presence of noise originating from the front and from the right side. Results were compared to a similar study using the English HINT.

Results: The T-mic, which is very near the entrance to the ear canal, produced the largest head shadow advantage. This advantage decreased by 5 dB or more at high frequencies for the BTE and PHP mics. This decrease in head shadow advantage reduced Noise Side thresholds by about 2 dB in Mandarin and up to 4 dB in English. The binaural directional advantage was decreased by 1 dB in Mandarin and by 2–3 dB in English.

Conclusions: These data suggest that the T-Mic can provide improved speech understanding in noise, especially when speech and noise are spatially separated. Results were comparable across the Mandarin and English versions of the HINT.

Z1 – O8

Field trial of Microlink radio aids with adult cochlear implant users

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Objectives: To evaluate the benefit and scope of use of plug in Microlink radio aids with cochlear implant speech processors for adult cochlear implant users in real life listening situations.

Methods: Five experienced cochlear implant users were fitted with Microlink MLxS radio receivers and Smartlink transmitters for use with their cochlear implant speech processors in their everyday lives for 3 months. The gain of the receivers was set using a word discrimination task in noise (1).The Glasgow Hearing benefit profile and the Speech Spatial Qualities questionnaires (2) were administered on fitting the radio aid and three months later. The subjects were encouraged to document their use of the radio aid and any comments they had about the radio aid in a weekly diary.

Results: The initial gain of the radio aid receiver was found to be too loud for 2 subjects and was turned down. The radio aids were reported to be useful in meetings and training situations. Interference was reported occasionally but, to date, no subject has found the radio aid cumbersome to use. Subjects' detailed comments and questionnaire results will be discussed further.

Conclusions: The use of a plug in radio aid is beneficial to some adult implant users in their working lives for meetings and training. MLxS receiver gains may need to be adjusted after an initial period of use. Consideration should be given to implant patients' lifestyle and whether providing radio aids could facilitate hearing in difficult listening situations.

Z1 – O9

Real world benefits of FM systems for children with cochlear implants

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Objectives: To evaluate the effectiveness and benefits of obtained by combining an FM system with a cochlear implant. Unique to this study was the focus on evaluating performance in the child's own classroom and home rather than through laboratory based measurements.

Methods: 12 students (8;5–15;3 years) participated in the current study. During the study, the students used the FM system combined with their cochlear implants at school and home. Performance was documented using measures of oral language comprehension (NEALE) in the child's daily classroom combined with self-report measures obtained from the parents, teachers and children (CHILD & COW).

Results: All students benefited from the use of FM. The difference in benefit was statistically significant ($t=4.83$, $df=11$, $p < .01$). Importantly, analysis indicated that the FM system allowed the children to access a higher level of comprehension (1.91 vs 3.00). Both the students ($t=2.66$, $df=11$, $p. < .05$) and parents ($t=3.17$, $df=11$, $p. < .05$) reported significant that the student had significantly less listening difficulty (as measured by the CHILD) in their daily life when using the personal FM system.

Conclusions: These results support the recommendation of combining a personal FM system with the child's cochlear implant to improve speech understanding in school and in the home. The use of FM increases students' ability to understand information in the classroom and at home. FM systems are beneficial at school during classroom teaching and small group work. At home, the use of FM systems is particularly beneficial while watching TV and listening in a car.

Z1 – O10

Landline and mobile telephone performance in MED-EL TEMPO+ users

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Objectives: The objective of this study was to evaluate performance of CI patients using mobile and landline telephones. Sentence understanding was tested in quiet and noise. A subjective rating scale was used to ascertain patient preferences. The premise of the study was that CI performance using a mobile telephone would not differ significantly from performance using a landline telephone under the same listening conditions.

Methods: Eleven adult subjects who received MED-EL COMBI 40+ devices and used CIS+. The same unfamiliar presenter was used for all subjects and test conditions. Speech stimuli (HINT Sentences) were presented using live voice via a landline in a quiet room. Noise was four-talker speech babble presented at 60 dB SPL. The subject was tested under six listening conditions: landline in quiet; landline in noise; Motorola in quiet; Motorola in noise; Nokia in quiet; Nokia in noise.

Results: There were no significant telephone differences between the landline and Motorola V60 in either quiet or noise conditions. For a subgroup also tested with the Nokia 5165, significant telephone differences were not seen between the landline versus Motorola V60 versus Nokia in either the quiet or noise conditions.

Conclusions: Study results support our premise that there was no performance decrease for our subjects when using a mobile telephone compared to a landline telephone. Subjectively, most subjects preferred listening with a mobile telephone to a landline telephone.

Z1 – O11

Successful telephone use

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Objectives: To investigate which factors most influence successful telephone use in adult cochlear implant users.

Methods: A questionnaire was sent to 134 adult cochlear implant users. Information about patterns of telephone use pre deafness and post implant, confidence and independence in using the telephone, use of communication strategies on the telephone and audibility was collected. Questionnaire responses were mainly on a five-point ordinal scale, but scores on individual questions within a theme (independence, confidence, etc.) were summed. Most recent BKB speech perception scores were also collected for each respondent. Independence in telephone use was used as the primary outcome measure and the influence of all other factors was assessed using a multiple linear regression model.

Results: 88 patients aged between 17 and 82 years correctly completed their questionnaires; of these 74 % used the telephone. Responses to questions on the theme of independent telephone use, for example, "Do you ever need someone to make phone calls for you?", were used to identify successful telephone users. Factors which most strongly correlated to independent telephone use were perceived clarity of speech over the telephone, BKB scores and confidence in that order. The longer someone had been deaf the less likely they were to use the telephone, however amongst those people who did use the telephone duration of deafness had no statistically significant correlation with independent telephone use.

Conclusions: In order to increase the number of independent telephone users, programming and rehabilitation should be orientated towards improving the perceived clarity of speech over the telephone and confidence building.

Z1 – O12

Assistive device and telephone use by adult CI users

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Objectives: The aim of the proposed study is to determine the extent of assistive device use and telephone use of our adult cochlear implant recipients. One of the differences between different types of devices is their connectivity with different assistive listening technology. Availability of information about which assistive devices are most commonly used will help inform future patients when making a choice between different manufacturers. Postoperatively, all patients in our programme are given several different types of assistive listening equipment and training on its use. Information about the actual use of this equipment in daily life will help us to allocate therapy time and equipment more effectively.

Methods: A questionnaire was sent to all of our adult cochlear implant recipients (268). Responses will be summarized and the responses will be correlated with variables including age, vocation, speech perception ability and type of implant.

Results: The results of the questionnaire will be summarized. Data will include the frequency of use of the following devices: T-coil or T-switch, personal audio cables, FM systems and lapel microphones. We will also summarize the types of environments in which people use these devices. Telephone use will be summarized.

Conclusions: It is believed that many of our users may not take advantage of the assistive listening technology that is available to them. We will examine the results of this survey and make conclusions regarding allocation of therapy time and equipment resources. We will also summarize conclusions that may help to inform cochlear implant candidates about expectations.

Z1 – O13

The use of line and mobile telephone following cochlear implantation

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Objective: Telephone usage, and especially mobile telephone usage, is a difficult dare for cochlear implanted patients. The goals of this study were to evaluate speech discrimination through line and mobile telephone in cochlear implanted patients, and to compare different mobile telephone models in order to find out which could be more advisable for them.

Methods: Twenty-five implanted postlingual patients went through different speech discrimination tests with a line telephone and three mobile telephones. CID sentences and bisyllabic words were presented both in quiet and noisy environment. A specific telephone adapter was also tested.

Results: Mean scores for telephonic speech discrimination were 84–92 % using CID sentences, 27–58 % using bisyllabic words in quiet environment and 15–41 % using bisyllabic words in noisy environment. In noisy environment, the adapter increased discrimination significantly from 31.7 % to 44.7 %. No statistical difference was found between speech discrimination in quiet environment without the adapter and speech discrimination in noisy environment with the adapter. Among the mobile telephones tested, the Siemens M55 reached the best scores.

Conclusions: Telephonic speech discrimination is achieved by a significant number of cochlear implanted patients. The telephone model may be a critical factor for telephone performance.

Z1 – O14

Comparing the acoustic-to-phonetic level of processing in postlingual deafened adults with cochlear implants to that of normal hearing in quiet and in noise

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Objectives: To investigate the ability of postlingually deafened adults (PDA) with cochlear implants (CI) to perceive differences along phonetic and non-speech continua, and to compare the data to that of normal hearing (NH) in quiet and in noise.

Methods: Subjects were 10 PDA with CIs and 38 normal hearing (NH). Stimuli consisted of: a /ba–pa/ continuum which varied in voice-onset-time (VOT) values, and an acoustic analog continuum, consisting of two tone sequences which varied in the onset of the lower tone in relation to the higher one. NH hearing listened to the continua in quiet and at signal-to-noise ratios (SNR) of 0 and –3 dB. Subjects labeled speech stimuli as /ba/ or /pa/ and identified complex tones as “lead” or “lag”.

Results: Results of CI using the phonetic continuum showed atypical patterns of phonetic perception that differ from NH by the nature of the perceived categories (more voice-less than voiced), the category boundaries, slopes of the functions and maximum performance. These patterns resembled those obtained in NH when performing the same tasks at SNR=-3dB. The results of the tonal continuum revealed that those CI users who were able to show categorical-identification functions had similar CBs as NH in quiet.

Conclusions: These results suggest that although general areas of auditory sensitivities seem to be maintained in CI users, the implant device and/or the impaired auditory system impose constraints at a very basic level of the speech perception process similar to the ones imposed by noise in NH.

Z1 – O15

Results with the MED-EL PULSARCI[100] cochlear implant

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The PULSARCI[100] is the latest cochlear implant, developed by MED-EL Medical Electronics GmbH. In comparison to the COMBI 40+, the new implant will feature the possibility of stimulation at higher rates, stimulation of channels simultaneously, and the possibility of using triphasic pulses for stimulation. The PULSARCI[100] implant fully supports all the features of the TEMPO+ speech processor, running the CIS+ speech coding strategy. The PULSARCI[100] implant will also be compatible with a next generation speech processor and speech coding strategies, currently under development. These will hold many new features, that are believed to be beneficial for speech understanding, both in easy and in difficult (in noise, on the telephone, etc.) listening conditions, music perception and perception of tonal languages.

The first implantation of Med EL Pulsar CI[100] worldwide took place in Vienna in March 2004. In the meantime more than 90 patient are implanted with the Pulsar CI[100] in Vienna, 35 adults and more than 55 children. The Cochlear Implant Programme in Vienna has investigated the speech perception outcomes in 15 adult users of the PULSARCI[100] cochlear implant. Subjects were assessed pre-operatively and then at regular intervals up to 24 months after first fitting. Results on monosyllables, sentences in quiet and noise will be reported on. Outcomes show an improvement in all speech perception scores over time, with the greatest improvement being in the first few months of device use – highlighting the quick benefit that users receive with the PULSARCI[100] cochlear implant.

Alternative Surgical Approaches (Z2)

Z2 – O1

Why use alternative surgical techniques for CI?

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Objective: Alternative surgical techniques for cochlear implantation were developed in order to obviate Mastoidectomy and its disadvantages. These approaches gained popularity among surgeon in Europe and to date more than 1300 implantations using alternative approaches were performed. The aim of this presentation is to portray the foundation of the alternative surgical techniques in cochlear implant surgery and to demonstrate its benefits over Mastoidectomy posterior tympanotomy approach (MPTA).

Methods: The principals of the alternative surgical techniques, the similarity and differences between them are presented. The surgical technique, pitfalls, complications and hearing outcomes are described in a group of 252 patients operated using the suprameatal approach (SMA) between September 1999 and December 2005.

Results: The advantages of using the SMA approach were found to be; wide exposure of the middle ear and promontory, less drilling, safe and easy drilling of the Cochleostomy through the external auditory canal, reduced surgical time and anesthetic risk and better aesthetic results. Speech perception performance of patients implanted using the SMA technique was found to be similar to that obtained with the MPTA.

Conclusions: The use of the alternative techniques which eliminates the need for mastoidectomy in cochlear implant surgery is highly recommended.

Z2 – O2

Six years Vienna experience with the suprameatal approach

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Parallel to cochlear implant development, different surgical techniques were described. The surgical procedure including mastoidectomy and posterior tympanotomy, introduced in 1979, is known as classic approach. In 2000 Kronenberg and Baumgartner presented the suprameatal approach (SMA) as alternative, save and effective method for cochlear implantation. Typical conventional mastoidectomy and posterior tympanotomy are not necessary.

Using the suprameatal approach, the active electrode is inserted without mastoidectomy and posterior tympanotomy, by creating a tympanomeatal flap and drilling a suprameatal (not dorsal) tunnel in the direction of the body of the incus. The active electrode array will be guided through the suprameatal tunnel in direction to the typically located cochleostomy. Cochleostomy and electrode insertion will be performed from an anterior position, through a classical tympanomeatal flap.

This surgical procedure preserves both, the facial nerve and the Chorda tympani. This suprameatal approach is a simple, safe and effective procedure, Chorda tympani is prevented in all cases, and there is no danger for the facial nerve. Analog to stapes surgery, the facial nerve will be always identified. The direction of the tunnel leads to the body of the incus, which additionally shelters the facial nerve.

Until May 2006, 170 patients in Vienna implanted through the suprameatal approach. Outcome for the patients shows no difference to the classical approach, however surgical time consumption was only 50 % and Chorda tympani was preserved in all cases.

Z2 – O3

Update on minimally invasive pericanal cochlear implantation without mastoidectomy

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Objective: Long-term evaluation of the minimally invasive pericanal cochlear implantation method with direct pericanal electrode insertion through the external auditory canal.

Pericanal cochlear implantation method: Surgery begins with a limited retroauricular skin incision. A posterior tympano-meatal flap is elevated. Cochleostomy is performed through the external auditory canal. A tunnel is drilled behind Henle's spine parallel to the external auditory canal down to the upper surface of the incus. There, the tunnel is connected to the tympanic cavity with a small rim. The electrode is inserted through the tunnel. The electrode is fixed with a small amount of bone paté. The electrodes and the implant are secured to the bone with a microtitanium plate. After closure of the retroauricular incision, the tympanomeatal flap is replaced and a dressing is placed into the external auditory canal.

Results: The pericanal cochlear implantation without mastoidectomy has been performed since 1999 in 57 patients, five being implanted bilaterally. Patients were implanted as follows: 33 Combi 40+ MED-EL, 11 Pulsar MED-EL, 12 Nucleus CI 24R Cochlear, 2 HiRes 90 K Advanced Bionics, 1 DX10/C MXM).

Pericanal electrode insertion was unproblematic and often particularly easy in all cases and with all CI types used. There were no surgical complications or electrode extrusions during postoperative observation periods ranging from 6 months to 6 years.

In 4 patients the CI had to be replaced: Revision surgery through the pericanal approach was unproblematic.

Conclusion: Cochlear implantation with pericanal electrode insertion is a straight-forward, fast and particularly safe procedure which may replace the classical transmastoidal cochlear implantation via posterior tympanotomy in adults and in adolescents. This minimally invasive method has several advantages, the most important being that the danger of facial nerve injury is minimized and that surgery time is reduced by up to 50 %.

Z2 – O4

The advantages of the modified paracanal approach for electrode insertion during CI

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Objectives: Since 1998 we implanted 83 patients in the Univ. ENT department Sofia. 53 Med El Combi 40 + and 30 Med El Pulsar 100+. At the beginning we implanted 23 patients using the classic method – posterior tympanotomy.

Methods: In all other patients we applied our modified paracanal approach to the middle ear. After reaching the meatus acusticus externus, a bit beneath spina suprameatum, we cut the canal`s skin and pull the auriculus forward. The next step is to dissect the skin on the back canal`s wall till annulus fibrosus shows and then we can enter the tympanic cavity. Part of the canal`s bone wall is removed, until the incudostapedial joint shows. A paracanal bone channel is formed with the help of a burr. Its direction is pointed to the incudostapedial joint, 2,3 mm from the back wall, so that we can enter the cavum tympani. This is followed by a cochleostomia and a forming a bone –bed for the implant, whose long electrode then is installed through the channel.

Conclusions:

- the level of danger of sacrificing n. facialis is immensely decreasing;
- shortening of the chirurgical and anaestaesical time is achieved;
- decrease in the level of bone destruction in comparison to tympanotomia posterior;
- fast recovery of the operated field.

Z2 – O5

Tympanic frame and attic protection in cochlear implants

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Objectives: – Learn about modifications in cochlear implant surgery 2- Expose a new method for implant fixing and protection of the attic and tympanic frame. 3- Understand the benefits with this modification of the classical technique.

Methods: This work has the purpose of contributing, in cochlear implant surgery, to a higher security in the anchorage of the implant and protecting the tympanic frame and attic when is necessary a wide posterior tympanotomy, specially when the tympanotomy gets widely over the upper edge of the frame, coulding take place later in time the descent of the frame and the projection of the electrode over the tympanum, middle ear space and sometimes being able to appear even in the external ear canal. This simple and practical technique consists in placing a thin piece of bone from the mastoid cortex over the array once it is fixed, supported by spongostan and muscle that plugs the cochleostomy and tympanotomy.

Results: This modification of the classical technique has given security to the tympanic frame and attic with no adverse results and with an excellent long term evolution avoiding some usual complications in all patients who have received this method.

Conclusions: A simple modification in the technique of cochlear implants surgery with the objective to protect the tympanic frame and attic has a significant relevance to prevent some usual complications when a wide posterior tympanotomy is needed.

Z2 – O6

Med-El small incision cochlear implantation with device fixation

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Objectives: Small incision techniques for the Cochlear and Advanced Bionics (ABC) devices that improve cosmetic outcomes and decrease flap edema have been reported. The Med-El device requires a larger well and more sophisticated sutures to fixate the device. The objective is to demonstrate that the Med-El Cochlear Implant can be inserted successfully and safely through a small incision with device fixation.

Methods: In all patients a cochlear implant was completed through a 3 cm incision positioned posterior and superior to the auricle immediately along the hair line. The internal housing was secured with suture fixation. Patient charts were reviewed to document post-operative complications and operative times. Evolution of the surgical technique to allow for implantation of the Med-El device is reviewed.

Results: One hundred and three consecutive devices have been implanted utilizing this technique: 43 Med-El, 36 Cochlear, and 24 ABC. Children ranged in age from 6 months to 12 years, mean age of 38 months. There were a total of 4 complications that occurred early in the series, including two post-operative hematomas (1 Med-El and 1 Advanced Bionics) and 2 cerebral spinal fluid leaks from the well site (both Med-El). Total room time for the Cochlear and ABC devices averaged 2 hours and for the Med-El device 2.5 hours.

Conclusions: The Med-El cochlear implant can be inserted and secured through a small incision. There is an initial steep learning curve. Post-operative complications have lead to modifications in the surgical instruments and technique. Since modifying the procedure there have been no further complications.

Z2 – O7

Small incision surgery with Med-El cochlear implant: a clinical experience

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Objectives: The MED-EL cochlear implant is rarely considered for minimally invasive surgery because the distance between the bony bed and the mastoidectomy limits to drill there by the same, small incision. This is a report of a MED-EL minimally invasive operation on a consecutive series of 30 patients (12–72 years).

Methods: A small incision (5 cm) is made behind the retroauricular speech-processor template. Inferiorly it end at cantho-meatal line. The skin is raised off the underlying tissues and a periosteum flap is carefully elevated to the mastoid tip, the posterior border of the external auditory canal and the zigomatic root. The posterosuperior flap is elevated to make a subpericranial pocket that can accomodate the receiver-stimulator. The size of the subpericranial pocket is checked with the implant template. A cortical mastoidectomy is carried out as usual.

A self-made metallic shell is then used to elevate the posterior flap in order to protect soft tissues and to easily drill the bed for the receiver-stimulator on the skull underneath the fibroperiosteum pocket.

Results: Based on a simple randomization protocol, in 16 patients tie-down holes were drilled around the bone bed and the receiver-stimulator was thus fixed on the skull while in the the remaining 14 patients it was'nt sutured. The other surgical steps were done as usually. Histoacrylic glue was used to close the skin. The mean duration of the operation was 2 hours. No intraoperative complications occurred. At follow-up (mean 1.2 years) no flap-related complications and no migration of the receiver-stimulator was observed.

Z2 – O8

Modified minimal incision for Med El

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Objective: Main factor forcing a larger incision in cochlear implant surgery is the need of receiver fixation. However, drilling holes for tie down sutures requires a wider exposure.

The shape of the Nucleus® and Clarion 90K® devices allow to be implanted via small incision. However, MedEl® device has larger receiver with ceramic covering, which tend to migrate unless fixed. In this presentation a modified incision technique with a fixation method is described for MedEl® device.

Surgical procedure: Modified minimal incision was used since 2002. Incision is about 4 cm in the postauricular area. After a standard mastoidectomy, the implant bed was drilled. For the fixation sutures a drill hole was created anteriorly. A 4–0 Vicryl or Prolene suture is passed from this suture hole and then the needle is passed through the periosteum at the posterior part of the implant bed and brought forward. After opening the facial recess and cochleostomy, the implant was tightly secured to the bone. The insertion of the electrode array was done in the usual way.

Results: MedEl® Combi 40 + device was implanted in 78 patients since 2002 using this approach. No major complications were encountered during the operations and in the follow up period.

Conclusion: The modified minimal access surgery is a safe technique that can be used in cochlear implantation cases with all kinds of etiologies. No major complications were encountered during and after the surgery. The operation and hospitalization time is reduced. Minimal shaving decreases the frustration caused by shaving especially in children and adolescents.

Z2 – O9

Round window insertion of Advanced Bionics HiFocus 1j electrode

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Objectives: To study the effect of round window insertion on the implanted array location in the basal cochlea and by neural response imaging assess the response parameter and compare them with those following traditional cochleostomy approach.

Methods: After a wide cochleostomy the round window niche was expanded with a low velocity burr to display it in its entirety. Its size was the assessed and if found to be less than 1 mm the bone antero inferiorly is removed. A linear incision is made antero inferiorly in the membrane. The Hifocus I J electrode was then advanced of its introducer by 1 mm. It is then gradually pushed into the scala tympani by a micro elevator. Intra-operative NRI with specific reference to electrodes 15 and 16 was performed. Post operative CT scanning examined the electrode position in the basal cochlea in relation to the modiolus. Comparisons were made with retrospective findings from patients having had a routine cochleostomy anterior to the round window niche.

Results: Post-operative CT scanning suggest that round window insertion is associated with a closer modular location for the proximal electrodes. Neural response imaging displayed clearer responses than found after traditional cochleostomy.

Conclusion: und window insertion may result in improved outcomes due to a superior location in the basal turn of the cochlea.

Z2 – O10

Cochlear implantation under local anaesthesia

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Objectives: Case Report of a cochlear implant adult candidate where General Anaesthesia was contraindicated and the Cochlear Implantation was performed under local anaesthesia. The objective of the poster or paper is to highlight the difficulties encountered and suggestions on how to avoid them.

Methods: Consent
Premedication
Local Anaesthesia
Draping
Surgery

Results: Surgery was successfully completed within two hours, well tolerated by the patient, no complications.

Conclusions: It is feasible to perform Cochlear Implantation under Local Anaesthesia in adults if General anaesthesia is contraindicated, provided the mentioned precautions and suggestions are adhered to.

Z2 – O11

Transcanal technique for cochlear implantation: The Indian scene

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Surgery for Cochlear Implantation has undergone several modifications since the beginning. The conventional or the classic technique uses a mastoidectomy & posterior tympanotomy approach to the middle ear & the cochlea. Though it is a successful technique it is more time consuming & prone to various complications. In the era of Minimal invasive techniques & need for better accessibility (of the cochlea in this case) the Trans-canal or the Veria Technique is very helpful.

In this case a Trans-canal Tunnel is created with a special "Perforator" in the cortex of the posterior canal wall, which enters the middle ear through the facial recess. A tympanomeatal flap is elevated to do the Cochleostomy and insertion of the electrode in the scala-tympani.

We present here the result of 72 cases done by this technique, using all the three Implant systems namely Medel, Nucleus & Advanced bionics with very good results in patients ranging from 9 months to 50 years.

The results include cases with Cochlear & Middle ear cleft anomalies, deep insertion in all cases including with the Medel long electrode, etc. The advantages of the Veria technique vis-à-vis the conventional technique have also been discussed.

Z2 – O12

Computer modelling of landmarks for cochlear implantation

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Objectives: 1) Demonstrate the anatomical relationship of middle ear landmarks to the basal turn and apex of the cochlea as shown by a three dimensional computer model. 2) Demonstrate that landmarks identified using the computer model are useful when performing a facial recess approach for cochlear implant insertion.

Methods: A three dimensional computer model of the middle and inner ear was used to create virtual surgical access viewpoints useful in cochlear implantation. Using this model, the relationship of the basal turn and apex of the cochlea to middle ear landmarks was examined. Landmarks evaluated include the facial nerve, the chorda tympani nerve, the cochleariform process, the tensor tympani muscle, and the stapes. Using this model as a guide, temporal bone specimens were dissected using a facial recess approach and the anatomic relationships shown in the computer model were verified.

Results: Reliable and consistent relationships exist between middle ear landmarks, the basal turn of the cochlea and the apex of the cochlea.

Conclusions: Computer modelling is a useful tool in understanding the complex relationships in the middle and inner ear. The unique viewpoint afforded by virtual imaging allows the landmarks to viewed from multiple angles and approaches. Understanding these complex three dimensional

relationships can be helpful in identifying the location of the basal turn and apex of the cochlea during cochlear implantation.

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Z2 – O13

New strategies for high precision cochleostomy using a hexapod robot system

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Objectives: The temporal bone represents a special challenge for the surgeon's spatial imagination. In cochlear implantation, a highly precise cochleostomy is a basic condition for preserving inner ear functions and optimal placement of the electrode array. Virtual image analysis with a robot controlled and navigated instrument guidance could be a solution to achieve the required precision of less than 0.5 mm.

Methods: A mastoidectomy with posterior tympanotomy was performed in a human temporal bone specimen. Titan screw markers were fixed on the prepared bone for referencing of the navigation system and the hexapod robot. A DICOM data set was produced with a 64-slice CT scan for virtual image analysis and robot navigation. We generated a virtual endoscopic surface model of the tympanic cavity and inner ear with the open source image processing program OSIRIX.

In a first experiment the trajectory for directing towards the cochleostomy was planned with this model, and a drill fixed on the hexapod was used for navigation-controlled cochleostomy via posterior tympanotomy.

Results: The location for cochleostomy, with the appropriate allocation on the axial CT layer, could be defined for the surgeon on the virtual 3D model. The preliminary data suggests that an instrumentation path through the posterior tympanotomy and the opening of the tympanic scale could be accomplished without collisions.

Conclusions: Connecting a virtual 3D model with a hexapod cinematic could offer in the future the possibility of highly precise navigated cochleostomy.

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Z2 – O14

Navigation surgery in cochlear implantation

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Objectives: Image guided surgery is used for sinus surgery all over the world, but its application in otology has been limited. In difficult cases of ear surgery potential danger of facial nerve injury has to be taken into consideration. For better visibility and control of the delicate structures of the middle ear we began combining cochlear implantation with image-guided surgery.

Methods: During the last 4 years a modified suprameatal approach (SMA) has been used at our department in most of the cases. Since 2004 three-dimensional intraoperative localization technology was introduced with the modified SMA technique in twelve cochlear implant patients with GE Healthcare InstaTrak 3500 Plus ElectroMagnetic surgical navigation system.

Results: Surgery was successful in all cases and there was no complication in the image guided group. However, use of image guided surgery led to a slight increase in operative time.

Conclusions: Image-guided surgery offers a safe and reliable method facilitating cochlear implantation. It enables exact determination of the anatomical landmarks during surgery and helps avoiding possible damage to the facial nerve. In case of unusual anatomy, congenital malformations, ossified cochleas and revision cases the navigation surgery offers increased accuracy and safety.

Z2 – P15

Transmeatal approach: an alternative save approach for cochlear and middle ear implants

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Objectives: A modification of non-mastoid, transcanal electrode insertion technique for cochlear and middle ear implantation is described. The conventional technique for cochlear implant surgery and middle ear implant through mastoidectomy and posterior tympanotomy is worldwide known approach, which may harbor some potential complications including facial nerve palsy.

Methods: The steps of the procedure after the modification from other non-mastoid cochlear implant surgery is by creating a protection bony groove or gutter in an open transcanal tunnel starting from the annulus superior the chorda tympani and incus body and laterally towards the suprameatal region.

Results: We reported 55 cases, 52 pediatric and 3 adult patients between May 2004 to January 2006 who had implant surgery. The follow-up for these cases was between 1 to 21 months and there were no electrode extrusion occurred as a result of this technique.

Conclusion: The transmeatal approach has several advantages, it is a direct access to scala tympani as well as simple,

safe and shortens the time of the procedure, but the most important aspect is minimizing the risk of facial nerve injury. Also, transmeatal approach can achieve direct access to the middle ear structure in congenital malformation as in Mondini dysplasia or in case of ossification of the cochlea, without the need to remove any of the middle ear structures. The detailed steps of the procedures and outcomes will be discussed.

Testing (Z3)

Z3 – O1

Fitting of very young children

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As a result of the newborn screening more children are implanted at a very young age less than 12 months old. Despite the aspects of surgery in these young children's group, also the fitting process needs attention. Usually, these very young children cannot be tested with routine children and play audiometry, especially because these children have no hearing experience. Therefore, the fitting is a challenge for the engineers, technicians and the rehabilitation people. The paper describes the procedure for fitting in young and very young children, using a scaling procedure based on calibrated daily life sound sources. In addition, guide lines and fitting strategies are described.

Z3 – O2

Test-retest reliability of three cochlear implant questionnaires

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Objectives: Nijmegen Cochlear Implant Questionnaire (NCIQ), Asssement of Quality of Life (AQoL) and the Hearing Participation Scale (HPS)questionnaires test-retest reliability in cochlear implant patient's have not been measured.

Methods: 82 long term implanted CI users were sampled with all 3 questionnaires, randomized in order of presentation. Of these 42 returned the forms. A group of 36 were re-sent the forms, and 26 returned these an average of 7 weeks later. Correlations and testing of the test-retest scores was determined for the 3 questionnaires.

Results: Of the original mailing, 38 NCIQ, 42 HPS and 38 of the AQoL were usable. In the second mailing questions were answered accurately to allow data analysis in 24 NCIQ, 27 HPS, and 21 AQoL. The Pearson correlation statistics for the test-retest statistics were NCIQ:0.88 (ranging from 0.63 to 0.88 for subscales), HPS:0.59, AQoL: 0.74. There was a significant difference ($p = 0.001$) between the means of the test and retest NCIQ, with the retest being lower, both in the total score and several sub-scores. There was no significant difference in the score of the AQoL or the HPS on re-testing.

Conclusion: In general, there is good correlation between the test and retest scores in all scales. The NCIQ showed a significant reduction in total and some subscale scores on re-testing. This needs to be kept in mind in using this for assessing benefit.

Z3 – O3

How do different cochlear implant questionnaires correlate with each other?

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Objectives: To determine how 3 popular cochlear implant questionairres compared with each other, and with a simple 1–10 scale of satisfication with the implant.

Methods: The Nijmegen Cochlear Implant Questionnaire,(NCIQ), Assessment of Quality of Life (AQoL) and the Hearing Participation Score (HPS) were distributed to 81 long term CI users, along with a simple question about how satisfied the patients were with the implant on a scale of 1–10. Correlation coefficients between the questionnaire results were calculated. Results of each test were plotted on q-q plots to ensure normal distribution prior to testing. The AQoL is a general quality of life instrument.

Results: Usable responses were obtained in between 34 to 42 subjects for the different comparisons The Pearson Correlation Coefficients for HPS vs Nijmegan was 0.46, Njmegan and Satisfaction: 0.36, Nijmegen and AQoL:0.74, HPS and AQoL: 0.371, HPS and satisfaction: 0.14, and AQoL and Satisfaction: 0.56.

Conclusion: There are generally only modest correlations between the different questionnaires. The HPS seems to correlate the least with the other measures of subjective satisfaction. They may be measuring different aspects of the hearing handicap.

Z3 – P4

Development of a DVD version of the UCL CUNY sentence test

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Objectives: The CUNY sentence test, initially developed by Boothroyd, at City University New York was translated from American English to English and rerecorded by the UCL cochlear implant program. It is now part of many UK clinics standard test battery. The original test was Laser videodisc based, a technology no longer available. The objective was to upgrade the test to Digital Versatile Disc (DVD), and to develop a Visual Basic user interface.

Methods: The test consists of 26 lists of twelve topic related sentences. Each sentence contains three to fifteen words with length counterbalanced across topic. Testing is conducted using lip-reading only, or lip-reading with audio,

either in quiet or with noise. The original analogue recordings were transferred digitally onto DVD. Individual sentence files were produced. A display adaptor capable of driving two screens simultaneously ("subject" screen allowing lip-reading and "clinician" control screen) was created and software prepared to drive it. The existing interface was simplified and control added for scoring and report generation.

Results: DVD provides acceptable quality video and audio. A subset of the test already works, the remainder being currently finalised. A computer station will be available for demonstration.

Conclusions: Long term provision of the UCL CUNY sentence test being safeguarded, the future steps will be to investigate a laptop version, potentially making a portable system available.

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Z3 – P5

Speech tracking revisited

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Objectives: To evaluate the use of Speech Tracking as a training approach for teenagers and young adults with cochlear implants and/or hearing aids.

Methods: Two different approaches were evaluation. The first was a computer-controlled system that determined the form of the text and automatically measured the receiver's performance. Measures obtained include Tracking Rate and Ceiling Rate in words-per-minute, and Proportion of Words Blocked. The second approach presented materials line-by-line, but did not require a verbatim response. The subjects using this approach were scored for the number of words correctly identified.

Results: The results showed that the performance of subjects receiving either form of training improved over time. Some subjects were able to transition from the second to the first approach, but this latter approach proved to be too difficult for others.

Conclusions: The results obtained showed the value of both training approaches. Suggestions will be made as to how clinicians can determine which approach is optimal for an individual subject. A variety of Tracking materials will be shown, and suggestions made for how these can be presented to individual subjects.

Z3 – P6

Everyday listening survey: Evaluation of every day performance with the CII / HiRes 90K cochlear implant

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Objectives: Adult cochlear implant recipients often comment on how unrealistic standard clinical speech assessments are. They express concern that outcome measures, whilst showing improvement, do not truly reflect how they cope in everyday life. This study aims to assess how well CII/HiRes90K implant recipients, cope with the challenges of everyday listening in 4 key areas.

Methods: The everyday listening experiences of Advanced Bionics Cochlear implant users were evaluated with a Questionnaire presented by the clinician, during routine visits. The sections cover: Patient Profile, Telephone use, Music appreciation, Social activities and Professional interactions. The Category of Auditory Performance and speech perception test results were also completed.

Results: The results will be shown from a group of adults (older than 16 years) indicating their experiences in different listening situations and the relationship of these scores to standard clinical assessments.

Conclusions: We have found this to be a very comprehensive questionnaire, which can be conducted in 30 minutes and allows us to formally assess capabilities in 'real life' and may allow identification of difficulties not shown by traditional outcome measures.

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Z3 – P7

LittlEARS diary for parents and therapists – documentation method for early auditory and verbal development of infants

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Objectives: Parental observation is an important instrument and well-accepted method used for assessment of speech development. Such documentation is also useful in the speech rehabilitation. "My LittlEARS Diary" is a second module of the LittlEARS comprehensive test battery and a new tool for Parents and Therapists to assess the early verbal expressions in infants with hearing impairment. The main aim of the diary includes documenting the first vocabulary development and establishing the first word list of an infant after CI implantation or fitting of hearing aid.

Design: The LittlEARS Diary is available in German and English and it includes three parts:

1. A Parent's Booklet containing an introduction, a glossary and list to document infants first 100 words.
2. A Therapist's Booklet containing information for therapists with a tabular overview of the early development.
3. "My LittlEARS Diary": containing space for personal parental documentation of the first 26 weeks after first fitting of the device.

Perspectives: With the LittlEARS Diary we hope to make the first steps in documenting the very early pre-verbal development of hearing impaired infants. The prospective plan is to

use the documentation for research purposes to gather semi-structured information on early auditory development. The First Word List is intended as a research tool to establish the first 100 words list spoken by hearing-impaired children.

Z3 – P8

Little EARS auditory questionnaire – Evaluation results

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Objectives: The Auditory Questionnaire is a parent questionnaire and its main aim is to assess the progress of the auditory development of infants between 0 and 24 month of life. 35 questions were developed, which reflect infant's early auditory behaviour. Categories of auditory developmental dimensions comprise receptive, comprehensive and expressive auditory behaviour.

Method: The Auditory Questionnaire was adapted into a number of languages. In a cross-sectional study, normal hearing infants were assessed by their parents using the questionnaire. Data was compared across languages to determine a regression curve, and thus validity of each language translation. These are compared to the original validation of the questionnaire in German and a norm-reference curve was obtained for each language. In a longitudinal study, children receiving a cochlear implant were assessed over time. These results are compared to the data from the normal hearing group.

Results: The results demonstrate the normal regression curve for each language, based on assessment of normal hearing infants and also show that the regression curve is essentially equal in all the adapted languages. Outcomes from the longitudinal group demonstrate quantitative differences between auditory developmental progress of normal hearing and CI children.

Conclusion: The Questionnaire, standardized in normal hearing children, provides norm values. It is a language-independent tool. The LittlEARS Questionnaire is a proven, reliable and valid instrument for the assessment of early preverbal auditory progress in hearing-impaired children.

Z3 – P9

LittlEARS auditory questionnaire – Validation study on normal hearing infants in Romania

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Objectives: LittlEARS Auditory Questionnaire is a comprehensive tool designed to assess age-appropriate auditorybehaviour in infants. It is useful for follow-up investigations after newborn screening for normal hearing infants, under 2 years, or hearing impairment infants with hearing aids or CI, within 2 years after the fitting of the device.

Methods: The Questionnaire has been translated into Romanian and it was given to parents with normal hearing children, between the ages of 0–24 months. The study was realised in 5 cities in Romania (more then 500 children) and the results were centralised in ENT departments.

Results: We believe that most of the parents understood the importance of LE – A Questionnaire and most of them were very interested in the results. Sometimes they had to be helped to understand some items (e. g. 10 and 29). Some of them were very anxious to know if their child is a normal hearing one according to this test.

Conclusions: Romanian version of LE-A Q is valid and reliable in comparison to German assessment results.

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Z3 – O10

The Teen-EARS test battery – A new tool for the assessment of auditory skills in teenage cochlear implant users

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Increasing numbers of adolescents are seen in cochlear implant programs. This brings along the necessity for the development of new assessment tools for this special patient group who might be too good for paediatric tests and still not advanced enough to cope with adult testing material.

The Teen EARS test battery, which is commercially available, consists of 8 parts: one questionnaires and 7 tests for the assessment of different levels of auditory skills. In detail, the Manchester teens questionnaire and the following subtests: listening skills screening, common phrases test, categories of auditory performance, speech intelligibility rating, paediatric telephone test, 1990 UCH environmental sounds test, tres trax. The test battery can be used both for longitudinal and transsectional studies.

Up to date we have tested adolescence who have been unilaterally implanted for 2 to 8 years and were between 12 and 19 years of age. They had been born deaf or hard of hearing and suffered from progressive hearing loss. All of them at present attend mainstream secondary education. This special subgroup of teenagers enjoyed doing the test. They almost reached ceiling level in all of the subtest. The Manchester teens questionnaire proved to be not applicable to this group.

For the tested group the test proved not to be demanding enough. In the near future we will test implanted teenager who attend educational settings for the hearing impaired.

Z3 – O11

Korean HINT: cross-language equivalency in normal and CI listeners

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Objectives: A Korean version of the Hearing in Noise Test (HINT) was developed to facilitate comparative cross-language studies of functional hearing. The HINT simulates the effects of the head and ear (for normally hearing subjects) and of microphone placement (for CI users) using head-related transfer functions (HRTFs). This study determined the equivalence of Korean and American English versions of the HINT in normal listeners and CI users.

Methods: Eight normal-hearing adults and six HiResolution Bionic Ear users were tested with the Korean HINT. The study mapped the relationships between adaptive rules, S/N ratios at threshold, and percent intelligibility at threshold for the normal-hearing subjects. Performance-intensity functions were compared between normal-hearing Koreans and Americans. HINT results were compared for Korean and American cochlear implant users with the results anchored to the norms for their respective languages.

Results: The relationships between the rules used to measure HINT thresholds in Korean, the S/N ratios at threshold, and percent intelligibility at each threshold were similar to those for English. The PI functions for both languages were almost identical for normal-hearing subjects. When the Korean and American CI users were compared directly using the normative anchor points for each language, performance of both groups was similar.

Conclusions: Using the HINT to make direct comparisons of CI performance across languages provides a tool that will enable research and clinical advancements to spread more rapidly throughout the world. This tool can facilitate international collaborations with common outcome measures that heretofore would not have been possible.

Z3 – O12

The Bark scale in children with cochlear implants: Ongoing findings

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Objectives: The Bark Scale is an innovative method for evaluating the vowel production and vowel space of children with a cochlear implant. Vowel space is directly affected by auditory perception. We examine the use of vowel production and vowel space as an outcome measure in children with cochlear implants.

Methods: Cross-sectional study of children with unilateral and bilateral cochlear implants. Speech samples of the three cornerstone vowels /i/, /a/, and /u/ in isolation gathered using an imitative paradigm were analyzed spectrographically. Formant energy for the cornerstone vowels were converted into Bark scale values and the F1-F0 and F3-F2 differences were calculated. The area of the vowel triangle was also calculated. Results were calculated as a function of age of implantation, device, speech processing strategy, and length of time implanted.

Results: Serial data was collected on 25 subjects across all three implant device manufacturers. Vowel space and tongue placement changes as a function of age of implantation and length of time implanted are reported. Normalization of vowels is age of implantation dependent. Preliminary normative vowel space and placement of the cornerstone vowels as a function of age of implantation are reported.

Conclusions: Analysis of the cornerstone vowels in young CI children provides insight into speech perception at an early age and may be a useful tool to guide mapping changes in the very young child for whom specific speech discrimination data cannot be obtained.

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Z3 – P13

Evaluation of fourth book in 'Murat' reader series

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Objectives: This reader series was designed to provide professionals and parents with an inexpensive, ready to use, comprehensive material to help promote spoken language skills in cochlear implanted children. Objective of this study was to trial "Murat's Birthday Present' and obtain feedback from parents and professionals.

Methods: The book with guidelines was trialed with 4 professionals and 15 parent/child pairs. All children were MED-EL CI users, average age 6.5 years. Each parent/child pair and professional used this book over 8 habilitation sessions. After completion of the book both parents and professionals were asked to fill in a questionnaire. Questions for parents focused on whether the material had prompted positive interactions and work on listening, at home. Questions for professionals focused on ability of material to: provide basis for conversation; opportunities for repetitive language; provide listening tasks of varying difficulty; keep child interested and actively involved; facilitate session planning and provide topic related activities for completion at home.

Results: Parents reported they had worked more frequently, completed a wider variety of topic related activities and done more work on listening with their children. Professionals reported: photographs provided a good basis for conversation; 'props' (made from drawings in book) helped to sustain child interest; materials could easily be passed onto parents facilitating reinforcement of language at home; suggestions for listening tasks and follow up activities made session planning and involvement of parents easier.

Conclusions: Positive feedback confirmed usefulness of 'Murat' reader series in habilitation of children learning spoken language through listening.

Z3 – O14

Differences in perception of handicap between cochlear implant users and spouses

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Objectives: To determine how the perception of handicap of the spouse or signifcant other differs from that of the CI user.

Methods: The Nijmegen Cochlear Implant Questionnaire,(NCIQ) was administered to 42 long term cochlear implant users. At the same time, the spouse or significant others were asked to rate their perception of the patient's hearing handicap using the same instrument, as if they were assessing the patient by proxy. The correlations between these two assessments were compared.

The results were analyzed for correlations of perception.

Results: Usable responses were obtained in between 35 subjects. The Pearson correlations for subjects and spouses varied between 0.63 (Basic Sound Perception subscale) to 0.83 (Avanced Perception subscale). The overall total score correlation was 0.8. There were significant statistical differences in the results of the Basic Sound and Self Esteem subscales between evaluations between the two groups. The rest of the subscales showed no systemic effect.

Conclusion: There are generally good correlations between spousal perception of handicap and patient's perception, although spouse's thought the handicap was higher in general in two subscales than patient's did.

Z3 – P15

Talker familiarity's affect on cochlear – implant users' sentence recognition

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Objectives: to determine the role of talker-specific information in speech perception via a cochlear implant (CI) and the extent to which this information affects accurate analysis of the speech signal's linguistic information.

Study Design: A mixed 2 X 2 design was used. The between-subjects variable was participant type (adult cochlear-implant users, adult normal-hearing listeners) and the within-subject variable was talker type (familiar, novel).

Methods: The effect of talker-familiarity on sentence recognition was studied with experiments modeled after those of Nygaard and colleagues (Nygaard & Pisoni, 1998; Nygaard et al., 1994; Nygaard, Sommers, & Pisoni, 1995). Participants were first trained to recognized different talkers' voices. After being tested on how well they learned the voices, the participants completed a sentence recognition test in noise to assess the role of talker-familiarity on their sentence recognition skills.

Results: Differences were noted between normal-hearing and CI listeners – the CI listeners performed overall more poorly than the normal-hearing listeners on the sentence recognition test and did not demonstrate an effect of talker familiarity. Great variability in performance was noted across CI users.

Conclusions: Literature suggests the speech signal's talker-specific information plays an important role in speech processing in normal-hearing listeners (Johnson & Mullenix, 1997), as replicated in the present experiment. CI users, however, appear to face challenges associated with listening through a device that seems to constrain much of the talker-specific information contributing to the facilitatory effect of talker familiarity.

References

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Z3 – O16

Assessment of parental views of their cochlear implanted children

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Objective: To assess parental views and experiences of following cochlear implantation of their child using the questionnaire and free opinions.

Setting: The University of Tokyo Hospital in Japan.

Subjects and Methods: The parents of 43 children who had been born deaf or were deafened by age 10 years and who had been implanted for these five years were surveyed using the closed-format questionnaire. The questionnaire was established by O'Neill et al (Int J PORL 68:149–160, 2004). Meantime, in addition, free opinions were asked for writing frankly.

Results: Most of parents circled "strong agree" and "agree" in questions of communications, general functioning, self-reliance, well-being and happiness, social relationships, education, process of implantation, effects of implantation, decision to implant, and supporting the child except few questions. However, in free opinions parents asked for better communication between parents and doctors for medical problems, and parents and school teachers for understanding their child in school.

Conclusion: The use of this questionnaire and free opinions can result in valid comparisons of outcomes among different cochlear implant centers internationally.

Z3 – O17

Early intervention and cochlear implants: Parental perspectives

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Objectives: To determine whether Early Intervention (EI) services provided to parents of hearing impaired children affect family decision-making relative to cochlear implantation. Additionally, to explore whether and how such services might impact a child's cochlear implant outcomes.

Methods: A four-page mail survey on parent experiences with early intervention was sent to a stratified random sample

of parents of young children (birth to six years) who had received a cochlear implant.

Results: Most families indicated that the information they received from EI professionals did not cover the full range of communication options available to a deaf child; information tended to be biased for one option. Fewer than one-third of families were given Information on their child's possible cochlear implant candidacy. Low and moderate-income families were under-represented in the cochlear implant population and were less likely to use spoken language than children from middle or upper income families.

Conclusions: Early Intervention programs provide an important opportunity for all hearing impaired children to have access to the range of technology and services that can help them maximize language development. Our study demonstrated that the information and services provided under EI do not fully support the cochlear implant option. Middle and upper income families have greater resources and are better equipped to go outside of publicly provided programs to secure information and services. Outreach programs such as Sound Support in Michigan provide training to families and professionals to improve access to, and outcomes with, all options including cochlear implantation.

Z3 – O18

Parental decision making regarding choice of implant manufacturer for their children

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Objectives: The purpose of the study was to document the issues parents felt to be important in the choice of implant manufacturer for their children.

Method: Three sets of parents who recently chose to implant their infant or toddler participated in the study. Each set of parents were interviewed in their home. The parents answered a list of prepared open-ended questions during the interview. In addition, each parent completed a rating scale designed to assess the influence of various factors such as physician preference or marketing on the decision the family made.

Results: The interviews suggested marketing practices of the implant companies including personal contacts by the companies and audio-visual materials were highly influential in the decisions made by two families. These parents seemed most impressed by child seen in the promotional materials and the personal relationship they developed with a representative of the implant manufacturer. In contrast, Family 3 who had two children with implants had specific issues regarding the implant that had been problematic in their older child as a reason for choosing another manufacturer for their second child. For Families 1 and 2, their objective rating scale results were inconsistent with their interviews.

Conclusions: Our small sample suggests parental decision making regarding the choice of CI manufacturer during the first year of life is highly emotional and heavily influenced by marketing materials.

Z3 – P19

Development of an effective pediatric counseling tool

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Objectives: In counseling parents of children who are potential cochlear implants recipients, parents frequently have misinformation and unrecognized (or unexpressed) expectations that are unrealistic. They are thus unprepared for the challenges of managing the cochlear implant system and the need for ensuring an enriched auditory, speech and language environment for their child. The objective was to develop a dynamic standardized interactive counseling tool which will teach and reinforce the basics of sensorineural hearing loss, realities of cochlear implants, factors affecting outcomes/success and the need for parent/family commitment. Such a tool will help prepare parents to make knowledgeable choices, develop appropriate expectations and commitment, and optimize the outcomes for their child.

Methods: A PowerPoint presentation incorporating a variety of multimedia resources that provides standardized and comprehensive information for parents/guardians with sensitivity towards differing backgrounds and philosophies was developed. To evaluate the effectiveness of our counseling tool and counseling process, a questionnaire was created to assess a family's knowledge and understanding of basic principles regarding hearing loss and cochlear implantation prior to and following counseling.

Results: A structured, visual counseling tool allows for standardization of the counseling process and is effective in teaching and preparing families for the reality of living with a cochlear implant on a daily basis.

Conclusions: An interactive, standardized and structured counseling tool facilitates effective teaching of parents and management of appropriate parent and family expectations. Our counseling tool has made counseling time more efficient and effective in providing education and in shaping appropriate expectations.

Z3 – P20

ABQuest: handling research questionnaires efficiently

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Objective: In a research study often several kinds of data must be combined, e. g. speech understanding tests or rehabilitation questionnaires may be correlated with program parameters or objective measurements such as eCap or ESRT. This can be most easily done if the data is available in electronic format, e. g. an Excel spreadsheet. Currently, in many cases study forms on paper are used. Re-entry of the data may be time-consuming with a risk of making errors. As an alterna-

tive an easy-to-use, flexible and open software has been developed to collect study questionnaires electronically and assist in the analysis.

Methods: The ABQuest tool uses the same database technology as the SoundWave programming software. The application supports the typical research study process flow. Subjects can be managed and enrolled in a study. Taking a new questionnaire is performed with a software wizard. For multicenter studies the same questionnaires can be taken in several languages. The tool also provides a tracking plan to facilitate the scheduling of subject visits. For custom data analysis a flexible export capability to Excel is provided. When exchanging data between study partners, the data can be exported anonymously.

Results: Several study questionnaires have been implemented. The most complex questionnaire is the everyday listening survey, which is an extensive questionnaire documenting the benefits of CI use in daily conditions.

Z3 – P21

Advocacy program at The Let Them Hear Foundation

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Objectives: To describe the methods and success of advocacy techniques used to secure insurance coverage for patients receiving Cochlear Implants in the USA as available in a new non-profit program.

Methods: The primary method used for written appeals is to take a legal approach, rather than a reimbursement approach in navigating the insurance appeals process, focusing on highlighting inadequacies in the insurance company's research and data relied upon in making their adverse determinations. State and federal law must be carefully researched for every case as up to 10 % of denials appealed through the LTHF advocacy program have been illegal.

Results: 100 % success rate in overturning insurance denials resulting in 62 patients in total receiving full coverage valued at almost $ 2.3 million USD for medical services originally denied by the insurer. One-third of these cases centered around denials for cochlear implant surgery or limitations on post-implant audiology or speech therapy services, including 18 bilateral cochlear implants. 60 % of cases were resolved after a single written appeal, another 18 % after a second written appeal, and 7 percent required in-person hearings or arbitration.

Conclusions: Parents and medical service providers are well served in having an independent third-party advocate in the insurance appeals process when the advocate is well-versed in both the legal and medical issues involved. American insurance companies cannot be relied upon to have up-to-date data on either research regarding the medical services being requested or the law controlling their obligation to provide such services.

Electrophysiology (Z4)

Z4 – O1

Electric-acoustic stimulation: auditory nerve single fiber results

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Objectives: To determine how acoustic stimuli alter auditory-nerve coding of electric pulses trains, both during its presentation and afterward.

Methods: Responses were recorded from acoustically sensitive cats implanted with an intracochlear electrode. Electric stimuli were 250 pps pulse trains, the acoustic stimulus was a wide-band noise. Single-fiber responses were evaluated for threshold, dynamic range, jitter, latency, etc. The electrophonic and "direct" (membrane depolarization) responses were assessed separately.

Results: Relative to responses from deaf ears, electric thresholds were higher and dynamic range slightly greater. Simultaneous acoustic stimulation greatly desynchronized responses to electric stimuli. Post acoustic-stimulus effects included enhanced synchrony to electric pulses, which can markedly affect even ECAP responses (Nourski et al., 2005). Additionally, electrophonic responses were shown to adapt much faster than "direct" responses. Unusual response patterns, such as "build-up" and "bursting", were also observed.

Conclusions: Acoustic stimulation can cause simultaneous effects and post-stimulus effects related to neural adaptation. Both acoustically driven and spontaneous spike activity markedly change the temporal response of fibers to electric stimuli relative to that observed in deaf ears. Responses to electric stimuli after offset of the acoustic stimuli are complex and can include both enhanced and adapted responses to electric pulses. Combined electrophonic and direct responses, due to their differential adaptation rates, may lead to complex percepts. Unique findings recently reported in the ECAP from hearing ears, such as its non-monotonic recovery after acoustic stimulation (Nourski et al., 2005), can be interpreted from these single-fiber result.

References

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Z4 – O2

Do auditory cortex fMRI activations predict CI outcome?

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Objectives: Before cochlear implant (CI) surgery, the integrity of the auditory pathway is usually tested by promontory testing (PT) or electrical ear canal stimulation (ECS) (Schmidt et al., 2003). ECS is the only choice for children, but the evaluation of reactions as auditory are only subjective.

Methods: To objectify the prognostic value of ECS, functional MRI (fMRI) was performed during ECS in 18 CI candidates (23 ears) and 5 normal hearing participants (5 ears).

Results: In the CI candidates, sensations due to ECS were auditory in 16 ears, uncertain in 6 ears, and non-auditory in 1 ear. Unequivocal fMRI activation of the primary auditory cortex was detected in 9 of 16 cases with auditory sensations during ECS. Of the 6 ears with uncertain sensations, unequivocal activation was detected in only 2 ears. FMRI activations tended to be more bilaterally distributed in CI candidates than in normal hearing participants. Neither pre-operative residual hearing, nor sensations during PT or ECS, nor fMRI activations predicted CI outcome. Substantial correlations were found only between PT and ECS, and between ECS and fMRI activation.

Conclusions: Because a good CI benefit was also obtained when sensations during PT or ECS were lacking, the predictive value of these tests seems doubtful.

References

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Z4 – O3

Can fMRI predict outcome for cochlear implantation in children?

SK Holland, DI Choo, VJ Schmithorst, M Altaye, P Karunanayaka, A Patel, D Brown, E Eads et al.

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Objectives: We will demonstrate that fMRI can detect central auditory and language processing in infants and toddlers under sedation and that this technique is capable of providing important data to clinicians that is not available by any other means in prelingual babies. We present early results from a large-scale study designed to ascertain whether fMRI can reveal clinically relevant details about the central auditory system in infancy.

Methods: Severe to profoundly hearing impaired (HI) infants, toddlers and normal-hearing age matched controls are sedated for clinical MRI brain scans. FMRI is performed on a 3.0 Tesla MRI scanner using specially designed silent background fMRI imaging method.[1] Auditory stimulation is administered using narrow band noise tones or natural language through a calibrated MRI compatible audio system with sound levels adjusted to exceed measured hearing thresholds for each subject.

Results: Activation maps are constructed using a generalized linear model and are transformed to a common reference frame for presentation and quantitative analysis. Cortical activation has been detected during auditory stimulation tasks administered under sedation in infants and toddlers with severe to profound hearing loss. Primary auditory cortex, cortical language areas and other areas activate consistently; exhibiting both positive and negative BOLD effect.

Conclusions: As outcome measures of auditory and language performance with cochlear implants become available in this cohort 2 years after CI, correlations between preimplant fMRI and outcome will be performed to assess the prognostic value of fMRI in cochlear implant staging in infants.

Z4 – O4

fMRI before cochlear implantation (CI) in small children

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Diagnostic neuroimaging of CI candidates has to establish the prerequisites for successful placement of the implant. An undefaced cochlea and integer auditory pathways are affirmative predictors. Structural integrity of the cochlea and the cochlear portion of the VIIIth cranial nerve is confirmed by high-resolution (HR-) MRI and, to exclude calcifications, by HRCT.

HR-CT is also required to ascertain a normal course of the facial nerve through the temporal bone before surgery. Functional integrity of the auditory system can be demonstrated by promontory electrical stimulability or residual hearing in conjunction with functional MRI (fMRI) irrespective of subjective audition, task performance, and even under shallow anaesthesia.

Hypoplasias and aplasias can be more or less limited to the cochlear branch. Here, fMRI can potentially discriminate the two conditions which are frequently associated with facial nerve course abnormalities. Promontory electrostimulation optimized for fMRI allows bilateral assessments of the primary auditory cortex as well as of subcortical centres of audition and, in contrast to unselective demonstration of residual hearing, potentially predict which ear should host the CI.

Z4 – P5

Electroaudiometry – its present role in preoperative assessment of the CI candidates

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Objectives: Electroaudiometry is the subjective neurophysiologic method for assessing the auditory pathways. Electric impulses are sent through an electrode in the external ear canal, and the auditory sensations perceived by the examiners are registries. The voltage of the stimulating electric current, required to evoke auditory sensation in patient is measured.

Methods: At the ENT Department on University Medical Centre Ljubljana, from March 1996 to December 2005 there were 133 patients who were operated on for cochlear implantation (CI). With one exception, the hearing with CI was established in all patients. Electroaudiometry is one of the tests to asses the CI candidates, besides electrocohleography and electrically evoked auditory brain-stem responses (EABR).

Results: In the last ten years electroaudiometry was performed in 82 CI candidates, aged between 3, 5 and 76 years. The Med El, Medical Electronics electroaudiometer was used. The duration of deafness ranged from one month up to 60 years. During the electroaudiometry the auditory sensations were assessed in 75 candidates (91.5 %). Among patients with positive electroaudiometry test, 57 patients are already successfully implanted. Three patients with negative electroaudiometry testing are as well the successful CI users. In two patients after severe cerebral and temporal bone trauma, the (EABR) were undetected, imaging doubtful, electroaudiometry was positive and they are also successful CI users.

Although electroaudiometry is a subjective method, we found it easy and useful to perform in CI candidates older than 3, 5 years. It gives candidates a taste of "the new way of hearing" with the CI.

Z4 – O6

Stochastic neural firing applied to neural excitation spread

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Objectives: To gain a better understanding of the effect of stochastic firing on neural excitation spread.

Methods: Multi-electrode implant performance is, among other things, constrained by uncontrollability in neural excitation spread. The neural response telemetry (NRT) measuring system allows measurements of the electrically evoked compound action potential (ECAP) of the auditory neurons to study the extent of neural excitation spread. However, NRT measurements can be simulated to gain greater understanding of the origins of the ECAP. The simulation of the auditory neural ECAP has recently been added to a combined volume conduction-neural model of the cochlea and auditory nerve. Due to the deterministic dynamics of the ion currents as described in the Hodgkin-Huxley (HH) model, most versions of HH based neural models used to simulated the ECAP, lack a stochastic firing response to input signals as observed in real neurons. Recent advances in mathematical physiology suggest that, apart from the effect of additional membrane noise, stochastic firing can also result from non-deterministic dynamics in the ion currents. In this study non-deterministic ion current dynamics are included into the neural model.

Results: Initial results suggest a better approximation of the amplitude and width of the neural excitation spread and ECAP profiles.

Conclusions: Inclusion of non-deterministic ion currents into the current neural model may possibly lead to a greater understanding of the underlying mechanisms of neural excitation spread and eventually to its reduction.

Z4 – O7

Electrically evoked auditory change potentials

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Objectives: The primary goal of this study was to evaluate the feasibility of recording the acoustic change complex in cochlear implant users.

Methods: Initial results recording the electrically evoked auditory change complex (EACC) in Nucleus implant recipients are described. Data from both adults and children will be presented. In this study, NIC routines were used to allow us to bypass the speech processor of the cochlear implant. The stimulus consisted of a 600 ms burst of a 1000 Hz pulse train. Midway through the 600 ms stimulus pulse train, a change, either in the stimulating electrode or in the temporal properties of the stimulus, was introduced. Stimulus artifact was minimized through the use of both analog and digital filtering (1–100 Hz).

Results: Preliminary results show that reliable change potentials can be recorded from cochlear implant users and the morphologic characteristics of this response are very similar to those reported previously for acoustic stimulation. Response amplitudes were shown to vary systematically as a function of the magnitude of change that was introduced. The effects of development that were observed were consistent with results described previously in the literature for the P1-N1-P2 complex.

Conclusions: Although recording the EACC is more challenging and time consuming to record than any of the more peripherally generated evoked potentials, the fact that this is a cortical response and that it reflects processing of stimulus change makes it potentially a valuable tool for assessing neural response to electrical stimulation.

Z4 – O8

Electrophysiological responses within the spiral ganglion

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Objectives: Neurons of the mouse spiral ganglion are not identical, but instead display electrophysiological differences that vary subtly from neuron-to-neuron (Adamson et al., 2002). To determine with precision how these parameters vary with cochlear location we developed a novel preparation in which the entire ganglion is cultured as an explant, thus pre-

serving the relative location of all postnatal spiral ganglion neurons in vitro.

Methods: Patch clamp electrophysiological recordings in the whole-cell current clamp configuration were made from identified individual neurons.

Results: Our analysis showed that different firing features have specific ganglionic distributions. For example, membrane kinetics, such as action potential latency at threshold, showed a graded distribution. This parameter was brief in basal spiral ganglion neurons (10.6 ± 0.7ms n = 29), intermediate in middle neurons (11.4 ± 0.8ms n = 24), and prolonged in apical neurons (12.6 ± 0.8ms n = 37). Action potential threshold, however, showed a more region-specific distribution, being significantly elevated in the basal neurons (44.0 ± 1.0mV,) when compared to neurons located within the middle (49.2 ± 0.7mV; $P < 0.01$) and apical (50.0 ± 0.6mV; $P < 0.01$) portions of the cochlea. Lastly, some parameters did not vary according to ganglion region. Characteristics such as the firing pattern classifications of non-accommodating neurons were similar regardless of whether the neurons were found in the apex, middle, or base of the cochlea.

Conclusions: Our data suggest that at least three different patterns describe the distribution of the electrophysiological parameters in the spiral ganglion. These patterns could potentially contribute to the coding of specific parameters of sound stimuli.

Z4 – O9

Differential patterns of brain activation during auditory processing in cochlear implant recipients

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Objectives: To investigate the time-course and brain activation patterns involved in auditory processing in post-lingually deafened adults using cochlear implants (CI) by means of auditory event-related potentials (AERPs) and low resolution electromagnetic tomography (LORETA).

Methods: Sixteen post-lingual adult CI recipients and a group of normal hearing (NH) controls participated in the study. AERPs were recorded while subjects were performing oddball discrimination tasks consisting of tones and speech stimuli with increasing acoustic-phonetic difficulty. The LORETA algorithm was used to compute the smoothest possible 3-dimensional current density distribution which generated the P3 potential to target stimuli.

Results: In CI recipients results suggest that with increasing acoustic-phonetic difficulty reaction time and P3 latency increased whereas performance accuracy and P3 amplitude decreased. Compared to NH, P3 latencies of CI recipients were prolonged and amplitudes were decreased in all tasks. LORETA estimations revealed differential patterns of brain activation in CI recipients characterized by enhanced ipsilateral activation of the temporal lobes (i.e. right activation for patients with right CI and left activation for patients with left CI). Furthermore, CI recipients showed enhanced ipsilateral occipital lobe activation during speech processing.

Conclusions: A combined behavioral-electrophysiologic-imaging approach provided temporal as well as spatial information regarding the process of speech perception in CI recipients. The differential patterns of brain activation in CI recipients compared to NH, and in those with right compared to left implants, have implications regarding alterations in central auditory system activation and brain plasticity following cochlear implantation. Clinically, such data may contribute to decision making regarding ear of implantation.

Z4 – O10

Alteration in low frequency place pitch with electrical stimulation

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Background: In the normal auditory system, the perceived pitch is closely linked to the location of basilar membrane vibration along the cochlea. It is assumed that electrical stimulation by a cochlear implant electrode also evokes a pitch sensation similar to this place principle seen in normal hearing. If true, electrodes must be advanced far into the cochlea to activate low frequency regions. However, deep insertion carries more risk to functioning auditory structures. The 10 mm Iowa/Nucleus Hybrid Cochlear Implant was originally developed to stimulate basal high frequency regions in patients with residual low frequency acoustic hearing.

Study design: We studied 19 subjects from initial stimulation though 4 years experience. Pitch sensations were measured electrically through the implant and acoustically in the contralateral ear.

Results: Pitch perception using the Hybrid cochlear implant often shifts dramatically downward in frequency during the first few years of implant use. The early pitch sensations are closer to predicted pitch sensations based on electrode location in the cochlea, while later pitch sensations are 1–3 octaves lower than predicted.

Conclusions: These results suggest that early pitch sensations may reflect peripheral innervation patterns, while late pitch sensations may reflect higher level, experience-dependent changes. The late pitch sensations are similar to the frequencies allocated by the implant speech processor. These changes in pitch sensation over time are the first behavioral evidence of plasticity in absolute pitch perception, and show that central processes and experience have a markedly greater influence on perceived pitch than previously imagined. This finding may impact future electrode design concepts in that deep insertion may not be necessary to provide low pitch sensations.

Z4 – O11

Lateralisation of speech processing in cochlear implant users

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This study aimed to investigate hemispheric speech processing in cochlear implant users. Cortical activity resulting from auditory stimulation was measured using [^{18}F]-FDG positron emission tomography. Eighteen adult cochlear implant users were studied over the course of 29 activation states. Four main effects were observed: (i) bilateral auditory cortical activation was present in all subjects; (ii) activity was greater in the left than the right primary areas; (iii) activity was greater in the association areas contralateral to the side of implantation; and (iv) visual cortical responses were higher in patients with left than right cochlear implants. These data demonstrate that there is no strong left hemisphere dominance for language in cochlear implant users, and suggest that lateralisation of association area speech processing shifts following cochlear implantation. The additional visual recruitment in the left implant users may be as a result of excessive demands on the speech processing abilities of the right auditory areas. In total, these findings provide evidence of the development of new speech processing strategies that occur following cochlear implantation.

Z4 – P12

A bipolar electrode for objective electromyographic registration of stapedius muscle reflexes

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Objectives: Intra-operative visual observation of the stapedius muscle reflex is a well established method which allows preliminary setups for a speech processor, especially in children. However, there are a number of middle ear factors which may influence or even impede the visibility of the reflex. Electromyography as an objective method may offer many advantages in terms of measuring the stapedius muscle contraction.

Methods: Based on the results of other researchers we recently develop a technique which allows electromyography of the stapedius muscle using a bipolar electrode. For proving the feasibility of the method, a bipolar electrode was inserted into the muscle via a drill-hole in the pyramid process. For a less traumatic access we designed special electrodes which may enter the pyramid process along with the stapedius tendon. The final goal is to establish a method in which the muscle reflex may be used for a permanent control loop for setting the speech processor.

Results: First results of this method are presented – as well as prototypes of specifically designed needle electrodes.

Conclusions: Bipolar electromyography of the stapedius muscle reflexes seems feasible in the new concept.

Z4 – P13

Intra-operative stapedius reflex threshold: Comparison of multi channel stimulation versus single channel stimulation

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Objectives: Objective of this study was to determine the difference of the threshold of the electrically evoked stapedius reflex (ESRT) evoked by conventional single channel stimulation to the multi channel stimulation of speech bursts in Soundwave.

Methods: ESRT was determined intra-operatively in more than 20 adults using a sequential 16 channel program in Soundwave with default settings stimulating with speech bursts. This results in an ESRT value for 7 groups of four channels in each subject (1–4, 3–6, 5–8, 9–12, 11–14, 13–16). In addition ESRT was measured when stimulating just one single channel like it is done conventionally. For this measurement one channel per group was stimulated, i. e. 3, 7, 11, 15, respectively. Both ESRT values were correlated to the M-level used in the subjects 16 channel sequential program three months after first fitting.

Results: In the majority of subjects ESRT could be determined, at least for some channels. The success rate was lower in the basal part of the array, especially when using single channel stimulation. For most of the subject ESRT for speech burst stimulation was lower than for single channel stimulation, about 25 to 30 CU. In average the M-level is at 80 % of the ESRT.

Conclusions: As known from early studies ESRT is a reliable tool with high success rate and can be valuable for estimation of postoperative M-level especially when using speech burst for stimulation.

Z4 – P14

Electrically evoked action potential (EAP) parameters obtained from pre-lingually deaf implanted patients

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Objectives: Pre-lingually deafened adolescents represent a unique population in that EAP parameters can be compared to reliable psychophysical measures in congenital deafness. The aim of this study was to characterize EAP parameters in pre-lingually deafened adolescents receiving a HiResolution Bionic Ear implant with respect to the psychophysical levels used for cochlear implant (CI) fitting.

Methods: Fifteen subjects were enrolled in this study (mean age at the time of implantation 16.9 ± 8.4 years). M levels were set at the most comfortable level while T levels were automatically fixed at 10 % of the M levels. EAPs were

obtained intra-operatively, at first fitting and at 2 weeks, one month, 3, 6, 9 and 12 months after CI connection at three electrode locations (15, 9 and 3) by utilizing biphasic pulses with 32 ms phase duration presented at 30 Hz with an alternating polarity.

Results: Mean EAP thresholds obtained at first fitting and 12 months after CI connection were 180 ± 59 and 189 ± 58 CU respectively for the apical electrode, 213 ± 44 and 190 ± 61 CU for the intermediate electrode, and 225 ± 71 and 210 ± 64 CU for the basal electrode. M levels increased during the first three months and stabilized thereafter. Mean ratio of EAP thresholds to M levels at 12 months were 58, 53 and 61 % for the apical, intermediate and basal electrodes.

Conclusions: EAP measures were very stable over time and showed low variability among subjects and across electrodes. EAP thresholds could be utilized to set M-levels in prelingually deaf patients receiving a HiResolution Bionic Ear implant with an acceptable degree of reliability.

Z4 – P15

Measurement of the electrically evoked auditory brainstem and cortical responses using the Nucleus® Freedom™ cochlear implant

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Objective: The objective of this study was to evaluate the technical feasibility of recording the evoked auditory brainstem response (EABR) and cortical evoked response (CEP) using the neural response telemetry (NRT™) amplifier of the Nucleus Freedom cochlear implant and two extra-cochlear electrodes.

Methods: The EABR and CEP were recorded in four deafened guinea pigs acutely implanted with an 8 electrode scala tympani array. Potentials were recorded from two transcutaneous needle electrodes at the neck and vertex respectively and subsequently amplified using the Freedom implant's NRT amplifier controlled by an L34SP research processor.

Results: Results indicated that both the EABR and CEP of the deafened guinea pigs could be recorded using the Nucleus Freedom cochlear implant NRT amplifier using two extra-cochlea electrodes.

Conclusions: The success of the animal model measurements is hoped to be replicated in human recipients of the Freedom Cochlear implant where it is anticipated that such responses might be detected using conventionally implanted extra-cochlear electrodes.

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Radiologic Evaluation (PE1)

PE1 – O1

State of the art: Radiologic evaluation pre and post cochlear implantation

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PE1 – O2

Cochlear implantation in children – do we need MRI scan in all potential candidates?

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In newborns suspected for profound hearing loss an extensive audiologic evaluation and a computer tomography (CT) is realised. Only in children with evident risk for neural central disorders a MRI scan is included in this diagnostic procedure. Because of the lack of clinical neural observations in very young children it seemed to be mandatory to include in the evaluation process also an MRI scan.

In the time between January and December 2004 we evaluated 162 children with up to 12 years of age. In 30 (18,5 %) patients a pathologic radiologic finding was detected, including malformation, aplasia of the labyrinth and / or hearing nerve, central brain etc.

In 21 children of these patients a Cochlear Implantation was realised. In the residual 9 children the therapy concept I still in discussion. The diagnostic procedure will be finalised by either neurological and psychological examination or an audiological / functional evaluation of the neural auditory system.

In conclusion in all affected patients the radiological findings was effective. Especially in these patients an early, complete diagnosis is important to take advantage from the plasticitiy of the neural system. MRI scan in all candidates should be realised.

PE1 – O3

Combination of CT and MRI as neuroradiological imaging modalities in patients before cochlea implantation

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Objectives: To answer the question if a preoperative cost reduction is reasonable by performing only CT or only MRI before cochlea implantation and to point out the diagnostic value of each modality for these patients.

Methods: Retrospective analysis of 72 patients` CT and MRI data. Two neuroradiologists evaluated 144 examinations (72 CT; 72 MRI) in consensus. Pathologies of the inner ear, cerebral abnormalities and anatomical variants of the temporal bone were documented.

Results: Out of 72 patients 30 patients had no pathologic finding on CT or MRI, 23 patients had pathologies in both CT and MRI. In 14 patients only CT and in five patients only MRI revealed pathologic results. In 15 patients variants of vessel anatomy like aberrant internal carotid artery were found.

The pathologies only observed on CT were ossification of the cochlea (1x), round window changes in otosclerosis (1x), otitis media (5x) and missing pneumatisation of the mastoid (7x), whereas pathologies only recognized on MRI were abnormal neuronal migration (heterotopia) (1x), parenchymal lesions after cerebral CMV-infection with involvement of the primary auditory cortex (1x), superficial siderosis (1x), fibrosis of the cochlea (1x) and one contraindication to cochlea implantation – aplasia of the cochlea nerve (1x).

Conclusions: In 19 (26 %) out of 72 patients pathological findings were only detected on either CT or MRI. These findings had peri- or intraoperative consequences for the mostly very young patients. Therefore, the authors recommend that the preoperative diagnostic management before cochlea implantation should be a combination of both imaging modalities – CT and MRI.

PE1 – O4

Application of temporal bone computed tomography in selection for cochlear implantation

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Objectives: Preoperative assessment for cochlear implant surgery determines whether the patient is appropriate for implantation and, if so, assists in the choice of ear to be implanted and the surgical technique. Computed tomography and/or magnetic resonance imaging are considered to be the best methods that enable to view anatomical structure of temporal bone. The aim was retrospective comparison of radiological (CT) findings of patients qualified for cochlear implantation with audiological and medical data in terms of proper selection and proper surgical technique.

Method and Material: The material consists of 55 subjects, aged from 10 months to 54 years, with diagnosed profound or severe hearing loss, qualified for cochlear implantation. Computed tomography was performed with SSCT and MSCT systems in protocol for temporal bone assessment.

Results: Ossification of the cochlea was found in 11 patients and it affected ear choice in 8 cases, in 2 cases split electrode was used. Inner ear malformations were found in 14 patients and it affected ear choice in 7 cases, the decision of implantation was cancelled in 1 case. In 4 patients non-ossified fracture was diagnosed. Advanced otosclerosis was found in 2 patients.

Conclusions: Computed tomography is an essential part of the preoperative assessment for cochlear implantation. The results affect ear choice and determine whether modifications to the surgical technique are necessary to ensure proper placement of the electrode array.

PE1 – O5

Multislice CT in preoperative assessment of ear anatomy for cochlear implantation

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Objectives: To evaluate a role of Multislice CT (MSCT) in preoperative assessment for cochlear implantation, especially in “problematic” ears, such as inner ear malformation or suspected ossification after bacterial meningits.

Methods: Multislice CT scan was performed on Somatom Sensation 64 which obtaines 64 slices per rotation with extreme resolution due to 0.4 mm voxel size. Acquisition time is approximately 4 sec. Picture analysis and postprocessing allows complete 4D reconstruction.

Results: Multislice CT was performed in 5 out of 25 cochlear implanted patients. In four cases deafness was due to bacterial meningitis with incomplete ossification of basal turn. There was one case of severe cochlear hypoplasia in one side and cochlear agenesia on the oposite side. The extent of ossification was defined more precisely by MSCT, than it could ever be seen in conventional CT. In case of bilateral cochlear malformation MSCT have revealed cochlear agenesia in the left ear which was not clearly shown on previous CT scan. The right ear have shown severe cochlear hypoplasia and incomplete fundus of internal acoustic meatus. Based on MSCT results we prroceeded with successful implantation on the right side. Preoperative assessment by MSCT enabled us to plan the impantation using standard electrodes of MEDEL devices.

Conclusions: MSCT has improved preoperative imaging for cochlear implantation due to prefect image resolution, quick data acquisition and extraordinary postprocessing abilities with 4D reconstruction and virtual reality. It is very important for assessment of the anatomic details in case of inner ear malformation or ossification of cochlea after bacterial meningits.

PE1 – O6

Interest of pre-operative evaluation of cochlear size from CT scan

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Objectives: Limiting insertion depth of electrodes to about 360° is generally accepted to result in better preservation of low-frequency hearing. The diameter of the basal turn of the cochlea varies between about 8 and 11 mm and this gives a variation of >5 mm in the length of the lateral wall to 360°. This study was designed to define methods to predict final insertion depth angle from pre-operative high resolution CT scan.

Methods: A two dimensional view of the basal turn of the cochlea was developed. Cochlear size was defined by the largest distance between the round window and the lateral wall. 15 patients were implanted with the Nucleus 24 Contour Advance electrode array using a linear insertion depth of either 17 mm (N = 9) for hearing preservation, or 19 mm (N = 6) otherwise. Post-operative X-rays were analysed using the method of Xu to obtain the insertion depth angles for individual electrodes.

Results: The mean variation of insertion depth angle with linear distance for apical electrodes was 48.2°/mm. The mean difference in insertion depth angle between the 17 mm and 19 mm groups was 80°. A significant correlation (r-sq = 0.51) was found between the size of the cochlea and the insertion depth angle for the 17 mm group.

Conclusions: Variations in cochlear size account for significant variations in insertion depth angle, approximately 45°/mm. For cochleae with largest diameters less than 9 mm we propose that the Nucleus Contour Advance is only inserted 16 mm to ensure a final insertion depth angle of between 360 and 400 degrees.

PE1 – O7

Low field MRI on CI candidates evaluation – Study of 18 deaf and blind children

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Objective: To evaluate the utility of a low field MRI tomography on the study of inner ear, cerebelopontine angle and brain in 18 deaf and blind children candidates to cochlear implantation.

Methods: All children were scanned on 0.2 Tesla Magnetom Concerto SIEMENS. Axial secuences on protonic density, T2. Axial and coronal secuences on 3D CISS. Young children were tested under general anestesic.

Results: No complication related to anestesic took place. The average time of the study was 19 minutes. In all cases, 36 ears VII and VIII nerves, basal turn of the cochlea, vestibule and semicircular chanals were visualized. Eyes disorders were found in 5 children, atrophy of one eye in 3 of them and retinian disorders in other 2. About brain 7 of them were found with periventricular atrophy one asociated to cerebelar atrophy and vascular disease in 2 patients.

Conclusion: MRI of the brain and inner ear using low field machine was an efective test on the anatomic evaluation of the cochlear implant candidates. Knowing low field machine are cheaper than higth field it could be a less expensive alternative of MRI test on evaluation of this patients in developing countries.

Refereces

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PE1 – O8

Micro-CT anatomical study of human cochleae

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Introduction: X-ray computerized microtomography (micro-CT) allows visualization of the internal structure of opaque specimens with a quasi-histological resolution (down to 5 μm).

Objective: To obtain anatomical data on human cochleae with the micro-CT technique and to characterize the anatomical variability of the dimensions of chosen intracochlear structures, such as the cochlear scala's, the organ of Corti, the Rosenthal's canal, stria vascularis, etc.

Material and Methods: 10 human temporal bones (5 right and 5 left) were used for the study and scanned at 18 μm resolution with the Skyscan-1076 micro-CT machine. Acquired shadow projections have been reconstructed as virtual slices perpendicular to the axis of the internal auditory canal using the custom made software tool [F. Vanpoucke]. 2D-cross-sections through the cochlear scala's were determined perpendicular to the lateral wall of the bony labyrinth and according to the angular position (every 30 grades). In each of the obtained 2D-sections a set of characteristic points that describe the intracochlear topology were marked and used for calculation of the anatomical variability of the examined intracochlear structures.

Results: Micro-CT images of human temporal bones are presented together with an evaluation of the anatomical variability between the bones.

Conclusions: Micro-CT is a very accurate technique allowing for an artefact-free quasi-histological-quality evaluation of the intracochlear anatomy.

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Acknowledgement: This study was sponsored by Advanced Bionics Corporation

PE1 – O9

Virtual cochlear implantation

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Objectives: The purpose of this work is to develop a haptic-rendered surgical simulator that offers realistic visual and force feedback during cochlear implant insertion. Validation of the system is required so that it can be used to train surgeons in the delicate operation.

Methods: A virtual model of the human Scala Tympani (ST) is derived from measured data and reconstructed in ANSYS (Leap Australia) (Todd and Naghdy, 2005a) for use in the simulation. Visual and haptic rendering of cochlear implant insertion is implemented in the Reachin API (Reachin Technologies AB). The user interactively inserts a virtual replica of the Nucleus® 24 ContourTM array. Simulation results are compared with those obtained experimentally. Insertion studies were carried out using an Instron (Instron Pty Ltd.) force measurement device to advance the electrode array into a synthetic model of the ST (Todd et al., 2005).

Results: The surgical simulator enables the user to insert a sub-sampled replica of the ContourTM electrode into an anatomically accurate model of the human ST (Todd and Naghdy, 2005b). Force profiles from the simulation are statistically compared with insertion results obtained experimentally, particularly in the region of the Basal Turn.

Conclusions: A training tool has been developed that enables the user to perform virtual cochlear implant insertion in real-time. The system is the first of its kind to offer realistic visual and force feedback for this type of surgery. Simulator behaviour has been validated with results obtained by insertion force tests. The product of this work will enable otologists to practice the procedure pre-operatively on patient-specific models in a risk-free, cost-effective environment.

PE1 – O10

Evaluation of the implanted cochlear implant electrode by CT scanning three dimensional reconstruction

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Objective: The identification of the cochlear implant electrode inserted within the cochlea is very important for postoperative fitting of cochlear implant. This work was designed to evaluate the image feature of the X-ray plain film and the spiral computed tomography (CT) scans and three dimension reconstruction of inner ear with implanted cochlear implant electrode.

Patients and Methods: Twenty-two patients of cochlear implant (MEDEL Combi 40+) recipients were involved in this study. The implanted electrode of all patients were examined on the fifth to seventh postoperative day, by the use of both X-ray plain film with anteroposterior transorbital projection and / or cochlear position, and spiral CT scans with axial 1 mm image slices.

Results: The X-ray plain film from both of anteroposterior projection and cochlear position can provide satisfactory image of implanted electrode including the shape and the position in the temporal bone. The insertion depth of the electrode can be evaluated indirectly. In contrast, the images from CT scans with 3 D reconstruction of the inner ear demonstrate more accurately the shape, the position, and the insertion depth of the electrode. Moreover, each of the electrode pairs can be identified clearly.

Conclusions: X-ray plain film can meet the routine needs of postoperative evaluation of the implanted electrode with several kind of head position of projection. But CT scans with 3 D reconstruction of inner ear provide more accurate image of the relationship of the electrode in the cochlear canal with direct demonstration of electrode insertion depth in the cochlea.

PE1 – O11

MSCT-analysis of cochlear anatomy and electrode position

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Objectives: To test the applicability of multi slice computed tomography (MSCT) to study the variability of cochlear dimensions in vivo and their consequences for the electrode position and the insertion depth.

Methods: In 60 ears from 30 patients implanted with a HiFocus 1J implant two independent observers made multiplanar reconstructions parallel to the cochlear view from pre- and postoperative MSCT-scans. A cylindrical coordinate system was set up, with landmarks not influenced by cochlear implantation (the modiolus and the lateral semicircular canal). The position and size of the round window and other cochlear dimensions were scored, as well as the position of each electrode contact.

Results: MSCT yielded enough detail to visualize both intracochlear structures, such as the modiolus and the walls of the cochlear duct, as well as individual electrode contacts. In all but one case good alignment between pre- and postoperative scans was achieved. The location of the cochleostomy, the distance of the electrode contacts to the modiolar wall, and the insertion depth could be documented well. The angular position of the round window was 32.5°± 4°. This value was surprisingly independent of the size of the cochlea. The interobserver variability was just 1°, considerably less than the variability between patients.

Conclusions: With multiplanar reconstruction and the coordinate system described, MSCT-scans provide accurate, and reproducible anatomical information, both pre- and postoperatively. The angular position of the round window is independent of the other cochlear dimensions. These techniques are applicable to select electrode size and insertion depth on a per-patient basis.

Brainstem Implants (PE2)

PE2 – O1

First successful case of electrical stimulation of the human inferior colliculus

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Objectives: We illustrate the surgical technique employed to reach the inferior colliculus (IC) in humans and demonstrate that electrical stimulation of the IC with surface electrodes can produce hearing sensations without extra-auditory side effects.

Methods: The relatively poor speech recognition results with the ABI in NF2 patients may be attributed to the disease process (or to the relative treatments) producing damage to the cochlear nuclei areas. Thus, it may be necessary to target higher level auditory nuclei to achieve good speech recognition for NF2 patients. We have thus placed a surface ABI implant (Med-El Pulsar 100) at the level of the IC in a 28-year old patient suffering from multiple NF2 lesions. An infratentorial supracerebellar median approach was utilized to expose n.IV, superior cerebellar artery and IC area. The electrode array was placed on the surface of the IC and covered with muscle and fascia.

Results: Twelve out of 12 electrodes were activated, all of which furnished subjective hearing responses. Stimulation produced a full range of loudness sensations on each electrode and a wide range of electrode specific pitch sensations. No extra-auditory responses were observed with any of the electrodes. The middle latency responses and the performance achieved in terms of psychophysical responses and speech recognition will be reported in detail and compared with ABI's fitted in NF2 and non tumour patients.

Conclusions: The present findings indicate for the first time that the IC in humans can be safely and effectively stimulated with surface electrodes, producing hearing sensations without extra-auditory side effects.

PE2 – O2

Concept electrophysiological assessment and safety studies of the Auditory Midbrain Implant (AMI)

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Based on several clinical and neurophysiological findings, the inferior colliculus central nucleus (ICC) is an appropriate target for prosthetic stimulation of the central auditory pathway. The AMI (Cochlear Ltd.) is a central auditory prosthesis designed for penetrating microstimulation of the human ICC. In order to investigate the electrophysiological properties of the AMI and validate its ability to provide low-threshold, frequency-specific stimulation, a set of acute experiments based on electrical stimulation of the ICC and multi-unit cortical recordings was performed in guinea pigs.

In these experiments, a multichannel Michigan electrode was positioned along the tonotopic gradient of the primary auditory cortex (A1) and the AMI electrode was inserted along the tonotopic gradient of the ICC. The best frequency (BF) for each site in A1 and ICC was determined in response to pure tone acoustic stimuli to ensure both electrodes were aligned along similar frequency ranges. Each ICC site was stimulated with single, biphasic, charge-balanced, monopolar pulses (200 μs/phase) and the corresponding neural activity was recorded in A1. Based on the results, frequency-specific stimulation is achievable using the AMI. Stimulation threshold levels to evoke A1 activity ranged between 10 to 40 μA, which is well within the safe limits suggested for stimulation of the central nervous system (Agnew and McCreery 1990). These findings suggest that the AMI may provide an alternative approach for hearing restoration in the patients with bilateral retro-cochlear deafness. Reports on the surgical procedures of the first patients will be given at the conference.

This work was supported by Cochlear Ltd Australia.

PE2 – O3

Auditory implant surgery in Neurofibromatosis-2: Early and long-term management

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Objectives: Bilateral deafness in NF2 may be treated by cochlear (CI) or auditory brainstem implants (ABI), in selected conditions. Implant dependent hearing is threatened by disease progression and tumour recurrences. Evaluation of early and long-term challenges of treatment and related results was performed with the focus on long-term maintenance of auditory function.

Patients and Methods: 29 patients with proven NF-2 were operated under multimodality electrophysiological monitoring with ABI implantation, while 3 received a CI. Cranial nerves surgical finding and functions, surgical sequels, early and long-term implant function, incidence and effects of ipsi- / contra-lateral recurrences and related surgery were evaluated.

Results: In 28 ABI and 3 CI patients hearing sensations could be elicited. Speech recognition was substantially enhanced by ABI compared to pure lip reading, and three patients with open-set speech understanding are being observed. Previous radio-surgery was correlated with poor or under-average results in 4 patients. Facial nerve reconstruction was performed in 3 patients.

9 patients (8 ABI and I CI) became symptomatic for recurrences, 6 of which were operated (two ipsilateral, 4 con-

tralateral to the implant side) with implant preservation in all cases and functional improvement in two patients.

Conclusion: Satisfactory clinical function may be achieved by implant surgery under monitoring guidance. The interdisciplinary neurosurgical and ORL team has to be prepared for re-evaluating implant function at surgery of schwannoma recurrences.

PE2 – O4

Auditory brainstem implant in NF2 and other otologic indications

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Objective: To evaluate the Auditory Brainstem Implant (ABI) performances in neurofibromatosis type 2 (NF2) and other otologics indications, as postmeningitis ossified cochlea.

Material and Methods: Between 1996 and 2005, 30 patients (17 to 71 years) have been implanted with a 21 electrodes NucleusR device. Indications were: NF2 (23 cases) , ossified cochlea (3 cases), vestibular schwannoma with controlateral lesions (2 cases) or inner ear's malformations. The pre-operative evaluation included clinical, radiological, lipreading, and psychological status. A translabyrinthine or retrosigmoid approach was chosen.

The auditory perception with the ABI was evaluated by testing, the words recognition in open-set lists, and the speech understanding with usual sentences.

Results: In NF2 patients, best results were obtained in 8 cases of smaller vestibular schwannoma and none, or short term, auditory deprivation. Negative prognostic factors were duration of total hearing loss (> 10 years), tumor size (> 3 cm), difficulties in electrode array placement, complications during post-operative course and number of active electrodes (< 10). In cases of postmeningitis total deafness with totally ossified cochlea, 2 over 3 patients were implanted first with cochlear implant, with transitory or none auditory benefit. Results with ABI in these 3 cases demonstrated a good benefit reaching these obtained with cochlear implant in post-meningitis deafness.

Conclusion: These results show a clear benefit of ABI in NF2 patients, with or without previous tumor removal, in case of small tumor with a short duration of hearing loss. In case of postmeningitis ossified cochlea, results potentially reach those of cochlear implants.

PE2 – O5

Cochlear and brainstem implantation in patients with vestibular schwannoma and profound contra lateral hearing loss

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Objectives: To evaluate our strategy of vestibular schwannoma (VS) management with contra lateral hearing loss using cochlear (CI) or auditory brainstem implants (ABI).

Material and Methods: Between 1990 and 2004, among 804 solitary VS operated on, 5 (0.6 %) presented with a contra lateral profound hearing loss. The group was composed of 4 males and one female with a mean age of 57 years (range: 51–70). VS size was assessed as stage 2 (< 15 mm in the cerebellopontine angle, CPA) in 2 cases, as stage 3 in one case (16–30 mm in the CPA), and as stage 4 in 2 cases (> 30 mm in the CPA). Hearing on the side of the VS was assessed as class C in 2 cases and as class D in 3 cases (AAO-HNS classification). The contra lateral hearing was evaluated as class D in all cases.

The cause of the contra lateral hearing loss was sudden sensorineural hearing loss in 2 cases, advanced otosclerosis in one case, intratemporal cholesteatoma in one case, and trauma in one case. All VS were operated on through a translabyrinthine approach. A CI was implanted on the contra letral side in 4 cases: before VS surgery in 2 cases, and after VS surgery in 2. In one case the CI was associated with an ipsilateral ABI. In one case, only an ipsilateral ABI was implanted. The mean follow-up period was 17 months (range: 1–31 months).

Results: For patients with contra lateral CI, word recognition ranged from 50 to 80 % only with the implant, and 60 to 100 % with implant and with lip-reading. For the patient with ipsilateral ABI, 16 electrodes were activated. Word recognition improved from 40 % with lip-reading to 80 % with lip reading + ABI. Sentence recognition were also improved in all these cases. In the case of ipsilateral ABI and contra lateral CI, all CI electrodes and 19 ABI electrodes were activated. The patient will be tested for auditory performances soon.

Conclusion: Contra lateral CI and ispilateral ABI are efficient means of managing the profound hearing loss after VS surgery with contra lateral profound hearing loss.

PE2 – O6

Comparison of ABI results in NF2 and non-tumour patients

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Objective: In general ABI speech performance in NF2 patients is modest; similar to that of single channel cochlear implants. Recent results from ABI patients without tumours (Colletti and Shannon, 2005) show high levels of open set

speech recognition. The present study collected a wide range of psychophysical and speech measures in an attempt to understand the source of these differences in performance.

Methods: Psychophysical measures were collected on threshold, electrode interaction, modulation detection, gap detection, and pulse rate discrimination from 28 ABI patients without tumours and 14 NF2 patients. Speech performance was also measured for vowel discrimination and open set sentence recognition.

Results: Absolute thresholds and electrode interaction were not correlated with speech recognition but temporal psychophysical measures were.

Conclusions: Speech recognition was not correlated with differences in electrode proximity to the cochlear nucleus (as indicated by threshold level) or to selectivity of stimulation, but was correlated with temporal psychophysical measures. This result suggests that either the disease process of NF2 or the surgical intervention may damage structures in the auditory brainstem which then produces poor performance on both speech recognition and temporal psychophysical measures. Damage to such structures might also underlie the differences in performance in non-tumour patients, depending on the etiology. This result implies that either the cause of the damage must be discovered and avoided if possible. Alternatively, NF2 patients may require more central implant sites to achieve good speech recognition.

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PE2 – O7

Magnetic resonance imaging (MRI) in patients with implanted ABI (Combi 40+): Experience in 5 Cases

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Objective: ABIs are used to restore hearing mostly in NF-2 patients. As NF-2 patients develop other central nervous system tumors, it is indispensible to perform routine follow up imaging.

Method: In 5 NF-2 patients with ABI, MRI examinations were performed. Prior to the MR examination a bandage was applied on the patient's head. The patient's head was positioned with the implant parallel to the magnetic field. For the scanning procedure we avoided sequences with either a high specific absorption rate (SAR), a short echo time (TE) and repetition time (TR) and with a high number of slices. We did not apply T2 weighted sequences.

Results: In all patients diagnostic images of the head and the spine were obtained. Good results were obtained with a conventional T1- weighted spin echo sequence for the head and spine. The posterior fossa of the operated side was distorted, with a large susceptibility artefact. After MRI examination patients were able to use their device as before. The attraction force of the coil to the magnet was not impaired and the fitting parameters of the implant were unchanged.

Conclusion: With the Combi 40+ ABI implanted it is safe and feasible to perform MRI investigations with good and useful results. There were no negative effects on patients or on the device itself.

PE2 – O8

Intra-operative EABR and post-operative hearing in the ABI

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Objectives: To date, 32 patients with neurofibromatosis type II have received the Nucleus 24 auditory brainstem implant in Manchester. During surgical placement of the device, electrically evoked auditory brainstem responses are recorded to assist in the placement of the electrode array over the cochlear nucleus in the lateral recess of the IVth ventricle. The EABR is recorded from bipolar stimulation at various sites on the electrode. This study examines the results from EABR measurements and how these correlate to post-operative auditory sensations.

Methods: EABR waveform morphology will be categorised from different sections of the electrode array and correlated with the areas of the array that produce auditory and non auditory sensations in psychophysical testing post-operatively.

Results: Of the 21 electrode contacts on the array, the mean number of auditory only electrodes is 11, the mean number of non auditory electrodes is 6 and the mean number of mixed auditory/non auditory electrodes is 5. This study investigates the morphology of the EABR recordings from the auditory, non auditory and mixed sensation areas of the array.

Conclusions: This study will conclude whether intra-operative EABR recordings can predict which areas of the electrode array produce auditory sensations during psychophysical testing post-operatively.

PE2 – O9

Results of the Digisonic® SP auditory brainstem implant

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Objectives: The aim of this study is to assess the potential benefit of the Digisonic SP Auditory Brainstem Implant (ABI) manufactured by Neurelec with patients suffering from neurofibrosis type II (NF2).

Methods: This study consists of a retrospective analysis of patients with NF2 who underwent implantation with auditory brainstem implant during surgery to remove the tumor. The Digisonic SP ABI has a small profile with innovative system for reliable and easy fixation. A specific pad carrier optimises positioning and maintaining of the electrode-array on the lateral recess of cochlear nucleus over time. A pre-operation evaluation was performed including clinical, radiological, lip-reading and psychological assessments. The recipients considered for this study have a minimum of 3 months follow.

The auditory perception with ABI was evaluated using closed and open-set lists of words and sentences.

Results: Results of 25 patients using a Digisonic SP ABI are presented.

There were few complications related to the surgery. Auditory sensations were present in most of patients. Global results showed an improved quality of life, in part because of their auditory orientation within the environment.

Conclusion: The results show that significant benefits are obtained using the Digisonic SP ABI.

PE2 – O10

Auditory outcomes in children fitted with ABI

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Objectives: Only patients with NF2 older than 12 years are candidates for an auditory brainstem implant (ABI). We include children with other cochlear or cochlear nerve malfunctions who would not benefit at all from a cochlear implant (e. g. cochlear nerve aplasia or avulsion) or would receive compromised benefit (e. g. cochlear ossification).

Methods: In our Department from February 2000 to January 2006, 18 children aged 14 months to 16 years received an ABI.

Two children had NF2 tumors. Ten children had bilateral cochlear nerve aplasia, four with associated cochlear malformations, 2 with associated unilateral facial nerve agenesia and 1 with combined microtia, aural atresia and middle ear malformations.

Two had been previously unsuccessfully fitted elsewhere with a CI. Three children presented cochlear malformations: two had bilateral incomplete cochlear partition and one bilateral common cavity. One child, who had previously been fitted elsewhere with a CI had an auditory neuropathy.

One child showed post-meningitis bilaterally total cochlear ossification and one had profound hearing loss with cochlear fractures after a head trauma.

In all the retrosigmoid approach was used. Intraoperatively, EABRs and NRT were performed.

Results: No postoperative complications were observed. All children have sound environmental awareness. On the CAP they ranged 2–7 (average: 3,2); MAIS 2–97,5 % (average:31,6 %); MUSS 5–100 % (average: 51 %) and LIP they scored from 5–81 % (average: 37,5 %).

Conclusions: This study indicates that auditory brainstem implantation is technically feasible in children and that the ABI is the only appropriate device for auditory (re)habilitatiton in these patients with cochlear and cochlear nerve malfunctions.

Hearing Aid and Cochlear Implant (PE3)

PE3 – O1

Bilateral cochlear implants and combinations with acoustical aids

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Objective: Characterize advantages of soundfield hearing into broad categories of localization and recognition.

Methods: Localization and speech recognition was assessed on patients using bilateral cochlear implants or a cochlear implant and a hearing aid.

Results: Patients listening with one ear cannot localize unless they can move their head or have knowledge of the expected sound spectrum. Generally, patients with bilateral implants localize better than those with a hearing aid and a cochlear implant, but in both categories performance is far worse than in normal. A wide range of recognition abilities exists among unilateral implant patients, and the ability to benefit from a 2nd implant depends on the spatial separation of the targets and jammers, differences in performance between ears, and central mechanisms necessary to integrate or ignore information between ears.

Conclusions: Most (but not all) patients are quite happy to have hearing from both sides, but our ability to measure these benefits will require some new approaches.

PE3 – O2

Restoration of binaural hearing capabilities with unilateral CI's in patients with residual hearing with the opposite ear

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Objective: Fitting patients with a cochlear implant is beneficial in patients with residual hearing, if the hearing aid does allow for an adequate speech recognition. Retrospectively, we evaluated 45 postlingually, severely to profoundly hearing-impared patients concerning postoperative speech understanding and binaural hearing abilities like directional hearing and speech discrimination in noise.

Materials and Methods: The test protocol included Freiburger monosyllabic word test, the HSM test with background noise. To assess binaural effects in adults, speech reception was measured using a symmetrical four-loudspeaker set-up. The evaluation after first fitting ranged from 2 days to 5 years.

Results: In the best aided condition the patients scored 48 % monosyllabic words with the hearing aid (@0dB SPL). 90 of the patients reached an open-set speech understanding with scores between 70 % to 90 % in the Freiburger monosyllabic test (CI alone).

Conclusion: Binaural hearing abilities such as directional hearing are influenced by individual performance.

PE3 – O3

Optimising hearing of adults who use hearing aids with cochlear implants

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Objectives: To determine whether benefits of bimodal stimulation (unilateral cochlear implant with contra-lateral hearing aid) can be found when using the Desired Sensation Level (DSL)[1] prescription procedure, in conjunction with the loudness balancing component of a previously developed bimodal fitting method based on the NAL-RP procedure.

Methods: Twenty experienced post-lingually deafened adult CI subjects, with some residual hearing in the contra-lateral ear, were recruited and fitted with two programs randomly loaded into a Phonak Supero 412 HA, one with an optimised fitting and one with the standard (unoptimised) fitting. Each program was used for 4 weeks, after which speech perception performance was compared in the following conditions: CI alone, CI+HA (optimised) and CI+HA (unoptimised). The BKB sentence test was presented in noise using an adaptive signal-to-noise ratio (SNR) with spatially coincident and spatially separated speech and noise. Horizontal sound localization was assessed using an array of 11 loudspeakers. The speech, spatial and qualities of hearing (SSQ) questionnaire was used to obtain subjective information about hearing performance in everyday life situations specifically related to spatial hearing.

Results: Preliminary data suggests that bimodal stimulation using an optimised HA fitting can provide benefit to speech discrimination in noise and sound localization for some subjects. However, there has been considerable variation in the amount of benefit across subjects and statistical significance has not been reached. Data collection is almost complete and further analysis will be performed and the final results reported.

References

Seewald RC (1992) The desired sensation level method for fitting children: version 3.0. The Hearing Journal 45: 36–41

PE3 – O4

Binaural-bimodal hearing: Evidence on binaural advantages

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Objectives: This paper aims to summarise the binaural advantages for speech perception, sound localization, and functional performance for children and adults who received a cochlear implant in one ear and a hearing aid in the other ear.

Methods: Fifty subjects (29 children and 21 adults) who received a Nucleus cochlear implant in one ear participated in the experiments. They were fitted with a hearing aid in the non-implanted ear. For each individual, the hearing aid was adjusted to complement the cochlear implant using a procedure developed and validated at the National Acoustics Laboratories. Performance measures included speech perception, horizontal localization, and functional performance in real life. Binaural benefits were quantified by comparing performance with a cochlear implant alone, and performance with a cochlear implant and a hearing aid. The relation between the amount of benefit and hearing thresholds was examined.

Results: All children and adults showed some binaural benefits. The amount of speech perception benefit was not significantly correlated with hearing thresholds in the non-implanted ear. The use of a validated method to fit and fine-tune a hearing aid for use with a cochlear implant enables users of bimodal hearing devices to derive binaural advantages from bimodal fittings.

Conclusions: The evidence supports binaural-bimodal fitting of all adults and children with unilateral cochlear implants who have residual hearing in the non-implanted ear, even when the degree of hearing loss is severe to profound.

References

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PE3 – O5

Cochlear implant and contralateral hearing aid: Binaural advantages

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Introduction: Binaural hearing permits optimal performance of speech in quiet and in noise and to localize sounds in space. The improvement in hearing performance is determined by a combination of physical phenomena (head-shadow-effect) and neurological processes (binaural squelch effect and binaural summation) that are known as Binaural Advantages (BA).

The benefits derived from bimodal stimulation are studied.

Material and methods: Twelve adult Spanish subjects, with a severe-to-profound hearing-impairment, experienced with optimally fitted conventional amplification, are included in the study.

A single subject study design was used. Speech recognition using Spanish words and sentences materials were carried out preoperatively in aided monaural and best-aided conditions and at 6 months postoperatively in CI alone, contralateral HA alone and bimodal listening conditions in quiet and noise.

Results: Mean improvement for speech recognition in the bimodal condition was significant with the CI alone condition for: disyllabic words in quiet at 70dB SPL ($p = 0.006$) and at 55 dB SPL ($p = 0.028$); for disyllabic words in noise at +10dB

with speech and noise spatially separated with the noise source closest to the contralateral HA (S0NHA) ($p = 0.0005$); and when the noise source was closest to the CI ear (S0NCI) ($p = 0.002$).

Conclusions: Significant BA as a result of binaural summation and the binaural squelch effect suggest successful integration of the auditory information provided by the two modes of stimulation centrally. The absence of significant head-shadow effect (except for some individual cases) was found and , may be due to asymmetric performance with the CI ear dominating.

PE3 – O6

CROS systems, bimodal use, and bilateral implantation – a comparison of outcomes

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Objectives: To provide information on the relative efficacy of Contralateral Routing of Signal (CROS) systems, contralateral hearing aids used in conjunction with a single cochlear implant, and bilateral cochlear implantation.

Methods: A prospective randomised crossover design examined the relative efficacy of CROS systems and bimodal use in experienced post-lingually hearing impaired cochlear implant recipients. Quality of Life, Speech in Noise and Localisation Performance was assessed. A subset of the subjects underwent second side implantation and similar assessments after a period of acclimatisation.

Results: Results demonstrating the relevant performance of the three conditions will be presented.

Conclusions: Inferences as to the relative efficacy of the three conditions will be presented.

PE3 – O7

Perception of suprasegmenal features of speech by children with cochlear implants and children with hearing aids

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The suprasegmental features of speech play a very important role in the process of speech understanding. They enable the listener to interpret communicative intentions. Perception of these features is accomplished through the perception of the time-energy envelope of the speech signal and/or its fundamental frequency information. Many individuals with severe or profound hearing loss experience difficulties in perceiving these features. Previous research studies demonstrated the advantage of children with cochlear implants (CI) over children who use hearing aids (HA) in the perception of the segmental features of speech. Much less attention, however, was given to the perception of suprasegmental features. Thus, the present study aimed to evaluate the suprasegmental perception performance of children with CIs in comparison to that of children wearing HAs. Thirty children ages 8–15 years participated in the study. All children had prelingual bilateral sensorineural hearing loss. The participants were divided into three groups of 10 participants each: 10 children used CI, 10 children had severe hearing loss (M = 77 dBHL) and used HAs and 10 children had profound hearing loss (M = 99dBHL) and used HAs. All the children used spoken language as their main mode of communication and were included in regular classes. Auditory perception of the following suprasegmental features was evaluated: intonation, stress, and emphasis. The ability to perceive pattern perception was evaluated as well. Evaluation was conducted via closed-set materials. Speech performance of the three groups was compared. Data are currently being analyzed, and results will be presented and discussed.

PE3 – O8

Changes over time in the benefit of contralateral amplification in unilateral cochlear implant users

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Objective: To evaluate binaural–bimodal auditory ability and its early changes over time after unilateral cochlear implantation in patients with residual hearing in the non-implanted ear.

Material and Methods: Sentence identification in background noise was tested in 12 patients under three listening conditions: CI alone, HA alone, and CI + HA.

Results: *Group results:* First testing session: The results with CI + HA did not differ significantly from the results with CI alone. Second testing session: Significant difference was found between the results with CI + HA and the results with CI alone. Comparison between the results of the first and second testing sessions showed significant improvement in results with both CI and CI + HA. Relative to the first phase, the improvement added by CI + HA in the second phase was significantly greater than the improvement with the CI-alone mode.

Individual results: In the first testing session, the mean score in background noise was 34.9 % with CI alone and 41.1 % with both devices. In the second session, when all subjects could recognize sentences in noise with CI alone, seven showed further improvement with added amplification.

Conclusions: The benefit of a contralateral HA in unilateral cochlear implantees with residual hearing in the non-implanted ear improves over time. The latter of course represent a different group of candidates, namely those without any effective residual hearing and therefore able to receive bilateral auditory stimulation only via bilateral CI. Unilaterally implanted patients who initially show significant enhancement of speech perception with a contralateral HA might later experience deterioration of residual hearing on the HA side, with consequent deterioration of speech perception scores in the CI + HA mode. For such patients, contralateral implantation should be considered.

Quality of Life and Safety in Cochlear Implants (PE3)

PE3 – O9

Quality of life measures for patients with bilateral cochlear implants

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Objectives: To investigate the quality of life in patients with bilateral cochlear implants. More specifically, to design and validate a questionnaire which measures their quality of life.

Methods: It has been well established in literature that hearing difficulties can have an adverse effect on the quality of life of the individual. Cochlear implants can improve the patients' quality of life. To date, there have not been any published studies on the patients' views on how their life changed when they got two cochlear implants sequentially. This study sample consists of patients from the UK National Health Service who have recieved two implants sequentially. They were sent an open-ended questionnaire and interviewed. Their responses will be used to develop a close-ended questionnaire for the same purposes. This will be validated with the help of more patients.

Results: Questions aimed at prompting responses about their view of how the second implant changed their lifestyle and comparing their present quality of life to when they only had one implant. The conceptualisation of the data emerged from the actual data itself. Categories from the qualitative data were identified and these will be the foundations on which the close-ended questionnaire will be developed.

Conclusions: Better understanding of quality of life after receiving the second implant will aid professionals dealing with these patients in understanding what the practical limitations of these devices are and advising future patients accordingly.

PE3 – O10

Impact of cochlear implantation on quality of life in postlingually deaf adults – results of long-term follow-up

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Objective: Long-term results of cochlear implantation (CI), in terms of health-related quality of life (HRQoL) were investigated.

Methods: Results obtained in 2004 were compared to a previous measurement in 1998 and furthermore the change of HRQoL in time, regardless of CI was explored. Participants were postlingually deaf adults, fitted with a CI at least a year before inclusion into the study in 1998. Questionnaires were sent to 37 long-term CI users (group I), 10 adults who have not been implanted (group II) and 29 people who had received a CI after 1998 (group III). Three questionnaires were used: the disease-specific Nijmegen Cochlear Implant Questionnaire (NCIQ), the generic Health Utilities Index (HUI mark 3) and the Medical Outcome Study Short Form (SF36). Additionally, speech perception scores were obtained.

Results: The three instrument outcomes demonstrate in general the beneficial effect of CI and this effect remained stable over an additional six years after implantation. Nevertheless, various domain scores of the three instruments show different results. There was a statistically significant effect of CI before and after implantation. The control group without CI demonstrated a slightly decreasing trend in outcomes. This trend is especially seen in the NCIQ and the HUI3. Speech perception test results of group I CI patients showed an improvement in time.

Conclusions: Long term effects of CI, based on HRQoL, are stable, but scores do decrease to some extent in time. This decrease was comparable to that found in the control group of postlingually deaf subjects who were not implanted.

PE3 – O11

Economic and outcome analysis of non-use among CI patients

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Objectives: Analysis and economic impact of non-use of cochlear implants.

Methods: Of 340 implant patients treated between 1990 and 2005, 12 children and 2 adults are classified as non-users. Collation of clinical files was used to construct life table of use and assess the reason for becoming a non-user.

Results: Life table shows that majority of children use their implant for 4 years with a probability of 0.7 using their devices over 11 years. The 2 adults soon stopped using their implant because of psychological issues or lack of enjoyable stimulation.

Economic analysis shows that initial costs are high reflecting the surgery and implant costs. Subsequent years reflect programming issues and maintenance. When considering non-use there are two effects, first, no more costs are incurred and second, no more years of use are accumulated once a child has become a non-user. Thus non-use reduces both costs and years.

There are two methods of comparing costs. Costs of gaining a year of use as a function of time, shows that there little impact from the twelve non-users on the average cost of management. As a ratio of no non-use and observed non-use – the ratio is 1.07 by 13 years of implantation.

Conclusion: The non-use has added 7 % to the average cost of implanting and maintenance. Audit identifies that initial patient selection in the beginning of the programme was in retrospect an important issue and following comprehensive assessment with the Children's Implant Profile significantly reduced non-use. Unfortunately, the adults were not identifiable before surgery.

PE3 – O12

Improved access and center viability part 1: Value stream mapping

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Objectives: To apply principles of the Toyota Production System in order to develop a framework for understanding patient flow through the implant process. This fosters identification of areas to target process improvement.

Methods: Patients were tracked through the implant process from initial inquiry through to device activation. Data on time for each step, distance traveled by the patient, audiological and medial testing, insurance preauthorization, reimbursemement and patient satisfaction were mapped to clearly detail process flow. The tools used for developing the value stream map are described along with process improvement applied to problematic areas.

Results: An independent consultant from the Kaizen Promotion Office at Virginia Mason Medical Center did all observations. The value stream map was drawn up and evaluated by members of the implant team. Preoperative evaluation time was reduced from 6 weeks to 3 days. 45 % space reduction was achieved simultaneously with a 22 % increase in the number of patients served. Five full-time employees were reduced to 3 in the same interval. Patient satisfaction was uniformly improved.

Conclusion: The value stream map is the first step in understanding a business line , according to the Toyota Production System. We will present our value stream map and illustrate areas where we have been able to deliver high quality patient care while reducing the cost of care delivery. Dramatic improvements in access for additional patients and improved financial performance will be discussed.

PE3 – O13

Necessity for quality control after cochlear implant surgery

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Objectives: To evaluate quality of intracochlear electrode insertion in adult cochlear implant (CI) recipients by means of rotational tomography and to investigate whether the electrode position is one contributing factor for outcomes of rehabilitation.

Methods: Adult CI patients (n = 50) that received a Nucleus Contour or Contour Advance CI were evaluated by rotational tomography postoperatively. Site of insertion was assigned to be in the scala tympani, the scala vestibuli or a dislocation from one scala to the other. Results in speech understanding were collected at 1 year postoperatively.

Results: We found a high rate of scala vestibuli insertions and also dislocations from scala tympani to scala vestibuli by using the Contour electrode. In the Contour Advance group we found a high rate of scala tympani insertions with a reduced rate of dislocations. Speech test results indicate a positive correlation with insertion into the scala tympani being superior to scala tympani insertions with a dislocation or scala vestibuli insertions.

Conclusions: The rate of scala tympani insertions was influenced by surgical technique. Control of electrode position by rotational tomography provided surgeons with a feedback of insertion quality that induced learning effects. The reduced rate of dislocations in the Contour Advance group is mainly a result of design changes of the inserted electrode. The intracochlear site of insertion may be one important factor that contributes to patient outcomes. A postoperative quality control is able to improve insertion quality resulting in overall better outcomes and is a necessity in cochlear implant surgery.

PE3 – O14

Safety and reliability of cochlear implants

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Objectives: Since the beginning of the Hanover Cochlear Implant Program in 1984 all explantations and reimplantations of cochlear implant devices have been monitored. From a population of now approximately 3000 implant users, 146 subjects had to be revised due to various reasons which can be divided into two major groups: subjects with medical problems (41 cases) and subjects with device failures (105 cases).

Methods: Retrospective study, all device failures since 1984 were analyzed. Information was gathered from patient files as well as from the device failure reports of the manufacturer (Cochlear Ltd and Advanced Bionics Corp.). All these information were put into a data bank and were analyzed statistically.

Results: As result is was found that independent of the brand mechanical impact was the major reason (~35 % for both devices) for device failures. Other failures could be grouped into: leakage, electronic circuit failures, electrode defects and others.

Conclusions: This result lead to the development of a new impact test, which will become part of the new European standard for cochlear implants: EN 45502–1 “Active Implantable Medical Devices”. Although the manufactures of medical devices have already to comply with very specific and extended regulatory requirements this new test may help to prevent device failures due to mechanical impact. However, it has to be stated, that the overall high cumulative survival percentage of more than 99 % for the present Nucleus and Clarion devices (>36 months of observation time) demonstrates the efforts of the manufactures to produce reliable and save devices.

PE3 – O15

CI explants reported according to new reliability standard

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Objectives: To report all explanted CI according to the newly adapted standard reliability reporting structure and compare with reports from the manufacturers after root cause analysis.

Methods: Implants removed between July 1997 and January 2006 were reviewed. Symptoms, best implant performance, pre-explant medical evaluation and audiometric testing and performance 6 months after re-implantation was compared to the patients' best performance. Devices were sent to their respective manufacturers for analysis. Reports of "in" or "out of specification" and final root cause analysis will be presented. Comparison between placements in category C of ISO standard 5843–2:2000 will be contrasted with inclusion in category C by the new definition of "out of specification" adopted in the United States.

Results: 332 cochlear implants were placed at our center during the study period. 9 devices were explanted from adults and 9 in children for a 5.4 % explant rate. 10 MED-EL Combi-40+, 3 Nucleus-22, 3 Clarion, and 2 ABC 90K internal stimulators were removed. 1 Patient chose not to be re-implanted, 1 was re-implanted with an ABI and the rest had immediate re-implantation. 3 chose a different manufacturer at re-implant. 3 were classified as "Biological" and would be excluded as category C. 2 were not functioning at explant but tested normal in vitro. 14 were "out of specification".

Conclusion: At the time of these explants, no standard definition for failure was accepted by all manufacturers in the United States. 2 devices were not included in CSR reporting which would be included in the new reporting scheme.

PE3 – O16

Cochlear implant market dynamics – Expansion versus saturation

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Objectives: Due to heterogeneuous and scattered data bases in the different CI centers, there is no clear understanding of the actual size of the relevant cochlear implant market. We describe a realistic model of the German cochlear implant and severely hearing impaired market, based on insurance data, and discuss different future scenarios which will have a huge impact on the overall development of the provider structure.

Methods: We analysed and evaluated the entire medical database of one of Germany's largest public health insurances (2 million insurers) for the years 2002 to 2005. Age, gender and social status were matched with the technical and economic prescription data for hearing aides as well as with the clinical and financial data from cochlear implant surgery. Using these data, we developed a scenario model, allowing us to calculate systematic sociodemographic effects on the overall costs and market characteristics.

Results: Our study shows that the incidence and prevalence of cochlear implant and hearing aid candidates are much lower than estimated in different studies before (approx. 25 %). Furthermore, the analysis of the pathways that patients with a progressive hearing loss follow, demonstrates a long latency period which might lead to a significant delay in the supply or even a non-supply with adequate medical aides, e. g. cochlear implants.

Conclusions: Cochlear implant market characteristics build an important and basic input for the development of strategic options for medical centers. We discuss several scenarios (growing vs. saturated market) and their implications for the setup and market behaviour of the payors and providers.

Electrode Design (PE4)

PE4 – O1

The slim lateral electrode array: Designed for round window insertion

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Cochlear implant developments have progressed significantly, and with it, speech perception and sound quality for the users has improved significantly. This leads to an expansion of patient inclusion criteria towards more and more residual hearing. In recent years, several groups worked on the combination of electrical and acoustical stimulation in subjects with a reasonable amount of low frequency hearing. For the implantation of such patients special electrodes are necessary that ensure preservation of residual hearing.

Advanced Bionics is developing a special electrode array suitable for preservation of residual low frequency hearing. The major features of the so called "slim lateral electrode array" are a) reduced length (active length: 13.4 mm), b) a reduced diameter (tip: 0.424 mm, c) well controlled insertion process, d) suitable for insertion though the round window because of the small diameter and a simple insertion tool. After identification of some deficiencies in the first revision, a further iteration implemented a rounded tip, a softer material especially for the tip and a release button on the insertion tool.

The recent iteration was tried in four temporal bones, all inserted via the round window. The insertion process itself was smooth and the surgeon could control it well. The first analysis showed a nice placement of the electrode array and no intracochlear trauma.

Data on the full set of temporal bones will be presented. Further conclusion can only be drawn when all data are available.

PE4 – O2

Comparison of round window and cochleostomy approaches with a prototype hearing preservation electrode

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Introduction: Preservation of residual hearing in Cochlear Implant recipients provides benefit of combined electric and acoustic auditory stimulation. A prototype 16 mm multichannel array has been designed to facilitate atraumatic placement of 22 electrodes.

Aim: To evaluate insertion trajectory and presence of trauma to intracochlear structures with the prototype electrode inserted by either the round window membrane or cochleostomy.

Materials and Methods: 18 human temporal bones prepared using a standard transmastoid facial recess technique. 12 prototype electrodes inserted via the round window membrane. In Melbourne fluoroscopic control was used and a further 6 inserted via a small scala tympani cochleostomy. Specimens were embedded and fixed with acrylic resin and the cochleae examined histologically at 200 micron intervals.

Results: Full insertion of the electrode was achieved without resistance in all round window membrane (RWM) and cochleostomy specimens. In two RWM specimens, fold over of the electrode tip occurred and in one specimen the electrode penetrated the spiral ligament to lie in an "endosteal "position. In one cochleostomy specimen the electrode was rotated to face laterally. RWM electrodes lay in a more perimodiolar position along the first part of the basal turn with an average depth of insertion of 240 degrees, compared with 255 degrees for the cochleostomy electrodes. Histologic examination showed no damage in any specimen to the modiolus, osseous spiral lamina or basilar membrane.

Conclusions: A prototype hearing preservation electrode array was successfully inserted by either round window membrane or a scala tympani cochleostomy without evidence of significant intracochlear trauma.

PE4 – O3

New cochlear implant electrodes contribute to the improvement in outcome

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Objectives: In temporal bone studies it was shown that the Contour Advance electrode can be inserted in a very atraumatic way using AOS insertion technique (Stöver et al., 2005). The aim of our study now was to investigate whether patients really benefit from this more atraumatic electrode and insertion method.

Methods: Retrospectively, the data from all patients implanted with a Nucleus cochlear implant and one of the following electrode arrays were extracted from the database at MHH: A) Contour electrode with Softip (modiolus-hugging, atraumatic insertion, N = 37), B) Contour electrode (modiolus-hugging, N = 153) or C) Straight electrode (N = 69). The threshold (T) and comfort (C) -levels from first fitting until one year post surgery and, additionally, speech test results for the different groups were evaluated.

Results: Introduction of Contour electrodes with Softip resulted in slightly reduced T-levels and increased dynamic ranges compared to the Contour electrode whereas both electrodes led to significantly lower T-levels than the Straight electrode. The improved dynamic range also results in improved speech test results with each new electrode array.

Conclusion: Each new electrode array increased the dynamic range and therefore also the range that can be used for speech coding. This might be responsible for better speech test results.

Reference

Stöver T et al. (2005) Evaluation of the Advance Off-Stylet Insertion Technique and the Cochlear Insertion Tool in Temporal Bones. Otol Neurotol 26(6): 1161–1170

PE4 – O4

Round window approach with different types of electrodes design for hearing preservation

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Objectives: To describe the round window surgical technique used to preserve low frequency hearing with application of different types of electrodes. Results of preserved low frequency hearing in Partial Deafness Cochlear Implantation (PDCI) in patients receiving partially inserted MED-EL cochlear implant electrodes are reported.

Method: Electrodes were inserted during the surgical procedure as follows: 1) Antrotomy, 2) Posterior 3) Tympanotomy to allow for visualisation of the round window niche 4) Puncture the round window membrane 5) Approach the scala tympani directly through the round window membrane (with partial insertion of the electrode array) 6) Electrode fixation in the round window niche with fibrin glue (membrane must be partially uncovered to preserve its mobility) 7) Fixation of the device in the well created in the temporal bone.

Results: Results obtained so far, indicate that with developed surgical procedure and using sufficient flexible electrodes it is possible to insert an electrode thought round window as well as preserve hearing in the majority of patients.

Conclusion: When using an electrode array that is atraumatic in nature and a round window approach hearing can be preserved in cases with excellent low frequency hearing.

PE4 – O5

Implications of the oblique course of apical nerve fibers

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Objectives: Recent observations indicate that the place-to-frequency maps of Rosenthal's canal (RC) and the organ of Corti (OC) are essentially different. This study aims to get insight in the functional consequences of the fact that RC ends after 13/4 turn, while the peripheral processes extend to the full 23/4 turns of the cochlea, with an oblique course in the apex.

Methods: In a realistic 3D spiral computer model of the human cochlea implanted with a HiFocus implant the nerve fiber trajectories were adjusted to include the length difference between RC and OC based on recent experimental findings (Leake et al., CIAP2005). Potential distributions computed with this volume conduction model served as input for an active nerve fiber model. The latter used human kinetics and a realistic double cable model representation of the sparsely myelinated human cell body.

Results: At the basal end of the cochlea the fibers ran almost radially, as in previous, idealized simulations. Towards the apex modiolar-wall electrode configurations elicited lower pitches than predicted by their position in the Greenwood map. Lateral wall electrodes did not show such a phenomenon. With increasing current strength, the oblique fiber trajectories induced a shift towards even lower frequencies for all apical electrodes. Electrode contacts until 1.7 turn were able to stimulate distinct regions of nerve fibers. Contacts at more apical locations always stimulated subpopulations of the contact at 1.7 turn.

Conclusions: Lateral wall electrodes are less susceptible to the effects of the oblique trajectories. Contacts beyond 1.7 turn are less functional.

PE4 – O6

Evaluation of the swine cochlea anatomy as a model for human cochlea implantation

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Objectives: Evaluation of new electrodes for cochlea implantation in humans is always dependent on electrophysiological findings. Up to now these testings are done mostly in guinea pigs or cats, animals whose inner ear anatomy differs considerably from humans. Therefore we investigated the normal swine cochlear anatomy as a new model for electrophysiological testings in CI to get a better model for testings in human dimensions.

Methods: Swine temporal bones where harvested right after death in a regular slaughtery and where immediately fixated in a formalin solution. They where either decalcified or passed through a special technique which allows sectioning of undecalcified bone. Histological evaluation was done with regular light-microscopy in comparison to human cochlear slices.

Results: Outer anatomy shows very similar dimensions as in humans, but on four turns. This results in a wider basal turn, as the following turns are narrower. Neural dimensions are comparable at least for modiolar distances.

Conclusions: The further evaluation of the swine cochlea as an anatomical and electrophysiological animal model for upcoming CI electrodes in humans seems to be promising. Investigational focus needs now to be laid on the surgical approach to the swine cochlea in a living animal.

PE4 – O7

Further experience with "pull-back" of perimodiolar electrodes

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Objective: To observe the influence of electrode pull-back after cochlear implant insertion of perimodiolar electrodes with the custom sound software and to estimate the maximum point of pull back.

Method: In a prospective, intraoperative study, we analyzed the spread of excitation after cochlear implant electrode insertion and compared these data to those obtained after a subsequent, controlled pull-back of the electrode with the new custom sound software. Additional we estimated the point of maximum pull back by a combination of ECAP, CT and video-analysis.

Results: Even with the Custom sound software with a controlled pull-back a significant decrease of the spread of excitiation at the basal region of the cochlea was found in comparison to the recordings after the primary, normal insertion procedure. The mean ECAP amplitude was increased with an apical-to-basal tendency. ECAP amplitude decreases by pulling back further than an estimated point.

Conclusion: Controlled CI electrode pull-back is a technique which optimizes objective intraoperative electrophysiological recordings in patients implanted with perimodiolar cochlear implant by a greater approximation of the electrode to the modiolus.

PE4 – O8

Providing appropriate cochlear implant electrodes to different cochlear malformations: What suits and what are the outcomes?

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Objectives: Many children present to cochlear implant centres with a cochlear malformation. This provides the clinical team with unique challenges in terms of counselling the family regarding possible outcomes, as well as surgery and rehabilitation. It is not uncommon to provide these children with a cochlear implant (with Michel's Deformity still being contra-indicated); however the outcomes may be poorer when compared to children who receive a standard electrode variant in a normal-shaped cochlear. This paper will demonstrate the

use and outcomes of MED-EL cochlear implants with different electrode variants in relation to different types of malformation.

Methods: This work will relate a number of MED-EL implants with different electrode variants to different types of malformation. Additionally, the auditory perception outcomes of some children implanted with these electrode variants are provided.

A collection of case studies from various congenital inner ear malformations are reported on.

Results: The case study collection for different types of inner ear malformations shows appropriate electrode choice, surgical techniques and outcomes. In all cases adequate implantation and electrode positioning could be achieved despite of the malformation. Results clearly demonstrate substantial patient benefit.

Conclusion: The cases reported on demonstrate the viability of implanting children with inner ear malformations.

PE4 – O9

Electrode design considerations for reducing trauma

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Objectives: Since the early days of multichannel cochlear implant research there has been a requirement for electrode designs to minimise trauma in the cochlea. This focus continued as indications expanded from profound loss to severe hearing impairment. More recently, the goal of minimising trauma has become an imperative with the development of the concept of electro-acoustic stimulation.

This paper presents an overview of design considerations for reducing trauma caused by intra-cochlear electrodes with the goal of preserving residual hearing.

Methods: A design methodology for selecting design parameters is introduced, based on the stages of the lifecycle of an electrode from implantation, through chronic use, to possible explantation/reimplantation.

Results: The methodology has been used to develop a proposed list of the most critical design parameters for an electrode targeted specifically at hybrid or electro-acoustic stimulation.

Conclusions: Careful and systematic analysis of the stages of the lifecycle of the electrode can contribute to optimal design of electrodes to minimize trauma for hybrid and electro-acoustic indications.

PE4 – O10

Advanced Bionics electro acoustic system design considerations

EH Overstreet

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Objectives: A substantial number of hearing-impaired individuals suffer from precipitous high-frequency hearing loss. These individuals typically receive little benefit from conventional hearing aids and, under current indications, are not candidates for a traditional cochlear implant. A potential treatment for this population is to provide electrical stimulation for the damaged high frequency or basal region of the cochlea while simultaneously allowing acoustic stimulation (either aided/or unaided) for the more apical cochlear region. A combined electroacoustic system would necessitate a very different set of requirements compared to a standard cochlear implant. Most importantly, residual hearing must be consistently preserved.

Methods: This presentation will provide an overview of Advanced Bionics' design requirements and technical specifications for an electro-acoustic stimulation system. In addition, we will describe our strategy for hearing preservation including electrode design and drug delivery capability. Signal processing of both electric and acoustic information will also be discussed.

Signal Processing (G1)

G1 – O1

European multi-centre study on the determination of perceptual channels

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Objectives: With independent current sources, it is possible to create a number of stimulation sites between physical electrode locations. A European multi-centre study was initiated to estimate the minimum, maximum and average number of perceptual channels across the electrode array and to find predicting factors.

Methods: Data of more than 60 adult subjects from five European centres were included in this analysis. All were implanted with the CII-Bionic Ear® or HiRes90K™ cochlear implant system and had used the HiRes speech coding strategy for more than three months. Stimulation was delivered to pairs of adjacent electrodes at three sites. Following an adaptive adjustment of the proportion of current delivered simultaneously to both electrodes of the test pair, the smallest audible pitch difference was determined. Performance with the cochlear implant was estimated by Categories of Auditory performance, allowing a language independent analysis.

Results: 90 % of subjects were able to discriminate the pitch between adjacent electrodes and 80 % had at least one intermediate channel. The maximum number of intermediate channels extrapolated for the full array was 230, with an average of 39. There was no correlation between the number of channels and the demographic data or stimulation level. However, only the users with good speech understanding achieved a high number of perceptual channels.

Conclusion: Intermediate channels created by sharing the stimulating current between adjacent electrodes lead to addi-

tional pitch percepts. Thus, the number of pitch percepts can be increased to multiples of the number of physical contacts, depending on the users individual resolution.

G1 – O2

Influence of HighRes 90k stimulation parameters on the evoked stapedius reflex

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Estimating the most comfortable loudness level (M) in the course of programming the cochlear implant speech processors for young children is a challenging task. During the initial fitting we use the electrically evoked stapedius reflex threshold (ESRT) as the upper boundary for the estimation of the M-levels in these cases. ESRT can be recorded visually during the operation and acoustically post implantation.

Our test setup for post operative ESRT measurements comprises a PC and an interface to stimulate the auditory nerve via the speech processor and the cochlear implant, a standard clinical tympanometer (interacoustics AT235) and a touch-screen. A trigger impuls synchronous to the stimulation allows latency recordings. The stimulation parameters are controlled by BEDCIS the Bionic Ear Data Collection System (Advanced Bionics) and NIC the Nucleus Interface Communicator (Cochlear) respectively. We developed the Kieler Stapedius Reflex Software (KISS) to assist the measurements as well as analyse and document the evoked impedance changes. For documentation purposes the tympanogram and the measurements at up to 22 Electrodes can be plotted on one page.

We investigated the influence of stimulation parameters as rate and number of stimulating electrodes on the stapedius reflex and its threshold with adult postlingually deafend patients using the HighRes 90K implant. Different stimulation rates were used and stimulus intensity was varied to record amplitude growth functions of the reflex. The patients indicated their perceived subjective loudness on a categorical scale via the touch screen. The reflex amplitudes were manually measured and the reflex threshold was detected visually as well as by linear regression. Results are correlate with psychoacoustically recorded M-levels.

G1 – P3

The Freedom speech processor for N24 series cochlear implants

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[3] Cochlear Limited, Sydney and Melbourne, Australia
[4] Cochlear Corporation, Denver, USA

Objectives: The Freedom speech processor, which was originally developed for Freedom (CI24RE) cochlear implants, was recently modified for users of the previous generation Nucleus 24 series cochlear implants (CI24M/R).

This paper will demonstrate the impact of providing new technology in a backwards compatibility context.

Methods: In this study, 30 subjects from Australia and the United States were upgraded from the ESPrit series or Sprint series speech processor to the Freedom speech processor. A comprehensive clinical trial was conducted to determine the impact of extending the users input dynamic range, and the variation of frequency allocation on the performance of recipients.

Recipients also received input speech processing features for use in noisy and soft listening environments. These were comprehensively evaluated using qualitative questionnaires and speech perception testing.

The power requirements for the Freedom speech processor with the CI24M/R recipients were carefully monitored and logs were kept with the provision of various battery options.

Bilateral and bimodal cochlear implant recipients were evaluated with regard to the use of the Freedom processor with other technology.

Results: Results for all subjects and various groups of subjects will be discussed with an emphasis on the impact of increased input dynamic range and input processing.

Conclusions: Results have implications for ensuring that technology continues to consider the impact of backwards compatibility on recipients of cochlear implants.

G1 – O4

Current steering through quadrupolar stimulation and "virtual channels": spectral resolution and speech perception

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Objectives: To compare the effects of quadrupolar and "virtual channel" electrode configurations on channel selectivity and speech perception in a crossover design.

Methods: Eleven subjects were included using each of three strategies for 2 weeks. Each strategy was a HiRes variant using 14 channels, 1100 pps/chan and 32 us/phase pw. 1) Monopolar (MP), 2) Hybrid Quadrupolar (HQ) with current returning to adjacent electrodes and a Remote Current Fraction RCF to the extracochlear reference, and 3) a monopolar 120 "virtual channels" strategy (VC). Intracochlear electrical fields were recorded using the EFIm package. Individual RCF's were selected using a spectral resolution test, as opposed to the fixed RCF of 50 % used in an earlier study (Mens and Berenstein, 2005).

Results: Nine subjects finished all tests; one subject refused the HQ strategy, another the VC strategy. Averaged speech recognition in quiet and in noise differed only marginally between strategies, as did music appreciation. Spectral resolution was poor, did not depend on RCF and did not seem to correlate with speech recognition performance and music appreciation. Effects of strategy on the voltage distribution will be discussed, as well as preliminary frequency difference limen data.

Conclusions: Even after individual optimization of the RCF, no clear advantage across subjects for the quadrupolar compared to the monopolar strategy was found for speech recognition, nor did we find better results for a "virtual channel" processor. These strategies, however, may be useful alternatives to optimize individual results. To do so, an early (psychophysical) indicator of success is desirable.

G1 – P5

Concept and technical features of the new HiRes Auria+ processor

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In the beginning of the cochlear implant technology, it was not only the space for the processor's electronics which was a limiting factor in signal processing and sound processor design, but also the volume of a battery. Today's technology allows the miniaturization of electronics into a small housing to be worn behind the ear. With advanced battery technology, there are also more power and computation efficiencies,,which has lead to an acceptable battery life time from a very small battery worn at the ear level.

The Auria+ represents Advanced Bionics' third behind-the-ear (BTE) processor generation for CII and HiRes90K users. Even though the housing is similar to the current Auria processor, the electronics are new and several new features are introduced. The Auria+ is the only BTE that supports the HiRes 120 speech coding strategy. The front end is redesigned to achieve an input dynamic range of 94dB, thanks to a 16 bit resolution front end. In addition to the current assistive listening devices, the Auria+ has an integrated induction coil, allowing easy switching to an inductive signal. A tricolor LED is implemented for diagnostic purposes. The processor is powered either by rechargeable batteries or by a body worn power pack. Battery life time can be increased significantly compared to the current Auria to achieve more than a full day operating time.

The Auria+ processor thus introduces significant benefits for both children and adults: the potential for increased number of speech coding strategies; improvement in connectivity; more user-friendly; and improved comfort.

G1 – O6

Combined processor for electro-acoustic stimulation with Nucleus 24

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Objectives: Benefits of combined electrical and acoustic stimulation in the same ear have been shown to give benefits for speech perception in quiet and in noise and sound quality for Nucleus 24 Contour Advance recipients. Our additional study had two aims: Firstly, to show the absolute benefit in noise of ipsi-lateral residual hearing compared to contra-lateral residual hearing when used with a cochlear implant. Secondly, to evaluate an experimental processor that produces both electrical and acoustic output.

Methods: Subjects were adult recipients of the Nucleus 24R or 24RE Contour Advance cochlear implant with residual hearing better than 80dBHL at 125–250 Hz in the implanted ear. Recognition of MMBA2 sentence lists was tested in babble for CI alone, CI+ipsi, CI+contra and CI+both ears. Headphones were used for acoustic stimulation with direct input to the speech processor to prevent cross-leakage of sound due to good low-frequency residual hearing. Monaural recognition of Fournier disyllabic words was tested with the patients' own Phonak ipsi-lateral ITE hearing aid and the experimental electro-acoustic speech processor, with and without CI. The patient was re-tested after a further one month period using the experimental device.

Results: Initial results with two subjects suggest that value of conserving residual hearing after cochlear implantation may be underestimated when ear-plugs are used with sound-field presentation to evaluate implant-alone or implant-plus-one-ear performance. Initial trials with the experimental electro-acoustic speech processor indicate performance at least equivalent to the Phonak Aero 33. Data for additional subjects will be available at the time of presentation.

G1 – O7

Performance with a miniaturized, cable free FM for CI users

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Objectives: Frequency-modulated (FM) systems can help overcome some of the listening problems created by distance, noise, and reverberation for cochlear implant users. The Phonak miniaturized MLxS FM receiver together with Auria iConnectTM cable-free FM adapter reduce the complexity of fitting and wearing an FM system. The purposes of this study are to: (1) assess speech recognition performance with the FM plus implant compared to implant alone, (2) determine the appropriate mixing ratios and gain settings for FM use, and (3) assess ease of FM use and benefits in everyday situations.

Methods: Subjects are children and adults who are fitted with the Phonak miniaturized MLxS FM receiver together with Auria iConnectTM cable-free FM adapter. Subjects are tested in the soundfield to identify the combination of mixing ratio and gain setting that yields the highest speech recognition performance. Stimuli are presented at 35 and 50 dB HL in quiet and at 50 dB in noise (+5 dB SNR). Then, the mixing ratio and gain setting that yields the highest performance is used in everyday situations. Subjects (or guardians) complete a questionnaire that assesses everyday benefits with FM-listening.

Results and Conclusions: The study is in progress. Approximately 10 adults and 10 children will participate in the study by the time of the conference. It is anticipated that benefits with the FM and implant will exceed those obtained from

the implant only/ Speech recognition results with different mixing ratios and gain settings will be used to develop fitting guidelines.

G1 – P8

The Auria iConnect: an ear-level connector for an FM receiver

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The use of FM systems has been advocated for many years, particularly in classrooms for children with hearing impairment. FM systems overcome the listening problems created by distance, noise, and reverberation. Currently, the Advanced Bionics Auria behind the ear sound processor can be used with a body-worn FM system by connecting the output of the FM system to the audio-socket via a custom-built patch cable. This cable has some electronic components inside to attenuate the signal level from the FM receiver and to help reject spurious signals.

The new development of the iConnect allows connecting an FM receiver on the ear level without any additional cables. Basically it is a special ear hook for the Auria processor that allows plugging on the FM receiver with an additional battery to ensure power supply of the receiver without compromising the battery life time of the processor.

The iConnect will be tested in a group of 8 subjects. Speech perception with background noise, sound quality, comfort of wearing and operating range will be evaluated. In addition, recommendations for the optimal setting of the Auria program will be developed.

Preliminary results promise less interference compared to body worn FM receivers and higher reliability due to the omission of a patch cable.

G1 – O9

Infant speech processor conversion study from SPrintTM to ESPrit 3GTM

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Objectives: To assess the fitting of the Cochlear ESPrit 3G (E3G) ear level speech processor with children under the age of five, over a 2 year period, after initial stimulation with the Sprint bodyworn speech processor.

Methods: 20 children from two UK centres were recruited to the study and were initially issued with the Sprint. At 3 months post initial stimulation and at subsequent programming sessions the child's progress was assessed using the E3G Upgrade Study Profile (USP). The USP covers functional listening and speech processor use. A child was converted when they met 'no concern' for every factor. Children were seen for follow up 3 months post conversion and their performance assessed using questionnaires (including the MAIS/IT MAIS) and soundfield aided thresholds. At the end of the study it was determined whether the child continued to use the E3G or reverted back to the SPrint.

Results: All children have reached at least the 12 month interval post initial stimulation. At the 3 month interval all children remained on the Sprint. Three, two and six children were successfully fitted with the E3G at 6 months, 9 months and 12 months respectively. Nine of these have completed the 3 month trial post conversion and 7 families have chosen to continue to use the E3G in preference to the Sprint. No deterioration in performance has been reported by families or clinicians.

Conclusions: Young children can be successfully converted from the Sprint to the E3G if appropriately selected and their progress will continue as expected.

G1 – O10

Benefits of the T-Mic in the HiResolution cochlear implant system

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Objectives: The T-Mic is the in-the-ear microphone that works with the HiResolution system manufactured by Advanced Bionics Corporation. It was designed to provide easy access to cellular telephones, consumer audio electronics, and assistive listening technology. In addition, because of the T-Mic's location within the cochlea, listeners may be able to take advantage of the sound filtering effects of the outer ear. Those effects can provide better speech understanding in noise in some situations and improved localization of sound. The purpose of this study is to compare speech perception and self-reported benefits with the T-Mic and the conventional BTE microphone.

Methods: Subjects include previously implanted adults (CII or 90K devices) who demonstrate a monosyllable word score of 40 % or higher with their current microphone arrangement and can converse on the telephone. Five subjects use the T-Mic as their current microphone and 5 subjects use the BTE microphone. Subjects are tested on speech recognition measures (words and sentences in noise) with their current microphone and complete a questionnaire. Then, subjects are fit with the alternate microphone and return one to two weeks later for reassessment and questionnaire completion. Subjects complete a preference questionnaire for T-Mic versus BTE microphone at the end of the study.

Results and Conclusions: The study is in progress. Initial results suggest that some subjects perform better with the T-Mic in noise. Most subjects prefer the T-Mic to the BTE microphone in everyday listening situations.

G1 – O11

Telemedical application for remote cochlear implant fitting

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Objectives: Optimal fitting of cochlear implant system is necessary for patients to gain hearing benefits. It requires frequent visits in cochlear implant centers and repetitive fitting session. Very often patients have to travel long distances and spend a lot of time to reach a center. Fortunately, development of informatics and telecommunication technologies, especially internet, gives us new possibilities. New version of software for cochlear implant system fitting allows remote fitting with use of internet connection. This possibility, if prove safe and reliable, could be very useful in clinical practice.

The aim of this study was to assess usefulness and safeness of remote fitting via internet.

Methods: Material of the study consist of 11 adult cochlear implant users, implanted witch Nucleus devices. Platform for remote fitting for Freedom cochlear implant system was used in the study. Patients were connected to the programming interface in one of satellite centers of Institute of Physiology and Pathology of Hearing. Specialists, performing fitting and electrical hearing tests were connected to the programming interface via Internet from International Center of Hearing and Speech, part of Institute of Physiology and Pathology of Hearing

Results: First experiences of application of this new technology was described. Properties and possibilities of the method, by means of quality, time effectiveness, cost etc. were evaluated. Risk of using this technology, connected with danger of overstimulation, connection breakdowns etc. was also assessed.

Conclusions: Based on preliminary results, remote cochlear implant system fitting via internet seems to be a useful and safe technology, which should be used in clinical practice.

G1 – O12

Multicentric study on adult patients implanted with the Digisonic SP cochlear implant system

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Objective: This aims of the study is to review a multicentric experience with the Digisonic SP cochlear implant system with respect to rehabilitation outcomes. Surgical complications and reliability data will also be discussed.

Methods: The authors have performed a retrospective study of the patients implanted with the Digisonic SP CI system manufactured by Neurelec. These patients, aged from 18 to 77 years, have a minimum of 3 months follow up. Age, sex, etiology, presence or absence of complications and auditory performances with word and sentence recognition testing were evaluated.

Results: One hundred patients were evaluated. Significant improvement in speech understanding was seen in the majority of patients.

Conclusions: The multi-centric experience with the Digisonic Multi-Strategy Cochlear Implant has been characterized by minimal surgical morbidity and significant improvement on the open-set test measures of sentence and word recognition.

The majority of improvement in speech understandings appears immediately in post-operator period (the first record at 3 months), but later enhancement of performance is seen still at 2 years after the implantation.

Our experience supports the safety and effectiveness of the Digisonic SP Cochlear Implant in rehabilitating the profoundly deaf adult population.

Tinnitus and Cochlear Implant (G2)

G2 – O1

Tinnitus treatment with CI in unilateral deafness

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Objectives: To assess the effectiveness of CI to reduce tinnitusloudness and tinnitussuffering of patients in whom unilateral profound hearing loss provoked incapacitating tinnitus.

Methods: 10 patients received a fully inserted CI type Med-el Combi 40+M electrode. Selection criteria: 1° unilateral incapacitating and refractive tinnitus due to profound unilateral sensorineural hearing loss 2° in the contralateral ear no to moderate hearingloss 3° adult and consenting with the study according to the IRB.

Tinnitus outcome parameters visual analogue scale (VAS) for loudness, and the tinnitus questionnaire (TQ) following Goebel, which is a tnnitus specific quality of life questionnaire.

Hearing evaluation was performed using headphones and free field speech in noise.

Results: All 10 patients used their CI every day, the whole day throughout the full 12 months. A significant tinnitus reduction was realized in all ten patients. Mean VAS score decreased from 8.9 (sd 1.2) to 1.5 (sd1.3) ($p < 0.01$) while wearing the CI.. The TQ decreased from 59.6 to 36.8 ($p < 0.01$). The degree of improvement of the hearing did not correlate with the degree of tinnitus control.

Conclusions: CI is an adequate treatment for unilateral continuous incapacitating tinnitus in unilateraldeafness. These results support the hypothesis that tinnitus is a deafferentiaion type f sensation in these patients and that this physiopathological mechanism is reversible.

G2 – O2

Hearing capabilities after CI in unilateral sensorineural deafness and tinnitus

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Objectives: The aim of this clinical study was to assess speech in noise and hearing-specific-quality-of-life effects of cochlear implantation in patients with unilateral profound hearing loss and incapacitating tinnitus.

Methods: 18 patients were selected for cochlear implantation in the deaf ear, where the tinnitus is perceived. Selection criteria are unilateral tinnitus, profound unilateral sensorineural hearing loss with more than 50 % suppression of the tinnitus on promontory testing, after exclusion of all treatable causes. Hearing evaluation was performed using headphones and free field speech in noise, the disability hearing scale and the SSQ questionnaire.

All patients were implanted with a Med-el Combi 40+M electrode, applying full insertion.

Results: All 18 patients use their cochlear implant every day, the whole day. In all patients a significant increase in hearing capabilities can be seen.

Conclusions: Cochlear implantation can significantly improve hearing capabilities in daily life. There was no conflict between the hearing with CI and the hearing in the opposite ear. However, it has to be taken into account that the primary indication for cochlear implantation in these patients was the tinnitus reduction.

The preliminary results of these 18 cochlear implantations suggest that cochlear implantation is an adequate treatment providing improved hearing in unilateral profound sensorineural hearing loss combined with tinnitus.

G2 – O3

Swiss multi-centre study on tinnitus and cochlear implantation

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Objective: To investigate the influence of cochlear implantation on tinnitus.

Methods: In a prospective, multi-centre study involving all five Swiss cochlear implant centers, cochlear implant patients were questioned preoperatively and six months after first fitting of their speech processors about their tinnitus. Implantees under the age of 14 and patients undergoing a second implantation due to device failure or to provide binaural stimulation were excluded. After an audiologic assessment, patients were asked to fill in a tinnitus questionnaire (ref) and to rate their tinnitus on a visual analog scale.

Results: Data from the first 61 patients included was analyzed. 44 patients (72 %) reported tinnitus pre-operatively. In this sub-group, tinnitus improved in 36 patients (82 %) after 6 months of cochlear implant use. Tinnitus remained unaffected in 2 patients (5 %) and worsened in 6 patients (13 %). Among the 15 patients, who did not report any tinnitus before cochlear implantation, 2 (15 %) developed a mild tinnitus within the first 6 months of cochlear implant use. Age at implantation and duration of tinnitus had no clear influence on tinnitus reported post-operatively.

Conclusions: Tinnitus present preoperatively, is influenced favorably by cochlear implantation in more than 8 of 10 users. In patients, who did not have tinnitus preoperatively, a mild tinnitus can occur postoperatively, a phenomenon known from other surgical procedures which may affect inner ear function.

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G2 – O4

Tinnitus suppression by electrical stimulation with cochlear implants: Study of 100 patients

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Objectives: The aim of this study was to evaluate the efficacy of electrical stimulation for tinnitus suppression in patients implanted with cochlear implants.

Material and Methods: This has been a retrospective, questionnaire-based study. The questionnaires were sent to 100 adult (i.e. older than 18) cochlear implant recipients with at least 6 months experience of using their devices. The patients were randomly chosen out of a total population of over 500 patients implanted at our clinic with the Nucleus, CII, Hi-Res 90k and LAURA devices. The responder rate was 93 %. The questionnaires evaluated the presence, the type and subjective loudness of tinnitus before and after cochlear implantation. The presence and loudness of tinnitus post implantation was evaluated also regarding to the status of the speech processor (switched on or off), the epidemiological, medical and fitting data of the patients.

Results: The preliminary analysis of the questionnaires showed that within the study population 65 % of the patients had pre-operative tinnitus complaints (65 % of these patients had bilateral tinnitus and 35 % unilateral). In 29 % of the patients implanted in the ear with tinnitus, the tinnitus was totally gone after implantation. Additionally almost 30 % of the patients reported a decrease in the tinnitus loudness when the speech processor was turned on. The final results and statistical analysis of the tinnitus suppression rate relative to the

epidemiological data and the stimulation strategies used by the patients will also be presented.

Conclusions: Electrical stimulation with cochlear implants is effective for tinnitus suppression in almost 60 % of the patients.

G2 – O5

Auditory system gain and the treatment of tinnitus in implant patients

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Objectives: Tinnitus is a common and bothersome symptom in patients with hearing loss. Cochlear implantation relieves tinnitus in many patients but in a subset of patients tinnitus remains bothersome or is even worsened by implantation. This study aims to explore if treatment of auditory system gain in the form of tinnitus retraining therapy.

Methods: The effect of sound on auditory system dynamic range was measured in cochlear implant patients. Patients complaining of residual tinnitus after implantation were treated with broadband noise using an MP3 player linked into the implant. The effect on tinnitus was examined using pre and post administration of the tinnitus handicap index (THI).

Results: After 6 months of tinnitus retraining through a cochlear implant, THI scores were reduced and patient satisfaction improved due to control of tinnitus.

Conclusions: Tinnitus retraining therapy can be conducted in patients with cochlear implants. Sound therapy may alter auditory system dynamic range and can provide a treatment modality for these difficult patients.

G2 – O6

Tinnelec®: Tinnitus reduction implant by electrical stimulation of the oval window

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People with unilateral cophosis and tinnitus can not benefit from the different treatments offered for normal hearing persons. The use of a cochlear implant can be a good method to reduce tinnitus because the electrical stimulation can increase the process of habituation based on the principle of the TRT with an acoustical stimulation. However, the main disadvantage of using a CI is the cost and the possible interaction with the normal ear in this population of patients.

The principle of the Tinnelec® developed by Neurelec is to offer a cost/effective and safe solution for reduction of tinnitus in unilateral deafness.

Description of the surgery and the system: The surgery is based on the otosclerosis technique. One extra-cochlear electrode is placed in the contact of the oval window. The Tinnelec® implant is a implantable stimulator based on the Digisonic SP CI with a ground electrode placed under the temporal muscle.

A Digi SP external processor generates an electrical signal which masks the tinnitus with a special and programmable pattern.

Protocol: 9 patients with a disabled tinnitus after two years and a single side cophose.

All patients have been tested before implantation with a promontory test to check the possible tinnitus suppression.

Different questionnaires are used to test the efficiency of the therapy: degree of tinnitus, impact on the auditory perception, psychological and social. In addition the DET test measure the subjective distress.

Results: Preliminary results have shown a significant reduction of the tinnitus for all patients with a good improvement in the quality of life.

Conclusion: The Tinnelec® implant is a safe, reliable and an efficient solution to the rehabilitation of tinnitus with single side deafness. A larger population is necessary to confirm theses preliminary results.

Cochlear Implant in Multihandicapped Patients (G3)

G3 – O1

Clinical characteristics of children with cochlear nerve deficiency

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Objective: To describe the clinical characteristics of a group of children identified as having cochlear nerve deficiency (small or absent).

Design: A retrospective review of the clinical records, audiological testing results, and magnetic resonance imaging (MRI) studies. Fourteen children with cochlear nerve deficiency on MRI were identified.

Results: Most children with cochlear nerve deficiency presented following failure of routine newborn hearing screening. Many ears with cochlear nerve deficiency displayed evidence of a cochlear microphonic and absent neural responses on ABR testing similar to that seen in auditory neuropathy. Normal internal auditory canal (IAC), inner ear and bony cochlear nerve canal (BCNC) morphology did not accurately predict the presence of a cochlear nerve. All ears without a cochlear nerve were identified as having a profound hearing loss.

Conclusions: Children with cochlear nerve deficiency can present with electrophysiologic characteristics of auditory neuropathy. That IAC, inner ear, and BCNC morphology do not accurately predict cochlear nerve presence makes MRI the study of choice for evaluating children with sensorineural hearing loss. While hearing aids or cochlear implants may be beneficial in the presence of a small auditory nerve, they are obviously contraindicated when a auditory nerve is absent.

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G3 – P2

Clinical spectrum of inner ear malformations

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Objectives: To assess the spectrum of morphologic and functional characteristics in children with inner ear malformations and to describe feasible management options.

Material and Methods: A modification of an established classification system for inner ear malformations was used to identify 72 pediatric subjects. Cases were diagnosed with MRI and/or HRCT imaging. Audiometric data was available for all patients.

Results: Cochleovestibular malformations were present in 121 ears. Michel aplasia was present in 1 ear, cystic cochleovestibular malformations were observed in 17 ears, malformations of the incomplete partitioning spectrum were present in 52 ears, and abnormalities of the hypoplastic spectrum were seen in 44 ears. Also, bilateral x-linked stapes gusher syndrome was observed in 3 subjects. 11 ears showed isolated abnormalities of the internal auditory canals with normal inner ears.

The majority of malformed inner ears showed profound sensorineural hearing impairment. However, mild or moderate hearing losses were encountered in about 20 % of patients and managed accordingly. Cochlear implantation was performed in 34 subjects.

Conclusions: The clinical spectrum of inner ear malformations observed in this report contained multi-handicapped children with absent cochlear nerves who had to be habilitated with sign language as well as children who presented with mild unilateral hearing loss only. Also several associations between morphologic criteria were observed that deserve future attention. Despite the anatomic abnormalities, cochlear implantation has been a successful treatment in cases with profound hearing loss.

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G3 – P3

Cochlear implantation in Osteogenesis Imperfecta

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Objectives: to describe the surgery and rehabilitation after cochlear implantation of patients with severe sensorineural hearing loss due to Osteogenesis Imperfecta (OI).

Methods: Perioperative imaging, medical charts and programming notes were evaluated of three patients with OI. Psychoacoustical (electrical threshold level, comfortable level and pitch scaling measures) and electrophysiological measures (average electrode voltages, AEVs and neural response telemetry, NRT) were performed.

Results: Most of the specific observations in ear surgery on patients with OI, such as brittle scutum, sclerotic thickening of the cochlea, hyperplastic mucosa in the middle ear and persistent bleeding, were encountered. In case 3, misplacement of the electrode array into the horizontal semicircular canal occurred. Even after reimplantation, non-auditory sensations led to non-use. In all 3 cases, AEVs were deviant in accordance with an abnormally conductive otic capsule and programming was hindered by non-auditory stimulation such as facial nerve stimulation (FNS). Spread of excitation responses showed poor frequency specificity for several electrodes, often accompanied by FNS. In case 1, the estimated pitch of the electrodes that caused FNS varied consistently. After 1 year follow up, phoneme scores of 81 % and 78 % were reached in case 1 and 2, respectively.

Conclusions: When aware and prepared for the specific changes of the temporal bone in OI, cochlear implantation can be a safe and feasible procedure. Preoperative imaging is recommended to be fully informed on the morphology of the petrosal bone. Rehabilitation is often hindered by FNS requiring frequent refitting. Despite the electrophysiological changes, Case 1 and 2 obtained high phoneme scores.

G3 – P4

Outcome of cochlear implantation in Refsum's disease

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Objectives: To outline our experience of cochlear implantation in patients with Refsum's Disease (RD).

Method: Analysis of early and late standard outcome measures in 2 patients who have been successful implanted with Refsum's disease who also have associated progressive loss of vision.

Results: Two patients were successfully implanted with no anaesthetic or vestibular complications. The BKB results for the first patient showed a marked improvement in sound from a score of 0 % pre-implant to 92 % in quiet and 62 % in noise, at two years following single implantation. The second patient improved from a score of 0 % to 80 % at three months

following bilateral implantation. Both patients had poor vision and poor lip-reading skills. The intervention has led to a significant improvement in quality of life.

Conclusion: RD is an autosomal recessive disabling disorder affecting many systems and senses. We did not encounter any operative complications however, teams implanting patients with RD need to be aware of the potentially serious consequences associated with metabolic problems of this disorder.

Both patients have benefited from their cochlear implants, especially in view of their failing vision. Patients with dual visual and hearing loss should be considered for bilateral cochlear implantation which helps sound localisation and hearing speech in the presence of background noise.

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G3 – P5

Successful cochlear implantation in a child with Cornelia de Lange syndrome

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Cornelia de Lange Syndrome is a sporadic autosomal dominant transmitted disease. This syndrome is characterized by multiple congenital malformations and mental retardation.It occurs in approximately 1 of every 10 000 live births, affecting males and females equally. Often, the diagnosis of CDLS cannot be made at birth, and in some cases the typical appearance is not present during the first year of life. Symptoms are typical facial appearance including a small nose, anteverted nostrils, down – turned mouth, prominent philtrum, convergent eyebrows and long, curly eyelashes, low – set ears, heart defects, abnormalities of the limbs and of male genitalia and mental retardation and often sensineural hearing loss. There exists an individual variance of symptomatic expression. Often the intellectual competence of the patients is masked because of the insufficient support of sensineural hearing loss.

In February 2002 we implanted a six year old girl (weight 10 kg) with bilateral congenital deafness, craniofascial dysplasia and cochlear malformation by CdLS with a Combi 40+ Cochlear Implant (Med El, Innsbruck, Austria). Using the suprameatal approach (SMA), we were able to insert the electrode array 31 mm into the malformed cochlear.

In the meantime (4 years after implantation) the aided thresholds appears stable pantonal at 30 dB (A). The child reacts to verbal orders and shows audioverbal development and speech production.

As far as we know, this is the first case of a patient with Cornelia de Lange syndrome, who was successfully supported with a cochlear implant.

G3 – P6

Successful cochlear implantation in a peri-lingually deaf patient with the Melnick-Needles syndrome

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Introduction: Melnick-Needles syndrome (MNS) is a rare X-linked genetic bony dysplasia characterized by skeletal and facial abnormalities. The molecular basis of the MNS is a mutation in a gene FLNA encoding the cytoskeletal protein filamin A. This is the first report on the bilateral inner ear malformation as a possible phenotypic feature of MNS. This is also the first report on a successful cochlear implantation in a MNS patient.

Material and Methods: A female patient suffering from MNS and peri-lingual profound hearing loss was implanted with the HiRes device at the age of 38 years. The case history and the functional benefits from cochlear implantation are reported.

Results: 6 months after implantation 70 % speech identification in an open-set monosyllabic CVC test (phoneme-score in adult NVA list in quiet) and 80 % word score in bi-syllabic words (BLU list) was obtained. In noise (adult NVA lists), the results were the following: 55 % for SNR +15dB, 30 % for SNR +10dB and 21 % for SNR +5dB. The patient is also able to discriminate all 22 phoneme pairs in the phoneme-discrimination (APE) test. This allows the patient to obtain significant communication ability through telephone.

Conclusions: 1.) Bilateral inner ear malformation is possibly one of the phenotypic features of MNS. 2.) A cochlear implant is potentially a good functional solution for patients suffering from MNS and profound hearing loss. 3.) Exceptionally good results on auditory performance have been obtained in this MNS patient with peri-lingual profound hearing loss and almost 36 years duration of deafness.

G3 – P7

Cochlear implantation in Cockayne Syndrome – our experience of two cases with different outcomes

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Objectives: We offer details of our experience with the cochlear implantation and follow-up of two female patients with Cockayne syndrome.

Methods: We present an introduction to the syndrome and its diverse manifestations. Two patients with Cockayne syndrome who underwent cochlear implantation for progres-

sive bilateral profound sensorineural hearing loss are discussed. Pre-operative clinical course and assessments are outlined followed by post-operative performance.

Results: Cochlear implant surgery was performed uneventfully in both cases. The first case was implanted with a Nucleus 24 Sprint (R) device in 1999 at the age of 22 years and we present 6 years follow-up data. The second case received a Clarion Auria device in 2003 at the age of 36 years and we present 3 years follow-up data. Both individuals made significant initial progress in rehabilitation. The effect of this progressive condition is discussed in light of their present and anticipated future performance.

Conclusions: To the best of our knowledge we present the first series with robust follow-up data of cochlear implantation in two patients with suspected Cockayne syndrome. It is hoped that our experience will provide some guidance to other programs when faced with similar implantation decisions.

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G3 – P8

Implantation of three children with KID syndrome

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Objectives: Keratitis, Ichthysosis and Deafness (KID) syndrome is a rare genodermatosis with less than 70 reported cases. The syndrome presents with typical skin and hair changes and gradual loss of vision secondary to the vascularizing keratitis and sensorineural hearing loss associated with Connexin-26 gene mutation which may be profound. Ichthyotic involvement of the ear canal epithelium and associated nonerosive keratosis obturans can complicate hearing assessment and aid fitting. The tendency to eczematous dermatitis is also a potential risk with cochlear implantation. Hampton et al (1997) reported one case of wound breakdown and partial device extrusion in a child with KID syndrome. The outcome was reported as satisfactory in that case but no others have been reported.

Methods: Three children with KID syndrome have received cochlear implants in Victoria. One child suffered significant problems with bilateral chronic otitis media and underwent middle ear obliteration prior to second side implantation. The other two children were implanted without major problems to this time. Standardised testing has been carried out at more than 6 months after implantation.

Results: Speech perception and language results in all cases have been measured at or above average levels for typical implanted children.

Conclusions: The cochlear implant is a suitable device for this group who show excellent results despite some medical challenges.

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G3 – O9

Cochlear implantation in children with Mondini deformity

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Objectives: This study reviews the results of cochlear implantation in 13 children between the ages of 2 to 18 years with Mondini deformity of the cochlea, who underwent surgery between 1988 and 2005. Of these, 7 children had a true Mondini with incomplete partition and 6 had a "cocks" common cavity.

Methods: A Hortmann ball electrode device was used in 3 cases, a Medel ball electrode device in 1 case and a Medel compressed Combi 40 in 2 cases. 7 cases received Clarion devices, 4 precurved enhanced bipolar, 1 HiFocus I, and 2 HiRes 90K. One case with a precurved underwent revision surgery with a CII Bionic Ear. 10 patients underwent Mastoidectomy with Posterior Tympanotomy, 1 patient underwent Varia technique and 2 patients underwent Lateral Skull Base Approach for insertion of electrodes. 3 cases with a common cavity developed a postoperative leak and had to have a lumboperitoneal shunt.

Results: The speech perception and speech production average scores attained were higher in patients with a true Mondini deformity with multielectrode devices, and with enhanced bipolar and HiRes 90K Implants, using MPS strategy and HiRes 90K Paired Strategy.

Conclusions: From this study, we concluded that cochlear implantation in Mondini cases is feasible in spite of the acceptable risk of complications. Children with true Mondini deformity and multielectrode devices, although slower, perform as well as their matched counterparts.

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G3 – P10

Cochlear implantation in "common cavity" deformation

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We report on a 4 year old boy with Townes-Brocks-Syndrome including severe inner ear hearing loss. Although the boy started developing speech when using hearing aids this process stopped. Considering cochlea implantation we performed CT scans and found a both sided common cavity deformation of the cochlea. The facial nerve was in correct position and the internal auditory canal was not enlarged.

Cochlea implantation has been performed successfully in various malformations of the inner ear. Therefore we decided to use a special designed electrode based on the Pulsar CI 100 stimulator (MED-EL, Innsbruck, Austria) for the implantation. This electrode is made longer with a silicone tube strengthened with a wire. The cochlea was approached in the usual way by a posterior tympanotomy and the common cavity was opened in slit shape. In order to avoid malpositioning of the electrode into the vestibular system the electric active middle part of the electrode was inserted as a "U" in the cavity. The opening in the common cavity was sealed with connective tissue with great care as cochlear malformations are associated with an increased incidence of bacterial meningitis.

First results of the cochlear implant fitting will be presented.

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G3 – P11

Cochlear implantation results in Kearns-Sayre syndrome

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Objectives: Deafness is common in mitochondrial encephalomyopathies, including Kearns-Sayre syndrome (KSS). Although the hearing loss is believed to be cochlear, there is histopathologic, radiologic and clinical evidence of central neurologic involvement. The objective of this study is to provide electrophysiological and speech perception data regarding the site of lesion in 2 patients with KSS who underwent successful cochlear implantation.

Methods: Within our centre's cochlear implantee population of 289 patients, two patients were identified who were diagnosed with Kearns-Sayre syndrome. Following implantation, these patients underwent electrically-evoked Auditory Brainstem Response (eABR), Middle Latency Response (eMLR) testing and assessment of speech understanding abilities. The results in the 2 patients with KSS were compared to the general (non-KSS) cochlear implant population in our Clinic.

Results: The eABR and eMLR peak latencies and amplitudes were indistinguishable from those in the general cochlear implant population. On tests of speech understanding, the scores for the patients with KSS were comparable to the non-KSS group of implantees.

Conclusions: The initial site of lesion for deafness in KSS appears to be in the cochlea. The auditory pathway and cortex appear to generate normal responses, consistent with relative sparing of the central auditory system early in the disease. Cochlear implantation appears to be an option for hearing habilitation with a high likelihood of success.

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G3 – O12

Two year post implant results with custom electrodes for common cavity

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Objectives: Patients with congenital malformation of the inner ear are a small subgroup of all cochlear implant recipients. It remains uncertain how different types of cochlear malformation benefit from implantation.

Methods: We implanted two children with common cavity malformation with custom-made COMBI 40+ devices. We report on the surgical approach and the surgical and clinical outcome over two years.

Results: Case 1 (VP) a female with bilateral common cavity malformations with profound SNHL. She received her implant at 2 1/2 years of age in the right ear. She is cognitively normal; however, she comes from a single-family home with limited resources. She scores 20 % on the MAIS scale at 12 months after activation. Two year post implantation speech, language, cognitive, and auditory learning will be reported, and compared with pre-implantation data.

Case 2 (EF) a female with bilateral common cavity malformations with profound SNHL. She was implanted in the left ear at 1 year of age. She is cognitively normal and resides with two parents and siblings. The family has adequate resources. Her sound awareness has steadily increased over time and she scores 70 % on the MAIS scale at 12 months post implantation. Second year post implantation speech, language, cognitive, and auditory learning will be reported and compared with pre-implantation data.

Conclusions: A common cavity malformation should not be considered a contra-indication for cochlear implantation. Although our clinical outcomes have varied both children are making progress with respect to sound recognition, speech production, language development, and cognitive development.

G3 – O13

Cochlear implantation in deaf children with additional disabilities

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Objectives: A prospective model based on the CDaCI multi-center study has been adopted to track the post-implant development of children from special populations. We report on the first year of follow-up in 5 deaf children with additional delays or disabilities, using measures of perceived self-efficacy and parental stress, as well as more traditional metrics of auditory performance.

Methods: Five deaf children with additional developmental disabilities were assessed pre-implant and within one year following implantation, using measures of detection, meaningful use of sound (IT-MAIS, MAIS), parental self-efficacy and involvement (SPISE), and parental stress (Parenting Stress Index, PSI).

Results: All children showed improved detection thresholds and use of sound in everyday situations, although IT-MAIS/MAIS scores showed a slower rate of change than expected in otherwise normally developing children during the first year of implant use. However, these auditory gains were not always paralleled by improved parental self-efficacy (SPISE) or reductions in parenting stress (PSI).

Conclusions: Given the additional complexity imposed by deafness on families of children with developmental disabilities, traditional metrics of auditory performance alone may not be sufficient to describe or predict post-implant outcomes. In this sample, the lack of congruence between auditory findings and more global measures of child and family dynamics may reflect a shift in expectations on the part of some parents regarding post-implant effectiveness or the rate at which improvement may occur.

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G3 – O14

CI surgery in special cases with anatomical and functional outcome

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Objectives: Surgery for cochlear implantation is a standard clinical procedure. Adequate placement of receiver and electrode array is the conditio sin equa non. There are situation in which the surgery may create a major problem for the anatomical and functional outcome. On the other hand there some cases in which the anatomical condition preoperatively may predict poor functional outcome.

Methods: In this presentation we evaluate surgical outcome and functional results in the following condition: Common cavity (2), obliteration of cochlea (2), deaf and blind patient (4), and patient with SICRET syndrome (1), patients with narrow internal meatus (1) and patients after revision surgeries for CI (8).

Results: In Common cavity short version of electrode was used with 12 resp. 10 electrodes inside the cavity. In obliteration split electrode was used in one case and in the second patients single electrode was used. In deaf and blind patients, SICRET syndrome patient and narrow meatus the insertion of electrode array was done in a standard way. During the revision surgery implantation of the other side was done in 2 patients, the same side with similar depth of insertion was done in 6 cases. The functional tests are under the evaluation.

Conclusion: For the special cases of cochlear implantation there are special surgical techniques that bring excellent anatomical results. The functional results seem to be of appropriate level. These cases are good indications for cochlear implantation.

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G3 – O15

Cochlear implant in inner ear malformations: labyrinthotomy approach

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Introduction: Cochlear implantation in abnormal cochlea can be challenging. We present a case of common cavity malformation implanted using a transmastoid labryinthotomy approach to place a multichannel electrode. Intraoperative video footage demonstrates the feasibility and facility of the trans mastoid labyrinthotomy approach in this patient.

Case report: A 37-year-old lady with a profound sensorineural hearing loss secondary to bilateral inner ear malformations had undergone right cochlear implantation, which resulted in grade 111 facial nerve palsy. Her initial single channel implant failed after 9 months. We have successfully reimplanted this patient with a Nucleus-24M device with out complications by using the transmastoid labyrinthotomy approach in the same side. There were 11 functioning electrodes within the cochlear cavity. No significant CSF flow was encountered, and the muscle plug was used around the electrode array at insertion site. Her auditory speech perception is monitored with BKB sentences and CUNY sentences (70dB) with and without lip reading. No non-auditory sensations were noted.

Conclusion: As demonstrated in this patient, the labyrinthotomy approach to cochlear cavity is an effective approach for placement of the electrode array. Such approach minimises the potential surgical complications in revision surgery with inner ear malformations.

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G3 – P16

Bilateral atresia of the internal auditory meatus – Case report

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The Wildervanck syndrome is a very rare disease.

We present a case diagnosticated in april 2005. A five years old girl was addressed to our clinic for deafness and lack of language development.

The functional evaluation of hearing (tonal audiometry, tympanometry, transient evoked otoacoustic emissions, BERA) showed complete bilateral deafness.

The child also has fused cervical spine and bilateral abducens nerve palsy.

The surprise was when we performed the CT scan of the temporal bones that revealed the agenesis of bilateral internal auditive meatus and anomalies of the brain. Although the child does not present any mental retardation or motor impairment.

In this case the therapeutical possibilities for hearing loss were very restrictive, the only possible treatment to recover the hearing being the ABI.

G3 – P17

Cochlear implants in cerebral palsy children

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Aims: To investigate the outcomes of cochlear implants in cerebral palsy children.

Methodology: Four congenital profound hearing loss children, aging 12–35 months, with different kinds of cerebral palsy were implanted with unilateral MEDEL cochlear implantations. The follow-up period was between 15–30 months. The speech development was evaluated regularly after surgery.

Results: The speech development of children with cerebral palsy after cochlear implants matched the normal profound hearing loss children.

Conclusion: The cerebral palsy children with profound hearing loss could be successfully implanted with a age-matched speech development.

G3 – P18

Cochlear implantation in a child with cerebral palsy

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Objectives: To report the cochlear implantation aspect and performance outcome in a child suffering from profound bilateral sensorineural hearing loss with cerebral palsy.

Methods: Retrospective case review.

Results: The patient was a 3-year-old boy who had cerebral palsy at birth and profound bilateral sensorineural hearing loss. He had been receiving treatment on pediatric department because of his cerebral palsy and became better and better. But the hearing loss hadn't been improved obviously even with hearing aids. His preimplant assessment took place one month before the operation. The only reliable response to sound observed before implantation was 105dB HL at 500 Hz with ASSR. He was therefore rated on the 1 Category of the CAP (only awareness of environmental sounds). His SIR level was Category 1 (pre-recognizable words). A temporal bone CT scan and cerebral MRI showed no deformity.

The patient received a cochlear implantation with full insertion of the electrode array. There were no complications.

After the operation, the patient made rapid progress in his listening skills. By the 3-month interval the patient had gone up three levels on the CAP (discrimination of some speech sounds without lip-reading). By the 2-year interval the patient even came to the 6 or 7 Category on the CAP (use of telephone with known listener) and Category 5 on the SIR (connected speech is intelligible to all listeners).

Conclusions: Cochlear implantation may be performed and lead to good outcome in some children suffering from profound bilateral sensorineural hearing loss with cerebral palsy if we can get the exact response to sound at some frequencies.

G3 – O19

Cochlear implantation in enlarged cochlear aqueduct

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Introduction: The cochlear aqueduct is a bony canal that connects the subarachnoid space to the scala tympani of the cochlea. The enlargement of the cochlear aqueduct has been suggested as a cause of sensorineural hearing loss and perilymph fistula (Farrior Laryngoscope 1971). We reported a case of a child with a enlargement of the cochlear aqueduct implanted in our department.

Case report: A 2 year-old boy was referred for cochlear implantation. Audiologic study demonstrated bilateral sensorineural hearing loss suitable for cochlear implantation. Radiologic study showed an enlargement of the cochlear aqueduct. During cochleostomy a perylimphatic leakage occurred. It required the sealing of the cochleostomy and middle ear with temporal muscle and lumbar drain during 3 days.

Discussion: The enlargement of the cochlear aqueduct is an infrecuent malformation of the otic capsule in our experience (1/284). In these cases special caution should taken during cochlear implantation because perilymphatic fistula can occur during cochleostomy.

G3 – O20

Cochlear implantation in children with Waardenburg syndrome

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Waardenburg syndrome is an autosomal-dominant trait resulting from mutations occurring in different genes. It is often characterized by varying degrees of: congenital hearing loss; dystopia canthorum; synophrys; broad nasal root; depigmentation of hair (white forelock), skin or both; and heterochromic or hypochromic irides. A retrospective case study was done to assess speech perception, speech production, general intelligence and educational setting in six profoundly hearing-impaired children with Waardenburg syndrome (four with type I, one with type II and one with type III) ranging in age from two years to 14 years, seven months (mean = six years, six months). None of the patients had malformation of the cochlea and were implanted using Nucleus 22/24 and Med-el combi40+. Five out of the six cases were of average intelligence and one had a borderline intelligence quotient. The follow-up period ranged from one year, 10 months to six years, six months (mean = three years, six months) after implantation. The evaluation of auditory perception in patients was

accomplished using the Persian Auditory Perception Test for the Hearing-Impaired, a Persian Spondee words test and the Categories of Auditory Performance Index. The Speech Intelligibility Rating test was used to evaluate speech production ability. All the patients' speech perception and speech intelligibility capabilities improved considerably after receiving the implants, and they were able to be placed in regular educational settings. Patients used their cochlear-implant devices whenever awake, implying that they benefitted from the devices. We suggest that any further expansion of cochlear-implantation criteria in children include those with Waardenburg syndrome.

MRI Safety in Cochlear Implantation (G4)

G4 – O1

MRI compatibility of the Digisonic SP cochlear implant

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Objectives: The aim of this study is to assess the effect of MRI on Digisonic SP cochlear implant on different aspects: torque, demagnetization, artefacts, induced voltages, and heating.

Methods: All experiments were done on a 1.5 T machine. Potential movement and magnet demagnetization of the cochlear implant was evaluated with a test bench. Induced voltages were measured on a head simulator compliant with prEN 45502–2-5. Clinical artefact study was performed with a human subject and temperature changes were measured with a temperature sensor fixed nearby the implant.

Conclusions: No significant demagnetization of the internal magnet occurred during repeated 1.5 Tesla MRI scans and no induced voltage occurred during the different MRI sequences. MRI on cochlear implanted patients, using Digisonic SP implant on 1.5 Tesla is a safe procedure. Removal of any magnet is not necessary.

G4 – O2

Magnetic resonance imaging (MRI) in patients with implanted ABI (Combi 40+) – Experience in 5 cases

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Objective: ABIs are used to restore hearing mostly in NF-2 patients. As NF-2 patients develop other central nervous system tumors, it is indispensible to perform routine follow up imaging.

Method: In 5 NF-2 patients with ABI, MRI examinations were performed. Prior to the MR examination a bandage was applied on the patient's head. The patient's head was positioned with the implant parallel to the magnetic field. For the scanning procedure we avoided sequences with either a high specific absorption rate (SAR), a short echo time (TE) and repetition time (TR) and with a high number of slices. We did not apply T2 weighted sequences.

Results: In all patients diagnostic images of the head and the spine were obtained. Good results were obtained with a conventional T1- weighted spin echo sequence for the head and spine. The posterior fossa of the operated side was distorted, with a large susceptibility artefact. After MRI examination patients were able to use their device as before. The attraction force of the coil to the magnet was not impaired and the fitting parameters of the implant were unchanged.

Conclusion: With the Combi 40+ ABI implanted it is safe and feasible to perform MRI investigations with good and useful results. There were no negative effects on patients or on the device itself.

G4 – O3

MRI safety of the MED-EL cochlear implants

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Objectives: The objective was assessing the safety of Magnetic Resonance Imaging (MRI) of patients using a MED-EL Cochlear Implant.

Methods: There are a number of fundamental issues concerning use of MRI with a CI. Interactions between the CI and excessive magnetic and electromagnetic fields can induce voltages, can lead to a temperature rise on metallic components of the implant, can generate force, torque and partial demagnetization on the implant magnet, can potentially cause unintentional stimulation, and can result in imaging artifacts.

These potentially harmful interactions were assessed in in-vitro experiments.

Results: MRI can be performed in a safe way when keeping to some guidelines. MED-EL's Cochlear Implants for pulsatile stimulation are robust against the MRI environment for field strengths up to 1.5 Tesla. Detailed results of in-vitro experiments are shown.

Conclusion: Possible safety-measures are being discussed. An update is given on practical experience with MRI.

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G4 – O4

Safety of Nucleus 24 implants with magnetic resonance imaging (MRI)

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Introduction: MRI has become one of the most important diagnostic procedures in medical practice and it is highly probable that most people would need MRI during their lifetime.

Objective: To evaluate the compatibility of the implantable part of the Nucleus-R24 with the 0.2T, 1.5T and 3.0T MRI devices.

Material and Methods: The interactions between the MRI magnetic and radio-frequency fields and the Nucleus-R24 cochlear implants were measured at field strengths of 0.2T, 1.5T and 3.0T with both the magnet removed and the magnet in place.

Results: With the magnet removed all interactions at each of the tested field strengths are acceptable according to the international standards. With the magnet in place, at 0.2T there is no risk of the magnet becoming dislodged or demagnetized. At 1.5T the use of a simple compression bandage wrapped around the implant site safely retains the magnet in place, and demagnetization is < 10 %. At 3.0T the torque produced is too severe to safely retain the magnet, and demagnetization is >90 %. Retention of the magnet increases the image artifact by approximately 60 %.

Conclusion: Nucleus-R24 implants have the option of either leaving the magnet in place for MRI scans at field strengths of 0.2T (without conditions) and 1.5T (with the use of a simple compression bandage) or alternatively removing the magnet to reduce the artifact size. At 3.0T however removal of the magnet will be required to ensure safety.

References

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G4 – O5

MRI and cochlear implant: clinical experience in more than 100 cochlear implanted patients

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The goal of this investigation was to provide evidence that MRI can be performed safely and effectively on CI patients, who require diagnosis of additional diseases.

A retrospective study was performed over 12 years. In a total of 1500 CI patients, MRI was performed whenever it was medically indicated.

More than 100 patients underwent scanning in a Philips Gyroscan MRI machine.

The patients had a wide variety of conditions necessitating MRI, including cervical discus prolapse, hypophyseal adenoma, epipharynxcarcinoma, joint degenerations, parotid tumor, kidney tumor, and preoperative evaluation for re-implantation and bilateral implantation.

No adverse effects from the MRI were reported. No dislocation or demagnetization of the cochlear implant internal receiver or technical failure was evident. All implants that were fully functioning before MRI exposure had the same function after the examination. No changes in fitting parameters or speech perception were evident in any patients. In all patients the images proved to have diagnostic value and prevented the patient from undergoing further invasive and expensive treatment.

MRI on cochlear implant patients, using the Med El Combi 40 / 40+, Med El Pulsar and Nucleus mini 22 series at 1.0 and 1.5 Tesla, can be a safe procedure. Good MRI resolution, diagnostic value, and minimal artefacts were observed at 1 and 1.5 Tesla.

We believe that this setting is safe for the patient and the implant, when diagnostic outcome and benefit are considered. Removal of any magnet is not necessary.

G4 – O6

Is Gamma Knife radiation really a contraindication?

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Surgical removal of tumors in patients with NF2 is usually the recommended treatment of choice. Saving of the auditory portion of the eigth nerve will allow cochlear implantation if needed. When the nerve is not preserved then a brainstem implant is indicated. Gamma knife surgery for NF2 is on the rise but when hearing is not preserved the wisdom has been that implantation is probably not indicated – that the nerve is affected rather than the cochlea. However, it may be that the blood supply to the cochlea is compromised but the nerve still is perfectly capable.

We present a 58 year old white male with NF2 who underwent gamma knife surgery bilaterally for his tumors. Unfortunately, he lost his hearing completely in his right ear and uses a hearing aid in the left. In promontory stimulation he had hearing in his right ear with stimulation that fluctuated in intensity. Our patient underwent subsequent implantation and is now 3 months out from activation. His results demonstrate ongoing success. At 2 months post activation his words per minute were: CI and HA auditory and speechreading 43.5, for auditory only the CI and HA was 26.5 and the CI alone was 22.5. At 3 months this has increased to 57.5, 35.5 & 35 respectively. In addition his hearing handicap inventory has increased significantly as well. Thus, cochlear implantation may have a role in gamma knife surgery and promontory stimulation may play a role in this particular instance.

Bilateral Cochlear Implantation (F5)

F5 – P1

My own case study: An audiologist with bilateral cochlear implants

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The subject and author went through different stages from normal hearing via hearing impairment to total hearing loss during his puberty and early adulthood. Having been forced to drop out from medical school due to his hearing loss, the first CI enabled him to graduate with the Masters of Science in Clinical Audiology.

Since that he was implanted with the contra lateral CI working as a clinical audiologist.

The presentation will combine professional insights with personal experience of an audiologist com patient who went over time from total deafness to bilateral implantation.

F5 – O2

Limitations on the perception of interaural time differences in electric and acoustic hearing

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Objectives: Laback et al. (2005) and Majdak et al. (2005) showed that bilateral cochlear implant (CI) listeners lateralize stimuli based on interaural time differences (ITD) in the fine structure. For the "better performing" CI listeners, the highest pulse rate showing effects of fine structure ITD was comparable to that of normal hearing (NH) subjects listening to acoustic simulations of electric stimulation. This study attempted to verify that the performance of the NH listeners was not underestimated by a potentially unfavorable choice of the center frequency of the stimulus (4590 Hz) based on the following hypothesis: if the ringing of the auditory filters limits ITD perception at higher pulse rates, the maximum pulse rate showing significant effects of ITD will increase with increasing center frequency.

Methods: Rectangularly gated pulse trains carrying ongoing ITD were band-pass filtered, simulating fine structure ITD in electric hearing. Lateralization discrimination was tested at different pulse rates (200 to 800 pulses per second) and center frequencies (4590, 6490, 9180 Hz).

Results: The maximum pulse rates showing significant effects of ITD did not vary with center frequency.

Conclusions: The auditory filters of NH listeners do not limit ITD perception for center frequencies down to 4590 Hz. Thus, the comparison between the results for the NH and CI listeners in the cited studies appears to be valid.

References

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F5 – O3

Effects of interaural time differences in fine structure and envelope on lateral discrimination

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Objectives: Bilateral cochlear implant (CI) listeners currently use stimulation strategies which encode interaural time differences (ITD) in the temporal envelope but which do not transmit ITD in the fine structure, due to the constant phase in the electrical pulse train. To determine the utility of encoding ITD in the fine structure, ITD-based lateralization was investigated with four CI listeners and four normal hearing (NH) subjects.

Methods: Lateralization discrimination was tested at different pulse rates for various combinations of independently controlled fine structure ITD and envelope ITD.

Results: Results for electrical hearing show that the fine structure ITD had the strongest impact on lateralization at lower pulse rates, with significant effects for pulse rates up to 800 pulses per second. At higher pulse rates, lateralization discrimination depended solely on the envelope ITD. Furthermore, results for CI listeners show an ambiguity in lateralization discrimination due to the periodicity of the fine structure ITD cue combined with a small sensitivity to the envelope ITD cue for large ITD values (600 μs) and higher pulse rates (>400pps). However, there were strong individual differences: the better performing CI listeners performed comparably to the NH listeners.

Conclusions: The data suggest that bilateral CI listeners benefit from transmitting fine structure ITD at lower pulse rates. A new ITD coding rule is proposed which resolves the ambiguity, giving an improved lateralization discrimination in electrical hearing.

F5 – O4

Bilateral cochlear implantation – 10 years of experience

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Objectives: With unilateral implantation the loss of binaural hearing abilities is still present, resulting in a deterioration in speech understanding in noisy environments and in a missing ability to localize sounds. We started bilateral cochlear implantation in 1996 and have bilaterally implanted 29 adults and 101 children so far. To evaluate the benefit of bilateral implantation, a series of studies has been conducted.

Methods: In adults, speech reception was measured using a set-up where speech was presented from the front and noise from either left or right. At 10 dB SNR, the average sentence score was 31.1 % higher with both CIs compared to the CI ipsilateral to the noise, and 10.7 % higher with both CIs compared to the CI contralateral to the noise. The average monosyllable score was 18.7 % higher with both CIs than with the better unilateral CI.

To assess directional hearing in adults, sound localization experiments in the frontal horizontal plane where conducted. In addition, sensitivity to interaural cues was investigated. 8 out of 9 subjects significantly showed the ability to localize sounds with a mean deviation in azimuth of 22.6°. These subjects also showed a significant sensitivity to ILD's and ITD's.

To assess the bilateral benefit in children, speech reception was measured (18 subjects) and sound localization in the frontal plane was measured (14 subjects) in a simplified set-up. At 15 dB SNR, the mean score was 18.4 % higher when listening with both CIs as compared to listening with one, the better CI only.

Results and Conclusion: From our results we conclude that bilateral cochlear implantation provides a significant benefit in speech understanding for both children and adults. Bilateral CI users seem to benefit from all binaural and monaural effects that are known from normal hearing. Head shadow effect, squelch effect and binaural summation. In addition, bilateral cochlear implantation potentially restores spatial hearing in adults and allows children to develop the ability for directional hearing.

F5 – O5

Performance with a current-steered 'virtual' channels strategy (HiRes 120) on bilateral cochlear implant recipients

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Objectives: Compare bilateral performance with a current-steered 'virtual' channels (HiRes 120) strategy to a 16-channel (HiResolution) strategy.

Methods: New recognition and localization tests developed to more closely approximate realistic listening situations as well as standard word and sentence recognition were administered to three bilateral Advanced Bionics cochlear implant recipients. New tests consisted of cued speech reception threshold, movement direction, multiple-jammer speech reception threshold, and localization in noise. Subjects were loaned Auria+ processors to use for a three-month period. Experienced 16-channel strategy (HiResolution) users were tested. Multiple baseline data were obtained in the best unilateral and bilateral conditions. Subjects were then fit with a current-steered virtual channels strategy. Testing was completed after three months of use. At the three-month interval, subjects were switched back to their original 16-channel strategy and re-evaluated.

Results: In evaluation of results with unilaterally implanted subjects, results indicate improved benefit with a current-steered virtual channels strategy. Therefore, we hypothesize that the current-steered strategy will show improvements in binaural performance over the 16-channels strategy. We also hypothesize that the tests developed to approximate more realistic testing situations will be more sensitive in detecting binaural advantages.

Conclusions: Clinical procedures that provide a more accurate assessment of real-world listening will provide a more sensitive testing paradigm for evaluating the binaural benefits of increased spectral resolution provided by a current-steered virtual channels strategy.

F5 – O6

Aspects of bilateral cochlear implantation

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Objectives: To assess the principal benefits and some limitations of bilateral cochlear implantation.

Methods: We have in the last years conducted extensive studies which demonstrated large improvements in both speech perception and sound localization, with bilateral cochlear implants (CI) in both adults and children. However, these studies also revealed some of the limitations bilateral CI users experience in comparison to normal hearing subjects. This presentation discusses some of these limitations in terms of magnitude and possible reasons.

Results: Regarding sound localization, experimental results showed that bilateral CI users show larger localization errors in the frontal horizontal plane than normal hearing subjects. Further studies revealed that these errors can be at least partly contributed to the automatic gain control (AGC), the maplaw, and differences in electrode insertion depths. In children, a particularly important aspect is the development of spatial hearing as is demonstrated by longitudinal data. Regarding speech perception, experimental results showed that bilateral CI users show a smaller head shadow effect and a smaller squelch effect than normal hearing subjects. Further studies revealed that at least the smaller HS effect can be partly attributed to bilateral CI users lacking the pinna as in a CI system today the microphone is normally located above the pinna. Tests in children showed similar bilateral benefits as in adults.

Conclusions: Despite of some limitations experienced by users of bilateral cochlear implants, bilateral cochlear implan-

tation is on average successful in improving speech perception and restoring spatial hearing.

F5 – O7

Comparison of bilateral versus monaural pediatric cochlear implantation

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From 1996 until 2006 at the Vienna ENT University department 50 children underwent simultaneous or sequential bilateral cochlear implantation. In the same time period 160 other children were implanted unilateral only. Aim of this study was to find out, if bilateral cochlear implantation is a benefit for the children, compared to monaural implanted children in terms of pure tone thresholds, speech understanding scores, hearing in quiet and noise, listening skills, development of speech, speech production, social behaviour, type of school education, school results and acceptance of parents and childrens environment.

Although the study group of 210 children is inhomogeneous results in therapy, listening skills and school environment show a difference.

In some categories, like school type, bilateral paediatric cochlear implantation gives a significant higher chance for a child to attend mainstream school successfully.

Beside the pure audiological testing, which has already proven the bilateral benefits of squelch effect, summation effect and directional hearing , even in smaller children, all other benefits of bilateral hearing (f.e. ease and speed of communication) are present in a bilateral paediatric cochlear implant population.

Concerning to our data unilateral paediatric cochlear implantation in bilaterally deaf children, shows analogue to unilateral hearing aid support in bilateral hearing impaired children, a poorer outcome than bilateral cochlear implantation or bilateral hearing aid support.

As a result we suggest bilateral cochlear implantation whenever indicated (no residual hearing) and possible.

F5 – O8

Benefits of early versus late bilateral cochlear implantation in children

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Objectives: A longitudinal multi-centre study with 42 bilaterally implanted children was started to quantify the additional benefits of the second implant. In this presentation we will report on the children's speech perception abilities, language development and subjective benefits in order to determine the extent to which age of implantation affects their communicative abilities.

Methods: Age-appropriate language tests and CVC-word lists (in quiet and noise) were presented to 35 bilaterally implanted children (5 to 14y). In addition, communicative abilities, type of school and subjective reports were collected by means of an open-ended, the SSQ and the Würzburger questionnaires.

Results: Pre-implantation results and those at 24 months after the activation of the second implant clearly show that bilateral cochlear implantation improves all of the children's communicative abilities in complex listening situations. Scores of speech-in-noise tests appear significantly better with two implants. Normal language skills were documented in 70 % of children who underwent implantation within 2 years of onset of deafness. The Würzburger and SSQ questionnaires also indicate a higher total score for all children, but the average increase is significantly smaller for the older children. This also applies to the CAP scores, the educational situation and mode of communication.

Conclusions: Results of all administered tests and questionnaires indicate that all children benefit from bilateral implantation. A closer look at the data reveals a greater evolution in the children who received the second implant before the age of 6. Only a small progress is determined in the older implanted children.

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F5 – O9

Sound localization and lateralization in NH and bilateral CI children

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Objectives: To measure binaural hearing capacities in bilaterally implanted children, procedures for testing sound localization and lateralization were adapted to the mental level of pre-school children. These modified procedures were evaluated with a large group of normal-hearing children, before being administered to several bilaterally implanted children.

Methods: Fifty seven normal-hearing (4–10 yrs.) and several implanted children lateralized a 160Hz clicktrain on the basis of interaural time differences (ITDs). An adaptive 2AFC procedure leaded to the minimal audible ITD. Stimuli were routed to headphones or to the audio input of the CI processors.

Nineteen normal-hearing (4 yrs.) and several implanted children localized a telephone signal presented through one of 9 loudspeakers positioned in the frontal horizontal plane.

Pictures and play stories were designed to make tests more childfriendly.

Results: Lateralization: the minimal audible ITD was in the order of 20–30 µs for normal-hearing children between 5 and 10 years of age and 313 µs (SD 373 µs) for the 4 years old.

Localization: the mean RMS error of the 4 years old was 13° (SD 8°). Data of the implanted children have not been completed yet.

Conclusions: Lateralization and localization experiments with normal-hearing children indicated the presence of binaural hearing capacities at a very young age. From the age of 5 children performed close to adult norms. Worse results for the 4 years old are probably attributable to the task difficulty and a shorter attention span. First results of bilaterally implanted children will be available at the time of the conference.

F5 – O10

Progress report of a 5-year multi-center study on bilateral implantation in young children

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Objectives: The primary objective of this investigation is to evaluate longitudinal efficacy in young children implanted bilaterally with MED-EL COMBI 40+ / PULSARCI^{100} cochlear implant systems as compared to young children implanted unilaterally with one MED-EL COMBI 40+ / PULSARCI^{100} cochlear implant system.

Methods: Bilateral implantation is performed using a single-stage procedure or, alternatively, a two-stage procedure with the second implantation occurring within 2–8 weeks of the first. Speech perception, speech production, and language acquisition are measured over a 5-year period in children who receive bilateral (n = 35) or unilateral (n = 60) cochlear implants between the ages of 12 and 36 months. Unilateral subjects are also followed for HA use in the contralateral ear when applicable. Subjects move through the testing sequence based on performance on individual tests. Localization and speech perception in noise will also be evaluated at one test interval.

Results and Conclusions: To date, over 20 subjects have been enrolled in the study, with the first subject now reaching the two-year test interval. Initial results for the current subject population will be presented, as well as programming issues, investigator observations and overall study experience.

F5 – O11

Results of bilateral cochlear implantation in children

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In the recent years cochlear implantation has been proven to be an effective treatment of children with acquired or congenital deafness. To avoid acoustic deprivation an efficient treatment should start as early as possible. The performance of the implanted patients could be improved by further development of new devices. An additional option for further improvements in cochlear implant users is bilateral implantation, due to the fact that binaural hearing is necessary for good speech understanding in noise. For adults we could demonstrate the benefit of bilateral implant use in previous studies.

To evaluate the effects of bilateral cochlear implantation also in children we present the following study. At our center 31 patients got bilateral cochlear implants so far, 22 children and 9 adults. All of them use Med-el Combi-40, Combi-40+ and Pulsar 100^{CI} devices. The implanted children underwent different speech tests adapted to their different step of speech and language development. The older and more experienced children were tested in a set up with speech and noise presented from the front. In addition we did lateralization and sound localization testing in these children.

All children show clear benefit of the additional implant. They all show at least sound lateralization and some of them sound localization. In speech tests in quite and especially in noise a clear benefit of the second implant could be demonstrated.

F5 – O12

Complications of simultaneous versus sequential bilateral cochlear implantation in children

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Objectives: To compare complication rates between simultaneous and sequential bilateral cochlear implantation in children.

Methods: Retrospective cohort.

Results: Twenty-eight children underwent bilateral cochlear implantation: 22 children (78.6 %) had sequential devices and 6 (21.4 %) had simultaneous. Mean length of follow-up was 5.6 years for sequential group and 1.1 years for simultaneous group. In the sequential group, the mean age at first implantation was 3.0 years and 6.8 at the second. Intra-operatively, 2 patients (9 %) had unilateral cerebrospinal fluid fistulae. Post-operative complications included one case of meningitis in a patient with a Clarion C2 device with positioner placed three years prior. Other post-operative complications in this group included transient balance problems after second implant placement in 3 patients (13.6 %), new onset of migraine headache in one patient (4.5 %), and re-implantation in one patient (4.5 %) who sustained a head trauma and fractured the receiver of the device. In the simultaneous group, the mean age was 1.0 year. No intra-operative or post-operative complications ensued in this group, except for small bilateral seromas in one child.

Conclusions: Complication rates of simultaneous bilateral cochlear implantation are comparable with those of sequential bilateral cochlear implantation.

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F5 – O13

Development of binaural hearing in sequentially bilaterally implanted subjects

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Objectives: Unilaterally implanted cochlear implant (CI) users only can roughly estimate the direction of sound sources when they have learned how to use the different timbre of sounds depending on the sound incident angle. When they get the second implant on the other side they have to learn to use interaural cues for localization. Up to now it is unknown how fast and to what extent the ability to localize develops after second implantation and by which factors this process is governed.

Methods: We developed an easy to use localization test to investigate localization skills in the frontal horizontal plane. Speech stimuli from five sound sources separated by 45° each have to be localized by pointing. Presentation of stimuli is repeated in each direction four times in a random order. Evaluation parameters are the number of total correct responses, the mean response direction and the variance of responses for each direction. Sequentially bilaterally implanted CI users were examined repeatedly in increasing time intervals.

Results: As it is an ongoing study with long term observation preliminary results of up to now five adults and five children will be reported and discussed with respect to patient inherent factors.

Conclusions: Based on the results of this study and in combination with results from perception tasks of speech in noise it is planned to derive prognostic factors of binaural hearing ability and finally of the potential benefit of bilateral implantation in the individual case.

F5 – O14

Advantages of two in-the-ear microphones in bilateral implantees

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Objectives: To study in bilateral implanted adults the advantages of the anatomical shape and position of both auricles on directional hearing and on speech understanding in noise.

Methods: Speech intelligibility in noise and minimal audible angle (MAA) have been tested in bilaterally implanted adults with Combi 40+ or Pulsar 100 cochlear implants. Custom made omni directional microphones were compared in the regular frontal position of the Tempo plus speech processor to the in-the-ear microphone position in the ear canal. Spatial discrimination was tested in free-field experiments using a rotating loudspeaker where the blinded subject was asked to indicate the direction of the sound source. Speech intelligibility was assessed by the German Oldenburg sentences (OLSA) in noise at varied levels.

Results: In-the-ear microphone experiments showed significantly better spatial discrimination on the side of the first implanted ear and a slight improvement on sound localization in front and back of the subjects as compared to regular position. MAA ranged between 7 degrees and not localizable. Speech intelligibility in noise – as a particularly difficult task – showed lower thresholds only in a few individuals in the in-the-ear microphone experiments.

Conclusions: Advantages of the anatomical shape of auricles tested in bilateral cochlear implant subjects with in-the-ear microphone position improves spatial discrimination for sound localization on the left and right side, while speech intelligibility in noise is not much influenced.

F5 – O15

New protocol for speech recognition with bilateral implantation

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Objectives: The primary objective of this study was to assess the sensitivity of speech recognition measures and test conditions in the evaluation of benefit from bilateral cochlear implantation. More specifically, to identify clinically useful measures that reflect more real-life listening conditions.

Methods: Bilaterally implanted adults were assessed using speech recognition measures that compared the following: soft (50 dB SPL) and normal (60 dB SPL) stimulus presentation levels, multiple talkers and rates, and speech spectrum noise and 4-talker babble using either a fixed signal-to-noise ratio or an adaptive procedure. Subjects were tested with each implant alone and in the bilateral condition.

Results: Subjects demonstrated benefit 1) in the bilateral compared to the poorer ear unilateral condition for most measures and 2) in the bilateral compared to the better ear unilateral condition for at least one measure. Particular measures were more sensitive to bilateral benefit than others. Specifically, test stimuli that included varied talkers, rates, and accents (TIMIT) were more sensitive compared to stimuli presented with a single talker and rate (HINT). Testing in the presence of background noise, particularly 4-talker babble with an adaptive procedure, was the most sensitive measure in noise.

Conclusions: Although bilaterally implanted recipients indicate a strong preference for bilateral compared to unilateral listening, commonly used speech recognition test procedures may not document bilateral improvements. Inclusion of measures (e. g., multiple talkers and more challenging sentence material) and conditions (e. g., softer presentation levels and background noise) that reflect more real-life listening are needed.

Implantable Hearing Aids (F6)

F6 – O1

The bionic middle ear for the failures of ossiculoplasty

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Objectives: The present criteria for Vibrant Soundbridge (VBS) limit its application to patients with sensory-neural hearing loss (SNHL) and normal middle ear function.

With the VBS onto the RW, the indications have been extended to include patients with ossicular chain defects. With this approach the classic cochlear stimulation mechanism is inverted, i.e. from the RW to the OW.

Methods: Eleven patients aged 24–74 years with severe mixed HL for previously middle ear reconstructive surgeries were operated on with the new approach onto the RW.

Results: Short term test results from these patients indicate dramatic improvements in pure tone threshold and speech understanding with outcomes very similar to stapes surgery. The sum of the mean PTA (0,5–4 kHz) was 75.61 (SD=+/-4.2) pre-operatively and 21.67 (SD=+/-6.9) dBHL 11 months post-operatively ($p < 0.01$). The sum of mean percentage of bi-syllabic words was 5.5 (SD=+/-3.5) before surgery and 89.7 (SD=+/-9.1) 11 months post-operation ($p < 0.01$). No short term complications have been observed so far.

Conclusions: The outcomes of the present paper indicate that a magnet implanted on the RW can be used to mechanically stimulate the cochlea much as sound input at the middle ear does and this energy input mechanism functionally transmits vibrational energy to the cochlea with a frequency response equal, or even better than, the energy delivered acoustically to the middle ear. The functional gains as verified with pure tone and speech audiometry are clearly beyond what we have obtained from traditional middle ear recontructive surgery.

F6 – O2

Middle ear implantable hearing device concepts and implementations

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Objective: This presentation will review the current state of implantable hearing aids including an overview of basic principles and technologies behind these devices, a summary of advantages and disadvantages of their application and discussion of alternative placements on the stapes footplate and round window.

Background: Middle ear implantable hearing devices (MEIHDs) have emerged as a viable means to overcoming many problems inherent to conventional hearing aid designs such as acoustic feedback and sound distortion. Recent research studies and clinical applications also support the ability of these devices to provide rehabilitation alternatives for problem mix losses and middle ear pathologies. Generally, the advantage of the MEIHD comes from the implantation of a piezoelectric, electromagnetic or electromagnetically-based vibrational transducer that directly vibrates structures of the middle and inner ear.

Conclusions: Replacement of the traditional acoustic transduction mechanism common to conventional hearing amplification devices eliminates the problem of acoustic feedback, removes the necessity for a tight fitting ear mold. Problems of feedback control, acoustic distortion and long-term comfort are minimized, if not, eliminated. Use of alternative transduction also may provide unique opportunities arise with regard to signal and noise processing.

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F6 – O3

A round window implantable hearing device using a floating mass transducer

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Objective: This study investigates placement of an implantable hearing device vibrational transducer on the cochlear round window membrane in human temporal bone. Results from this work provide the theoretical validity for clinical use of this approach.

Methods: Ten fresh frozen human temporal bones were implanted with floating mass transducers (FMT; Vibrant Med-El, Innsbruck, Austria). These bones were tested in three stages of implantation: (a) un-implanted, (b) implanted with a standard incus FMT placement (I-FMT), (c) implanted with an FMT placed on the round window membrane (RW-FMT). Derived measurement of induced displacement provided objective measurement of the vibratory input to cochlea and throughout the middle ear.

Results: Displacement of the cochlear fluid is achieved using a FMT applied to the round window membrane. Data indicate that for a similar electric signal to the transducer, the RW-FMT provides 10–15 dB greater linear displacement than the I-FMT.

Conclusions: The round window membrane provides an alternative pathway for introducing vibrational energy into the cochlea. This approach may have advantages over ossicular device placements specifically in cases of chronic conductive and mixed hearing losses. Continuing studies in patients will provide greater insight into perceived loudness differences between these two methods of cochlear stimulation and help define surgical technique and clinical applicability of the round window approach.

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F6 – O4

Fully implantable microphone – a piezoelectric sensor in the middle ear

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Objectives: For future generations of fully or partially implantable cochlear implants and hearing aid systems, there is a great demand for implantable microphones.

Methods: An implantable microphone consisting of a piezoelectric sensor for ossicular vibrations of the middle ear is presented. The basic idea of the approach is to incorporate the normal middle ear function into the implantable microphone and to make use of the middle ear and outer ear transfer characteristics. The tympanic membrane serves as a natural microphone membrane that transfers the sound signal into structural vibrations of the ossicular chain. These vibrations are picked up by a piezoelectric sensor at the long process of the incus.

Results: The discussed microphone has a flat frequency response in the typical frequency range of hearing aids with a sufficient sensitivity. Numerical simulations are compared with experiments performed on human cadaveric temporal bone preparations comprising an experimental prototype of the piezoelectric sensor. The process of mathematical model building affecting the sensor design is discussed.

Conclusions: The discussed design is a feasible approach for an implantable microphone of a fully or partially implantable cochlear implant or hearing aid system.

F6 – O5

Concept of a passive / active prosthesis for a social hearing in the chronically disabled middle ear

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In many patients with chronic middle ear diseases, like recurrent cholesteatoma, persistent tube dysfunction etc., modern surgical techniques often result in an elimination of disease with a dry, small radical cavity, but even repetitive tympanoplasty cannot restore a social hearing. Many of these patients depend on hearing aids due to a persistent air-bone gap.

Implantable hearing aids promise a new alternative for these patients. Contrary to SNHL-patients with their concern on ear-surgery, this group of patients often agrees to the proposal of a tympanoplasty for an improved hearing, due to their experience with previous surgeries. Furthermore, their normal inner-ear function promises a nearly normal aided hearing.

The idea of a composite middle ear implant, which acts as a passive prosthesis in cases of adequate air conduction, but which will stimulate the cochlea by an active vibration in case of a chronically disabled middle ear, is obvious. Yet previous concepts had to be disregarded due to technical reasons. We designed a new type of implant, which integrates the reliable Vibrant Soundbridge transducer in a titanium holder for a TORP-reconstruction. Our concept promises a surgically easy procedure similar to normal tympanoplasty without potentially inflicting cochlea damage by additional surgical manipulations. Temporal bone experiments have confirmed the acoustical efficiency of this composite columellar implant.

F6 – O6

History, present and future of the floating mass transducer design

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Objectives: The goal of implantable hear device design is to develop and deliver systems that offer positive clinical utility while at the same time solve the human factors and performance needs of patients. The Med-El Vibrant Soundbridge middle ear hearing implant has proven to be an effective alternate treatment modality for patients suffering from mild to moderate sensorineural hearing loss.

Methods: The design inputs and system requirements were evaluated and resulted in several patented design iterations. The design inputs and system and bench test results correlate well with clinical trial results. New systems are being developed with the same process of bench testing, clinical evaluation and device approval. ASTM standards now in place validate the design approach.

Results: Several FMT design applications are now approved in many countries for human use. New design iterations are in formal clinical investigations. Variations of the design have allowed the expansion into new treatment applications. Future designs shall expand the indication range even further.

Conclusion: The FMT has been a proven effective design in several treatment applications for patients with hearing loss. It has had extremely good reliability and now forms the platform basis for a new class of otologic treatment options. The design history and how it was arrived at offers an insightful approach to device design from both engineering and medical treatment perspectives. The future platform designs leverage the results and could offer the field and patients new options for hearing treatment previously not realized.

F6 – O7

The transfer function of the Vibrant® Soundbridge® on the non ventilated middle ear

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Objectives: The Vibrant® Soundbridge® (VSB) is an implantable hearing aid designed for the normal and healthy middle ear. It is intented to treat sensorineural hearing loss. In the classical way the device is fixed onto the incus process of an intact ossicular chain. The aim of the study was to investigate the sound transfer of the VSB when the device is directly coupled to footplate in cases of destroyed ossicular chain and poore middle ear ventilation.

Methods: The sound transfer function of the middle ear was measured on fresh temporal bone specimens. After disruption of the stapes crura by CO_2-Laser the VSB was directly placed at the footplate. The device was covered by cartilage and the middle ear cavity was filled with ultrasasonic gel. After stimulation of the VSB the footplate vibration was measured by Laser-Doppler vibrometry.

Results: After directly coupling of the VSB to the footplate the measured transfer function was better than after coupling to the long incus process. After complete filling the middle ear with gel the sound transfer was reduced only about 10 dB.

Conclusions: The VSB seems to be not only useful in cases of intact ossicular chain and ventilated middle ear. The direct coupling on the footplate is possible and can lead to good hearing results also in cases of non ventilated middle ears like after radical mastoidectomy.

F6 – O8

Minimal access surgery for the Vibrant middle ear hearing implant

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Objective: To develop a minimal access approach to the implantation of the Vibrant Med-El implantable middle ear hearing device. This approach ideally employs the smallest skin incision possible, minimal hair shave, and the least possible amount of tissue and bone manipulation. This will facilitate the acceptability of the procedure to the general community and reduce the flap-related complication rate of the procedure. The procedure is similar to the minimal access approach previously described for cochlear implantation by O'Donoghue and Nikolopous.

Methods: Nine Vibrant Med-El devices were implanted in nine patients over a 42 month period. The first two patients underwent the traditional implant procedure with postauricular hair shave, postauricular S-shaped incision, and implant receiver suture fixation to the temporal bone. The following seven consecutive patients received a progressively smaller linear postauricular skin incision, no hair shave, retrograde skull drilling for the implant seat, and no implant suture fixation until the technique closely approximated the minimal access cochlear implant procedure. Postoperative performance of the Vibrant Med-El® was evaluated through acoustic testing and subjective patient reports.

Results: The Vibrant Med-El can safely be implanted using the minimal access method through a 5 cm skin incision. There were no complications related to the minimal access technique. Implant performance was similar regardless of approach.

Conclusion: This is the first description of a minimally access technique for implantation of the Vibrant Med-El® Middle Ear Hearing Implant. This technique may make the device more accessible to individuals who have concerns regarding cosmetics and potential flap complications.

F6 – O9

Alternative transmeatal approach for Vibrant® Soundbridge® middle ear implantation without posterior tympanotomy

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Objectives: To propose an alternative transmeatal approach in Vibrant® Soundbridge® implantation, less invasive than the regular approach by posterior tympanotomy, for patients without external auditory meatus (EAM) diseases.

Methods: The modified surgical implantation consists of:
- a limited retroauricular incision
- an open bony bridge for demodulator fixation on the mastoid
- a limited mastoidectomy without posterior tympanotomy
- the elevation of the skin of the EAM and the annulus
- the opening of a bony slot through the posterior wall of the EAM.

The implant is fitted into the bony bed The conductor link drops naturally into the mastoid. Therefore, it is easy to guide the link through the open slot and to put the FMT into the middle ear. After fixation of FMT on incus, the bony slot is rebuilt with bone paté. The tympano-meatal flap is then put back in place.

Results: No complication occured in twenty-five first patients. Audiometric and subjective results were similar to traditional approach.

Conclusion: The transmeatal approach appears as a safe technique, without danger to neither the facial nerve or chorda tympani, nor risk of extrusion since the conductor link is stored in the mastoid. The FMT fixation appears to be easier with a wider incus exposure. This simplified approach without posterior tympanotomy providing a fast and simple implantation, may lead to a larger diffusion of Vibrant® Soundbridge® implantation in outpatient procedure. It has been already chosen as routine procedure by the authors for patients without EAM pathologies.

F6 – O10

VSB middle ear implant for rehabilitation of high frequency hearing loss

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Objectives: Patients presenting high frequency hearing loss but only mild hearing loss in the low frequencies suffer from problems associated with conventional hearing aids, such as occlusion of the ear canal and feedback. For this group of patients the Vibrant Soundbridge (VSB) offers advantages, since the ear canal remains open and amplification can be provided across a broad frequency spectrum up to 8000 Hz without risk of feedback.

Methods: The VSB was surgically implanted in 30 ears (bilateral implantation in 3 patients), and the Floating Mass Transducer was clipped onto the long process of the incus.

Main outcome measures were pure tone audiometry, speech audiometry in quiet and in noise.

Results: Residual hearing was preserved in all cases. Functional hearing gain was in proportional representation to the individual hearing losses, and was remarkably high in the high frequencies up to 8000 Hz.

High frequency hearing loss was defined as a slope 25dB or more within one octave in the subgroup of patients with high frequency hearing loss. As expected, these patients needed only little gain in the low frequencies, but audio-processors were adjusted for great amplification up to 65 dB functional gain in the high frequencies at a comfortable level. Speech recognition scores in quiet and in noise were significantly higher with the implant as compared to the unaided situation.

Conclusions: The VSB Middle Ear Implant has shown to be powerful especially in the high frequencies. It offers a new solution for rehabilitation for high frequency hearing loss.

F6 – O11

The middle ear implant Vibrant Soundbridge® used as an open ear solution for SNHL – experience from the German military Hospital Ulm

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The Vibrant Soundbridge is an active semi-implantable middle ear implant for the rehabilitation of patients with a sensorineural hearing loss who are not able to derive adequate benefit from conventional hearing aids for different reasons. The Vibrant Soundbridge (VSB) was the first device to be used routinely after commercial release in February 1998 in Europe and August 2000 in the United States.

28 Patients were implanted in the last 3 years in the ORL-HNS-Department of the BWK Ulm. No clinically significant change was observed for residual hearing postoperatively. All patients reported they were either satisfied or very satisfied with the Vibrant Soundbridge.

The results indicate a high level of satisfaction with the VSB as a treatment of sensorineural hearing impairment in patients with a wide range of characteristics. In conclusion, the Vibrant Soundbridge is a suitable treatment option offering advantages over conventional open fit hearing devices in moderately to severe SNHL by providing more amplification to the hearing-impaired person with a high-frequency hearing loss.

F6 – O12

Bilateral Vibrant® Soundbridge® implantation: audiological benefits in noisy environments

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Objective: To evaluate the benefits of bilateral Vibrant Soundbridge (VSB) implantation on gain, speech in quiet and speech in noise, compared to unilateral implantation.

Methods:

- prospective study with intra-patient comparison between unilateral and bilateral implants results.

- seven otological and otoneurological tertiary university referral centres.

- Fifteen patients (9 females, 6 males) who underwent bilateral Vibrant Soundbridge implantation from 1998 to 2005, with a minimum 6 months follow-up after the second implantation. Ten patients used to wear hearing aids (5 bilateral, 5 unilateral), and 5 pts had at least tried HA before the first implantation. Minimal 12 months follow-up after the first implantation with trial of controlateral HA was required before decision of the second implantation.

- Main outcome measures: postoperative follow-up. Audiological tests focused on gain, speech in quiet, and speech in noise (Garin and Galle test), in four conditions (unaided, right implant, left implant, two implants). Subjective assessment with questionnaires.

Results: All patients wear and use both their implants. The mean gain with 2 VSB in free field is 25 dB (13 dB at 500 Hz- 36 dB at 4 Khz). Garin-Galle tests demonstrate an improvement of 12 % of speech intelligibility with an –5dB S/N ratio. Questionnaires show significant improvement of vocal discrimination in noisy conditions with several speakers especially in noise and a better sound localization.

Conclusions: Speech intelligibility in noise is improved in bilaterally Vibrant Soundbridge implanted patients, compared to unilateral VSB, without significant benefit in quiet conditions. Questionnaires demonstrate subjective improvement in noisy conditions and during conversations with several speakers.

F6 – O13

A novel implantable hearing system with direct acoustical cochlear stimulation: DACS

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Objectives: For effective correction of combined severe hearing loss, an innovative implantable hearing system DACS directly coupled to the inner ear fluid on the principle of a power-driven stapes prosthesis has been developed.

Description of the DACS: The DACS consists an implantable electromagnetic transducer and an externally worn audio processor. The transducer which drives a tiny rod is implanted behind the ear using a specially developed retromeatal microsurgical procedure in order to position the rod next to the incus in the free space of the tympanic cavity. After removal of the stapes, an off-the-shelf stapes prosthesis is crimped to the rod of the transducer and placed in the open window to allow acoustical coupling to the liquid of the inner ear. To reconstruct the natural sound transmission by the ossicular chain, a second stapes prosthesis is placed in parallel to the first one into the oval window and attached to the incus as performed in conventional stapedectomy. The oval window with the two stapes prostheses is sealed with adipose tissue.

Results: The DACS system was implanted first in temporal bones and then in isolated human heads. Measurements with Laser Doppler showed an equivalent sound pressure amplification of 130 dB SBL (125 dB broadband) applied to the inner ear fluid. Finally, the DACS system was implanted in 3 adult patients with severe mixed hearing loss due to far-advanced otosclerosis with preoperative hearing thresholds (mean 0.5, 1, 2, 4 kHz) of 101, 95, and 77 dB in Bern and then in a fourth additional patient in Hanover. Surgery with stapedectomy and postoperative recovery was uneventful. Audiological testing after 3 to 6 months show hearing gains of 44, 65 and 53 dB for the activated DACS in the 4 patients. Even without DACS activation, all have improved hearing due to stapedectomy. All patients indicate substantial improvements compared to the preoperative situation with conventional hearing aids.

F6 – O14

Implantation of a titanium tube in the outer ear and possibilities of its use for implantable hearing devices

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To overcome physical and acoustical occlusion, to preserve all outer ear effects, to minimize feedback and the multiple resonances of the silicon tube of a conventional hearing device a new way of sound conduction was developed for an implantable hearing system [1–3].

A titanium tube will be implanted in the lateral part of the outer ear. It can be connected to a hearing processor as well as to a microphone, which picks up the sound from the outer ear canal. The signal of the latter solution can be transported ipsilateral or contralateral to a conventional or implanted hearing system.

With the implanted titanium tube a semi implantable hearing system can be realized, which is mostly suited for a high frequency hearing loss. Furthermore the sound can be directly picked up from the ear canal and transferred to other locations e. g. the contralateral ear or an ipsilateral or contralateral implanted hearing device.

With the implanted tube different types of hearing solutions can be realized, minimizing the problems which are mentioned in the objectives above.

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F6 – O15

Audiological results with the semi-implantable hearing aid system RetroX

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Objectives: A disadvantage of conventional hearing aids is the partial or complete occlusion of the ear with an ear mould of BTE or the shell of ITE hearing aids. This often leads to discomfort and refusal of the aid. The semi-implantable transcutaneous air conduction hearing aid system RetroX provides an alternative treatment modality for patients suffering from mild to moderate high-frequency sensorineural hearing loss. The new sound induction procedure remains the ear canal open and therefore solves the key problems: the occlusion effect and the damping of lower frequencies.

Methods: The subjects are implanted under local anaesthetics in an outpatient procedure, and, after a wound healing phase of around four weeks, receive the hearing module in order to provide individualized compensation for their hearing loss.

The RetroX system has been under evaluation in different studies monitoring the objective and subjective characteristics using adaptive speech tests in quiet and in noise, localization tests and questionnaires e. g. the International Outcome Inventory for Hearing Aids (IOI-HA).

Results: The results are very promising, even in comparison to conventional hearing aids, and the patients consistently report their contentment with the open ear fitting and the natural sound quality.

Conclusions: This transcutaneous air conduction hearing aid system provides an alternative to conventional hearing aids. The open ear canal avoids any acoustical and physical

occlusion and ensures, that the ear canal resonance is preserved and a natural quality of sound perceived.

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F6 – O16

Reaction of retroauricular tissue after titanium tube-implantation

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Objectives: With respect to implanting titanium tubes for a transcutaneous air conduction hearing aid system (TACHAS) this study aims at the histological reaction between the retroauricular soft tissue and the titanium surface.

Methods: Optical devices: Transmission electron microscopy (Philips CM 10), Light microscopy, Scanning electron microscopy (CAMSCAN 24).

Tissue sampling: For the histology both native retroauricular tissue and tissue of a 15 months old blend implantation channel were used, taken from the entrance, the inner exit and the intermediate region of the channel. Additionally, 15 months persisting tubes as well as new ones were studied in the SEM.

Results: The histology of the native tissue varies with respect of the location in a small range and the epithelium is more or less similar to the common skin. All the biopsies of the 15 month persisting channel showed a complete epithelialization and weak keratinisation. A very remarkable result is the ability of the tissue being in contact with the titanium tube to degrade the superficial keratinized layers to a liquid substance.

Conclusions: The degradation of the superficial generations of the keratinizing cells corresponds to the clinical observations in lacking of any problems during the current long-term TACHAS-implantations.

Implantable Hearing Aids II (F7)

F7 – O1

Clinical results: 8 years experience in monaural and bilateral Vibrant Soundbridge implantation

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Since 1996, about 2150 Vibrant Soundbridge (since april 2003, Medical Electronics, Innsbruck, Austria) implantable hearing devices have been implanted worldwide.

In Vienna since 1998, 52 devices have been implanted into 48 patients. Four patients are implanted bilaterally.

Surgical procedures and postoperative follow up (up to 8 years postoperative) are uneventful. All implanted devices are still in full function. One technical failure after four years of full function was replaced through a new Vibrant Soundbridge device. This single revision surgery was uneventfull, the patient had the same good hearing parameters and positive soundbridge effects after revision surgery. 88 % of the implantees are full users all over the day and are according to the APHAB-questionaires, happy, or very happy device users. Speech understanding and hearing performance are superior, compared to the preoperative hearing aid setting. In four patients we could not find an enhanced speech understanding, compared to prior hearing aid setting. In bilateral implantation we see synergistic effects, like in bilateral healthy listeners, or bilateral hearing aid , or cochlear implantation. We report about the current status of vibrant soundbridge technology.

F7 – O2

Middle-ear implant transducer results of the coupling of the floating mass transducer (FMT) to the round window in patients with mixed hearing loss – Surgical technique and performance results

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Introduction: The middle ear implant Vibrant Soundbridge (VSB) consists of an electro-mechanical floating mass transducer (FMT) which is typically attached to the long process of the incus via a titanium clip. The VSB is an effective method to treat hearing in patients with sensorineural hearing loss in patients who cannot benefit from conventional hearing aids. To date, patients with mixed hearing loss have not been considered candidates for the VSB.

Objectives: The objective is to evaluate VSB implantation in patients with mixed hearing loss by positioning the FMT in contact with the round window membrane.

Methods: The round window niche was exposed by drilling a bed of the size of the FMT. The round window was protected by patient's fascia. The FMT was positioned in close contact to the round window membrane. Connective tissue was applied over the FMT.

The performance of the patient was evaluated with standard audiological evaluation methods.

Results: Standard audiological tests which evaluate speech performance and functional gain show a dramatically improvement from the unaided situation to the aided situation.

Conclusions: The round window surgical approach used to apply the VSB in close contact to the round window is a new treatment option for patients with severe mixed hearing loss.

F7 – O3

Auditory rehabilitation with the Vibrant Soundbridge by oval window stimulation after subtotal petrosectomy

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Introduction: The tympanomastoid exenteration with obliteration of the mastoid cavity and exclusion of the external meatus has regained new interest in our department for two reasons.

Firstly because hearing rehabilitation is possible today in most cases and this thanks to developments in implantable hearing aids: by a CI for profound or total sensorineural hearing loss, by a middle ear implant for moderate hearing losses and by a BAHA for pure conductive losses as well as for single sided deafnesses.

Secondly because postoperative follow-up of the obliterated cavities is nowadays possible by serial MRI using new sequences that can reliably detect enclosed epithelial pearls or residual cholesteatoma.

Material and Methods: Amongst 29 consecutive subtotal petrosectomy operations for severe COM : five patients received a CI, five received a BAHA and two a middle ear implant (Vibrant Soundbridge). This paper focuses on the latter two patients operated in two stages, presenting no ossicular chain and where the floating mass transducer was fixed onto the stapes remnant presenting sound vibrations directly at the level of the oval window. The preoperative and postoperative audiograms will be presented. Audiometric selection criteria of the different implantable hearing aids after subtotal petrosectomy cases will be presented.

Results and Conclusions: The advantages of the technique are the elimination of the disease process in the first stage and in the second stage the hearing rehabilitation with preservation of the natural pathway of sound input. Long term effects of this new way of stimulation have to be further awaited for.

F7 – O4

Vibrant Soundbridge middle ear implant : Vibroplasty techniques in mixed hearing losses

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Objectives: Up to now, conventional hearing aids, bone anchored hearing aid (BAHA) and/or middle ear reconstructive surgery were the only options for patients with mixed hearing loss.

The Vibrant Soundbridge (VSB) middle ear implant is classically indicated in mild to severe sensorineural hearing loss. Preliminary works have shown the possibility of using the VSB in mixed hearing loss. We present here the results of 3 patients with a mixed hearing loss, implanted with a VSB.

Methods: For all these patients, the surgery combined classic middle ear reconstructive surgery with VSB implantation. This surgical method can be described as "Vibroplasty".

One vibroplasty indication is primary otosclerosis: two approaches, depending on the airbone gap size, are possible.

Out of the three patients, one case presenting an important airbone gap (> 30 dB) was implanted combining a piston prosthesis with the VSB (FMT crimped on the incus over the piston). Another case presenting a small airbone gap (< 20 dB) was implanted with the VSB alone, leaving the stapes intact.

The third case consisted of a malformation of the ossicular chain (incudo-stapedial dysjunction). The surgical method included incus transposition and FMT placement on the incus used as a PORP.

Results: All patients are getting significant benefit showing that the VSB is not only able to treat the sensorineural component of the hearing loss but also to bypass the conductive component.

Conclusion: In this presentation, limits and long term outcomes and risks of vibroplasty will be discussed. Alternative approaches such as round window direct acoustic stimulation or implantation on stapes have been suggested and could offer new treatments in mixed hearing loss.

F7 – O5

Alternative clinical indications for the VSB: the experience of the clinic in Meran

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Introduction: The Vibrant Soundbridge (VSB) is a middle ear implant already CE marked as a treatment for patients with sensorineural hearing loss, who cannot benefit from conventional hearing aids. Recently patients with mixed hearing loss have also been considered candidates for the VSB.

Objectives: The objective is to evaluate VSB implantation in patients with mixed hearing losses of different aetiologies.

Methods: The surgical technique was adapted to the different conditions of the middle ear. The best positioning of the FMT was evaluated on the bases of the aetiology in order to achieve best performance results for the patients.

Results: All patients were tested following a standard evaluation protocol. The preliminary results are described and discussed for each single case.

Conclusions: The possibility of new surgical approaches in concert with the VSB could extend the indications of the middle ear device to mixed hearing losses. It is necessary to collect further experience to prove efficacy and effectiveness of this new treatment for mixed hearing loss. Moreover further studies are needed in order to define a standard surgical technique in each different aetiology.

F7 – O6

New indications of Vibrant Med-El middle ear implant in conductive hearing loss

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Objectives: Vibrant MedEl implant is indicated in sensorineural hearing loss with normal ossicular chain, based on the requirement of normal anatomical conditions to fix the Vibrant Prosthesis. On the other hand, patients presenting a conductive or mixed hearing loss may have abnormal external auditory canal and normal ossiculair chain. Until now, they were refered for bone anchored hearing aid as soon as they were unable to wear air conduction hearing aid or to benefit of surgery. The objective of this study is to present the interest of Vibrant in mixed or conductive HL with external ear pathology, associated to normal ossicular chain.

Methods: 4 patients were included ; they had a pathology of external auditory canal, and were initially refered for baha. Normal ossicular chain gave the opportunity to place a Vibrant MedEl device.

Results: In the four patients, the result was immediat and favorable. They all had a significant gain on air conduction thresholds, and on speech audiometry. For each case, comparative data will be given, comparing thresholds between Vibrant, baha (headband) and hearing aid (when possible). Where was no adverse effect.

Conclusion: Vibrant MedEl may be an efficient treatment of conductive or mixed hearing loss due to external ear pathology, and give a significant benefit in these cases.

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F7 – O7

Simultaneous use of Vibrant Med-El and traditional hearing aid

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Objectives: The Vibrant Med-El middle ear hearing implant has proven to be an effective alternate treatment modality for patients suffering from mild to moderate sensorineural hearing loss. The purpose of this study was to evaluate the audiologic performance of patients wearing the Vibrant Med El and a traditional hearing aid simultaneously in the same ear. This study was prompted by several Vibrant Med El patients, with marginal audiologic implant criteria, who reported that they obtained improved hearing with simultaneous use.

Methods: Two patients reported marginal performance with their implants after surgery. However, these patients reported significant improvement with simultaneous use of a canal hearing aid and the Vibrant Med El. A full audiologic battery was performed on these patients.

Results: Both patients reported a significant subjective improvement in performance using both devices. Word discrimination scores were significantly improved when both devices were worn.

Conclusion: This technique may be offered to patients who are marginal candidates for either device separately and may be a benefit as an alternative to cochlear implantation.

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F7 – O8

Middle ear implants: patients' satisfaction

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Objective: The objective of the study was to determine and evaluate the subjective effect of middle ear implantation using self-assessment scales.

Methods: The study group comprised 23 patients with moderately to severely sensorineural hearing loss and severe chronic external otitis. Subjective benefit was assessed prospectively based on scores of the APHAB and Glasgow Benefit Inventory (GBI).

Results: The mean aided value on the APHAB for the subscale "ease of communication" was close to reference values for conventional hearing aid fittings. For the subscales "reverberation" and "background noise", a discrepancy was found with reference data which was ascribed to the unilateral applications of the middle ear implant. On an individual basis, 12 of the 23 patients had a significantly improved score. The mean overall benefit value on the GBI was substantial ($p < 0.001$) and 16 out of 17 patients who filled in the GBI reported a positive impact response. Compared to the literature, the improvements in APHAB scores were low. This was ascribed to inclusion criteria; in contrast to the literature, our patients were implanted for medical reasons, not because they were dissatisfied hearing aid users. A critical analysis of the published APHAB data suggest selection bias.

Conclusions: Middle ear implantation proved to have positive subjective effects on hearing difficulties comparable to those reported in studies with conventional devices. Patients with external otitis are probably the best study group to assess the surplus value of middle ear implants over conventional devices.

F7 – O9

Long-term study of "Vibrant® Soundbridge" implantable hearing aids

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Nowadays implantable hearing aids are an indispensable part of modern otologic and audiologic clinics. In principle, an active prosthesis using appropriate signal processing is implanted in the middle ear system. In this way the recipients can achieve better acoustic recognition and improved speech perception while the auditory ear canal remains open.

In this study 11 patients out of 49 patients, who received an implantable hearing device (Vibrant® Soundbridge MED-EL) at the Department of Otolaryngology of the Medical University of Hanover, are evaluated by means of a number of audiological tests. The postoperative observation time averages 6.3 years.

The results indicate a median functional gain of 30 dB. In monosyllabic speech tests the patients were able to achieve a 27 % median improvement of speech intelligibility at 65 dB SPL with the Vibrant Soundbridge. The results of multifrequency tympanometry revealed that the Vibrating Ossicular Prosthesis (VORP) has no significant influence on the resonance frequency of the middle ear over a period of 6 years.

Conclusion: If the criteria for patient recruitment are adhered to, implantable hearing devices yield a good hearing benefit and high qualified speech perception with more comfort.

F7 – O10

Vibrant Soundbridge implant: 5 years results of the first 100 French patients

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Objective: The level of satisfaction and the short term benefit with the middle ear implant Vibrant Soundbridge was published in the first 125 patients implanted in France [Sterkers et al., Otol Neurotol 2003]. The aim of this study was to analyse the audiological and subjective results of the same patients implanted for 5 years.

Methods: A retrospective survey of the first 100 French patients implanted between August 1997 and May 2001 in 19 ENT departments was conducted. Clinical and audiological data in quiet were compared to the results of the first study. The subjective level of the implanted patients was analysed using a self assessment scale and the GBI questionnaire.

Results: No serious complication occurred. Ten cases of device failure with the earlier version of the implant were reported (reimplantation in 7 cases). No device failure was reported for patients implanted with the presently available implant. No significant change of the residual hearing and of the benefit with the implant, compared to the early results, was observed. The number of patients satisfied with the implant remained stable (83 % in 2001 and 80 % in 2005). The most commonly side effect was fullness, which was not resolved over time (23 % in 2001, 27 % in 2005). Forty percent of patients were motivated for a bilateral implantation.

Conclusion: This study with a follow-up up than 5 years confirm the stability of the audiological benefit obtained with the Vibrant Soundbridge device and the safety of this middle ear implant.

F7 – O11

Vibrant® Soundbridge® clinical investigations: Expanding indications for use

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Background and Objectives: The Vibrant Soundbridge is a partially implantable "direct-drive" hearing system for the treatment of hearing loss and is currently indicated for use in adults who have mild-to-severe sensorineural hearing loss. Recently, the device has been applied to persons with mixed and conductive hearing losses to provide amplification to residual sensorineural hearing. In order to appropriately place the device in disordered and malformed ears, the manner and/or location of placement of the device is altered, and, in some cases, the device is used in conjunction with commercially available, passive middle ear prostheses. The objective of these studies is to evaluate expanding indications for use of the Vibrant Soundbridge to include persons with conductive and mixed hearing losses.

Methods: Subjects were implanted with the Vibrant Soundbridge implantable hearing aid, using either the Vibroplasty or Round Window Vibroplasty surgical technique. A single-subjects, repeated measures design is used to evaluate the safety and efficacy of the Vibrant Soundbridge in persons with conductive and mixed hearing losses.

Results: An overview of the study and its procedures, as well as preliminary results, will be presented.

F7 – O12

Estimated cost-effectiveness of active middle ear implantation in hearing impaired patients with severe external otitis

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Objective: The objective of the study was to determine the cost-effectiveness of middle ear implantations in hearing impaired patients with severe external otitis in the Netherlands.

Methods: A cost-effectiveness analysis was performed, using single subject repeated measures of quality of life and total cost determinations. The study group comprised 21 patients with moderately to severely sensorineural hearing impaired patients and severe chronic external otitis, eligible for the middle ear implant. Patients used either a Vibrant

Soundbridge device or the Otologics MET. The cost per quality-adjusted life-year (QALY), was calculated based on scores of the 36-item short-form (SF-36) questionnaire. Only direct cost were included in cost calculation.

Results: Mean health utility gain was 0.046 as measured at the mental component of the SF-36. With a mean profitable time of 19.4 years and an overall cost of €14.354, minimal cost-effectiveness of middle ear implantation was €16.085/QALY.

Conclusions: This cost/QALY is acceptable, so, middle ear implantation for hearing impaired patients with severe external otitis seems to be cost-effective. As far as we know, this is the first attempt to estimate the cost-effectiveness of middle ear implantation.

F7 – O13

Otologics Semi Implantable Device for Treatment of Severe SNHL

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Objectives: The objective of this study was to evaluate the Otologics Semi Implantable hearing device in severe SNHL patients.

Methods: In this retrospective multicenter study 20 patients with severe SNHL were implanted with the Otologics Semi Implantable hearing device. Pre and postoperative air conduction, bone conduction, as well as aided and unaided thresholds and speech scores with both the implant and a hearing aid speech scores were measured

Results: Pre operative mean tonal thresholds were 78 dB HL. Pre vs post operative air and bone conduction thresholds showed no significant differences immediately after surgery and when measured over 6 months. Average tonal gains ranged from 28 dB HL at 250 Hz to 42 dB HL at 1000 Hz, with some patients receiving more than 50 dB of gain at some frequencies. Average speech audiometry showed a 15 % improvement with the implant at 65 dB HL over the hearing aid.

Conclusions: Good results have been obtained with the Otologics Semi Implantable hearing device in severe SNHL patients with wearers expressing a greater satisfaction with the implant over their hearing aid due to perceived superior sound quality with the implant.

References

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Snik A, Noten J, Cremers C (2004) Gain and maximum output of two electromagnetic middle ear implants: are real ear measurements helpful? J Am Acad Audiol 15(3): 249–257

F7 – O14

Indicators for Efficient Coupling of the Otologics METä Transducer to the Incus

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Objectives: In implantable middle ear hearing devices, success and patient satisfaction crucially depend on the efficiency of the vibration transmission to the ossicles. In our study the appropriateness of electrical transducer impedance and ear canal sound pressure measurements as indicators for optimal coupling of the electromechanical Otologics LLC MET™ were investigated.

Methods: 7 fresh (< 48h) and 2 fresh frozen human temporal bones were implanted with the Otologics MET™ transducer. Laser Doppler vibrometry (Polytec HLV 1000 Vibrometer) was used to measure ossicle vibration driven by the transducer (multi-tone signal, 100Hz-8 kHz, 4/Okt). In addition, sound pressure level in the ear canal (Etymotics, ER-10B+) and electrical transducer impedance (200Ohm series resistor) was measured at different loading positions.

Results: During the loading procedure, both ear canal sound pressure level and MET transducer electrical impedance were sensitive indicators for initial contact between the MET transducer and the incus. While LDV measurements are sensitive over the entire frequency range (100Hz to 10 kHz), the acoustic signal can be used at frequencies < 1 kHz and the transducer impedance is sensitive at frequencies around the resonance frequency (1.5–3.5 kHz). In addition, the impedance can be used as sensitive intra-operative indicator for overloading of the transducer or the ossicles.

Conclusions: Both, transducer impedance and probe microphone measurements are sensitive indicators for initial contact to the incus. Our results served as basis for the development of the TLA (Transducer Loading Assistant). Since it was introduced no overloading was observed in >100 implantations.

F7 – O15

Otologics semi to fully implantable upgrade: Our first results

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Objectives: The objective of this study is to compare the clinical results of a patient upgraded from the Otologics Semi Implantable Hearing Device to the Otologics Fully Implantable Hearing Device.

Methods: Upgrade from the Semi Implantable to the Fully Implantable Device can be accomplished by exposing the Semi Implantable device, disconnecting the electronics capsule from the transducer lead via the IS-1 connector, enlarging the bone bed, and then connecting the Fully Implantable Device electronics to the transducer lead via the IS-1 connector.

This case study reports on a 49 year old patient upgraded from a semi to a fully implantable device in September

2005. Air conduction, bone conduction, as well as aided and unaided thresholds and speech scores with both the Semi and Fully Implantable Devices were measured.

Results: No significant differences between Semi and Fully Implantable patient aided thresholds, functional gains, and word recognition scores were noted. Patient comments indicated a preference for the Fully Implantable Hearing Device to its cosmetic advantages.

Conclusions: This case shows that patients can be successfully upgraded from Otologics Semi Implantable Hearing Device to Otologics Fully Implantable Hearing Device.

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F7 – O16

Otologics fully implantable hearing device surgical improvements

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Objectives: The objective of this study is to reduce surgery time and improve implantation ease of the Otologics Fully Implantable Hearing Device.

Methods: Surgical insertion of this totally implanted electromechanical transducer include: atticotomy exposure of incus, securing the transducer to the mastoid bone, attaching the transducer tip to the incus via insertion into a laser drilled hole, and post auricular implantation of the microphone/battery/electronics capsule.

Device improvements for the immediate future include, securing the transducer to the mastoid bone by use of a malleable template and bayonet lock system, improved transducer tip geometry precluding the need for a laser hole, new brackets to affix the electronics capsule and microphone to the mastoid bone, and intraoperative monitoring instrumentation aid in optimal ossicle loading.

Results: In vitro and in vivo measurements show that the device improvements described reduce the complexity of the surgical procedure and improve patient performance.

Conclusions: Rapid advancements being made to improve the Otologics Fully implantable hearing device indicate that this may become part of our standard armamentarium in the care of the hard of hearing.

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F7 – O17

Otologics fully implantable hearing device results

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Objectives: The safety and performance of the Otologics Fully Implantable Hearing Device was assessed in adults patients with bilateral moderate to severe sensorineural hearing loss.

Methods: The subcutaneous microphone of this Fully Implantable Device picks up ambient sounds, converts them into an electrical signal, amplifies the signal according to the wearer's needs, and sends it to an electro-mechanical transducer. The transducer tip is mounted in a laser-drilled hole in the body of the incus and translates the electrical signal into a mechanical motion that directly stimulates the ossicles and enables the wearer to perceive sound. The implanted battery is recharged daily via an external charger and the wearer can turn the implant on and off with a hand held remote control.

In this multicenter study 16 patients with moderate to severe SNHL were implanted with the Otologics Fully Implantable Hearing Device. Pre and postoperative air conduction, bone conduction, as well as aided and unaided thresholds and speech scores with both the implant and a hearing aid (when available) were measured.

Results: No significant differences between preoperative and postoperative pure tone averages were noted. Average improvement ranged from 20 to 25 dB of functional gain across audiometric frequencies. Word recognition scores and patient benefit scales demonstrated significant differences between unaided and implant-aided conditions.

Conclusions: Preliminary results of the Phase I trial of the Otologics Fully Implantable Hearing Device provide evidence that this fully implantable device may be a desirable alternative to currently available hearing aids in patients with sensorineural hearing loss.

Drug Delivery (F8)

F8 – O1

Rescue of auditory neurons: implications for cochlear implants

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Objectives: A sensorineural hearing loss initiates degeneration of spiral ganglion neurons (SGNs), target neurons for

a cochlear implant. These changes affect neural response properties to electrical stimulation, including elevated thresholds, evidence of conduction block and increased refractory properties. We examined potential therapies for SGN rescue based on chronic electrical stimulation with and without the delivery of exogenous neurotrophins.

Methods: Animals were deafened using aminoglycoside drugs and implanted with a drug delivery cannula and/or electrode array into the left cochlea using sterile surgical techniques. An osmotic pump chronically delivered the neurotrophin brain-derived neurotrophic factor (BDNF) with or without chronic electrical stimulation. Electrically-evoked auditory brainstem responses (EABRs) were recorded periodically to monitor the status of the auditory nerve. Following completion of the stimulation program cochleae were harvested for histology; SGN density from treated cochleae were compared with deafened controls while EABR thresholds were examined longitudinally.

Results: Chronic electrical stimulation of the auditory nerve provides minimal, if any, trophic support for SGNs and an increase in EABR thresholds. In contrast, exogenous delivery of BDNF showed significant rescue of SGNs and a reduction in electrical thresholds. Importantly, SGN survival was even greater in animals where BDNF was combined with chronic electrical stimulation. BDNF also showed significant rescue of SGNs in a second mammalian species.

Conclusions: These findings indicate that exogenous neurotrophins are effective in rescuing SGNs from degeneration following deafness; this effect is even greater when the neurotrophin is combined with electrical stimulation. The significant reduction in electrical thresholds observed following neurotrophin treatment has important implications for cochlear implant design.

F8 – O2

Monitoring of cochlear function during cochlear implantation

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Objective: To report the feasibility of monitoring cochlear function during cochlear implantation.

Study Design: Case report.

Setting: Tertiary care referral center.

Methods: A child with audiological features typical of bilateral auditory neuropathy (AN) underwent cochlear implantation. The scala tympani was entered inferior and slightly anterior to the round window membrane margin and smooth electrode insertion was achieved. Using single polarity click stimuli, the cochlear microphonic (CM) was measured at several steps during surgery.

Results: CMs were present at all stages during the implantation process and were clearly distinguished from neural responses by stimulus polarity inversion and constant latencies despite changes in stimulus level. With the electrode in situ, amplitudes were smaller but persisted until the final measurement at 10 minutes after insertion. At follow-up 2 weeks after surgery, behavioral audiometry results indicated profound hearing loss in the operated ear.

Conclusions: This paper demonstrates the feasibility of monitoring cochlear function during cochlear implantation. The routine surgical approach did not appear to adversely affect the functional measurements. Standard size, full electrode insertion did diminish the amplitude of the CM, possibly as a result of intracochlear mechanical impairment. Ultimately, profound hearing loss was documented indicating that factors other than immediate changes induced by electrode insertion were likely responsible for the loss of cochlear function.

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F8 – O3

Cochlear implantation and drug delivery from polymers

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Objectives: The short-term delivery of drugs to the inner ear from polymers may have a role in protection of the cochlea during implantation, or the guidance of auditory neurons towards new generations of cochlear implants. We report on experiments aimed at releasing therapeutic levels of neurotrophin-3 into the cochlea using polymers.

Methods: NT-3 was loaded into the polymers sodium alginate and Gelfoam™. The biological effect of in-vivo release was tested by counting the density of spiral ganglion cells (SGC) surviving in adult guinea pigs deafened 33 days prior with a single dose of kanamycin and furosemide. Seven days after deafening, NT-3 loaded polymers were placed on to the round window of the cochlea, and in an additional experimental arm a single dose of NT-3 was delivered to the scala tympani via a micro-pump.

Results: In vitro, NT-3 was released from the alginate beads into artificial perilymph over the 5-day observation period. In vivo, SGC cell densities were significantly greater than controls in guinea pigs receiving NT-3 loaded beads. Neither NT-3-loaded Gelfoam, nor the single-dose of NT-3, were effective in preventing apoptosis of SGC. SGC cells were significantly larger than controls in animals receiving a single dose of NT-3.

Conclusions: Round-window release of NT-3 from alginate beads can lead to the preservation of SGC for at least one month. Therefore, short-term delivery of NT-3 to the cochlea might have a role in the salvage of auditory neurons in the peri-operative period, especially if combined with other trophic modalities, such as electrical stimulation.

F8 – O4

Substance distribution in a cochlea model using different pump rates to simulate local cochlear drug delivery

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Objectives: The number of SGCs is considered to be among the factors defining the effectiveness of cochlear implants. Furthermore, reports on animal studies have shown protective effects of neurotrophic factors (NF) on spiral ganglion cells (SGC). A device for local inner ear treatment is therefore of great interest. We modified a Contour™ electrode and tested it for the purpose of drug delivery to the inner ear. We further developed a set-up to continuously determine dye distribution in a model cochlea.

Methods: Three different electrode prototypes with openings at varying locations were used: a) release of the dye at the tip, b) at the tip and the side, or c) only at the side of the electrode (6 mm from the tip). These prototypes were inserted into a plastic model of the scala tympani and the distribution of a dye (methylene blue) was observed over time. Pump rates of 100 µl/h, 10 µl/h, and 1 µl/h were applied. Dye concentration changes along the whole cochlea were investigated.

Results: Mean values for all experimental conditions show that the distribution along the array is fastest having two outlets whereas only having an outlet at the side of the array can't be considered as sufficient.

Conclusion: The established experimental setup provides the possibility of investigating prototypes of a fluid based drug delivery system for the treatment of inner ear pathologies and could easily being modified for a larger number of outlets.

F8 – O5

Bacteria or biofilm at the cochleostomy site?

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Objective: Biofilms are complex organizations of microorganisms attached to a surface. In a biofilm, bacteria are embedded in self produced slimelike deposits providing protection from host defense mechanisms (antibodies, phagocytic cells) and antimicrobial treatments. Biofilm bacteria are usually culture negative.Evidence is growing that biofilm plays a role in the pathogenesis of recurrent and chronic otitis media. In chinchillas biofilm has shown to be present in certain areas of the middle ear cavity during otitis media, while in humans only indirect proof for the existence of biofilm has been found so far.

Methods: If a biofilm is present in the tympanic cavity indeed, an electrode array of a cochlear implant (CI) may be exposed to biofilm bacteria prior to its introduction into the cochlea. Consequently, biofilm bacteria may be introduced into the scala tympani by the electrode array, which may have adverse effects. Therefore, in order to establish whether a biofilm was present in the middle ear cavity at the moment of implantation, mucosal tissue derived from different groups of CI patients was studied electronmicroscopically. Before opening the cochlea to introduce the electrode array into the scala tympani, mucosal tissue was collected from the cochleostomy site.

Results: Cochlear implant patient groups involved were: children with a history of otitis media, children without a history of otitis media and adults. The mucosa were examined electronmicroscopically, especially for signs of inflammation, bacteria and biofilm. Results will be presented.

F8 – O6

Drug delivery to the inner ear through a port and septum attached to the CI housing and electrode: long term in vitro safety results

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Objective: Drug delivery to the inner ear through a port and septum attached to the CI housing and electrode.

Methods: Chronic and acute drug delivery to the inner ear with a cochlear implant can be achieved through a titanium port with septum. The port is fused with the implant housing (PULSAR CI100) and the chamber is connected to a channel within the electrode array. The essential safety requirement is for the septum to be leak proof for the expected life of the implant (>20 years).

Nine ports with septum designed for CI drug delivery have been tested in accelerated conditions consistency for leaks. The septum's were perforated 25 times with a 30 gauge needle. The needle was left in place for 30 days at 37 C in saline solution. The needle was then removed. Pressure of up to 2.5 bars was applied to the back end of the port to examine if air bubbles were expelled through the saline. Subsequently the ports were placed in saline at 100 C and periodically tested for leakage.

Results: Design of the cochlear implant with drug delivery and results of the aging test will be presented up to conference time. Additional safety concerns that have been tested will be shown. The concept of safe fluid drug delivery to the inner ear will be addressed.

F8 – O7

Biofilm formation in cochlear implants with cochlear drug delivery channels

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Objectives: Cochlear drug delivery may improve preservation of residual hearing with cochlear implant (CI) placement in candidates for concomitant acoustic and electrical stimulation. Cochlear therapy may require a drug delivery channel (DDC). A DDC may lead to sequestration of bacterial contaminants, biofilm formation, and suppurative complications. The aim of this study was to evaluate the impact of DDC ports on biofilm formation.

Methods: Sterilized silastic models were constructed to represent CIs with a DDC, with in intact port, a widely opened port, a non-coring needle penetrating the port, and a non-coring needle removed from the port. "CIs" were suspended in culture media, inoculated with a biofilm forming strain of Staphylococcus aureus, incubated for 96 hours, then exposed to oxacillin for 24 hours to kill non-biofilm bacteria. Biofilms were lysed with ultrasonification and quantitative bacterial counts were performed. Scanning electron microscopy was performed to evaluate bacterial colony architecture.

Results: Bacterials counts were highest in CIs with widely open ports, followed by ports containing a non-coring needle. CIs with ports that had not been penetrated or had been penetrated by 30 g non-coring needles had significantly lower bacterial counts.

Conclusions: CI DDC port design may significantly impact biofilm formation. Biofilm formation may be minimized by delivering drugs with fine, non-coring needles and limiting the duration of port penetration.

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F8 – O8

Preservation of residual hearing: Cochlear implant drug delivery technology

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Objectives: The importance of preserving residual hearing during cochlear implantation has risen as implant criteria has expanded to include patients with more low-frequency hearing. In order to provide hearing benefit to this population via cochlear implantation, technology must be developed to facilitate hearing preservation following implantation and to minimize the effects of electrode insertion trauma. The traditional approach has been to refine electrode design and to modify the surgical approach and insertion technique. However, animal experiments suggest that pharmacological intervention may increase significantly the odds of hearing preservation. In particular, the delivery of corticosteroids, anti-oxidants, and glutamate receptor blockers has been shown to be oto-protective during cochlear trauma. The combination of atraumatic electrode designs with drug delivery capability may also provide the necessary foundation for a viable electro-acoustic stimulation system.

Methods: This presentation will review Advanced Bionics' development of several drug delivery technologies including a micro-pump and electrode bio-release capability.

Mapping Strategies (Z5)

Z5 – O1

OPUS1 – Signal processing and technical aspects of a Behind-The-Ear speech processor for fine structure stimulation strategies

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OPUS1 designates a complex, highly flexible speech processing platform miniaturized in a BTE speech processor. The fine structure stimulation strategy implemented is a mixture between high-frequency CIS-channels representing envelope information, and low-frequency channels representing both envelope and temporal fine structure information. The low-frequency channels are based on so called "Channel Specific Sampling Sequences (CSSS)", which are ultra-high-rate pulse trains started at the zero crossings of the band filter outputs. OPUS1 can drive MED-EL implants C40, C40+, and PULSARCI100. OPUS1 implements the so called "Selected Groups (SG)" – algorithm which allows to detect and to avoid stimulation pulses, which are inefficient because of spatial masking effects. Thus the effective stimulation rate can be enhanced significantly. For implants of type PULSARCI100, parallel stimulation utilizing so called "Channel Interaction Compensation (CIC)" can be used. For CIC, simultaneous stimulation amplitudes are computed based on parameters reflecting spatial channel interaction. The central part of OPUS1 is a programmable, fully digital CMOS-ASIC. The ASIC contains 12 independent peripheral DSP-kernels (one for each stimulation channel) and one central master DSP. The implementation of the band filters is based on 100 % stable and phase linear FIR-filters, and envelope detection is based on Hilbert transform.

Z5 – O2

Improved approximation of stochastic ion channel gating

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Objectives: Stochastic ion channel gating may be behaviourally important in cochlear implant (CI) stimulation of the auditory nerve (Bruce et al., 1999). Fox and Lu (1994) derived an algorithm for approximating the kinetics of ion channel gating that is substantially simpler and faster than exact methods, but Mino et al. (2002) showed that the approximation may not be sufficiently accurate in describing CI stimulation. Our objectives were to analyze the accuracies and correct them.

Methods: Simulations of electrical stimulation of a single node of Ranvier were performed using an exact method for the kinetics of channel gating (Chow and White, 1996) and the approximate method of Fox and Lu. The differences in channel gating statistics for the two methods were analyzed, and a framework was developed for correcting the Fox and Lu statistics.

Results: The Fox and Lu method assumes that channel kinetics have a stochastic term that is uncorrelated, zero-mean Gaussian noise. Our simulations demonstrate that in many cases the stochastic term in the Fox and Lu method should be correlated and non-Gaussian noise with a non-zero mean. However, we show that a simple correction to the Fox and Lu noise term mean and variance can greatly improve the accuracy of the approximation, without requiring that the exact noise statistics of the Chow and White algorithm be replicated.

Conclusions: Accurate and computationally-efficient modelling of the effects of stochastic ion channel gating in CI stimulation of the auditory nerve is feasible with a corrected Fox and Lu method.

Z5 – O3

Relating spectral resolution and speech understanding

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Objectives: We find a significant correlation between spectral modulation detection thresholds (SMDTs) for low-modulation frequencies (cycles/octave) and performance on a vowel (r=0.77) and consonant (r=0.93) identification tasks of cochlear implant recepients. We hypothesized that the spectral SMDT was determined by the activation pattern associated with electrical stimulation. Specifically, broad activation patterns would impair spectral resolution, resulting in an elevated SMDT. In this study we simulate broad activation patterns using a multi-band vocoder to determine if similar impairments in the SMDT and speech understanding scores could be produced in normal-hearing (NH) listeners.

Methods: Tokens were first decomposed into 15 logarithmically-spaced bands and then re-synthesized by multiplying the envelope of each band by matched filtered noise. The spectrum of filtered noise had a peak at the center of the band. Various amounts of current spread were simulated by adjusting the drop-off of the noise spectrum away from the peak (40 dB/octave to 5 dB/octave).

Results: Simulating broader activation patterns significantly degraded spectral resolution and speech understanding. The average SMDT at 0.25 cycles/octave increased from 3.5 dB to 13 dB, while vowel identification scores dropped from 91 % to 25 % and consonant identification scores dropped from 93 % to 56 %. In each condition, the impairments in speech understanding were generally similar to those found in CI listeners with similar SMDTs at 0.25 cycles/octave.

Conclusions: These results support the hypothesis that broad activation patterns would impair spectral resolution. Our multi-band vocoder may be a useful tool for evaluating methods to compensate for broad activation patterns.

Z5 – O4

Parametric cochlear implant map adjustments by recipients

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Objectives: The objective of the present study is to improve the ECAP-based fitting procedure of cochlear implant (CI) processors by giving the recipients the possibility to manually adjust the shift and tilt parameters of the C levels.

Methods: CI recipients with 6–12 months experience are fitted with an ECAP-based fitting procedure in which we use the profile of the ECAP threshold levels across the full electrode array measured intra-operatively. The overall level of the profile is shifted by an equal amount of current units per electrode until we find the threshold for live speech (new T levels) and the loudness comfort level (new C levels) (Smoorenburg et al., 2002). This fitting is used for three weeks, after which speech perception with the conventional and ECAP-based fitting is tested in quiet and noise. The next three weeks subjects themselves are able to optimize sound quality by manually adjusting the shift and tilt of the C levels during daily use. Finally, speech perception is tested with the ECAP-based fitting and the adjusted ECAP-based fitting.

Results: Preliminary results show that subjects primarily experiment with the shift and tilt during the first two weeks of the three week self-adjustment period. Speech perception scores differ only slightly between the conventional and the adjusted ECAP-based fitting.

Conclusions: Self-adjustment of the C level shift and tilt gives the experienced CI user the option of optimizing the CI-function in daily life. Speech perception scores with self-adjusted maps are only slightly affected.

Z5 – O5

Postoperative stapedius reflex tests in patients supplied with CI using multi-channel electrical stimulation

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Objektives: Postoperative stapedius reflex measurements are used by several research groups for the fitting of speech processors when implant settings based on objective methods are required. Since individual correlations between reflex threshold for electrical stimulation (ESRT) and behavioral comfort levels are fairly high, ESRT values are directly used for the fitting map. The present study was performed in order to reduce the time needed for testing in children and to check, whether ESR measurements could be limited to a smaller number of channels of the CI.

Methods: ESRT was determined using a standardized test protocol based on acoustic impedance audiometry during electrical stimulation via the implant for patients supplied with MED-EL cochlear implant systems. In addition to single channel stimulation, the patient was stimulated using a variable multichannel stimulation mode. Quasi-simultaneous stimulation of basal, medial and apical groups of electrodes was

applied. ESRT values for grouped stimulation were compared to ESRT for single channel stimulation.

Results: Preliminary results show that ESRT for multichannel stimulation appears always at lower stimulation levels as compared to single channel stimulation. There exists a general trend of decreasing ESRT with increasing number of stimulated channels. The channel profile of multichannel ESRT agrees with the overall shape of the single channel results.

ESRT – information from multichannel data can be used as a rough estimate of comfort levels for fitting of the CI. However, whenever a more precise individual fitting is needed, reflex testing with single channel stimulation is still required.

Z5 – O6

Excitation fields from cochlear implant stimulation: estimation with numerical models of the human cochlea

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Objectives: Cochlear implants stimulation parameters (such as stimulus intensity, pulse stimulation rate, and pulse duration) and electrode properties (such as electrode material, shape and configuration) affect, through the generated electric filed, the number of fibers excited or hyperpolarized, and the patient pitch perception. Knowledge of the relationship between the stimulation parameters and the electric field in the physiological tissue is crucial to develop more efficient and spatially focused excitations of cochlear neural tissues. Aim of this study is a systematic investigation of the relationship between the electric fields generated in the cochlear tissues around the electrode array and the stimulation parameters.

Methods: The distribution of the electric potential in the cochlea has been simulated by 3D mathematical modelling the electrical properties of the human cochlea and of the electrode array. Synthetic shapes resembling the true anatomy and the conductivities of the various tissues of a human cochlea, which were derived from both microphotographs of human cochleae and from CT/MRI scans of real implanted patients. The electrode array was modelled according to the size, shape, and materials of a true cochlear implant.

Results and Conclusions: Results showed a significant influence of stimulus parameters, the position of the electrode array inside the cochlea, and the position of the active electrode on the induced potential field, both for what concerns its magnitude and its spatial distribution. The proposed approach is useful to provide the excitation profiles inside the cochlea and in the design of new electrode arrays.

Z5 – O7

Which waveform is optimal for modulation rate discrimination?

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Objectives: The objective of this experiment is to determine which of four waveforms (sine, sawtooth, a sharpened sawtooth, square) provides the best modulation rate discrimination for electrical hearing. It is important to understand the different results from the four waveforms if amplitude modulation is to be used as a cue in a speech processing strategy.

Methods: Amplitude modulated pulse trains were presented on a single electrode with a modulation depth of 80 % of their dynamic range. Using a 4IFC adaptive task, the minimum discriminable rate of modulation faster than 100Hz was measured. The modulations were presented with one of four waveforms: sine, sawtooth, a sharpened sawtooth (sawsharp), and a square wave. The procedure was repeated for an apical, medial, and basal electrode.

Results: The waveform that produces the best modulation rate varies across subjects and electrodes, although results tend to be similar for all waveforms. Square waves provide the most difficulty for subjects. No subjects performed best with a square wave. Subjects tended to discriminate rates of approximately 110Hz from 100Hz.

Conclusions: No clear advantages are found for any of the waveforms. Ideally, it would be best to select the waveform optimal for a given subject. Practically, avoiding square waves is a good idea because it was most likely to be the more difficult than the others for modulation rate discrimination.

Z5 – O8

LAEP elicited by meaningful words and speech-like stimuli

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Objective: Objective measures of speech perception rarely goes beyond the usage of syllables. This study examined the influence of meaningful words vs. similar speech-like stimuli on late auditory evoked potentials.

Methods: Monosyllables and 3 groups of speech-like stimuli (reverse-played monosyllables, modulated and unmodulated CCITT-noise) were used to elicit late AEP in 20 normal hearing adults and 10 unilateral cochlear users. Stimuli were presented randomly at 70 dB SPL, after filtering, average responses were calculated of 50 trials per stimulus.

Results: Variability of N1/P2 latency and amplitude is higher after stimulation with complex stimuli than after unmodulated CCITT-noise. Between 350 to 600 ms after stimulus onset significant differences were found between different stimulus types, whereas no such difference existed within each group of stimuli.

Conclusions: Meaningful monosyllables elicit significantly larger amplitudes than speech-like stimuli with identical duration, envelope and spectral density.

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Z5 – O9

Intracochlear ECAP testing in children with auditory neuropathy

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Objectives: To analyze the results of intracochlear evoked compound action potential testing (ECAP) recorded in pediatric cochlear implant patients diagnosed with Auditory Neuropathy/Dys-synchrony (AN).

Methods: Twenty-two children have undergone cochlear implantation who previously exhibited the audiologic profile recognized as AN: absent auditory brainstem response in the presence of otoacoustic emissions and/or a cochlear microphonic. ECAP testing was completed using commercially available software [(NRT 3.1 , AutoNRT (Cochlear Corp, CO) or NRI (Advanced Bionics Corp, CA)] intraoperatively and again at subsequent mapping sessions. Default settings were used in the OR while parameters were optimized during subsequent mapping sessions.

Results: ECAP testing using either NRT or NRI demonstrated typical waveform morphologies (N1-P1) in most children. A positive relationship between present responses and speech perception performance appears likely. The influence of factors such as the presumed etiology and the child's ability to use conventional amplification are also considered.

Conclusions: In most cases, the presence of AN does not appear to adversely affect the ability to record an ECAP, implying neural synchronization. In fact, the presence of this response may correlate with speech perception performance as well as other patient characteristics.

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Z5 – O10

Can high performance be achieved by using simplified processor mapping?

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Objectives: The aim of this study was to assess the benefit achievable in users of the MED-EL COMBI 40+ system when a "standard" programme (map) is used, rather than the patient's usual "customized" map. Sometimes (e. g. with young children) it is difficult to obtain the measures needed to produce an accurate map, so this information could provide an understanding as to how important accurate map setting is.

Methods: Psychometric fitting data were examined for 90 long-term users to determine the average upper programming setting on each electrode. Using these data, standard maps were generated and tested on subjects in acute trials and compared to performance levels obtained using each subject's customized map. Additionally, a group of new users were tested at the "switch-on" session to see how standard and customized maps compared.

Results: Average sentence discrimination score for 8 long-term users was found to be 67 % for customized maps and 53 % for the standard map (statistically significant). However, while the standard maps produced lower scores it is likely that scores would be higher if users were able to gain familiarity with the new settings. Results at switch-on showed little difference between the benefits obtained by the two maps.

Conclusions: Results demonstrate that high levels of performance can be obtained using standard maps. This information is of considerable value when programming young children and it is likely that these findings will also be useful in the design of simplified devices for developing countries.

Z5 – O11

An acoustic model of phonetic perception in quiet and noise by CI users

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Objectives: First, to develop an acoustic model of the Nucleus 24 ACE strategy to determine effects of channel number, stimulation rate, noise and cross-electrode spread of excitation on consonant recognition; second, to compare performance of the model with equivalent CI user performance.

Methods: Eleven normal hearing subjects undertook a consonant recognition task in quiet and stationary noise at +10 dB SNR with stimuli processed via an acoustic model of the Nucleus 24 implant ACE processing scheme, with varying degrees of channel overlap, channel number and channel update rate. Data were also obtained in 9 adult Nucleus 24 CI users using analogous processing parameter settings.

Results: Consonant recognition was affected by channel number, degree of channel overlap and noise in the acoustic model. For CI users, there were no differences between map configurations, but noise had an effect on performance. For both groups noise had a greater effect on perception of phonological features requiring good temporal resolution. CI user performance was best approximated by an acoustic model in

which simulated channel interaction was equivalent to overlap across approximately 4 adjacent electrodes.

Conclusions: Spectral channel interaction has a significant effect on consonant recognition with an acoustic CI model and increases accuracy of predicting CI user performance. However, results suggest that deficits in consonant recognition by CI users are determined more by information loss associated with current CI processing strategies than by channel interaction.

Z5 – O12

Bimodal fitting strategies for adults and children

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Objectives: Recent studies have focused on the benefits that both children and adults receive through the combination of a hearing aid with their cochlear implant (Ching et al., 2001; 2004; Flynn & Schmidtke, 2004). Unfortunately, few studies have actually discussed practical step-by-step fitting procedures that can be used outside of the research setting.

Methods: 30 adults and 15 children participated in a study examining the fitting performance of advanced Power and SuperPower hearing aids in combination with a cochlear implant. Various fitting strategies were assessed and performance measured using objective speech perception measures in quiet and noise (HINT), localisation, and reports of benefit on the Bimodal Benefit Questionnaire.

Results: Results indicated that for all patients demonstrated objective improvements for speech understanding in quiet and noise ($p < .001$), localisation and through subjective reports of benefit. Examination of the fitting data indicated the importance of ensuring that loudness balancing is carried out using the sounds provided in the Genie fitting software in addition to the option of providing increased gain below 1500Hz.

Conclusions: These results support the recommendation of providing a hearing aid to adults and children with a cochlear implant. Importantly, the results demonstrate a quick and robust fitting method that can be used by clinicians. Of interest were the positive results for the advanced automatic systems such as feedback cancellation, directionality and noise reduction which have not been investigated in previous studies.

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Z5 – O13

Performance with ESRT generated speech processor programs

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Objectives: To calculate the incidence of electrically elicited stapedial reflexes (ESRs) in a large pediatric population of MEDEL COMBI 40 + and Pulsarci100 CI users and to evaluate the hearing acuity of children using ESRT generated programs.

Methods: Fitting data for 254 children was analysed. The number of children using programs where ESRT measurements were used to set maximum comfort levels was calculated. Implant sound field thresholds were measured at 6 frequencies for 50 children using ESRT generated programs for more than six months. 50 children were tested for recognition of monosyllables in 2 closed sets of 10 similarly sounding words. 30 children were tested for recognition of words in sets of 3 where there were only minimal sound differences between stimuli e. g. tuz, buz, muz. Each child was tested over 20 sets. 30 children were scored on GASP. The average age of children tested was 7 years and all had only ever used ESRT generated programs.

Results: The incidence of ESR was 83 %. Implant sound field thresholds clustered around 35 dB(HL) across frequencies 250 Hz to 6KHZ. The average score for recognition of monosyllables was 81 %. The average score for recognition of words with minimal sound differences was 83 % and the average score on GASP was 77.5 %.

Conclusions: High incidence of ESRs in pediatric CI users means ESRT generated programs can be widely applied. High auditory speech perception scores and low sound field thresholds indicate that ESRT generated programs give users optimal access to sound.

Z5 – O14

Objective classification of Neural Response Imaging (NRI)

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Objectives: Cochlear implants are now implanted in young children, who may be a challenge to program. Modern implants support objective measurements which can complement behavioural measures. However, the overlap of stimulus artefact with neural response makes it difficult to determine the neural response thresholds. This work aims at developing a rigorous, automatic, statistically based method for determining whether a neural component is present.

Methods: It is assumed that any NRI measurement consists of: neural response, noise, residual artefact. A principle component analysis approach is taken to reduce the noise. The measurement is labelled a response if it is significantly different from an artefact model. 1,043 NRI sets were classified as response or non-response by three experienced observers and using the automatic system. The set of measurements agreed to be responses by all observers was compared to the automatic classification outcomes.

Results: The objective method correctly identified 99.7 % of records labelled as responses by all observers. A similar number of non-responses were correctly identified. A metric was produced, sensitive enough to identify 99.7 % of neural responses classified by experienced clinicians, and reject the majority of non-responses (total error rate: 2.5 %).

Conclusions: This analysis has verified a model that accurately represents residual artefact. Such a system removes the subjective element from the interpretation of NRI and could provide a wholly objective system likely to be of great benefit to clinicians.

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Z5 – O15

Spread of excitation in the cochlea

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Objectives: Interaction between neighbouring populations of auditory nerve fibres stimulated in a cochlear implant may contribute to variability in performance. The NRT ™ system and the NRI system enable a measure of the spread of excitation in the cochlea. The forward-masking paradigm for recording the evoked compound action potential (ECAP) involves stimulation with probe and masker pulses. If they stimulate different electrodes, the response to the probe depends on the degree of overlap in the neural populations stimulated by each. As the masker is moved away from the probe, the size of the ECAP response reduces as the degree of overlap reduces. Our objective is to investigate the relationship between this and other measures of performance, and to evaluate its usefulness as a clinical tool.

Method: ECAP responses recorded in 25 CI24 and 6 HiRes90K users are described. The stimulus active electrode was kept constant, in the middle, basal or apical regions of the electrode array, with a roving masker. The response amplitude was recorded. The profiles provide a measure of the spread of excitation in the cochlea.

Results: Variability in profile amplitude and widths were observed. The relationship between this measure and speech recognition was investigated. A comparison of profiles of the two implant systems was also made.

Conclusions: Spread of excitation provides a quick, objective measure of channel interaction. This relates to the speech performance obtainable by cochlear implant listeners and can be used to investigate the observed variability in performance.

Speech Processing (Z6)

Z6 – O1

Signal processing and stimulation strategies for the Digisonic® SP cochlear implant system

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The Digisonic SP is a 20 channels CI systems. The implantable part consist of a small ceramic receiver (MRI compatible 1,5T) with a powerful and ultra low power consumption stimulator which is connected to 20 electrodes. The internal part is controlled by two external processors Digi SP (adults and children) and Digi SP'K (children below 3 years).

The signal processing strategy is based on weighted overlap filter bank with a 128 points FFT, a very hight input dynamic range from 30 to 95 dB-SPL and a variable and multislope compression function to optimize this dynamic.

A calibration of the microphone in a semi-anechoic room is processed to provide a flat response in dB-HL close the behavior of a normal ear. The system is composed of 2 microphones used for denoising and space selectivity.

Several stimulations strategies are used:

-The CIS strategy with stimulation frequencies ranging from 250 to 1000 Hz.

-The Fundamental Detection Strategy: the frequency of the stimulation is proportional to fundamental laryngeal frequency detected in real time. This allowed the frequency to be uncoded not only in a tonotopic way but also in a temporal way like it is the case in a normal ear behavior.

For both strategies, stimulation is pulsatile, biphasic through capacitive coupling, and sequential. The 64 computed FFT-energy values are grouped into 20 adjustable frequency bands corresponding to the 20 active electrodes. The flexibility of the stimulation sequence allows to adapt the information quantity with patient features.

Z6 – P2

Influence of cochlear implant stimulation on ASSR measures

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Objectives: Auditory steady-state responses measurement in the case of cochlear implant subjects can be disturbed by the nature of the cochlear implant stimulation. The electrical stimulation can be also recorded and be confused or hide the physiological response. The aim of this work, complementary to a last study published in 2004, was to characterize the stimulation artefact with the Digisonic SP cochlear implant in the case of ASSR.

Methodes: In this study we measure only the electrical stimulation of the implant without the physiological response of the auditory system, using two different models. In fact, It was important to distinguish the artefact from the true physi-

ological response for validity of the data. First, we realize measurement on the implant only. The external part received carrier frequency modulated in amplitude. The internal part was in physiological liquid with the EEG electrodes. Secondly we recorded ASSR responses on implanted subject with one of his electrode which doesn't produce any auditory preception. For those two methods, the implants stimulation can be recorded without disturbance and can be well identified. Different modulation frequencies and depth were tested for different stimulation intensity.

Conclusion: This study shown the possible measurement of ASSR on the digisonic cochlear implant and validate objective measures on cochlear implant with ASSR.

Reference

Menard M, Gallego S, Durant J, Collet L (2004) Auditory Steady-State response evaluation of auditory thresholds in cochlear implant patients. International Journal of Audiology 43: 1–5

Z6 – O3

Tonotopic coding of frequency within the FINEHEARING concept

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Objectives: With FINEHEARING, MED-EL is presenting a new concept of coding strategies which is designed to overcome the limitations of the envelope-based coding strategies in use to date. In this concept, Channel-Specific Sampling Sequences (CSSS) in combination with virtual channels are used to model normal hearing so that for low frequencies, the fine structure of a signal is both coded in time and place, and for high frequencies, the fine structure is coded in place only. First results have demonstrated the ability of this concept to code pitch effectively. This study further investigates place coding by assessing pitch produced by sequential and parallel virtual channels. In the further, a pitch percept intermediate to the pitches of two electrodes is produced by sequential stimulation of these electrodes, whereas in the latter parallel stimulation is used.

Methods: Pitch discrimination tests were performed to assess pitch coding using sequential and parallel virtual channels.

Results: Results show that distinct pitch percepts intermediate to pure electrode pitches can be produced by both methods. Results further point into a direction indicating that pitch discrimination might be somewhat better with sequential virtual channels than with parallel virtual channels.

Conclusions: The results indicate that within the FINEHEARING concept, virtual channels are effective in coding place-pitch. However, sequential virtual channels might be more distinct than parallel virtual channels.

Z6 – P4

Localization and speech discrimination with the new fine structure strategy

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Objectives: Localization and speech perception were tested in bilateral CI users with a new strategy including temporal fine structure (FS) analysis in the low frequency bands in comparison to the CIS+ strategy.

Methods: Subjects bilaterally implanted with a MED-EL C40+/PulsarCI[100] cochlear implant participated in the study. Two coding strategies were compared, i.e. CIS+ and FS. In FS the frequency range is extended to 100 Hz to 8500 Hz. Additionally, in FS the fine structure of the band pass signals is coded on the 2 lowest channels using channel specific sampling sequences (CSSS). Sound source localization of noise and speech signals in the frontal horizontal plane was tested. SRTs were measured unilaterally and bilaterally using the OLSA sentence test in different signal and noise/babble source configurations: S0N0, S0N-90, S0N90, S-90N90, and S90N-90. Head shadow effect (HS), summation effect (SU), and squelch effect (SQ) are calculated from the first three setups, whereas the last two setups generate maximum ITDs for both signals. Different types of signals were used that contain a varying amount of 'useful' fine structure in the low frequency region.

Results: Preliminary results will be presented and implications of coding fine structure on localization and the perception of spatially separated sound sources will be discussed.

Z6 – O5

Encoding fine time structure with CSSS: concept and first results

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Objectives: A speech processing strategy, aimed at incorporating temporal fine structure cues into the pulsatile stimulation pattern delivered in a cochlear implant, is presented. The strategy is evaluated in pitch discrimination and scaling experiments with a number of MED-EL implant recipients.

Methods: In the normal auditory system, pitch information is encoded by both temporal and place cues. Current clinical cochlear implant systems deliver interleaved fixed-rate pulse trains, which are amplitude-modulated with the channel envelope signals, to multiple intracochlear electrodes. Most or all fine structure information is discarded, and pitch information is encoded primarily in the place of stimulation and to a limited extent in the temporal fluctuations of the channel envelope signals.

In the new channel specific sampling sequence (CSSS) strategy, high-rate pulse bursts with a programmable amplitude profile are delivered to the apical-most electrodes, and CIS stimuli are delivered to the remaining electrodes. The CSSS pulse bursts are triggered by the zero-crossings of the

output signals of the corresponding filter channels, and their amplitudes are scaled with the instantaneous Hilbert envelopes of the filter output signals. Thus, both fine time and envelope information are represented in a CSSS channel.

Results and conclusions: Preliminary data, comparing pitch discrimination and scaling results for the new CSSS strategy and a standard CIS processor scheme, are presented. It will be discussed to what extent CSSS can support finer pitch resolution and different absolute pitch percepts than CIS.

Z6 – P6

Frequency discrimination with a fine structure strategy

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Objectives: The ability of cochlear implant users to detect low frequency changes is tested with a new strategy including temporal fine structure analysis in the low frequency bands in comparison to the CIS+ strategy in the MED-EL system.

Methods: Subjects implanted with a MED-EL cochlear implant participated in the study. The just noticeable frequency difference for sinusoids was measured with an adaptive 2 interval 2 AFC procedure. Frequency discrimination was measured at 150, 180, 200 and 250 Hz. Stimuli were presented over headphones. The CIS+ strategy was compared with a fine structure strategy using the TEMPO+ FSP. The fine structure strategy is analysing temporal fine structure using channel specific sampling sequences at the two most apical electrodes in a frequency range up to about 320 Hz. For both strategies the analysed frequency range was fixed between 100 and 8500 Hz.

Results: The frequency discrimination for sinusoids is significantly better with the fine structure strategy than with the CIS+ strategy up to 200 Hz. At low frequencies the average discrimination with CIS+ is 16 % of the base frequency, with the fine structure strategy it is 9 %.

Conclusions: The temporal coding at the lowest frequency bands in the fine structure strategy improves the detection of frequency differences. These results are relevant for the perception of music and the detection of FO changes.

Z6 – P7

A new stimulation concept based on "selected groups"

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Objectives and Methods: In cochlear implants, channel interactions tend to increase with decreasing spacing between electrode contacts. Applying a sequence of high-rate sequential pulses to adjacent electrodes, it can be assumed that only pulses with higher amplitudes will effectively elicit action potentials, whereas those with lower amplitudes are masked to a great extent and thus are much less effective. Instead of sampling and stimulating all channel outputs in an interleaved fashion such as in CIS, channels are subdivided into groups of adjacent electrodes (so-called "selected groups"), and within each group, only the channels with the highest amplitudes are picked for stimulation. Note that a N-of-M strategy represents a special case of selected groups with one group of size M. However, N-of-M strategies tend to select clusters of consecutive frequency bands, increasing the chance for interactions between adjacent electrodes (Nogueira et al., 2005). The proposed stimulation paradigm prevents this by arranging channels in several smaller groups.

The question to which extent the omission of masked pulses within selected groups affects speech perception and subjective loudness was investigated. Speech processor variations with different group sizes have been evaluated with MED-EL patients (C40, C40+ and PULSAR$_{CI}^{100}$ implants) by measuring speech reception thresholds for German Oldenburg sentences in CCITT noise.

Results and Conclusions: Preliminary results indicate that at least for small sizes of grouped neighboring channels, speech reception of sentences in noise does not differ significantly from a standard CIS control processor.

References

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Z6 – P8

The contribution of the apical region in PULSARCI100 cochlear implant patients: Investigations using the auditory nerve response telemetry (ART)

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Objektives: Objective measures are widely spread in the field of cochlear implantation. Intra-operatively they provide a first control of implantation success and post-operatively a simplification of the fitting procedure in very young children and in difficult cases can be expected. Especially the recording of the Electrically Evoked Compound Action Potential (EAP, ECAP) has become of increasing importance during the last years and cochlear implant systems of several manufacturers offer the possibility of intra cochlear ECAP recording.

Methods: The Auditory Nerve Response Telemetry (ART) of the PULSARCI100 cochlear implant provides high resolution ECAP recordings. Together with the standard electrode array, which allows insertion depths up to 31 mm, ECAP recordings of the apical cochlear region are possible as well.

In order to investigate the contribution of the apical region in cochlear implant users intra- as well as post-opera-

tive ECAP recordings using a research platform have been carried out.

Results: The presented clinical results show higher ECAP responses in the apical cochlear regions in most of the subjects.

Conclusion: Besides geometric reasons this might be due to a higher neural survival in the apex.

Z6 – O9

Multicenter pilot study: recording of the electrically evoked compound action potential (ECAP) in PULSARci100 users

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Objectives: The recording of the ECAP as a response of the auditory nerve to electrical stimulation is very common in the field of cochlear implantation. In an earlier study Zimmerling & Hochmair (2002) observed that the ECAP-amplitudes tend to be larger at the apical contacts. However the subjects were Ineraid patients where the electrode does not reach the apical region in the second turn of the cochlea. Therefore further investigations when stimulating more apical with the MED-EL standard electrode would be interesting.

Methods: The Auditory Nerve Response Telemetry (ART) of the PULSARci100 cochlear implant allows high resolution ECAP-recordings. Together with the deep insertion capability of the standard electrode ECAP responses can also be recorded from the very apical region of the cochlear. A Multicenter pilot study involving six centres has been carried out for the evaluation of post-operative ECAP recordings with the PULSARci100 in combination with a research platform. The subdivision of the electrode into an apical, middle and basal region allows a statistical comparison of the neural responses of these cochlear regions.

Results: The preliminary results show a dependency of the ECAP responses on the stimulation site within the cochlea. Especially the apical regions show higher response amplitudes and a steeper slope of the amplitude growth function than the middle and the basal regions in many subjects. The reason for that could be a higher survival rate and thus a higher number of nerve fibres or a shorter distance between the electrodes and the neural structures respectively.

Z6 – P10

Application of various stimulation pulse shapes in cochlear implants

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Objectives: Usually biphasic pulses are used for the stimulation of the auditory nerve. However, the use of other pulse shapes like triphasic stimulation pulses might be advantageous for the reduction of channel interaction and – during ECAP recordings – for the reduction of stimulation artifacts. In addition to that, the variation of pulse inter-phase-gaps could serve for threshold reduction and thus for saving stimulation power.

Methods: Psychoacoustic experiments as well as Electrically Evoked Compound Action Potential (ECAP) recordings have been carried out in PULSARci100 users. In order to investigate the influence of the stimulation pulse shape on the just audible thresholds as well as on several parameters of ECAP recordings (e. g. stimulation artifact etc.), triphasic pulses of various phase proportions and biphasic pulses of variable inter-phase gaps have been used.

Results: First results show the dependency of the just audible thresholds on the phase proportion of triphasic pulses and on the inter-phase gap of biphasic pulses. For triphasic stimulation pulses an increase of the thresholds can be observed whereas an increase of the pulse inter-phase gaps results into a threshold decrease. The influence of the pulse shape on characteristic features of ECAP recordings will be discussed during the presentation.

Z6 – P11

The RateCIS-strategy for cochlear implants

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Objectives: Nowadays technologies in cochlear implants provide a high degree of speech perception. However, for most patients the perception and the enjoyment of music are still not satisfying. Melodies are mostly not accurately transmitted and that a satisfying sound quality and recognition of instruments is not provided. One reason for this is the limited transmission of fine spectral differences.

Methods: In the MED-EL COMBI 40+ system the electrode distance of 2.4 mm causes different pitch perceptions at different locations inside the cochlea. Furthermore, changes in the stimulation rate can effect the pitch perception at a fixed electrode place. Therefore, a transformed speech coding strategy, the RateCIS strategy implements two possible stimulation rates for a number of electrodes. The RateCIS strategy was tested in comparison to the classical CIS strategy in nine subjects.

Results: During the acute switch over, the majority of subjects preferred the classical CIS strategy for speech perception and subjective evaluation of speech quality. However, for the perception of music, most subjects preferred the sound of the new RateCIS strategy.

Discussion: With the RateCIS strategy a first step towards a finer spectral resolution of the signal was made. The results show that changes in stimulation rate might help for a better appreciation and perception of music sounds.

Z6 – P12

Frequency to electrode allocation in the Med-El system for Spanish vowel

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Objectives: Based on the acoustic-linguistic vowels role concerning the oral speech comprehension and taking advantage on the different frequency bands distribution available in the Medel system such as logarithmic, lin-log, tonotopic, etc, the "user defined" distribution was selected in order to optimize the Spanish vowel perception.

Methods: The frequency bands distribution in the map of the patients were modified taking into account the first three vowel Formants F1-F2-F3, trying to minimize electrode overlapping in such a way that each of the five Spanish vowel, should activate different electrodes. Frequency boundaries were modified for male, female and for an average among those voices formant patterns. Patients were tested immediately, 1 and 3 months after changes, with isolated vowels, disyllabic words, formant transitions and every-day use sentences.

Results: Ten postlingual deaf adult patients participated in this study. Most of them showed improvements in the vowels comprehension and as a consequence, improvements in the speech comprehension were also noted.

Conclusions: The results obtained in this study, suggest that frequency boundaries changes adapted to the speaking language vowel formant patterns of the patients, could be a useful criterion to improve speech comprehension.

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Z6 – P13

Experiences with ART (Auditory Nerve Response Telemetry) in MED-EL PULSARCI100 patients collected in line with a multi-centre pilot study

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Objectives: The recording of Electrically Evoked Compound Action Potential (ECAP) as a direct response of the auditory nerve to electrical stimulation has been established during the last years in the field of cochlear implantation. Cochlear implants of various manufacturers offer the possibility of directly recording the ECAP via the implanted device, which could serve intra operatively, to prove the correct implant functioning, as well as post operatively, to simplify the fitting procedure in children and in complicated cases.

Methods: In line with a Multicenter pilot study first investigations with the Auditory Nerve Response Telemetry (ART) of the PULSARCI[100] cochlear implant have been carried out using a research platform. Besides the comparison of the ECAP responses of different cochlea sites preliminary tests regarding the correlation with psychoacoustic experiments have been performed. First results as well as interesting case studies will be presented and discussed.

Z6 – O14

Initial evaluation of the SmartNRI

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Objectives: To evaluate novel algorithm for automated acquisition of evoked responses that is based on rejection of non-biological signals.

Methods: We will describe a method for determining whether a neural response is present based on rejection of signals that are non-biological. In particular, response is classified as neural if it significantly deviates from the closest-fit artifact model. The method was validated by collecting responses in cochlear implant recipients below the psychophysical threshold. Such responses presumably contain only artifact.

The method for detection of neural signals was incorporated into an automated algorithm for estimating NRI threshold. Precision of the SmartNRI algorithm was evaluated by comparing the NRI threshold when the algorithm was started below threshold, or at upper comfort limit. The resulting NRI threshold was also correlated to psychophysical threshold to the same stimulus.

Results: The novel algorithm successfully rejected all of 402 sub-threshold recordings. Using the automated algorithm, we obtained responses in 98.5 % of 89 electrode pairs. The automated algorithm tended to converge to a consistent threshold both for sub-threshold and loud initial value (correlation

of 0.96). The collection time was less than a minute per electrode pair. The NRI threshold was also closely correlated with psychophysical threshold to the same stimulus (correlation of 0.9).

Conclusion: The novel SmartNRI algorithm provides a reliable and consistent NRI threshold that closely corresponds to psychophysical threshold to the NRI stimulus. The method promises to be of use in decreasing amount of time spent collecting evoked responses.

Z6 – O15

Neural spread of excitation: an objective tool to improve fitting?

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Objectives: The user's ability to discriminate between different pitches is related to speech perception scores (Nelson et al., 1995), therefore minimal electrode interactions should occur. Our objective was to find an objective way to measure interaction between contacts of the HiRes®90K cochlear implant and correlate electrode interactions with perceptual features.

Methods: Electrical Compound Action Potentials (eCAPs) were measured to assess neural spread of excitation around four electrode sites at various intensities in ten subjects. Two approaches for artefact reduction were used: masker roving and alternating polarity, both via Advanced Bionics research software. Pitch ranking and phoneme perception were also evaluated.

Results: Preliminary results show that electrodes with higher neural spread of excitation, as measured with both methods, tend to be less discriminated and that turning off such electrodes result in better phoneme perception.

Conclusions: The relationship between pitch discrimination, spatial spread of excitation and performance needs further investigation but measurement of neural spread of excitation appears hitherto as a useful tool to assess whether some electrodes should be turned off to improve user benefit. This study also allows comparison between two methods for recording eCAPs.

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Z6 – P16

Optimizing stimulation rate via NRI recordings in response to a burst

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The aim of the study was to investigate the tuning-in process at the onset of a high rate pulse train using Neural Response Imaging (NRI).

15 adult subjects implanted with either CII or HiRes90K were recruited; in six of them the influence of the stimulation rate of a HiRes program on speech perception and sound quality was investigated in a cross over study to gather data on their optimal stimulation rate. NRI recordings were performed with the Bionic Ear Data Collection System (BEDCS). The stimulating charge was kept constant at a level approximating comfortable loud and stimulation rates between 930pps and 3500pps were investigated.

By increasing the number of pulses in the burst, the response started to show an alternating pattern. By varying the stimulation rate, the amplitude of the response decreases with increasing stimulation rate. Above a certain rate, with further increase the pattern changes from the expected alternating pattern to a more complex one in some subjects.

For four subjects this transition was in about the same frequency range as the optimal rate in HiRes. One subject achieved the same speech perception scores for both rates tested and one subject was best at highest rate. For both the expected alternating burst pattern was found for all measured frequencies.

Our results indicate that it is possible to record the neural response evoked by an electrical burst via a telemetric recording system. These data indicate that the described technique may allow to optimize the stimulation rate.

Z6 – P17

Neural response imaging over time in pre-lingually deaf kids

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Aim: The Advanced Bionics Neural Response Imaging System (NRI) allows recordings of the auditory nerve activity in response to an electrical stimulus via the cochlear implant. To permit the method to be used to monitor the integrity of the auditory nerve over time base line data on the influence of electrical stimulation on the developing auditory system of children is required.

Design: A study was initiated to collect NRI recordings in a group of ten pre-lingually deaf children implanted with a HiRes90K and fitted with HiRes below the age of 4 years. The Advanced Bionics clinical fitting software Soundwave was

used to measure NRI recordings on four channels during surgery, at initial fitting and 3, 6 and 12 months after first fitting.

The NRI threshold was compared to the M-level used in the HiRes program.

Results: In the majority of children we could collect NRI recordings at least on three (of four) channels before starting the first fitting. Following our concept of a very careful beginning we mostly programmed around 120 CU for real comfortable starting levels, whereas NRI recordings usually varied between 50 and 200 CU.

During the next three or six months the levels show individual developments, and the standard deviation is higher than during first fitting. These levels are generally higher than the corresponding NRI recordings.

Conclusion: After collecting more data over the following months we will be able to perform preliminary statistical evaluations such as correlation coefficients, and regression functions.

Z6 – P18

Flexible NRI measurements with the HR90K implant

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Objective: NRI or eCap measurements can provide insight in various functional aspects of the auditory nerve. One common use in clinical practice is to assess how the nerve reacts to increasing current levels. The NRI amplitude growth curve may serve as a guideline during initial program fitting. Other interesting NRI paradigms are spread of excitation, recovery time or adaptation measurements. For some schemes multiple algorithms to cancel the electrical artifact are applicable. For users of the CII or HR90K devices, the clinical SoundWave programming software currently only supports one NRI paradigm, i.e. NRI amplitude growth with alternating polarity artifact cancellation. For the other NRI paradigms, the BEDCS research software was available. However, this tool requires a high level of technical expertise. Therefore new flexible software was developed to provide an intuitive interface to the full set of NRI paradigms.

Methods: New research software was created that provides NRI loudness growth, spatial mapping, spread of excitation, and recovery function measurements. All NRI measurements are stored and managed in a database. Where applicable, both alternating polarity and masker-probe artifact cancellation schemes are available. The graphical user interface provides rich graphical representations and flexible parameter access. The standard analysis includes eCap calculation, waterfall display and loudness growth. For custom analysis data can be easily exported to Excel.

Z6 – P19

Intra operative NRI's and eSRT's for prediction of MCL values

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Objectives: The purpose of this study was to compare NRI and ESRT (Intra-operative) values with M values on a map to determine whether NRI or ESRT measurements serve as a better guide to predict M values.

Methods: 15 patients undergoing cochlear implantation with HiRes 90K were studied intraoperatively. The ear was measured through neural response imaging with sound wave fitting software typically on stimulation and recording from electrodes 3/1, 7/5, 11/9, 15/13, the thresholds of NRI (ENRI). The ESRT recordings were performed using soundwave speech bursts and multichannel stimulation.

Results: In 7 out of 8 cases it was found that the ESRT values were closer to the M levels on the map as compared to the NRI values. In the map as compared to the NRI values. In the 9th case, the stapes was absent and ESRT could not be measured in the 10th case no ESRT values were obtained, although NRI's could be measured. An intra-operative X-ray showed the electrodes were not in the cochlea and on re-inserting the electrodes both ESRT and NRI were obtained.

Conclusion: From this study we conclude that intra operative ESRT's were more reliable in predicting the M levels than NRI measurements.

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Z6 – P20

Relationship between banded NRI and program parameters

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Objectives: To study the relationship between single channel and banded Neural Response Imaging (NRI); to evaluate whether banded NRI is better correlated to fitting parameters than single channel NRI.

Methods: The HiRes fitting system allows the use of "banded" stimuli to evaluate the program parameters: hearing threshold (T) and comfort level (M). Through research software, such stimuli are used to measure NRI. Being similar to the multi-electrode speech bursts used during programming, the banded stimuli may generate NRI responses better correlated to fitting parameters. Single channel NRI was recorded using the SoundWave® fitting software and banded NRI was recorded using the research software, typically: intra-operatively, at first fitting, and after three and six months of use.

Psychophysical measurements of loudness growth were performed, using a specific ten point loudness scale.

Results: Measurements were performed for twenty subjects. Banded NRI responses showed steeper growth functions and lower thresholds than single channel measures. The banded NRI growth function (GF) was more similar to the users' loudness GF than the single channel NRI GF. The development of banded NRI over time is presented.

Conclusions: Banded NRI appears promising for clinical application in terms of relationship between banded NRI growth function slope and perceptual loudness growth. However, more long term data is necessary to refine banded NRI based guidelines for HiRes programming.

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Z6 – P21

Correlation of banded and single channel NRI to psychophysical measurements

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Objective: To study the relationship between single channel and banded NRI and to determine the correlation of the two measurements to psychophysics.

Method: In the HiRes fitting system patients are fitted with banded stimuli (four electrodes at a time). Such banded stimuli can now be used to obtain NRI recordings. Single channel NRI was measured through Soundwave fitting software and Banded NRI was recorded using the research software intraoperatively, at first fitting, three months, six months and when possible at one year of use. Psychophysical loudness growth was also noted. Ten subjects were included in the study. Single and banded NRI thresholds, growth function and relationship to program parameters (T and M levels) are investigated.

Results: Banded NRI responses have steeper growth functions and lower thresholds than single channel measures. Patients' loudness growth functions are more similar to banded NRI slope.

Conclusion: Banded NRI is a potentially useful tool for clinical programming. Further data is required to develop guidelines for using banded NRI to optimize HiRes programs.

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Z6 – P22

Optimizing pulse width and rate in HiRes strategies

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Objectives: To study the effect on speech recognition of pulse width (PW) and rate in both CIS and paired (PPS) strategies.

Methods: Three groups of nine patients participated (SCLIN-group: =3 months of CIS (833pps/ch, 75 µs/phase); HiRes1 and HiRes2-groups with 1–2 year and >2 year of HiRes (±1400pps/ch, 21 µs/phase)). During 3 testing days nine 12-channel strategies were fitted following a latin-square design. After one hour test were performed with CVC-words (from CD, phoneme scores) in quiet and in speech-shaped noise with SNRs of +5dB and +10dB. The strategies allowed comparison between PWs of 11, 21 and 43 µs/phase at a rate of 967pps/ch, while for PW=21 µs/phase 773, 967, 1289 and 1933pps/ch were included. Finally, three comparable PPS strategies were included.

Results: No single strategy outperformed the others either in silence or in noise. PW=11 µs/phase reached inadequate loudness for 11 subjects. Picking each individual's best strategy on the basis of tests in quiet did not improve any group score in any of the SNRs significantly. However, optimizing at SNR=+10dB, gives an overall improvement of 59 to 68 % ($p < 0{,}001$) in this condition and a deterioration from 78 to 75 % ($p < 0.01$) in silence. Doing this, based on a combination of sound-only and SNR=+10dB, lead to an improvement from 59 to 64 % ($p < 0{,}001$) at this SNR, without deterioration in the sound-only condition.

Conclusions: If strategies are optimized individually, based upon a combination of tests in silence and in noise, significant improvement of speech perception in noise can be achieved without compromising more favorable listening conditions.

Z6 – P23

Statistics on impedances and programs of HiResolution users

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Objective: To collect normative data for electrode impedances and program parameters of a group of subjects implanted with the Advanced Bionics' CII or HR90K devices and using the HiResolution sound processing strategy.

Methods: All valid impedance and program records were extracted from the SoundWave database. In total 196 ears of 184 subjects were analyzed, 89 CII and 107 HR90K devices. A total of 1315 impedance measurements were present. There were 620 program records that had been downloaded into a

patient processor. These programs were probably the ones used for daily listening. Histograms were calculated for the electrode impedances and the stimulation rate, pulse width and most comfortable levels. A principal component analysis was performed on the M levels to determine the dominant fitting profiles.

Results: The average electrode impedance was 7.3 kO. For the program parameters 95 % of the subjects used the sequential HiRes-S strategy, reflecting the fitting practice at MHH. The remaining 5 % used the HiRes-P strategy. The average program parameters for stimulation rate, pulse width, most comfortable level and charge per phase were 2400 pps, 18.6 μs, 800 μA and 13.5 nC (173 CU). The variability on all parameters is substantial. PCA analysis shows a first dominant +/- horizontal profile. Higher components resemble a half and full period of a sine wave. Therefore the average SoundWave profiles are well approximated by a level and a slope.

Conclusions: Normative data for impedances and program parameters of HiResolution users are available as a guideline for clinical practice.

Z6 – P24

Spectral modulation detection in cochlear implant listeners

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Objectives: To understand the relationship between spectral modulation detection and vowel and consonant recognition in cochlear implant patients.

Methods: Spectral modulation transfer functions were measured for cochlear implant patients. These functions represent the amount of spectral contrast (dB) necessary for a patient to discriminate between an unmodulated spectrum and a sinusoidal spectral modulation for various modulation frequencies. Stimuli were created in the frequency domain by applying a sinusoidal spectral envelope of the desired frequency (0.25, 0.5 , 1 or 2 cycles/octave), starting phase and spectral contrast to a broad band noise (350 to 5600 Hz). The broadband stimulus was scaled to 60 dB SPL. For each spectral frequency, the modulation detection threshold (dB) was estimated using a cued interval two-alternative forced-choice paradigm. Two sets each of vowel and consonant recognition scores were obtained for each patient.

Results: The spectral modulation transfer functions obtained in cochlear implant patients show elevated thresholds for high spectral modulation frequencies. A high correlation was obtained between the modulation detection thresholds obtained at 0.25 and 0.5 cycles/octave and vowel ($r = 0.77$) and consonant ($r = 0.84$) recognition, respectively.

Conclusion: Vowel and consonant recognition in cochlear implant listeners is dependent on spectral resolution abilities. This correlation suggests that spectral enhancement strategies designed to improve spectral resolution could significantly improve speech understanding for cochlear implant patients.

Z6 – O25

Evaluation of the CSPE strategy using the SPEAR3 research processor

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Objectives: In our previous studies we have proposed a novel signal processing strategy named Channel Selection by pulse estimation (CSPE), which selects the stimulation channels by estimation the maximum amplitudes in time-amplitude matrixes, extracted from band-pass filtered signal frames. In those studies, we have used the Nucleus Implant Communication (NIC) research tools as a tool for presenting the off-line processed signals to CI listeners. Results of consonant recognition test were showing some better results compared to the listeners' everyday using strategies. Current study focuses on real time implementation of the CSPE strategy for SPEAR3 speech processor using the SPEAR3 hardware tools and software development library.

Methods: A user of Nucleus 24CI system with wearing experience of 30 months was participated in this study. The stimulus and loudness coding parameters of the CI listener's daily strategy were used for the evaluation of the CSPE strategy. The CI listener allowed to hear CSPE about one hour and then interviewed with the strategy.

Results: Analyses of a questionnaire provided during the interview showed preference of CSPE for soft and natural sounding. However, the participant preferred her daily strategy for clearness of speech signals.

Conclusions: The SPEAR3 research processor with the CSPE strategy could be given to CI listeners for future testing.

Improved clearness of speech signals could be acheaved with more experience of using the CSPE strategy.

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Z6 – O26

Combination of evoked compound action potential (ECAP) measurements: An investigation of possible application in speech processor fitting and optimal electrode placement during surgery

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The new Neural Response Telemetry of the Nucleus Freedom system offers much faster ECAP measurements than the previous version. Thus, valuable time saved during surgery can be used to obtain further information about nerve responses that may in turn have significant clinical implications. ECAP measurements in this study were carried out in >100 Freedom implants. A combination of ECAP measurements: threshold (T-ECAP), amplitude growth (AGF), spread of exci-

tation (SOE) and general waveform analysis were studied as well as individual electrode impedances.

Variance in the ECAP threshold and electrode impedances between intra-OP and post-Op were first compared. The change of the ECAP response (T-ECAP, AGF & SOE) in respect to changing current levels was measured and then compared with the psychoacoustic fitting levels T and C. For difficult electrode insertions, an ECAP shape analysis, ECAP amplitudes comparison and intra-OP X-ray investigation were studied. These measurements were found to be beneficial in providing feedback to the surgeon during the electrode array insertion for optimal electrode placement.

The Sound of Music (Z7)

Z7 – O1

Mu.S. I.C test battery – design and development

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Objectives: A test battery has been produced to measure music perception by cochlear implantees. There were four reasons.

Firstly, as cochlear implants have developed, there are increasing reports of CI users enjoying music.

Secondly, although some features of music have a cultural basis, many aspects are language independent; music testing allows truly international trials to take place.

Thirdly, some speech testing has ceiling effects, whilst music tests can legitimately contain some tokens which are so subtle that normal hearers cannot easily discriminate them, so allowing CI users to be scored on the same scale as normal hearers.

Fourthly, testing with musical sounds can reveal problems with the settings of CI processors which speech testing cannot identify.

Methods: In the initial version there are 6 objective modules, 5 requiring no musical knowledge. These are:

pitch limnen, down to the quartertone level for 7 different instrument families,

melody, rhythm and chord discrimination on various instruments,

determining the number of instruments playing.

The sixth objective module does require musical experience – identifying the instrument being played.

There are 2 subjective modules:

emotional response to specially composed musical pieces,

estimation of the degree of dissonance in a chord.

Conclusions: A test battery containing about 3300 music files has been developed and piloted. All music files are instrumental recordings.

Z7 – O2

Mu.S. I.C test battery – musical stimuli – a composer's perspective

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Objectives: A test battery has been produced to measure a variety of aspects of music perception in cochlear implant users. This composer's perspective looks at the creation of the various facets of the battery, as well as possible outcomes and conclusions.

Social conditioning, experiences and tonalities all contribute to our perception of music. The presentation examines the concept of dissonance in "normal" hearing people, and includes demonstrations of listening examples to highlight the wide range of the test. The musical intent is to explore predictability in music to provoke a musical and emotional response in each individual listener. When writing the pieces, it was necessary to consider not only their suitability for inclusion in a music test, but also whether they explored the full envelope of speech processor performance.

Design: Each module uses pieces that were composed specifically for the test battery:

Rhythm – 50 examples

How many Instruments? – specially written short work

Distinguish chords – distinguishing between 51 pairs of piano chords

Dissonance – assigning a dissonance/consonance rating to 45 piano chords of degrees of dissonance

Melody – 252 pieces at 7 difficulty levels

Emotion – 42 short pieces

Conclusions: All the music files have been recorded using live, acoustic instruments. The dissonance tests include subjective examples, as do the emotion files, which have an approximately equal number of generically happy/sad pieces, presented in a number of different ways. Normative testing suggests that the target levels of difficulty, dissonance, or sadness for which a piece was composed normally match the response of "normal" hearers.

Z7 – O3

Mu.S. I.C. test battery – results for normal hearers

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Objectives: With the introduction of the Mu.S. I.C. test battery for testing aspects of musical perception in CI users, it was obviously necessary to obtain normative data from normal hearers.

In addition, the efficiency and the user friendliness of the program was checked, in particular how well people respond-

ed to the test screens which used only pictograms and symbols, and no words.

Method: Tests on normal hearers have been carried out in Munich and North Wales, with normal hearers being defined as anybody who didn't use a hearing aid. The test conditions were the same as those used for CI users, for example headphones were worn. 116 people with ages between 8 and 80 were tested. All 8 modules were used and a brief review of the results for each module will be given. The results have also been analysed by age, gender and nationality.

Conclusions: The Mu.S. I.C. test battery is suitable for testing a wide range of different aspects of music perception. 64 % had a pitch limnen of 1 quartertone (or better) on piano, violin and puretone. Overall women had lower pitch limnen than men, and were better at distinguishing rhythms. Men were better able to determine how many instruments were playing at a time. In the subjective tests, British people tended to rate pieces as "happier" than the Germans.

Z7 – O4

Music perception of different CI users (unilateral, EAS, bimodal) and comparison to normal hearing subjects as assessed in the Mu.S. I.C. test

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The Mu.S. I.C. test covers 8 important aspects of music perception: pitch, rhythm, instrument identification, melody and chord differentiation, detection of the number of instruments, emotional impact and dissonance rating. This test battery was used to obtain an initial insight into the musical perception of unilateral, bilateral, EAS and bimodal CI users.

For this study a subset of files from each subtest was presented. Group analysis could be performed for the unilateral group (n = 32; α 0.05) vs normal hearing subjects (NH). For the other groups (EAS n = 15, bimodal n = 5) a matched pair analysis was performed vs NH and unilateral implant users. The matching was performed according to age and musical experience before hearing loss as assessed in the MuMu questionnaire.

Unilateral subjects scored significantly worse than NH in all subtests except the rating of dissonance and differently for the judgement of emotion. EAS users scored the same as NH for pitch, chord and melody differentiation and worse than NH in the instrument detection and differentiation tasks. No difference between those three groups was found for the other subtest. The results of bimodal users will be presented at the conference.

The Mu.S. I.C test allows the testing of a variety of different subjects and is useful to show differences between groups.

Z7 – O5

Bilateral cochlear implantation and music perception

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Objectives: Evaluation of music perception abilities of bilaterally implanted adult CI users in comparison to unilateral CI and normal hearing subjects. Anecdotal reports of patient's music perception exhibited strong preference for the binaural listening condition.

Methods: The Fitzgerald, Searle and Brockmeier test battery for music perception was adopted to evaluate music hearing of 15 experienced bilaterally implanted adult CI users. The test battery consists of 6 objective and 2 subjective individual tests, covering various aspects of music perception. Subjects performed the tests in both bilateral and better ear unilateral listening conditions. MUMU questionnaire results were used to select matching unilateral CI users and normal hearing subjects.

Results: In the bilateral CI listening condition, subjects performed as good as normal hearings, with the exception of interval differentiation of complex sounds. Performance is significantly lower in several tasks for the unilateral listening condition, yet still significantly better than performance of unilaterally implanted CI users.

Conclusions: The surprisingly good performance of bilateral CI subjects in spectral resolution tasks can explain some of most adult subject's strong preference of the binaural listenig condition. It is likely that binaural cochlear implantation increases the effective number of differentiable electrodes. Yet, for complex stimuli with many harmonics, normal hearing subjects still perform significantly better.

Z7 – O6

What is the difference between speech and music perception with a CI?

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Objectives: To study the similarities and differences between speech and music perception with cochlear implants. Although speech perception studies suggest that 6–8 channels of temporal envelope information are delivered, music perception studies suggest significantly fewer channels carrying more temporal information are present.

Methods: Music and speech perception tasks were performed by implant listeners with varying degrees of temporal information delivered to a clinical speech processor. The stimuli were encoded by an acoustic simulation typically used with normal hearing listeners. The tasks were an adaptive spondee in babble test, and a music test battery developed in our Center. The battery includes pitch discrimination, instrument and melody identification tasks.

Results: Performance increased when more temporal information was provided despite the fact that this information is theoretically discarded by the processor. This applied to both speech and music tasks.

Conclusions: Standard acoustic simulations are based on flawed assumptions regarding the amount of temporal information available to the CI listener The data suggests that fewer than 6 channels of information are provided but that these channels provide temporal information in excess of the envelope.

Z7 – O7

Discrimination of musical pitch by cochlear implant users

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Objectives: To assess the pitch discrimination abilities of adult cochlear implant users using synthesized musical stimuli.

Methods: The pitch discrimination abilities of a group of eleven adult postlingually deafened MED-EL Combi 40+ implant users was assessed in two experiments. In a discrimination test, the implant users were asked to indicate which tone in a sequence of three tones was "different". In an identification test, they were asked to identify the "higher" tone in a sequence of two intervals. The stimuli used in the two experiments included 4 musical instruments (trumpet, clarinet, violin, piano) representing different instrumental families based on principles of sound production (brass, woodwind, strings, pitched percussion). For each instrument, semitone spaced stimuli covering a fundamental frequency range from 175 Hz (F3) to 988 Hz (H5) were synthesized using a professional MIDI-Keyboard. Stimuli were presented through two speakers at a comfortable level of loudness. Just noticeable differences (JND) in both experiments were assessed using adaptive alternative forced-choice (AFC) tasks.

Results: Mean difference limens for change measured in the first experiment were found between 4.8 semitones (clarinet) and 11.7 semitones (piano). Mean difference limens for frequency measured in the second experiment were found between 2.5 semitones (trumpet) and 5.8 semitones (piano).

Conclusions: Implant recipients perform much less accurately than normal hearing subjects in musical pitch discrimination tasks. Furthermore the spectral and temporal characteristics of some instruments seem to have an influence on the pitch discrimination abilities.

Z7 – O8

A new test: appreciation of music by cochlear implantees (AMICI)

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Objectives: The purpose of this study was to develop a test that assesses the ability of persons with cochlear implants to interpret musical signals through the implant. The Appreciation of Music in Cochlear Implantees (AMICI) test was designed to measure the following abilities: discrimination of music versus noise; identification of musical instruments (from a closed-set); recognition of musical styles (from a closed-set); recognition of individual musical pieces (open-set).

Methods: The first phase of the study was test development and recording. The authors generated a list of musical and noise selections in the following categories:

1. Noise versus music discrimination: 20–30 sec selections from a wide variety of recorded musical sources have been listed. Noise stimuli have been selected from commercial recordings as well.
2. Identification of instruments: 20–30 sec selections from commercial musical recordings were identified. The selections were required to have the target instrument played without accompaniment or with accompaniment at a much reduced intensity relative to the target instrument. The target instruments were: trumpet, drum, flute, tympani, tuba, guitar, violin, female vocal, and male vocal.
3. Identification of musical style: 20–30 sec selections were identified in the categories: classical, Latin, country and western, jazz, rock 'n' roll/popular.
4. Identification of musical pieces: 20–30 sec selections were identified which were deemed part of the American cultural mainstream.

Conclusions: The stimuli developed in this study resulted in graded performance, with increasing difficulty reflected in the number of errors in each Section. As anticipated, the normal hearers had increasing difficulty as we proceeded from section 1 to 4, as listed above. The hearing impaired subjects, including CI users, made errors in Section 1 (noise vs. music discrimination) and in greater numbers in Sections 2 and 3.

Z7 – O9

A model of music perception and enjoyment by CI recipients

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Objectives: To present a model of music perception and enjoyment of adult CI recipients that addresses the contributions of technological factors, individual characteristics, and life experiences.

Methods: We tested a general model of mediating and moderator variables that influence perception of "real-world" melodies for CI recipients. The relations among these variables are based upon our multiple regression analyses, as well as prior studies (Gfeller, et al., 2001, 2002a, b; 2003; 2005). Multiple linear regression models, based on data from 207 CI recipients, were used to analyze the relations between the independent predictor variables (e. g., device, cognitive measures) and the dependent variables (perception, appraisal). From a potential 27 possible predictor variables, the best regression models for each outcome were chosen on the basis of Akaike's information criterion (AIC).

Results: Perceptual accuracy and appraisal emerged as 2 distinct aspects of music listening; the presence or absence of sung lyrics is an important moderator variable in perceptual accuracy and appraisal (p values < .09). Tests of individual parameters established that life experiences (e. g., music training) or individual characteristics (e. g., age, cognitive ability)

can significantly influence pitch discrimination and simple and complex melody recognition. Speech recognition scores were associated with few measures. Processor strategy predicted only timbre recognition. Life experiences were the strongest predictors for appraisal of complex melodies.

Conclusions: Multiple factors contribute to variability among adult CI recipients for music perception and appraisal. The relations among these factors provide a basis for a general model of music perception and enjoyment of CI recipients.

Z7 – P10

Pre-to-post cochlear implantation comparisons for music

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Objectives: This study investigated the effect of cochlear implantation on music perception by testing patients pre-surgery, whilst utilising a hearing aid (HA), and three months post-switch on of their cochlear implant (CI).

Methods: Nine postlingually deafened adults were tested on a music test battery incorporating five tasks: (i) pitch-ranking of one-octave, half-octave, and quarter-octave intervals; (ii) discrimination of 38 pairs of rhythms; (iii) identification of 10 familiar melodies; (iv) instrument and ensemble recognition; and (v) instrument and ensemble appraisal. Pre-surgery, subjects were tested with their HA only; post-surgery, they were tested using their CI only.

Results: Pre-to-post surgery comparisons showed that subjects were significantly worse with their CI at ranking pitches a quarter-octave apart ($p = 0.045$), only performing at chance level. For the larger interval sizes, there was no significant difference between the scores, although the post-implant scores were lower than the pre-implant scores. There were also no significant differences between the pre-to-post surgery comparisons for the rhythm, melody, or the instrument and ensemble recognition tests. However, appraisal ratings were significantly higher with the CI than the HA ($p = 0.026$).

Conclusions: This study indicates that the ability to perceive pitch may be decreased post-implantation when using only a CI. This may negatively affect a patient's enjoyment of music.

Z7 – P11

Music enjoyment following cochlear implantation

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Objective: The aim of this study was to evaluate musical perception and enjoyment in postlingually deaf CI patients.

Methods: A questionnaire was sent to 45 postlingually CI recipients, with a minimum follow-up of 1 year following surgery. The questionnaire included questions about difficulty in music enjoyment, musical background, satisfaction with the device for music listening, quality of musical sound heard through the implant, environmental circumstances that may influence the quality of musical sound, and factors that enhance or impede musical enjoyment. Thirty-six patients answered the survey and were included in this study. Responses were correlated with demographic data.

Results: Among 8 conditions, music and cinema enjoyment were the hardest skills to achieve. Most patients (78 %) in this study had very little musical training. The listening time per week was superior to 2 hours in 64 % of patients before deafness, and in 42 % following CI. The latter was significantly associated with the length of deafness. Half of the patients (50 %) stated to enjoy music following CI. Music sounded like music to 61 % of patients. Music enjoyment was not related to type of implant, etiology or length of deafness, and age at implantation. Known song (93 %), quiet environment (87 %), clear rhythm (86 %), and length of CI use (82 %) were stated as the main factors that enhanced musical enjoyment.

Conclusions: Enjoyment of music is a hard skill to achieve for CI patients, and it is influenced by several features. However, a significant number of recipients are able to participate in music activities.

Z7 – P12

Recognition of musical sounds among adult cochlear implant patients

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Despite being a developing country, many deaf Filipinos have growing inclination towards cochlear implants use because of its apparent benefit in improving the individuals hearing abilities. Though this may be the case, expectations are still limited because of reported difficulty in distinguishing different aspects of musical sounds as indicated in earlier researches. Because of the relative poor pitch perception abilities reported amongst individuals with cochlear implants, music recognition is said to be equally poor among its users. Notwithstanding current improvements on speech processing strategy and mapping techniques, this research intends to investigate the musical sound recognition abilities of all postlingually deaf Med El Cochlear Implant users aged twenty and above. Study participants shall be composed of all patients who have understanding of pitch and have consented to participate in the study. All adult participants shall be asked to identify different musical sounds recorded on a compact disc presented between 65dB to 75dB in a sound treated environment. Individual abilities on recognition of (1) different familiar musical instruments, (2) local songs with vocals and (3) those without vocals shall be measured under open and closed-set response condition. Data shall include recognition scores between individuals and different musical sound presentation. Subsequently, music appraisal abilities of all individuals with cochlear implants shall be established.

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Z7 – P13

Music benefits with HiRes 120 sound processing

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Objectives: HiRes 120 uses current steering to increase spectral resolution in HiRes sound processing. Because HiRes 120 offers the potential to perceive multiple and unique pitches, it is expected that HiRes 120 will result in a higher fidelity representation of music than HiRes. This multicenter study is assessing whether increased spectral resolution results in improved music perception and enjoyment in adult CII and HiRes 90K users.

Methods: Using an adaptive psychophysical procedure, the number of spectral channels that can be perceived using current steering is assessed in previously implanted (CII or 90K) postlinguistically deafened adult subjects. They then undergo music testing initially with HiRes and at one and three months after being programmed with HiRes 120. First, subjects rate the pleasantness of eight music passages (solo, small-group, or large-group instrument ensembles) on a scale from 0 to 10. Subjects then indicate how many instruments are heard and whether instruments are identifiable or distinct. Subjects also listen to music samples and identify the situation in which the sample is most likely to be heard (closed set: at a baseball game, wedding, birthday party, or New Year's Eve celebration). Music enjoyment in everyday listening situations is assessed by questionnaire. Music perception and enjoyment is compared between HiRes 120 and HiRes, and the relationship between number of spectral channels and HiRes 120 music skills is analyzed.

Results and Conclusions: Initial findings indicate subjects prefer HiRes 120 to HiRes for listening to music. Updated results from approximately 40 adults will be presented.

Z7 – P14

Music perception with a cochlear implant: preliminary results of a multi-centric study

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Objectives: This European multi-centric clinical study aims at determining the effect of frequency alignment (FA) for music perception in adults implanted with the HiResTM90k cochlear implant.

Methods: The FA setting uses a Greenwood-like model to derive the filter bank cut-off frequencies according to the individual electrode placement inside the cochlea. Subjects wear a HiResTM90k implant and have an interest in music. For each subject the study lasts six months. We assess music perception at regular intervals with an original test battery which includes: pitch ranking, melody identification and timbre comparisons. Each task is an adaptive procedure with feedback, which measures a "just noticeable difference" as a given parameter is varied.

Results: Ten subjects belonging to the same group have completed the study: they wore the default filter setting for the first three months and then were given the FA option for the following three months. Some of these subjects perform reasonably well on the pitch ranking task, and the custom setting FA allowed some of them to improve pitch discrimination abilities. Despite those improvements, the subjects show no significant improvement for the melody identification task. Concerning the timbre tests, subjects perform around normal-hearing people. Attack perception appears to be independent on FA, whereas FA allowed some subjects to improve on brightness discrimination.

Conclusions: We hypothesize that the High-Resolution processing scheme used in the HiResTM90k implant provides reliable timbre cues, that might also be used in simple pitch comparisons. Nevertheless the melody task remains difficult for the patients tested so far.

Z7 – P15

Music focus groups for adults with cochlear implants

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Objectives: Many adults with implants with cochlear implants report dissatisfaction with music. Music Focus Groups were developed to assist adults with music listening.

Methods: Adults were invited to attend a three-hour session in which they were presented with a variety of musical experiences – live and recorded. Attendees were encouraged to speak of their musical "history" pre- and post-implant. A series of simple musical exercises were devised to provide measures of the attendees' abilities to identify simple tunes, and discriminate between notes on a keyboard. A number of recordings were played to the groups and members were asked to rate each item. Attendees were asked to give their opinions of the Music Focus Group.

Results: Almost all reported deriving benefit from the experience. The results of the music tests indicated that most of the attendees were able to perform some simple musical discriminations. Attendees showed distinct preferences for some musical items.

Conclusions: The ramification of these results for clinicians will be discussed. Suggestions will be made as to the type of music that should be used in such sessions. Although subjects did prefer familiar items, they also indicated that music that met certain criteria such as singer gender, musical "mix", and presentation mode was preferred. An outline of the

course will be presented and offered as a model for other clinicians.

Z7 – O16

Effect of training on music perception by pediatric CI recipients

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Objectives: To examine the effect of training on pediatric CI recipients' recognition of well-known melodies and musical instruments. Prior research indicates that pediatric CI recipients are less accurate than adult CI recipients on familiar melody recognition and timbre recognition (Olzewski et al., in press), despite similar perceptual accuracy for pitch and rhythm. This study examines the effectiveness of acute computerized training on recognition of well-known melodies and musical instruments.

Methods: Twelve pediatric CI recipients (mean age = 11.7 yrs) were pre-tested in open and closed set for recognition of well-known children's melodies (no lyrics) and musical instruments. Participants then completed acute computerized training based on principles of paired-associate learning for both songs and solo musical instruments. Participants were prompted to attend to the unique rhythmic pattern for the familiar songs. Open- and closed-set posttests were completed to determine if training influenced perceptual accuracy.

Results: Participants scored 19.4 % (open set) and 49.9 % (closed set) correct in pre-testing on well-known melody recognition, and 69.4 % (open set) and 72.2 % (closed set) correct after acute training. The pre-test scores for instrument recognition were 27.8 % (open set) and 52.8 % (closed set) correct and 77.8 % (open set) and 77.8 % (closed set) correct following training. Repeated measures ANOVA revealed significantly greater accuracy following training for open-set melody recognition ($p < .001$) and open-set timbre recognition ($p < .002$).

Conclusions: Training based on paired-associate learning can assist pediatric CI recipients to more effectively use available cues in real-world musical stimuli, especially for open-set tasks.

Z7 – P17

The effect of kindergarten chants and music on fluency of prelingual cochlear implanted children

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Objectives: Using cochlear implantation to introduce hearing to a prelingual deaf child needs a thorough habilitation program, which in an ideal program should include all the auditory aspects of life, including rhythm, tonality, melody, and at the end, harmony, as well as auditory memory. Using music training in the habilitation program of such children can help reaching this ideal habilitation program.

Methods: All the children who have undergone cochlear implantation are potential candidates for this training program, if they and their parents are inclined. The first step of this program is the standard Orff method used for teaching music to normal children. In the second step, for older children who have shown enthusiasm to playing music, there is a special training course in Se-Tar (a traditional Iranian percussion instrument). The measured endpoints are rhythm understanding, frequency understanding, melody memory, and speech tonality.

Results: All children who have entered the music training programs, but one child, showed enthusiasm for the program and have significant improvements in their daily communications as well as the desired endpoints.

Conclusion: Music training can be, and should be, a part of post-implantation habilitation programs. It should not be confused with music therapy, which can play a part in rehabilitation of implanted children, as well as many other patients. We have introduced this approach a couple of years ago, and now it is completely incorporated in our routine habilitation program.

Z7 – P18

Music perception of children who use cochlear implants

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Objectives: This study assessed and compared the music perception and appraisal of children with normal hearing (NH) or a cochlear implant (CI).

Methods: Melody discrimination was assessed with the tonal subtest of the Primary Measures of Music Audiation (PMMA). The children (aged 9–16 years) were presented with pairs of short melodies and judged whether they were the same or different. To assess timbre perception, the children were presented with excerpts of recorded instruments and identified them from a closed set of twelve. Timbre appraisal was assessed using the same stimuli; the children gave a rating from one ('really dislike') to five ('really like') to each stimulus. Tests were also performed in the bimodal condition (CIHA) with those CI children who had aidable hearing in the non-implanted ear.

Results: The scores of the CI children were significantly lower and more variable than those of their NH counterparts for both the PMMA and instrument identification assessments. However, the CI children and the NH children gave similar timbre appraisal ratings. CIHA results did not differ significantly from those obtained in the CI-alone condition.

Conclusions: Significant differences were found between the music perception of these NH and CI children. However, unlike adult CI recipients, child CI users' music appreciation seems similar to that of their normally hearing peers. No benefit for music perception was observed using bimodal rather than CI-alone stimulation with these CI children.

Z7 – O19

Music enjoyment by listeners with a cochlear implant: A teacher's perspective

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A 'Teacher's Perspective' looks at strategies used in music education to help children with cochlear implants access their innate musicality, and looks at ways of assessing the musical development and achievements of these children. The paper analyses a number of DVD clips of children improvising, composing and performing to show qualitative differences in musical expression, and to discuss what implanted children can achieve, given the cochlear implant technology of today. The children range in age from 3 to 18 years old.

Discrete component testing of musical elements, such as pitch, rhythm and timbre gives an indication of what an individual hears. From a teacher's perspective, however, students perceive music as an entity, and experience it highly personally. Many students are motivated by the opportunity to perform music live, and at such times reveal a lot about their musical perception and awareness. The paper will highlight a number of case studies of implanted children who have gone on to achieve some exceptional goals.

The paper explores the need for a qualitative assessment of musical perception and discusses how a synthesis of the improvisatory techniques of music therapy combined with the structured methodologies of music education can help define such an approach.

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Z7 – O20

Children with CI – Playing music instruments

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Objectives: Children with CI are able to play music instruments.

Population: Children with cochlear implant playing different music instruments.

Methods: Case reports.

Results: Children with CI are able to play some music instruments very well.

Results will be demonstrated by video tape. Children with CI are able to distinguish important distinctive characteristics of melody and rhythm.

Conclusion: The therapy of children with CI should involve music – therapy. Music therapy with CI – Children has a lot of advantages. Music therapy influence positive the success of language acquisition, self confidence, satisfaction und inclusion. The content and the organisation form of music therapy in the CIC – Rhein Main Friedberg/Germany will be shown.

Complications in Cochlear Implantation (Z8)

Z8 – O1

Complictions of cochlear implantation

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Objectives: In this review, we examine the database of complications to share our experience and discuss our viewpoint with considerations and suggestions.

Methods: Information was gathered prospectively on the CI database. A minor complication was defined as a self-limiting, or a settling one with medical treatment and causing little distress to the patient. A major complication was defined as one leading to explantation or re-implantation, death of a patient, or excess of hospitalization more than one week.

Results: Amongst 442 patients implanted, complications were detected during the follow-up period. Four patients had transient facial nerve paresis and 1 patient had a late facial paralysis. Two patient had transient imbalance. One patient had arytenoid luxation due to intubation trauma. Perilymph fistula was detected in 2 patients and was sealed off. In one patient electrode was seen to be folded on itself in the cochlea making device useless. Most of the major complications are associated with chronic otitis media (COM) patients and mechanical and traumatic failure of internal device.

Conclusions: The majority of complications of CI surgery are reported to be minor and self-limiting, or amenable to medical treatment. Most of the major surgical complications are found to be because of prior mastoid surgeries which implicates the importance of surgeons experience in handling these groups of patients. Mechanical failure of the devices is another problem that comfronts the surgeon to major complications which should be overwhelmed by the companies. Traumatic failures of the devices can be also reduced by better technological designs.

Z8 – O2

Traumatic magnet displacement leading to complete magnet extrusion and healing of the extrusion site followed by unimpaired implant use in a 9 year old boy

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Objectives: To share our experience in the management of the unusual case of a 9 year old boy who sustained a number of minor head traumas resulting in the complete extrusion of his cochlear implant magnet followed by healing of the overlying skin and resumption of unimpaired implant use without evidence of infective sequelae.

Methods: The case is presented with history, and photographic documentation of the extrusion, healing and his adaptation to wearing a conventional adhesive disc over the implant site to maintain contact with his device.

Results: We present 12 months follow-up, an update on his recent performance and a discussion regarding future management options.

Conclusions: Although others have reported the displacement of removable magnets from cochlear implants after minor trauma, to the best of our knowledge this is the first case where complete extrusion and healing occurred with no obvious infective sequelae.

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Z8 – O3

The unspoken complication

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Objectives: To determine the complications caused by the transmitter coil due to the force of the magnet.

Methods: Retrospective multicentric study conducted in 3 centres on children less than 4 years of age who received cochlear implants.

Results: On evaluation of data from 3 centres it was found that children less than 2 years of age using magnet 2 developed problems at the site of transmission such as erythema and superficial ulcerations. This study highlights this problem especially as the age of implantation is reducing in most countries.

Conclusions: The authors feel that this problem needs to be highlighted so that adequate preventive measures can be taken in these young children to prevent this from occurring.

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Z8 – O4

Dislodged magnet from a cochlear implant: A new lasso technique

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Objectives: Magnet displacement is recognized as an uncommon, late complication following cochlear implant surgery. This complication necessitates surgical revision exposing patients to further surgical risk and morbidity. The purpose of this report is to describe a unique surgical technique for securing implant magnets which have dislodged.

Methods: A case involving a 5 year old cochlear implant patient is reviewed. This patient experienced magnet displacement on 2 occasions. Previously described surgical interventions are reviewed and we describe a new, simple unique method for re-securing the implant magnet via a lasso technique.

Results: The patient's magnet remains well placed postoperatively.

Conclusions: When compared to other surgical options our "lasso" technique represents an easy, quick and effective surgical option.

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Z8 – O5

Facial nerve protection

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Objectives: Learn about a new method to protect the facial nerve from a floating electrode stimulation.

Methods: W e operated a post-lingual patient with deep bilate ral neurosensorial hypoacusi a as result of an othosclerosis, who had been operated from both ears with cofosis, in whom we need to isolate the facial nerve during the surgery and protect its stimulation, when there is no falopium on the second and third portion of the facial nerve, by the extra –cochlear electrodes which are difficult to introduce.

This patient had a big deformation of both cochleas and she was 20 years old when she was implanted with a Nucle-

us 24 Contour, with a difficult insertion of 16 electrodes, staying the rest outside the cochlea. The problem in this patient is that the facial nerve aqueduct was completely destroyed on its second and third portion. In this cases there is a potential complication: the facial nerve lesion because of the electrodes and the nerve stimulation with the rest extra – cochlear electrodes. To avoid this we utilized the incus extracted and interposed under the array and over the facial nerve. This protects the nerve stimulation after turning on the implant and during the patient hearing life.

Results: The patient implanted had and excellent long term post-surgery result as well as her hearing result, without the complication of facial nerve stimulation by the extra-cochlear electrodes.

Conclusion: We consider this method an excellent way to protect the facial nerve from electrodes stimulation when the nerve is exposed. We think it has better results than fascia or mastoid bone.

Z8 – O6

Management of CSF leakage from cochleostomy during cochlear implant surgery

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Objectives: To determine the incidence and complications of CSF leaks at the time of cochlear implant surgery as well as accuracy of pre-operative imaging.

Methods: A retrospective review of 529 cochlear implant surgeries done between July, 1997 and December, 2005, at Vanderbilt University Medical Center (Nashville, Tennessee) or Virginia Mason Medical Center (Seattle, Washington) was carried out to determine the incidence of CSF leaks at the time of cochleostomy. Age at implant, sex, findings on neural imaging, leak management and device type were assessed.

Results: All CSF leaks were noted at the time of surgery. Six cochleostomy gushers were identified from the 529 patients studied for an incidence of 1.15 %. The mean age of these 6 patients was 20.2 (range 3–47 yr) years; male:female ratio of 1:5; and mean follow-up of 40.2 (range 5–52 mo) months. Two patients had normal CT images and the one patient with an MRI had a normal preoperative study. One subject had EVA plus enlargement of the vestibule, one had EVA plus a Mondini malformation, and one had no partition between the IAC and cochlea. His CT also showed a poorly developed auditory labyrinth with a rudimentary cochlea, absent round window and enlarged vestibule characteristic of an X-linked deformity.

Conclusions: CSF leaks are more common in the setting of cochleovestibular anomalies such as common cavity deformities and EVAS, they may occur in radiographically normal ears as well. Regardless of the etiology, CSF leaks occurring during cochlear implant surgery may be successfully managed using a stepwise algorithm of local packing conservative measures without routine lumbar drainage.

Z8 – O7

Saccular disorder after cochlear implant surgery

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Objectives: Cochlear implant surgery often results in postoperative vertigo of different extent. The long-term dizziness maybe caused by the intracochlear electrical stimulation which might activate the vestibular system too or the vestibular receptors of the the otolith organs are affected by the insertion of the cochlear implant electrode during surgery (i.e., saccular membrane distortion).

Methods: The occurence of vestibular evoked myogenic potentials, which are indicative for saccular function, was investigated pre- and postoperatively. Further the effect of intraoperative, intracochlear, electrical stimulation on vestibular evoked myogenic potentials were tested. Additional tests exclude other vestibular disorders (haptic vertical testing, video occulography during caloric irrigation and rotational chair testing).

Results: After cochlear implantation, no VEMPs could be elicited by air conduction in all patients. However, bone conducted VEMPs could be elicited in six (37.5 %) patients. A total of 10 patients (62.5 %) had a complete loss of VEMPs on the implanted side. Five of these patients suffered subjectively from a persisting dizziness and were significantly older (68.8 y) than the other patients (mean 46.7 y). In all patients electrically evoked VEMPs could be recorded only in monopolar mode. The threshold of the response was significantly different between apical (840 ± 10 μV) and basal (920 ± 14 μV) stimulation.

Conclusions: While acute, short-term dizziness after cochlear implantation can result from benign, positional vertigo, perilymphatic fistulae or endolymphatic hydrops, long-term dizziness seems to be based on saccular dysfunction. Our data also demonstrate that normal cochlear implant activation does not impair postural control by saccular dysfunction.

Z8 – O8

Cochlear implantation in vestibular aplasia

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Objectives: To report the results of cochlear implantation in a patient with normal cochlea and absent vestibular system.

Methods: Case report and review of literature of results of cochlear implantation in patients with this rare inner ear anomaly.

Results: Cochlear implantation is beneficial in pts with this anomaly. Loss of certain anatomical landmarks during surgery offer a challenge to the surgeon. Postoperative care and habilitaion has to tackle important issues of loss of balance.

Conclusions: Cochlear implantation is a good option for hearing in these patients provided parents are counselled with the problems of balance that these patients have.

Z8 – O9

Natural integration of CI ceramic housing into the skull

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Objectives: Need for special housing of cochlear implant receiver appeared after the healing failure of the wound over the silastic implant and skin tearing and implant breaking in ceramic receiver after head injury.

Methods: The concept comes from the idea of Noel Cohen. Ceramic receiver is placed to the level of surrounding bone. The bony island of the ceramic housing size is created on the dura. Then the edges of the bone are smoothed to the exact size. Implant is fixed by a single stitch.

Results: This surgical procedure has been done in 132 implantations without a single problem of wound healing or implant breaking after head injury. During the revision surgery in such a case one can see the implant is fully integrated into the bone of skull. Bone growth creates re-attachment of the detached edges of the bony island. Cosmetically in the post-operative period there is no deformity of the occipital and temporal area from the implant placement.

Conclusions: The natural integration of implant receiver is a safe and reliable surgical method to place the ceramic housing into the bone of skull with minimalisation the risk of implant breaking, displacement and risk of skin tears during the head injury.

Z8 – O10

Survey of prophylactic antibiotic use amongst UK implant surgeons

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Objectives: In 2002 there were a number of cases of meningitis in patients undergoing cochlear implantation. This lead to recommendations about the use of pneumococcal vaccination for all existing and future implant patients. The use of prophylatctic antibiotics at the time of surgery was also recommended however no clear guidelines were given with respect to which antibiotic to use, when to give it and for what duration. There were some suggestions that antibiotics should be continued orally after discharge which is not consistent with principles of surgical prophylaxis.

Method: We undertook a postal survey of all the consultants in the UK who undertake cochlear implantation to establish their antibiotic prophylaxis protocols.

Results: The findings will be presented at the Conference. The principles of surgical antibiotic prophylaxis and appropriate antibiotics will be discussed in general and with regard to cochlear implantation.

Z8 – O11

Trainee program to educate surgical skills in cochlear implantation

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Objectives: Cochlear implantation surgery has established as a standard procedure characterised by high reliability and low complication rate. Advanced surgical skills and "soft surgery techniques" now offer the possibility to prevent residual hearing by minimization of insertional trauma. Therefore, we find it essential to educate trainees of the cochlear implantation program with special respect to advanced surgical skills and experiences.

Methods: Apart from comprehensive knowledge of the backgrounds around cochlear implantation all trainees are asked to face specific topics which might be relevant to different steps of the implantation procedure. Thus, the influence of hand steadiness and tremor on surgical skills can be evaluated using a model to simulate microsurgical procedures. This model allows a laserinterferometric based assessment of manual tremor amplitude and maximum displacement to evaluate the subjects' fine motor skills. Further, relevant surgical experience is gained by using a cochlear model for insertion of practise electrodes. The measurement of manual insertion forces provides additional feedback to optimize the insertion performance.

Results and Conclusions: A structurized trainee's program of cochlear implantation seems useful for proper equipment of otosurgeons starting cochlear implantation surgery. Such a program should focus on the development of surgical skills which are specific and relevant for the implantation procedure.

Z8 – P12

Abnormal site of a common cavity patient

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A 2 year 9 months old Malay boy was diagnosed to have profound bilateral hearing loss since birth. This child had other congenital deformity such as ventricle septal defect [VSD], patent ductus arterosus [PDA] and polydactyl. VSD and PDA were surgical corrected at the age of 4 months with complete recovery. Magnetic Resonance Imaging and High Resolution Computerised Tomography Scan revealed a bilateral common cavity with the absence of cochlear structures such as basal turn, scala vestibules, scala tympanum and apex. Internal Auditory Meatus was seen to be present bilaterally but the presence of its content could not be determined. A supramea-tal approach was performed and middle ear was made assessable for cochlear implantation. Thick and abnormally positioned chorda tympani was noted and incostapedial joint was

identified. An attempt to drill at the normal position of the common cavity was unsuccessful as it was noted that the position of the common cavity was superior from the usual. This poster reveals that the site of the common cavity in abnormal inner ears could differ and often mislead despite of imaging. The patient was successful implanted with total insertion of 24 electrodes of MED-EL C40+ without any complications.

Cochlear Implantation in Malformed Ears (PE5)

PE5 – O1

Cochlear implantation in multi-handicapped children – an update over 171 children

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Detection of hearing impairment in newborns is partly realised by the introduction of newborn hearing screening. Although extensive audiologic evaluation is performed in suspicious newborns clinical finding of cognitive disorders in very young children, which can lead to a different outcome and therapy strategy, is only seldom at this age detectable.

This study analyses the outcome in 171 multi-handicapped children implanted between Sept. 1991 and June 2004. In order to correlate the outcome to the disorder the group was devided in subgroups including motoric disorders, auditory awareness defects, general organic defects, visual impairment, brain disorder, syndromes , general retardation of development, intelligence deficits, autism. The outcome is analysed using questionnaires (MAIS and MUSS) and auditory testing.

During surgery and postoperative no medical complications was observed. Independent from the handicap all children accepted to wear the speech processor. The development of speech understanding and oral speech communication was dependent from the type of handicap. Especially children with deficits in intelligence had a reduced benefit from the CI. However the positive development of auditory awareness demonstrated the constructive benefit of auditory rehabilitation also in multi-handicapped children.

PE5 – O2

Surgical results of cochlear implantation in malformed cochlea

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Objective: The aim is to report cochlear implantation results in 43 patients with malformations.

Methods: The age range was between 1–35 (average 8.5). The anomalies were classified according to Sennaroglu and Saatci classification. There were two patients with common cavity deformity, 14 cases of Incomplete partition type I (cystic cochleovestibular malformation), 9 cases of Incomplete partition (IP) type II (classical Mondini deformity), one patient with incomplete partition III, 16 patients with large vestibular aqueduct (LVA) and 1 patient with narrow IAC.

Results: Standard transmastoid facial recess approach was used in 40 patients. In the patients with common cavity deformity the electrode was inserted by transmastoid labyrinthotomy approach. No patient had facial weakness postoperatively. CSF gusher was encountered in 17 patients. It was found that CSF gusher was more profuse in patients with IP-I and IP-III than in IP-II and slightly larger cochleostomy is better to prevent CSF oozing around the cochleostomy. All patients showed improvement in language development. The patient with common cavity showed the maximum benefit from the implantation.

Conclusion: Cochlear implantation is a safe procedure in congenital malformations. In IP-I and common cavity patients modifications in the surgical approach due to abnormal course of the facial nerve may be necessary. Although all kinds of electrodes can be used in IP-II, in IP-I and common cavity patients full banded straight electrodes must be used. Hearing results are usually similar to implantation without malformations.

PE5 – O3

Cochlear implantation in children with inner ear malformations – Audiological results

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Objective: Inner ear malformations can be found in as many as 20 % of patients with congenital sensorineural hearing. The aim of this study was to prove that cochlear implantation is a beneficial method of rehabilitation in deaf children with bony and/or membranous malformations of the inner ear.

Methods: The evaluation of auditory responses to speech (EARS) test battery was performed on the children in this study after an average implant use of 3 years.

Results: Individual results of 8 children with inner ear anomalies receiving cochlear implants are presented in this study. Four of the patients showed an incomplete partition (Mondini dysplasia), one had a cochlear hypoplasia, one a Common Cavity and 2 suffered from an intraoperative cerebrospinal fluid leak. The majority of the children in this study are successful implant users. Wherever possible test scores are included and subjective case reports given.

Conclusion: Our results show that cochlear malformations are no general contraindication to cochlear implantation. Taking into consideration the small number of cases, it is very difficult to apply the findings described to a larger population.

Also, factors influencing the success of implantation are multiple, including a thorough preoperative radiological examination, a well-performed surgery and an individually tailored postoperative rehabilitation programme.

PE5 – O4

Evaluating Usher type 1 patients with cochlear implant: Quality of life, hearing and vision

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Objective: This paper focuses on the results of cochlear implantation in patients with Usher I syndrome. These patients with total congenital deafness, vestibular areflexie and progressive loss of visual field and vision have been more readily implanted at various ages because of their multiple handicap. This results in a relatively uniform group of patients with congenital deafness and a large variety in duration of deafness. Aside from the performance outcome of the patients, it is interesting to evaluate the subjective results of CI.

Methods: We have compared the different outcome measures between type I patients with and without a CI. Quality of life is measured by questionnaires, hearing impairment in the implanted patients with the equivalent hearing loss (EHL) principle and vision with the concept of functional vision score (FVS). We included 14 patients with CI (7 adults, 7 children) and 14 patients without CI (12 adults, 2 children) in this study.

Results: Patients with a CI report (significantly) better QoL scores on some questionnaire items than unimplanted patients. EHL worsens when age at implantation increases and FVS decreases with age of the Usher type I patient. Strong effect of the age at implantation is seen on speech perception performance. In the presence of severe vision loss, patients feel they benefit from CI, depending on the age at implantation.

Conclusions: Cochlear implantation in patients with Usher type 1 syndrome provides benefit to the patients. A factor involved in the obtained benefit is the age at implantation.

PE5 – O5

Facial canal anatomy in patients with microtia

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Objective: The most frequently encountered developmental abnormality of the external ear is microtia. Most patients with microtia have aural atresia and middle ear anomaly. The association of atresia and inner ear abnormalities is 11 % to 47 %. Cochlear implantation is an accepted method of auditory habilitation for profoundly hearing-impaired children who do not derive benefit from amplication. Temporal bone dysplasia is frequently associated with an anomalous facial nerve (FN), increasing the surgical risk of FN injury and FN stimulation. The goals of this study were to ascertain the location and course of FN in patients with microtia and compare them with respect to the severity of microtia.

Methods: We radiographically studied 50 patients less than 15 years of age with microtia (100 sides) using high-resolution computed tomography (HRCT). There were 30 patients with microtia and 20 patients with Treacher Collins syndrome (TCS). Findings were compared with those in 60 ears with normal auricles.

Results: The mastoid segment of the FN in patient with microtia was 3 mm more anteriorly and not more laterally displaced than that in normal subjects. Moreover, the segment of FN in grades II and III microtia was more anteriorly displaced than in grade I microtia. The mastoid segment of the FN in patients with TCS is displaced 2 mm more laterally and 3 mm more anteriorly than that in normal subjects.

Conclusion: The FN in patient with sever anomaly of auricle or TCS would be displaced. Preoperative imaging studies are essential to determining cochlear implant candidacy.

PE5 – O6

Cochlear implantation in cases of cochlear dysplasia

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Objectives: Congenital dysplasias of the labyrinth of the inner ear have been classified by Jackler et al (1). These anomalies vary in severity and correspond to an arrest of embryogenesis. Milder forms of dysplasia such as Mondini's deformity result from an arrest in development at the later stages. In these cases, cochlear implant surgery is usually relatively straightforward and not contraindicative.

In more severe forms of dysplasia, cochlear implantation is more complex and challenging. Recently, new innovative techniques have evolved that allow for cochlear implantation in cases of common cavity.

We have implanted nine patients with varying degrees of cochlear dysplasia. Two of these had common cavities and were implanted with MED-EL custom electrodes.

We will discuss our outcomes and experience.

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PE5 – O7

Children with additional disabilities and deafblindness, who have CI

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Objectives: The aim of this still ongoing study is to increase our knowledge about children with additional needs and deafblindness with cochlear implant. The major focus is a qualitative study of interaction, communication and language.

Methods: In this study, we are repeatedly visiting 10 children in their local educational settings. The children have additional disabilities or deafblindness, and they were between 1 year 9 months and 8 year 6 months when the study started. The children were implanted between the age of 2–7 years. Both kindergartens and schools have been visited. A multidisciplinary assessment of the children, as well as information about their educational environment and caregivers expectations has been gathered. Some of the traditional tools for

assessment are not suitable for use in our study, because of the children's delayed development.

Results: There is a wide range of abilities, skills and developmental level in the selected group. Many of the informants has described increased motor function after implantation. Some of the children are described as more approached to their environment after implantation. All the children in our study is reacting against sound. We find a variety of using voice, from cooing to spoken language, but all of the children are described as using voice more actively after implantation.

Conclusions: There are few documentations of children with additional disabilities and deafblindness with cochlear implantation. The children in our study has shown us that the outcome must be measured over a wide range, in addition to traditional tools used for speech perception and spoken language.

PE5 – O8

Cochlear implantation in children with hypoplastic auditory nerves

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Objectives: Hypoplasia of the cochlear nerves is found in a small percentage of congenitally deaf children being assessed for cochlear implantation, and some of these children proceed to implantation. The aim of this presentation is to alert clinicians to potential limitations in benefit for this group of children.

Methods: Two London Cochlear Implant Programmes have, between them, managed six children with hypoplastic auditory nerves. A retrospective case note analysis was carried out to consider the audiological findings, imaging, surgery, programming and progress of these children at least 2 years post-implantation.

Results: The children continue to use their implants at the time of writing, although the benefit received is limited. With the exception of one subject, the speech perception and production outcomes for this group were well below that expected for children implanted at the same age (Staller et al, 2002). Even for the most successful subject, progress is slower than would have been expected if his auditory nerves were not hypoplastic.

Conclusions: It seems likely that for congenitally deaf children with hypoplastic auditory nerves, progress in terms of speech, environmental sound recognition, and speech production will be severely limited. Implications for candidate selection and for counseling of families will be discussed.

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PE5 – O9

Auditory neuropathy / auditory Dys-Syncrony and cochlear implants: clinical cases

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Objectives: The goal of this study was to describe the first benefits shown in 20 children with Auditory Neuropathy/ Auditory Dys- syncrony after receiving Cochlear Implants.

Methods: The research was based on 20 case studies of children diagnosed with Auditory Neuropathy/ Auditory Dys-synchrony who had received Cochlear Implants at two separate Cochlear Implant Programs in São Paulo – Brazil. The data was obtained by gathering pre-surgery historic information, and evaluation of Neural ResponseTelemetry, behavior thresholds for electric stimulation, speech perception tests and sound field thresholds. All the patients were classified according to language and auditory categories.

Results: Electrical compound action potencial (EACP) was measured and all cases showed changes in the neural function after Cochlear Implant use. Auditory and language skills were significantly improved after the surgery, particularly in children who had used the cochlear implant for longer time.

Conclusion: The electric stimulation provided by Cochlear Implants appears to be an important strategy in the rehabilitation of children with Auditory Neuropathy by improving language and auditory abilities. However the results were heterogeneous particularly when each case was analyzed individually.

PE5 – O10

Clinical implication of inner ear anomaly in cochlear implant

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Objectives: To evaluate the surgical finding and results of cochlear implantation in inner ear anomaly.

Methods: 110 patients who underwent the cochlear implantation from January 2003 to January 2005 at the Yonsei University Severance Hospital were examined retrospectively, and inner ear anomaly was detected in 18 patients. Inner ear anomaly was classified to cochlear hypoplasia (n = 1), incomplete partition (n = 6) , semicircular canal dysplasia (n = 2), enlarged vestibular aqueduct (n = 4), and narrow internal auditory canal (n = 5). **Results:** Gush of the perilymph was 3 cases, facial nerve anomaly was 2 cases, and incomplete insertion of electrodes was 2 cases, nevertheless, after surgery, facial palsy, meningitis, and other complications were not developed. Facial nerve anomaly was detected in narrow internal auditory canal cases. In adults, without lip reading the word discrimination was feasible, and in children, except the narrow internal auditory canal case understanding of the commonly phrase without lip reading was possible.

Among 5 cases with the narrow internal auditory canal, auditory steady state evoked response threshold under 110dB HL was detected in 4 cases, but after surgery, they were not response to sounds at all (n = 3) or only response to the loud environmental sounds (n = 2).

Conclusions: None of cases developed important complications during surgery. After surgery, it was found that except in the cases with the narrow internal auditory canal, auditory performance was improved successfully.

References

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PE5 – O11

Surgical technique for the Nucleus double array cochlear implant in ossified cochleae

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Aim: The aim of this study is to prospectively describe the surgical technique of cochlear implant in patients with ossified cochlea using the double array cochlear implant.

Eleven patients were selected. The criteria included the etiology, the time of deafness onset and the audiology performance. These patients were CT and MRI scanned and submitted to surgery using a technique developed at our service: regular mastoidectomy followed by posterior tympanotomy. Two cochleostomies were performed. The basal cochleostomy was done using a cylindrical diamond burr, inferior and anterior to the round window and the apical was done just inferior to the cochleariform process and parallel to the tensor tympani muscle tunnel. Inside these two cochleostomies two electrode arrays were inserted.

Results: One patient had a CSF leak due to lesion at the internal acoustic meatus when performing the apical cochleostomy, with subsequent facial palsy and meningitis. A second surgery had to be performed to take off the implant and plug the mastoid cavity. The surgical technique achieved its aim on the other ten patients, once neural telemetry (intra op) has shown that neural structures were able to be stimulated with the cochlear implant.

Conclusion: Careful study of the ossified cochlea dimensions should be done to have right measures of the inner ear structures in other to avoid unnecessary damage. Right hand piece force with the correct burr is essential for a good cochlestomy performance. The surgical technique designed shows to be appropriate for the Nucleus 11+11 Double Array Implant.

PE5 – O12

Cochlear implants in children with autism spectrum disorder

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Objectives: To investigate the changes in language skills, auditory awareness, stereotypical behaviours and quality of life after cochlear implantation in a group of children with autism spectrum disorder (ASD).

Methods: Ten children using cochlear implants (mean age at implantation 2.7 years, range 1.1–4.5, SD 1.09) were identified from medical records and educational psychologist's reviews with behavioural characteristics of autistic spectrum disorder and additional developmental delay. Quantifiable measures of communication and stereotypical behaviours of ASD (eg. perseverative self-stimulatory behaviours) were analysed from video-recorded samples of six children pre-operatively and up to 48 months post-operatively. Formal language assessments (Peabody Picture Vocabulary Test and The Clinical Evaluation of Language Fundamentals-Preschool) were administered. Parental questionnaires were completed for all children to evaluate changes in communication, behaviour and quality of life.

Results: Pre-operatively, subjects demonstrated a range of expressive and receptive language abilities from non-verbal through to oral communication. All children demonstrated some gains on measures of language ability, behaviour and quality of life post-operatively. Video analysis results were consistent with parental reports of progress and provided useful data for both clinical management and ongoing research.

Conclusions: The presence of ASD has generally been regarded as a contraindication to cochlear implantation, based on the rationale that children with ASD may respond negatively to increased sensory input. The research in this area is extremely limited, providing little evidence for or against implantation in children with ASD. The current study indicated that most children exceeded pre-operative expectations, demonstrating linguistic and behavioural improvements over time.

PE5 – O13

Cochlear implantation in multihandicapped children

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In this study experience on 35 multihandicapped children who had implanted at Izmir Teaching and Investigation Hospital CI Center will be presented. Coclear implantation may be the only remedy for prelingually deafened multihandicapped children.

438 patients have been implanted at our center between March 1998 – December 2005. 309 of them were aged between 14 months – 16 years. 35 of them were multihandicapped. In some of them there were handicaps more than one. In 30 of them various degrees of mental retardation, in 2 patients visual disturbances and in 3 patients there were multiple neurological and orthopedical problems were seen. 11 of those patients were syndromic cases.Their implantation ages were between 1 year10 months and 9 years 6 months and implant usage durations were 22 months to 6 years 2 months.

For the fitting sessions at the beginning we have mainly used ESRT and NRI results. Speech performances and audilogical developments were satisfactory in 17 of 35 (according to PEABODY, CAP and SIR). Although the other patients can not succeed this developmental tests their performances were also satisfactory in comparison with similar non implanted patients.

In all patients cochlear implantation was thought to be the main channel for their communication and connection. Selection criteria for multihandicapped children need to be clarified.

PE5 – O14

Pneumocephalus and surgical emphysema: An unusual complication of cochlear implantation

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Case Report: A 53 year old woman with nasal polyps underwent uneventful cochlear implantation. Several days later, she blew her nose forcibly and blew air up the eustachian tube, through the middle ear, along the array and into the subcutaneous tissue. She also tracked air extradurally, and along a dural cleavage plane into the brain.

She was treated with 100 % oxygen, aspiration of the subcutaneous air, and a ventilation tube in the TM to prevent further forcible air pumping. She settled down with antibiotics and was a user for 6 months. She then developed an infection around the implant, with drainage through the skin but no exposure of the implant. The skin was opened, the implant moved and copiously irrigated, and the patient treated with 6 weeks of IV antibiotics. She did well for another 4 months, but the infection recurred with exposure of the implant through the skin. This was removed, and the patient will be re-implanted in 6 months.

This represents a previously undescribed complication of cochlear implantation, and serves as a warning about forceful nose blowing in the immediate post-operative period.

PE5 – P15

Cochlear implant in children with common cavity deformity (custom – made devices)

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Patients with congenital malformation of the inner ear are being considered for cochlear implantation in increasing numbers.
Surgery was not difficult as the cavity was located posteriorly in the location of the posterior semi-circular canal in normal ear.
We report the result of four cases , as there some speech recognition and indelibility few following surgery.

PE5 – P16

Morphological aspect of the trans-attical approach for cochlear implantation

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Since the development of cochlear implantation in the 1960s, both the surgical technique and the implant design have been modified. The suprameatal approach was developed by Kronenberg et al. in 1999. This method is a simple and safe surgical procedure that does not endanger the facial nerve and the chorda tympani.

The purpose of the present paper is to report the results of our study of anatomical variation and relations of the middle ear on the large collection of the temporal bones. Attention was paid to the structures and landmarks which are important for CI. In the mastoid region we examined: the type of pneumatization, the position of the sigmoid sinus, the course of the mastoid segment of the facial nerve and the facial recess. We noted great variability in the course of the facial nerve. The nerve bifurcation distal to the second genu was found in two cases. Dehiscence in the bony covering of the facial nerve were observed adjacent to the facial recess. Variations in the location of the chorda tympani nerve were also described. In the area of the attic we described the morphological variations. The compartment of the attic varies in shape and dimensions, depending upon the position of the auditory ossicles (the body of the incus and the head of the malleus) in relation to the attic walls, the degree of prominence of lateral semicircular canal and the direction of the course of the tympanic segment of the facial canal.

Knowledge of the morphological relations and variations is important for classical and alternative surgical method for cochlear implantation.

Audiological Outcome (PE6)

PE6 – O1

Applications of speech in noise testing using the BKB-SIN test for cochlear implant and hearing aid patients

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Objectives: We will review our experience with the BKB Speech in Noise Test as one method to assess outcomes in patients with hearing aids and cochlear implants. As these technologies improve, it becomes more important to differentiate among listening conditions. A simple “advantage” score

will be described that allows the direct comparison of benefit between 2 listening conditions such as 1 vs 2 cochlear implants in the same patient.

Methods: Pre-operative assessment included a comprehensive audiogram and speech recognition. Post-operative assessment also included a comprehensive audiogram and speech recognition testing in competing noise. Speech recognition testing included mono-syllabic words, sentences in quiet (Hearing in Noise Test – HINT) and Bamford – Kowal – Bench sentences in noise (BKB-SIN). All speech materials were presented at 60 dBA in sound field at 1 meter from a loud speaker at 0 degree azimuth.

Results: For each subject and condition, sentence recognition (percent correct) vs. the BKB-SIN score (dB SNR 50 %) were plotted on a scatter graph and correlated with linear regression (r = – .87) and a second order polynomial fit. The average BKB-SIN score (SNR 50 %) for the cochlear implant patients was 11 dB. The results will be highlighted by several interesting case study presentations.

Conclusions: Speech in noise testing is a simple and effective method to show speech recognition performance in patients with hearing aids and/or cochlear implants. The BKB-SIN test is time efficient and enables the comparison of different device uses as well as an overall basis for evaluating patient performance.

PE6 – O2

Effects of cochlear implantation on gustatory function

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Objectives: Due to the anatomical position of the chorda tympani in the tympanic cavity the nerve is at risk during cochlear implantation. The aim of the present study was to assess changes in taste sensitivity and the number of complaints in patients with cochlear implantation.

Methods: Eighteen patients (4m/14f, age 28–84, mean 52.4) were investigated using a newly validated procedure, which allows for the quantitative assessment of sweet, sour, salty, and bitter taste. Each side of the tongue was tested separately with four concentrations of each taste quality before and four days after surgery. The maximum score was sixteen.

Results: The mean taste score was 9.0 (SD 3.6) before and 6.2 (3.4) after surgery on the side of the tongue ipsilateral to the operated ear. This decline in taste sensitivity was statistically significant ($t=4.07$, $p < 0.05$). However, only one patient reported subjective taste loss due to surgery.

Conclusions: Our results show that unilateral impairment of taste function is seldom recognized by the patients. Preoperative testing of gustatory function is recommended in all patients which have allready been operated on one or both ears before.

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PE6 – O3

Outcomes of the multi-centre objective measures study

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Objectives: To develop guidelines for using Compound Action Potential (ECAP) and Stapedius Reflex Threshold (ESRT) to optimise HiResTM fittings.

Methods: 15 centres are participating. All subjects use a HiResolution Bionic Ear® system unilaterally. ECAP was measured on four locations through Neural Response Imaging (NRI), with the SoundWave® fitting software, intra-operatively, at first fitting, and after three, six and twelve months of use. ESRT recordings were performed intra-operatively, using SoundWave® speech bursts. Thresholds (Ts) and most comfortable levels (Ms) were measured with the SoundWave® default parameters.

Results: 93 subjects were enrolled in the study. Intra-operative speech burst ESRT was obtained with a success rate of 87 %, higher than reported in the literature with single channel measures. Intra-operative NRI responses were also robust, with a success rate of 88 %, increasing to 93 % post-operatively. Each tested subject had at least one response hence a 100 % success rate per subject. In the paediatric group Ms were virtually always higher than intra-operative tNRI or/and 50 % of intra-operative speech burst ESRT, and lower than intra-operative ESRT. A significant correlation was found between intra-operative speech burst ESRT and three month M levels.

Conclusions: A high success rate was observed in obtaining intra-operative ESRT, as well as intra- and post-operative NRI. Clinical recommendations were derived: bracketing of Ms between intra-operative tNRI, or 50 % of intra-operative speech burst ESRT, and intra-operative ESRT. Those recommendations will be refined at study completion.

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PE6 – O4

Chronic results from a psychoacoustic model based strategy

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In normal-hearing listeners acoustic masking occurs depending on frequency, amplitude and energy of specific signals. Those processes have been investigated in detail, i.e. by the Fraunhofer Institute[1] and the TNT[2], and are already implemented into well-known coding schemes such as mp3 (MPEG1 layer 3), successfully used in today’s portable mp3 music-players. However, in cochlear implant speech-coding strategies psychoacoustic masking has not been considered so

far. If the selection of stimulated channels in cochlear implant systems was based on a similar psychoacoustic model, information which is masked in normal-hearing listeners could be neglected, providing more bandwidth for signal components which are perceived by normal-hearing individuals.

Subsequently, a new strategy called PACE (Psychoacoustic Advanced Combination Encoder) has been developed which utilizes a psychoacoustic model for the channel selection instead of the simple maxima selection algorithm of the ACE strategy. It has been successfully implemented on a body-worn speech processor for chronic use.

A long-term cross-over study is currently being carried out to compare three different conditions: a) 8-channel ACE, b) 8-channel PACE, c) 4-channel PACE.

Acute tests from a pilot study with eight cochlear implant subjects yielded encouraging results with mean scores in the HSM sentence test in noise increasing from 51 % correct to 67 % correct. Results from the chronic study indicate that among all three conditions the 4-channel PACE achieves best results. Details of the new strategy and final results of the ongoing chronic study will be presented.

PE6 – P5

Long term follow up of psychophysical parameters in cochlear implant users

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During the fitting process it is the most important to determine the exact electrical threshold and comfort levels, which assumes a series of psychophysical measurements to be taken. The intensity at which just a hearing sensation is evoked (threshold level) and the intensity that causes a bearable loudness (the comfort level) must carefully be determined on each electrode. The speech processor will then transform the external sound stimuli – with the use of the appropriate speech coding strategy – to this dynamical range.

Psychophysical parameters show a temporal change which can be traced back to numerous reasons. The electrodes implanted into the inner ear will be covered with connective tissue which changes the electrodes' impedance. This way to reach the same stimulation one must set different amplitudes for the stimuli. During an adaptation period the central nervous system gets used to the louder sounds (especially in the case of praelingual and long lasting post lingual hearing loss). The comfort level rises, the hearing threshold drops, the dynamical range widens. As the result of continuous stimulation some regeneration processes occur at the periphery of the hearing nerve. This causes the change of thresholds (sometimes drastically). Numerous reasons can cause the electrodes to dislocate inside the cochlea. Because of the small sizes a sub-millimeter dislocation can cause a significant change in the threshold levels. Having the above in mind we must say that the regular programming of the device is very important.

PE6 – P6

Loudness function in cochlear implantees

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Objectives: The loudness function in CI patients could be described as a dependence of loudness sensation on stimulus intensity levels as well as on channel frequency, stimulus duration and interaction of different stimulation channels. The information on these relationships is important both for the improvement of speech processor programming results and understanding sound sensation mechanism with cochlear implant.

Methods: 14 cochlear implant wearers were included in the study (9 with Nucleus CI24M and 5 with Med-El Combi 40+ implants). The dependence of threshold levels as well as comfort levels of maximal loudness on the frequency and duration of stimulus were investigated. Additionally electrophysiological measures of temporary excitation summation at the spiral ganglion level (NRT) and subcortical nuclei (electrically evoked MLR) were performed.

Results and Conclusions: The data obtained suggest the existence of the temporary excitation summation at spiral ganglion and subcortical nuclei levels. At the same time, the loudness growth with stimulus frequency increase significantly exceeds the electrophysiological values of the excitation summation and can not be explained by this mechanism alone.

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PE6 – O7

Factors effecting speech perception in cochlear implanted adults

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Objectives: The aim of this study was to find factors influencing hearing benefits after cochlear implantation in terms of speech understanding in quiet and noise. This knowledge could be very useful in preoperative and postoperative prediction of hearing benefits and can be very helpful during qualification process.

Material and method: The material of this study was large and diverse population of over 170 patients implanted in Institute of Physiology and Pathology of Hearing, with age during implantation ranging from 15 to 60 years. There are significant differences in outcomes after cochlear implantation in terms of speech understanding and subjective assessment, even when audiological tests results are similar. It seems that there are more factors influencing hearing benefits that it was believed in recent years.

Results and Conclusion: Many factors was considered during the study: age of implantation, duration of deafness, hearing benefits from hearing aids before implantation and

many more. Dependences between those factors and speech comprehension test was presented in this study.

PE6 – P8

Peripheral physio-anatomical factors influence CI outcomes

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Objectives: Because large variation in outcome is observed across patients with the same cochlear implant system, yet mean performance levels across different devices are highly similar, we hypothesize that patient-dependent factors play a significant role in determining outcome in individual cochlear implant patients. We further hypothesize that outcome performance may be improved by addressing such factors in processor fitting.

Methods: Fourteen subjects implanted with the Clarion C-II or 90K implant systems have been examined using high-resolution CT imaging and recording of intracochlear evoked potentials (IEP) and electrical artifacts (EA). All subjects had normal insertions but varied in their speech recognition abilities. Measures of loudness growth, tonotopic electrode discrimination, and CNC speech reception were also made. Based on the combined imaging, electrophysiological and psychophysical results ad hoc changes were made in processor maps to minimize perceptual errors in information representation based on a vocoder model of speech processing.

Results: Significant variation in electrode insertion depth, medio-lateral placement and scala tympani/vestibule placement were observed. In addition, wide variation in IEP magnitude and spatial distribution of IEP and EA were observed. Simple manipulations of removing electrodes from the map, adjusting individual channels, and reducing rate of stimulation resulted in significant improvement in lower- and mid-performing subjects. All but one subject found the new map to be an improvement subjectively.

Conclusions: A large portion of the variation in CI outcomes is due to variability in physio-anatomical factors in the implanted cochlea. Attention to this detail in fitting can improve outcomes for many lower- and mid-performing subjects.

PE6 – O9

Prediction of outcomes for prelingually hearing impaired adults using cochlear implants

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Objectives: This study investigated the outcomes and predictive factors for prelingually hearing impaired adults with cochlear implants. This group receives little attention in the literature as outcomes can be variable and difficult to predict.

Methods: The study included 25 adults, with a prelingual onset of bilateral hearing loss, who proceeded with a cochlear implant at the Royal Victorian Eye and Ear Hospital (Melbourne, Australia). Speech perception data, demographic information and other related variables were collated and analysed. Predictor variables were explored, including expressive and receptive language skills, duration of preoperative severe-to-profound hearing loss, residual hearing, preoperative speech perception scores, preoperative device use, communication mode and type of speech processing strategy used. Pre and post implant speech perception scores were compared and multiple regression analysis was used to identify significant predictive relationships.

Results: 84 % of the participants demonstrated postoperative improvement in open-set sentence scores, providing support for the inclusion of this group of adults as candidates for cochlear implantation. Participants attained better postoperative sentence scores if they had a shorter duration of severe-to-profound hearing loss and greater expressive and receptive vocabulary skills.

Conclusions: Although speech perception outcomes for prelingually hearing impaired adults using cochlear implants are not as high as those reported for adults with acquired hearing loss, benefits for this group were significant. Individual benefits could be predicted to some degree from the hearing history and language ability. This information can assist clinicians to provide appropriate counselling.

PE6 – P10

Over the fence cochlear implantation: is it worthwhile?

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Objectives: From over 20 years of experience with cochlear implantation in adults with acquired deafness, it is now quite clear that open-set speech perception appears as an easily reachable target for this population. Following improvements in technology, candidates with more residual hearing were considered for implantation. Because of high levels of disability, some over-criteria candidates, that is candidates with more than 40 % open-set sentence perception ability, have also been selected for cochlear implantation by the Quebec Cochlear Implant team.

Methods: This study proposes a retrospective analysis of speech perception for those over-criteria candidates. Levels of open-set sentences perception following implantation, improvement of performance, and relation between pre and post implant capacities were assessed in order to examine the possibility of expanding further inclusion criteria for cochlear implantation.

Results and conclusions: Detailed results will be presented and discussed.

PE6 – O11

Preliminaries results on automatic cochlear implant fitting using interactive evolutionary algorithm

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Objectives: In cochlear implants many parameters could be tuned, and finding the best "fitting" was difficult since all patients are different (cause of deafness, number of years between total deafness and implantation, age, depth of electrode insertion, …). Cochlear implant fitting is performed by an expert practitioner.

This paper presents an interactive evolutionary algorithm (IEA) designed to help finding the best parameters of a cochlear implant and the first results with four patients are analysed.

Methods: The tests have been done with the Digisonic cochlear implant from MXM Inc. (France). Four patients not satisfied with their cochlear implant have been selected. An evaluation procedure has been elaborated to be useable for the IEA. The IEA approach has been tested in determining the optimal C (Comfortable intensity) and T (Threshold intensity) values for each electrode. The patients have been fitted "manually" by a practitioner and "automatically" by the IEA. The results of the four patients on discrimination and VCV tests have been compared for the two methods of fitting.

Results: Tests show that IEA approach permits to obtain results as good as those with expert fitting. The results show explicitly that for some patients the fitting problem is combinatorial with certain combinations of electrodes giving good results, on discrimination and VCV test, and other giving bad results.

Conclusions: The fitting approach with IEA shows encouraging results and has to be extended to other parameters (as frequency mapping).

References

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PE6 – O12

Results of cochlear implantation with Digisonic SP CI system

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Authors presented the results of a series of 44 cochlear implantation performed since 2002. All patients were operated by facial recess approach and anterior cochleostomy.

In 8 adult patients significant preoperative residual hearing was stated. Post-operatively residual hearing was preserved in all cases. Results of speech perception in this subgroup were better when compared with a subgroup of other adult patients.

In children there was a continuous progress in speech perception evaluated with TAPS II tests. Results in this group depended mainly on the age of implantation. In younger children results were significantly better.

Two patients were implanted with a Digisonic SP Binaural system. In both cases bilateral stimulation were better when compared with unilateral one.

There was also a case of auditory neuropathy. This patient achieved a tremendous improvement in all performed tests of speech intelligibility.

There was no technical failure of implanted systems.

Authors pointed out that implanted systems were safe and useful in different clinical conditions.

PE6 – O13

The effects of significant residual hearing on self satisfaction or self report of benefit in cochlear implanted adults

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Objectives: to demonstrate the self report of benefit after cochlear implantation in relation to the amount of residual hearing.

Method: The APHAB questionnaire was completed by subjects pre-operatively and then at 6, 12 and 18 months after receiving their cochlear implant. Pure tone audiometry, monosyllable testing in quiet and noise were conducted pre-operatively at 1, 6 and 12 months after initial device fitting.

Results: A paired comparison showed that the implants led to significant improvements in a number of factors: self-perceived communication skills, frequency of conversation with others, telephone usage, self-confidence and the impact of hearing impairments on family life.

Conclusion: The significant residual hearing has a great influence on subjective benefit of adult CI users.

PE6 – O14

Cochlear implantation in patients with significant residual hearing

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Objective: The purpose of this study was to describe the outcomes of patients with substantial residual hearing who have undergone cochlear implantation.

Study Design: Retrospective chart review.

Setting: Tertiary care referral center.

Methods: Chart reviews were completed for 12 patients with substantial residual hearing who underwent cochlear implantation. Preoperative and postoperative measures of

audiologic performance as well as complications were assessed.

Results: All patients who met inclusion criteria ultimately surpassed their preoperative aided performance level after implantation and gained significant benefit from their cochlear implant. At 6 months postimplantation, mean CUNY, HINTQ, andCNCscores were 93 %, 78 %, and 48 % in the implant ear alone, respectively. However, progress was slower than expected for many patients, and at least one patient took 1 year to surpass his preoperative performance level. There were no complications from surgery in this selected group of patients.

Conclusions: Patients with some degree of residual hearing do benefit from cochlear implantation. However, there may be an initial decline in performance as compared with preoperative levels. This decline is overcome in time in this patient population. These patients need to be counseled accordingly.

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PE6 – P15

Preservation of residual hearing in cochlear implantees – pilot study

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Objectives: To investigate the preservation of residual hearing in cochlear implantees after surgery and correlate with the surgical approach and the type of implant used.

Methods: Retrospective, multicentric study. Patients with residual hearing were assessed prior to surgery and reassessed with pure tone audiometry after surgery. The results were correlated with the type of cochleostomy ie soft surgery approach and the type of implant used.

Results: 30 patients with residual hearing were evaluated in this study from 3 centres in India.

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PE6 – P16

A Comparison of the acoustical and electrical stimulation on cochlear implanted patients

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Objectives: To compare electrical and acoustical stimulation on cochlear implant users: How do implant users perceive loudness of T, C and NRT threshold?

Methods: 5 Nucleus users were included in the study. 4 patients' 250 Hz threshold were better than 60 dB on the implanted ear; 1 patient was better on the contralateral ear. All patients' T, C and t-NRT levels were found on most apical (22nd) electrode. Stimulation rate was 900 Hz for T % C level and 80 Hz for NRT. Then, 250 Hz and/or 500 Hz acoustic stimulation was given via hearing aid to patients. Hearing aid output was measured by in-situ gain method. Patients were asked to compare electrical and acoustical stimulation for pitch and loudness level.

Results: Results will be discussed in the presentation.

PE6 – P17

Cochlea implantation in high degree burning

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Objective: The management of acute high degree burning is a challenge for specialized intensive care units. The long term consequences are commonly worked out by plastic surgeons. The results of ear and face affections are in some departments part of the ENT field. In high degree burning with affection of the head and a progredient sensorineural hearing loss treatment by cochlea- implantation difficulties are related to the changed skin structure.

Method and Results: Our treatment concept includes the combination of a cochlea implantation with a bone anchored ear epithesis. The different steps of surgical management are described. Explantation of residual concha cartilage. Implantation of the bone anchors and the cochlea- implant. Fitting of ear epithesis on the magnet abutment.

The importance of time spans between the different steps, possible complications and surgical hints are discussed.

Conclusion: The combination of cochlea implantation with a bone anchored ear epithesis is a solution in cases of deafness in patients suffering from a high degree burning.

PE6 – O18

Impact of cochlear implantation on subjective quality of life changes and correlation to audiometric data

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Objectives: To assess the impact of cochlear implantation (CI) on subjective quality of life (QoL) changes and to investigate the correlation between health utility scores (HUS) and audiometric data.

Methods: A quantifiable, self-assessment health related questionnaire on QoL changes (Nijmegen Cochlear Implant questionnaire, NCIQ) was completed by 54 postlingually deaf patients (mean age 54.1±8.6). HUS before and after CI were analysed using Wilcoxon pair test. Additionally, patients were tested by the Freiburger speech test for monosyllabic words and the HSM sentence test with and without noise. These results were compared to the current HUS (Spearman's rank test).

Results: In all subdomains of the NCIQ (basic sound perception, advanced sound perception, speech production, self-esteem, activity limitations and social interactions) the post-

implant scores were significantly higher than the pre-implant scores ($p < 0{,}001$). HUS of two subdomains, speech production and advanced sound perception, correlated significantly with the Freiburger speech test results ($p = 0.0008$, $p = 0.0011$), and the results of the HSM sentence test ($p = 0.0032$, $p = 0.0012$). The gain in QoL was highest in the patients with low pre-implant scores. 39 patients (68 %) reported to be always content with the change of QoL after CI. The majority (96 %) use their Cochlear implant all day.

Conclusions: The data obtained with the NCIQ reflects that CI has significant effects on several health-related QoL aspects, including physical, social and psychological domains. Our results indicate a close relationship between certain physical subdomains and audiometric data. The impact of CI on social and psychological domains seems to be independent from audiometric performance.

PE6 – O19

Cochlear implants in children: 10 years later

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Objectives: To assess a group of consecutively implanted children over 10 years after implantation with regard to speech perception, speech intelligibility, receptive language level and academic/occupational status.

Study design: A prospective longitudinal study.

Setting: Pediatric referral center for cochlear implantation.

Patients: Eighty two prelingually-deafened children implanted with the Nucleus multichannel cochlear implant

Methods: The main outcome measures were open-set PBK word test, discrimination of sentences in noise, connective discourse tracking using voice and telephone, speech intelligibility rating, receptive language level measured by Peabody picture vocabulary test, academic performance on french language, foreign language and mathematics and academic/occupational status.

Results: After 10 years of implant experience, 78 children (95 %) reported that they always wear the device and continue to gain considerable benefit from it. The mean scores were 72 % for the PBK word test, 44 % for word recognition in noise, 55.3 words/min for the CDT and 33 words/min for the CDT by telephone. The median value for speech intelligibility rating was 4 (over 5), and for the receptive language level 2 (over 6). Forty six children attended compulsory /secondary education (elementary/junior high school/ high school) in mainstream schools using oral/aural communication with a variety of levels of support, and 5 were studying in universities.

Conclusions: This long-term report clearly demonstrates that profoundly hearing-impaired children using cochlear implants can develop functional levels of speech perception and production, attain age-appropriate oral language, develop competency in a second language level in addition to their primary language and achieve academic performance like normally-hearing children do.

Electric Acoustic Stimulation (PE7)

PE7 – O1

Results from a multi-centre EAS clinical investigation

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Objectives: EAS has been proposed as a suitable treatment method for individuals with a moderate-to-severe sloping hearing loss, who gain little or no benefit from hearing amplification. Results have been reported from individual centres, demonstrating significant benefit for understanding speech in noise. This investigation assessed the viability of carrying over the success of EAS to a number of implant centres.

Methods: Suitable EAS candidates were implanted with a MED-EL COMBI 40+ cochlear implant, with an M-Electrode using the Frankfurt EAS surgical technique. Subjects were fit with a cochlear implant and used this condition for two months, during which they underwent a hearing rehabilitation programme. After two months, subjects were fitted with EAS, i.e. an Oticon Adapto hearing aid and CI ipsilaterally. Subjects were assessed at EAS fitting, then at three, six and twelve months after EAS fitting on a speech perception tests and a subjective evaluation. Hearing preservation was assessed using pure tone audiometry.

Results: 22 EAS surgeries were conducted, of which 14 subjects fulfilled all study criteria and were included in the analysis. Results will discuss the outcomes for each subject: including hearing preservation, final amplification outcome (EAS, bimodal or CI-only), and speech scores in quiet and noise. Results will show the difference in fitting conditions, comparing hearing aid only, CI-only and EAS.

Conclusion: In appropriately selected and counselled individuals, EAS is a useful treatment method for those with moderate-to-severe sloping sensorineural hearing loss. Benefit is particularly seen in noise and after a period of EAS experience.

PE7 – O2

Results of partial deafness cochlear implantation (PDCI) study

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Objectives: Partial Deafness Cochlear Implantation (PDCI) project has been conducted in the Institute of Physiology and Pathology of Hearing for 3 years in order to improve sound fidelity of cochlear implants users and create conditions

for a wider use of cochlear implants with combination of acoustic hearing (termed EAS – electric acoustic stimulation).

Material and method: 27patients with partial deafness received a partial insertion of a standard electrode, using the round window approach. Pure tone audiometry, monosyllable testing in quiet and noise were conducted pre-operatively, at implant fitting and then at 1, 3, 6 and 12 months after initial device fitting. The APHAB questionnaire was completed by subjects pre-operatively and then at 6 and 12 months after receiving their cochlear implant.

Results: Hearing was preserved in 25 out of 27 cases. Improvement in monosyllabic scores over time in both quiet and noise were significant.

Conclusions: Results obtained so far, indicate that with developed surgical procedure and a limited electrode insertion hearing can be preserved in the majority of patients with partial deafness. This preservation allows subjects access to low frequency hearing, which can benefit their speech perception outcome, as the combination of electric and acoustic stimulation provides a more complete representation of sounds than it would be possible with either modality alone.

PE7 – O3

Retention / improvement of residual hearing after EAS Cochlear implant surgery

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Objectives: To compare pre and post operative pure tone audiometry.

To measure low frequency hearing stability over time.

To assess the benefit of the cochlear implant over time.

To relate performance to implant position as evident by radiology.

Methods: Five patients underwent cochlear implantation with a view to EAS, using a Med-El medium electrode array and soft surgery technique. Pure tone audiometry was performed pre-operatively and post operatively at regular intervals for the first 12 months following implantation. Imaging pre and post operatively was compared to evaluate electrode position.

Results: Four out the five patients had functional hearing preserved and one had a significant improvement at two frequencies. One patient lost all residual hearing and has a poor outcome from the cochlear implant. Partial electrode insertion as measured radiologically was responsible for the poor outcome.

Conclusion: Residual hearing can be preserved successfully using minimal invasive surgery and an appropriate electrode array. However suboptimal insertion is associated with poor outcome.

PE7 – O4

Residual hearing and electro-acoustic stimulation with Nucleus 24 CA

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Objectives: To study conservation of residual hearing in recipients of the Nucleus 24 Contour Advance electrode array and the benefits of electrical and acoustic stimulation combined in the same ear.

Methods: Subjects were adult candidates for cochlear implantation. A "soft" surgery protocol was defined including 1–1.2 mm cochleostomy anterior and inferior to the round-window, and the perimodiolar electrode array inserted 17 mm using the "advance-off-stylet" technique. Pure-tone thresholds were measured pre-op and post-op at intervals. Speech recognition was tested for cochlear implant alone for all patients and combined with an ipsi-lateral hearing aid for those patients retaining significant residual hearing (El-Ac) in the implanted ear.

Results: Hearing thresholds were conserved to within 20dB in 50 % of cases at 125Hz and 250Hz and in 33 % at 500Hz where "soft" surgery was strictly followed. The median threshold increase was 23dB for 250Hz and 500Hz. For 9 El-Ac users mean scores for words presented at 65dBSPL were 45 % for CI alone, and 55 % for cochlear implant plus ipsilateral hearing aid (Diff. 10 % pts, $P < 0.05$, Paired-T). For sentences presented in noise at 5dBSNR, mean scores were 46 % CI alone, and 56 % CI+ipsiHA (Diff. 10 % pts, $P < 0.01$, Paired-T). Despite similar performance in quiet, mean performance in noise of CI-only users was worse (22 %) than El-Ac users.

Conclusions: Hearing could be conserved to within 20dB of pre-operative levels for conventional candidates for cochlear implantation provided that the specified soft-surgery techniques were observed. There were considerable benefits for speech recognition in noise using combined ipsi-lateral electrical and acoustic stimulation.

PE7 – P5

Clinical, surgical and histopathological results from Vienna electro acoustic surgeries

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In 1999 Christoph v Ilberg introduced the *E*lectro *A*coustical *S*timulation (EAS) as a combination of conventional hearing aid and cochlear implant *on the same ear*. After successful implantation, it is possible to wear and combine cochlear implant and conventional hearing aid on the ipsilateral ear.

Since 1999 we performed 15 cochlear implantations in residual hearing patients, concerning the aspects of EAS. In 12 of these patients we could preserve the residual hearing.

Those 12 patients use hearing aid and cochlear implant on the same ear effectively together. Cochlear implant device is a Med El Combi 40+ custom made device. Insertion depth is 18 to 20 mm only, compared to 30–32 mm insertion depth in conventional cochlear implantation.

To reduce the effects of drilling and trauma through the surgical procedure we, developed a surgical approach minimising the drilling effects to the cochlea and performing a controlled and atraumatic insertion.

All those ten patients are, concerning their speech understanding performance in cochlear implant only condition, so called "good performers". Their speech understanding scores in monosyllables, number and sentences are superior, compared to mean scores of the Med El Combi 40/40+ multicenter study (Helms et al.).

We think this is due to the increased number of full ability spiral ganglion cells , because of residual hearing.

Additionally we see positive effects of the preserved audiological hearing in the lower frequencies. Patients report about a positive, convenient, "classical used", sound feeling and environmental sound detection.

In signal/noise testing and in subjective evaluation, patients benefit from the ipsilateral combination of hearing aid and cochlear implant.

PE7 – P6

First case of bilateral electro acoustic stimulation

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Benefits of bilateral cochlea implantation have been shown for patients with severe hearing loss. So far no patient with residual hearing using electroacoustic stimulation (EAS) has been reported to be implanted bilaterally.

We describe the first case of an EAS-user whom we implanted bilaterally.

The right side of the female had been implanted in 1999 with a MED-EL Combi 40+-implant with standard-electrode using the surgical procedures for electric-acoustic stimulation (EAS). Therefore the electrode was inserted 20 mm, radiologically resulting in 360 degrees insertion depth. Residual hearing of this first implanted ear could be preserved completely.

In the following residual hearing of the implanted ear was stable over time. Sudden hearing losses of the contralateral ear always recovered completely, also resulting in stable hearing.

The patient is one of our best EAS-performers. After nearly 7 years the patient and we decided to implant the second ear because of her good performance with EAS and the stability of the contralateral ear.

For the bilateral implantation we used the MED-EL Pulsar ci100 with new FlexEAS-electrode. The insertion depth was 18 mm.

Again we could preserve residual hearing completely. Results of the speech tests (HSM in quiet and noise and monosyllables) of the second ear and in combination of both ears with EAS will be presented at the conference.

Bilateral use of EAS-strategy is possible and adds to the quality of life of the patients.

PE7 – O7

Electrophysiological and histological evaluation of the cochlear apical region in guinea pig after cochlear implantation: the viability of hearing preservation

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Introduction: The cochlear implant has been used as a rehabilitation method for profound bilateral deafness. Patients with high frequencies loss that don't benefit from hearing aids may be candidates for cochlear implant if the low frequencies could be preserved after the implant surgery. **Objectives:** The aim of this study was to evaluate the damage caused at the apical turn of the cochlea when the basal turn is implanted.

Material and Methods: Thirty guinea pigs were divided in two groups: the control group had the cochleostomy performed and the study group had the cochleostomy performed and the basal turn implanted 4 mm deep with a silicon array simulating the cochlear implant array. All guinea pigs had hearing evaluated with tone burst evoked potentials before surgery and 60 days after surgery. All of them had a histological evaluation of the apical turn through rodamin-phalloidin.

Results: The study group showed a higher frequency of damage (80 %) when compared with the control group (40 %) ($p = 0,03$). As long there was damage, it was confirmed with evoked potentials (100 %) ($p = 0,001$). The lesion occurred in every frequency at the evoked potentials evaluation.

Conclusions: There was any degree of lesion in 60 % ($p = 0,03$) of the guinea pigs on the control group and in 93,7 % ($p = 0,03$) in the study group. The auditory evoked potential was normal in 40 % ($p = 0,08$) at the control group and 6,7 % ($p = 0,08$) in the study group. Any degree of histological lesion corresponded to lack of response at the auditory evoked potentials.

PE7 – P8

Blood admixture to the scala tympani has detrimental effects on hearing thresholds

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Objectives: Electric-acoustic stimulation of the inner ear (EAS) is based on conservation of residual hearing. As shown in central nervous system hemorrhage, some blood constituents have neurotoxic potential. We therefore evaluated detrimental effects of blood admixture to the perilymph.

Methods: Eight guinea pigs underwent perilymphatic administration of 3 microliters of blood and Hank's solution in each ear, respectively via a scala tympani cochleostomy. Compound action potentials (CAPs) were measured before administration and at different intervals for 2 months thereafter.

Results: A mean threshold shift of on average 18 and 20 dB vs. 13 and 7 dB was observed postoperatively and at day 3 ($p < 0.01$). In the following weeks the difference in threshold loss decreased to stable values that averaged 3 to 5 dB ($p < 0.05$).

Conclusions: Even minor admixture of blood to the scala tympani, that may occur during CI-Implantation and drug administration via the round window, causes significant transient and permanent threshold shifts and should therefore be avoided.

PE7 – O9

Treatment options for patients with residual low-frequency hearing

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Objective: To assess treatment options for patients with residual low-frequency hearing.

Methods: Six patients who fit the clinical trial criteria for an EAS device were given a month-long trial of a frequency transposition hearing aid. Another group of 12 patients who fit the same criteria were provided a full electrode insertion in on their EAS-eligible ears. Smaller sets of patients who fit the same criteria received 10 and 20 mm insertions of electrode arrays. Both psychophysical and speech perception data were collected before and after implantation for the latter group of patients.

Results: The frequency transposition hearing aids provided, on average, a 10 percentage point gain in speech intelligibility. A full electrode insertion provided, on average, a 28 %percentage point gain in speech intelligibility for CNC words. In the contralateral EAS condition the gain was 46 % points. Data for the 10 and 20 mm insertions are still being collected.

Conclusions: Frequency transposition hearing aids provide minimal benefit to this patient population. A full insertion of an electrode array provides significantly greater benefit. The added benefit of having two partially hearing ears, i.e., a standard EAS surgery, remains to be determined.

PE7 – O10

Combined electric and acoustic stimulation of the ipsilateral cochlea

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Objectives: To assess, for patients using combined electric and acoustic stimulation (EAS), the relationship among pre-implant measures of auditory function and pre- and post-implant measures of speech, voice and music recognition.

Methods: Pre- and post-implant measures of psychophysical auditory function (i.e., frequency resolution, temporal resolution, nonlinear cochlear processing) as well as measures of speech and melody recognition were obtained in a small sample of EAS patients with a 10 mm electrode insertion (e. g. Gantz et al., 2004, 2005).

Results: Pre-implant estimates of psychophysical auditory function ranged from near normal to grossly abnormal across the listeners. Post-implant estimates of psychophysical function yielded varying degrees of change across the listeners. In a few cases, minor alterations of frequency selectivity and nonlinear processing were observed following surgery. Post-implant speech intelligibility data revealed a range of observable benefit from adding residual acoustic to electric stimulation. The largest benefit, however, was observed for sentence material in noise.

Conclusions: Preliminary findings demonstrate that the presence of an intracochlear electrode array does not necessarily result in a significant loss of psychophysical auditory function. Because both ipsi-lateral and contra-lateral acoustic stimulation can improve speech intelligibility afforded by electrical stimulation, comparisons of post-implant speech intelligibility performance will be discussed for individuals with similar degrees of pre-implant hearing who have received either full-insertion or a 20-mm insertion implant.

References

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PE7 – O11

Stability of hearing preservation after partial deafness cochlear implantation (PDCI)

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Objectives: To present stability of hearing preservation after Partial Deafness Cochlear Implantation. Preservation and stability of low frequency hearing after the surgery is the key factor allowing effective combination of acoustic and electric stimulation (EAS).

Method: Partial Deafness Cochlear Implantation, the procedure of treatment of patients with excellent low frequency hearing, was performed in a group of 27 patients (both adults and children). Hearing preservation stability was evaluated in 10 patients from the group, with at least 2 years experience in EAS.

Results: One patient from the group lost all hearing and four lost some hearing as a result of the surgery. two subjects lost some hearing over time. In three patients hearing is stable.

Conclusions: The results shown indicate that with round window surgery and a limited electrode insertion, hearing can be preserved in the majority of patients with a ski-slope hearing loss.

PE7 – P12

Bimodal hearing in electric acoustic stimulation

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Introduction: Binaural hearing provides the listener with distinct advantages over monaural hearing viz. the head shadow effect, summation effect and squelch effect. Research has shown that individuals with unilateral hearing loss have difficulties concentrating, hearing in noise and localising. Benefits of bilateral hearing amplification led to experiments with bilateral cochlear implantation. Studies show that bilateral CI restores the benefits of binaural hearing in most cases. Some studies have suggested that providing a hearing aid contralateral to the CI improves speech perception, localisation and speech intelligibility. As EAS is currently only implanted unilaterally, this study assessed the benefits that a contralateral hearing aid might provide the EAS user.

Methods: Those EAS patients, participating in the MED-EL EAS Clinical Investigation, and wearing a contralateral hearing aid were recruited for this study. Only one patient, implanted at the University Hospital Antwerp, qualified for this study. The subject was assessed under the following listening conditions: CI only, EAS, EAS and bimodal, and bimodal only. Tests conducted were: monosyllables, sentences in quiet, and sentences in noise at the following SNRs: 10dB, 5dB and 0dB.

Results: Results show considerable benefit with the addition of a contralateral hearing aid.

Conclusions: Bimodal fitting in EAS may provide additional benefit for EAS users. This would need to be considered on an individual basis; however all subjects should be offered the opportunity for a contralateral hearing aid trial. Further testing will need to be conducted, as well as the traditional tests to determine the binaural benefits that bimodal fititng in EAS may provide.

PE7 – P13

Listening quality in EAS individuals

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Objectives: Electric Acoustic Stimulation is a treatment method for individuals with moderate-to-severe sensorineural hearing loss. Studies have shown benefit for individuals who wear a cochlear implant and a hearing aid in the same ear, particularly in noise. This paper will address the reported subjective benefits of EAS.

Methods: The APHAB (abbreviated Profile of Hearing Aid Benefit) is a self-assessment instrument for determining the subjective benefit a person receives from amplification- It is a 24-item disability-based inventory that can be used to document the outcome of a fitting, to compare several fittings and to evaluate a fitting over time. Subjects participating in an EAS study completed an APHAB questionnaire pre-operatively, at EAS fitting and then at three, six and twelve months post-EAS fitting.

Results: Results will show subjective listening benefit of EAS in a group of users. Results relating to the following areas of listening quality will be discussed: ease of communication, background noise, reverberation and aversiveness to sounds. Cumulative improvement over time will also be shown.

Conclusions: Results show an improvement over time with device use, particularly in the first months of EAS experience. Subjective results substantiate the benefit of understanding speech in noise that is reported on in the literature.

PE7 – P14

Acoustic plus electric speech processing: Preliminary results of a multicenter clinical trial of the Iowa/Nucleus Hybrid implant

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Objectives: This communication details the latest preliminary results from an ongoing multicenter single-subject design clinical trial of the Iowa/Nucleus Hybrid 10 mm cochlear implant. Selection criteria, surgical strategies used for hearing preservation, and the benefits of preserved residual low-frequency hearing, improved word understanding in noise, and music appreciation are described.

Patients and Methods: The device has being implanted in 69 individuals with residual low frequency hearing.

Results: Hearing preservation has been accomplished in 65/69 subjects. Acoustic speech perception has also been preserved. Combined acoustic plus electric speech processing has enabled most of this group of volunteers to gain improved word understanding as compared to their preoperative hearing with bilateral hearing aids. A subset of subjects with 12 months or more experience demonstrates CNC word understanding continues to improve more than 24 months post implant. Improved word understanding in noise is also a benefit of acoustic plus electric speech processing.

Conclusions: The improvement of speech in noise and melody recognition is linked to the ability to distinguish fine pitch differences as the result of preserved residual low frequency acoustic hearing. Both of these measures are very important in real life to the hearing impaired. Preservation of residual low frequency hearing should be considered when expanding candidate selection criteria for standard cochlear implants.

PE7 – O15

Features of a combined EAS device and their effectiveness in EAS users

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Objectives: The DUET was recently introduced into the market. This is a worldwide first – a combined device for EAS (combined electric-acoustic stimulation) users. The device combines a CI-speech processor with a hearing aid in one single unit. Design features regarding compression, frequency ranges, signal processing and fitting have been implemented based on previous experience from EAS studies or findings in related fields. The aim of the study was to examine the effectiveness of these design features in EAS users.

Methods: A study with 12 EAS patients has been performed. Several design parameters have been evaluated and/or compared with the hearing aid and speech processor used by these EAS patients before changing to the DUET.

Results: Results show equal or superior results with the DUET. Patients report on increased user comfort.

Conclusion: The DUET EAS hearing system is an effective device for EAS users. While the design features examined in this study are proven to be effective; an ongoing learning process is expected with growing experience in this young topic of EAS. The DUET has flexibility in both the electric and acoustic part, to adapt to this learning process.

PE7 – P16

The influence of different speech processor and hearing aid settings on speech perception outcomes in EAS patients

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Objectives: Electric acoustic stimulation (EAS) is an increasingly popular means of treating individuals with a steeply sloping middle-to-high frequency hearing loss, who traditionally don't benefit from hearing instruments, yet often have too much residual hearing to be considered for a cochlear implant. Several studies have demonstrated the ability to both preserve the remaining low frequency hearing in these individuals, as well as the provide significant benefit through combining a cochlear implant with a hearing aid to amplify the same ear. These performance benefits have been especially noted in noise. Often overlooked is that these outcomes may be influenced by the fitting parameters of both the cochlear implant and hearing aid.

Methods: This study assessed four EAS subjects, with a minimum of one month's EAS use, on eight different fitting parameters.

Results: Sentence testing in different noise levels (+15, +10 and +5dB), as well as subject evaluations of each condition using a visual analogue scale, showed that on overlap of cochlear implant and hearing aid amplification produced best results.

Conclusions: The hearing aid should be fit to a patient-specific modified audiogram up to the point where low frequency hearing is lost. The cochlear implant should be fit from a higher frequency point than is standard, to provide some overlap with amplification provided by the hearing aid. Therefore, overlap of acoustic and electrical hearing does not interfere with speech understanding and actually enhances it.

PE7 – O17

Preliminary results with the new DUET® in EAS users

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Electro-acoustic stimulation (EAS) in patients with residual deep frequency hearing results in better speech understanding and better performance in delicate listening situations compared to unilateral cochlea implant users.

Up to now acoustic amplification could only be achieved by wearing an in-the-ear hearing aid in addition to the speech processor of the implant.

The new DUET® designed especially for EAS users seems to offer much more convenience, combining the benefits of a behind-the-ear hearing aid with the strategy of the MedEl Tempo+® processor in only one device.

To evaluate a possible benefit we changed patients using the EAS mode over to the DUET® and tested for monosyllable word scores and Hochmair-Schulz-Moser sentences in quiet and in noise before and after.

All subjects accepted the new tool easily. The auditory results will be presented at the conference.

PE7 – O18

Preservation of residual hearing with a new straight electrode

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Objectives: To evaluate the preservation of residual hearing after implantation of a new Nucleus EAS Cochlear Implant (Hybrid-L). To determine whether speech understanding can be enhanced by combined electrical and acoustical stimulation while maintaining preoperative levels of acoustic hearing.

Methods: The Nucleus Hybrid_L Cochlear Implant (CI) System is based on the Nucleus Freedom Implant with a newly designed straight electrode. The electrode is shorter and smaller in diameter compared to a standard Contour electrode resulting in an improved flexibility to reduce insertion trauma,

but also has 22 half band ring electrode contacts spread over a length of 15 mm. This electrode is inserted via the round window. Twenty patients with a profound sensorineural hearing loss for frequencies > 1500 Hz and mild to moderate hearing loss for frequencies < 1500 Hz are implanted with a Nucleus Hybrid-L Implant. A single subject design with repeated measures of unaided pure tone thresholds and speech performance is used comparing different modes of electro-acoustic stimulation.

Results: The preliminary results for 3 recipients show a maximum loss of 20 dB at only one frequency for two recipients. The loss for all other frequencies is 0–10 dB. First evaluations of the initial CI and HA fitting demonstrate a clear benefit of the combined condition over the pre OP situation with HA alone.

Conclusions: Preliminary results indicate that the Hybrid L electrode is capable of preserving residual hearing while offering the full flexibility of a 22 channel array at the same time, resulting in a substantial functional benefit.

PE7 – O19

Acoustic-electric stimulation with the Nucleus Freedom system

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Objectives: To determine whether hearing can be preserved with implantation of a conventional cochlear implant (Nucleus Freedom system) in people with steeply sloping audiograms, and to evaluate the benefit of combined acoustic-electric stimulation for these subjects.

Methods: Assessments of speech understanding are being compared for two sets of MAP parameters in the implant's speech processor. The first MAP has frequency-to-electrode allocations based on estimates of the pitch perceived for acoustic and electric stimuli, whereas the second MAP has conventional frequency allocations. Each MAP is being used by the subjects for 3 months.

Results: Partial hearing preservation (mean threshold increase of about 25 dB) was found post-operatively in two cases, with greater losses in the remaining two cases. The three subjects who have recently completed speech perception testing obtained much higher scores post-operatively than pre-operatively. For example, the average score increase in a monosyllabic word recognition test was approximately 50 percentage points. However, these preliminary data are insufficient to determine whether there is a difference in benefit between the two sets of MAP parameters.

Conclusions: It is possible to preserve hearing at least partially with implantation of a conventional electrode array, although total hearing loss can occur in some cases. Combined acoustic-electric stimulation is potentially highly beneficial for people having bilateral hearing losses with steeply sloping audiograms.

PE7 – O20

Preliminary results with Nucleus Hybrid cochlear implant

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Objectives: To evaluate the efficacy of the Nucleus Hybrid electroacoustic device in adults with sloping severe-profound high frequency hearing loss. Electroacoustic stimulation is designed to make use of acoustically amplified low frequency hearing and a cochlear implant for the higher frequencies.

Methods: Seven adult patients participated in this study. Subjects had a mean age of 66 years and 3 subjects were implanted with CI24 Contour hybrid implant and 4 were implanted with the Freedom hybrid implant. Length of implant use ranged from 3 to 12 months. Pre and post operative testing included audiometric testing, questionnaires, and speech perception testing including CNC words, HINT sentences in quiet and noise, and the BKB-SIN noise test. Testing conditions included: ipsilateral hearing aid, ipsilateral implant, ipsilateral bimodal, implant with contralateral aid, bilateral aids, and ipsilateral bimodal with contralateral aid.

Results: Preliminary results showed varying levels of improvement in performance in quiet and noise; however, 2 subjects showed decreases in hearing sensitivity and performance from preoperative levels at the 3-month evaluation interval. To date, the best and most satisfied performers have used the device for 12 months.

Conclusions: Individuals with sloping severe to profound high frequency hearing loss have the potential to benefit from a hybrid cochlear implant; however, the possibility exists for degradation in performance in the short-term.

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PE7 – O21

Interference with cochlear mechanics as a postulated mechanism for systematic loss of residual hearing following cochlear implantation

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Introduction: Loss of residual hearing occurs in 10–90 % cases after cochlear implantation. Numerous mechanisms for post-implantation hearing loss have been postulated, such as perforation of the basilar membrane, noise trauma, oxidative stress and inflammation, infection, compromised blood supply, etc.

Hypothesis: Another possible mechanism for systematic loss of residual hearing could be the mechanical distortion of the basilar membrane movement. This is due to the basilar

membrane being lifted by the electrode at approximately 180 o and at approx. 400o.

Material and Methods: Two experiments have been performed: 1.) HiFocus® and Contour® electrodes have been inserted in human cadaveric cochleas under direct visual control of the insertion process through the exposed basilar membrane. 2.) Repeated ABR measurements have been performed during implantation of the Nucleus 24R Contour® system in a patient with residual hearing. The results have been discussed with reference to the anatomy of the cochlear turns.

Results: 1.) Electrode insertion tests showed that with full (i.e. approx. 400o) electrode insertions significant lifting of the basilar membrane can be observed occurring at approximately 180o and 400o. 2.) Intraoperative ABR-registration showed clear wave-V as long as 5 or more electrode contacts remained outside the cochlea. From the moment of full (approx. 400o) insertion no reproducible ABR traces could be recorded anymore.

Conclusions: Results of this study support the hypothesis that the systematic loss of residual hearing in CI patients can be due to mechanical distortion of the basilar membrane movement.

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Cochlear Implantation In Very Young Children (PE8)

PE8 – O1

Cochlear implantation in infants

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Objectives/hypothesis: With the advent of universal newborn hearing screening, infants are now frequently presenting as possible cochlear implant candidates. Early intervention with hearing aids, when sufficient hearing is present, has been clearly demonstrated. It is hypothesized that similar benefits with cochlear implants will emerge.

Design: Prospective, longitudinal analysis of infants implanted before the age of 1 year.

Methods: A safety analysis of the minimally invasive surgical technique used in 15 deaf infants was performed. Special performance measurement tools such as the preferential looking paradigm have been modified and applied.

Results: The benefits of the currently applied surgical technique will described. No surgical or anesthetic complications occurred. Performance in infants can be documented by documenting increased looking times in infants too young to test using traditional measurement tools. Age at implantation appears to be the most significant preoperative performance predictor.

PE8 – O2

Surgical procedure for small children at Karolinska University Hospital / Huddinge, Stockholm

A Freijd

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Since the advent of CI surgery in Sweden, starting 1984 by Göran Bredberg, 586 patients have together undergone 717 surgeries in Stockholm, including primary surgery, implantation on second ear and revision surgery due to technical device failure. Besides two very early patients with single-channel devices, we have experienced no peri-operative complications, including infections, flap circulation or electrode problems, requiring revision surgery.

Due to increased awareness and neonatal auditory screening congenital deafness is discovered earlier than before. In Sweden approx 30 children are born annually with hearing impairment severe enough to necessitate a CI. In our clinic, since year 2000, 103 surgeries have been performed on children 30 months of age or less, the youngest being 7 months. Bilateral one- stage procedures have been performed 8 times in children below 30 months, the youngest being 12 months.

Due to our low complication rate and our experience with pediatric implantations, the MED-EL company kindly invited our clinic to present our surgical routines and procedures.

PE8 – O3

Surgical and general aspects of cochlea implantation in very young children under the age of 12 months

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Cochlear implants have proven to be an effective treatment for children with required or congenital deafness. With respect to the developing auditory pathways and the critical periods of language acquisition, efficient input should be provided as soon as possible to avoide the effects of acoustic deprevation.

Since the introduction of an ABR based universal newborn hearing screening, deaf children can be detected earlier and, if the diagnosis is safe, implanted earlier.

This influences our guidelines for cochlear implantation and to find the “best “ age for implantation.

The surgical guidelines are similar as those for adults. The anatomy of the temporal bone in children may make implantation more difficult and may implicate higher risks of surgery for the unexperienced surgeon. Particular attention has to be paid to the anatomical situation in children with smaller dimensions in the mastoid and a more lateral course of the facial nerve.

The general situation of small children with smaller airways and less blood volume has to be considered as well as

body temperature control. Anaesthesiological Concepts pay attention to this situation.

An experienced surgeon is required to save time during preparation and minimize blood loss. The paper describes general guide lines and conceps for cochlear implant surgery in young children regarding the aspects of skin incision, flap design, stable fixation of the implant, save wound closure and identifying landmarks to avoide surgical complications.

PE8 – O4

Surgical procedure of cochlear implantation in small children

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Objectives: To describe the surgical technique of implantation in small children.

Method: During routine surgical procedure, to prevent the infection within the area of the implant, anatomical closure of the mastoid is performed with the use of small piece of the cortex bone removed during mastoidectomy. Skin incision is tend to be as short as possible, with the use of Med-El systems periosteum separation area is small.

Results: Closed mastoid prevents the infections.

Conclusions: Propose surgical technique in children as young as 10 months is save and with no greater risk of complication.

PE8 – O5

Details in cochlear implantation fixation of receiver housing and electrode carrier in very young children

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As a result of Nadol newborn screening the age of children who receive cochlear implants decreased. More and more surgeons are faced with the question of offering an implant to children under the age of 1. It is well known that the of the skull as well as the dimensions of the mastoid are relatively small in these children's group in comparison to older children or to adults. The paper describes the surgical technique to place and to fix the receiver housing and analyses the results of these techniques in over 200 children. In addition, for electrode fixation a titanium clip had been used. The experience with these fixation techniques is discussed, also in respect to postoperative x-ray or MRI investigations.

PE8 – O6

Cochlear implants for infants under 12 months

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Objectives: Neonatal screening has facilitated earlier diagnosis and intervention for infants with hearing loss. Improvements in technology, two decades of paediatric clinical experience, and changes in the USA, FDA's criteria has lead to increased referrals of infants to cochlear implants centres worldwide. It is hypothesized that earlier implantation will facilitate speech perception and language acquisition.

Methods: Pre-implant audiological testing, CT scan and surgical records for 19 infants (6 to 12 months) and 88 toddlers (12 to 24 months) who received the cochlear implant in Melbourne, Australia were reviewed. Pre-implant and post-implant audiological (open-set word and sentence understanding), language (RI-TLS, PPVT, CELF) and educational psychologists' cognitive and motor assessment were completed.

Results: Mean rates of receptive and expressive language growth for children implanted less than 12 months matched growth rates achieved by normally hearing peers. Mean open-set speech perception scores were comparable to previous reports for children and adults who use cochlear implants.

PE8 – O7

Outcomes in children fitted with cochlear implant aged between 3 and 12 months

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Objectives: The age at which children with profound congenital deafness are fitted with cochlear implants (CIs) has recently decreased to less than 1 year and more recently to less than 6 months. Despite this strong and definite trend, most surgeons are concerned about implantation below 6 or even 12 months of age.

We have reviewed our experience regarding safe surgical practice in early implantation and the possible risks and benefits with CIs in infants aged 3 to 6 months and compared with older infants and children.

Methods: From November 1998 to June 2005, 89 children under 3 years of age were fitted with cochlear implants. Fifty-one children were between 1 and 2 years old and 14 children (6 male, 8 female) aged less than 12 months (mean age: 8.1 months; range: 3 to 11 months). All children under 1 year of age received a Nucleus CI 24 M device and have a follow-up longer than 6 months.

Results: Complete insertion of the electrodes was achieved in all patients.

Neural response telemetry and electrical auditory brainstem responses confirmed correct functioning of the electrodes. Mean duration surgery was 55 minutes. The main anesthesiological and surgical risk factors are discussed for different age group. The early audiological and linguistic results are clearly in favour of implanted younger children.

Conclusions: Since in our experience early CI surgery is safe and implantation facilitates developmental processes in the critical period of language acquisition, the time of implantation can be safely reduced to 3–6 months of age.

PE8 – O8

Medical aspects of cochlear implantation under the age of 2 years

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Objective: To present the medical aspects of cochlear implantation (CI) in children under age 2.

Method: The patients' medical records were reviewed retrospectively for age at the time of implantation, cause of deafness, history of middle ear disease and insertion of ventilating tubes (VT) before and after implantation, complications related to general anesthesia and postoperative complications.

Results: Seventy seven children aged 9 months to 2 years (mean 18.3 months) were implanted in our department between 1997 and 2005. Fifty children (64.9 %) experienced middle ear infection prior to implantation. Almost half of those children were treated for acute otitis media with/without mastoiditis in their postoperative period. Insertion of ventilating tubes prior to surgery in children with history of middle ear disease decreased significantly the incidence of the middle ear and mastoid infection post CI. Major complications, such as device failure, foreign body reaction, allergy to silicone and chronic OM with protrusion of the positioner required removal of the device with subsequent implantation. Disequilibrium, wound infection, flap breakdown, seroma, perforated ear drum and magnet migration were rare and successfully managed conservatively or with minor procedures. There was no morbidity of the general anesthesia in the studied group of children.

Conclusions: Device failure was found to be the most common complication of CI (11.7 %) in young children followed by wound problems (9.1 %), disequilibrium (5.2 %) and mastoiditis (3.9 %). Children with history of recurrent middle ear disease should undergo insertion of VT prior to implantation.

PE8 – O9

Early cochlear implantation – Comparison with a group of later implantation

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Objectives: to evaluate the benefit of early implantation in congenital profoundly deaf children.

Material and methods: Our study relates a population of 60 congenital deaf children, variable etiology, 19 months old to 7 years. All benefited , in addition to the pre-implant speech therapy assessment , from an evaluation according to a protocol used in the Lille University Hospital CIC (EELIC) at 3 months, 6 months, 1 year, 18 months, 2 years, 3 years and 4 years after the implantation according to the follow up. The population is divided in two groups: early (before 30 months) and late (after 30 months at implantation).

All children were implanted with a Digisonic SP CI.

Results: The study shows that the results of a cochlear implantation depend on education chosen by the parents (oralism, gestual, bilingualism), of the assumption of responsibility (school integration, semi integration, specialized institute), of family motivation and associated handicaps (medical, psychological, social...). Moreover, this study shows that the various levels of evaluation (auditory capacities, communication and evolution of language) are reached in a faster way for the children with a early implantation.

Conclusion: This study confirms the interest of early cochlear implantation in order to minimize the linguistic aftereffects of deafness and to allow a better social integration. This early implantation must, of course, being preceded by a early and adapted screening of deafness.

PE8 – P10

A prescreening method to detect CI candidates in infancy

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Objectives: According to our research there is a difference in the cry of babies with normal hearing and SNHL. Our goal is to develop a cheap, easy to perform and fast screening method to detect CI candidates.

Methods: In our register we have 158 infants and obtained 1361 crying signals. We use a digital camera for sound recording. During our investigations we used signal processing methods to obtain the melody of the cry.

Results: We have experienced a 70 % sensitivity of our investigations.

Conclusions: According to our results the suspicion of SNHL can be expected by using this method.

PE8 – P11

Validity of universal newborn hearing screening

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Objective: Universal hearing screening is an objective method being gradually introduced in many countries. The outcome is early diagnosis and intervention in management of hearing loss. Validity of this screening is evaluated.

Methods: Since 1977 all the children delivered in our hospital are screened for hearing loss by TOAE measurement.

Parents of 1032 that passed the screening with normal TOAE response have received the LittlEARS questionnaire. We received fulfilled questionnaire from the parents of 448 children. These children were divided into 16 groups according to their age. Expected average and minimal hearing capabilities in particular age categories were evaluated.

Results: Twenty-one children have not fulfilled the minimal age related hearing criteria. These children were invited for further evaluation. Parents of 7 children refused the testing since they were convinced on normal hearing of their child. Parents of three children did not react. In remaining 11 children TAOE and tympanometry were repeated. In one child SSEP were measured.. In one of these 11 children bilateral deafness was confirmed and in the other one severe sensorineural hearing loss with organic CNS impairment. In two children conductive hearing loss was discovered. In 7 children the hearing loss was not confirmed.

Conclusion: Despite the fact that universal newborn hearing screening may discover majority of pediatric hearing losses one has to think on new postscreenning hearing loss development, progression of nonsignificant sensorineural hearing loss. From these reasons the hearing of children must be regularly tested and the speech and hearing capabilities must be evaluated.

PE8 – P12

Hypoacusia early detection program in Rosario, Argentina

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Objectives: To make an early diagnosis of hypoacusia in order to provide prosthesis equipment.

To provide timely treatment appropriate to each infant's needs.

To prevent larger linguistic, intellectual, and social problems.

Methods: In this program we use Transient Evoked Otoacoustic Emissions (TEOAE) and Distortion-Product Otoacoustic Emissions (DPOAE) in newborns over 2,000 g weight and with high risk factors for hearing loss from different public and private centers in Rosario, Argentina.

If the Otoacustic Emissions (OAE) reveals good cochlear response, new controls are made in 2, 6, and 12 months.

If the OAE reveals absence of cochlear response the otologist performs a tympanometry and the OAE are measured again. If responses are still wrong, the infant is included in an early intervention program. After six months, the child is evaluated again with tympanometry, ABR, informal hearing evaluation, hearing prosthesis equipment with earphones, and improvement of hearing capability considering his or her language development. After using hearing prosthesis for more than six months, if the results are not optimum we discuss the inclusion of the infant in a cochlear implant program.

Results: We evaluated 1850 newborns: After the first control, 1240 (67 %) were normal and 610 (33 %) showed absence of cochlear response. Between the first and second evaluation, 74 patients deserted the study. After the second control, 118 (22 %) patients succeeded and 418 (78 %) showed wrong results. Out of these 418 infants, 46 (11 %) were diagnosed as neurosensorial hypoacusics and the remaining 372 (89 %) joined a follow-up program.

Conclusions: The lack of early hearing controls delays the diagnosis and treatment of hypoacusia, an unacceptable fact in our health system, which is equipped with several resources to avoid this problem.

It is remarcable that the hypoacusia early detection program needs an interdisciplinary work to achieve its objectives.

PE8 – P13

High risk indicators for hearing loss in neurosensorial hypoacusia in Rosario, Argentina

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Objectives: To establish the incidence of high risk indicators for hearing loss found in the hypoacusia early detection program.

To develop a comparative analysis of the results obtained in public and private centers in order to improve prevention policies.

Methods: The audiologists of the "Hypoacusia Early Detection Program" carried out in private and public centers in Rosario, Santa Fe, Argentina, registered the high risk indicators for hearing loss incidence (Joint Committee on Infant Hearing 1994 criteria) of 1850 newborn infants. The newborns were all over 2000 g weight and were evaluated with Transient Evoked Otoacoustic Emissions (TEOAE) and Distortion-Product Otoacoustic Emissions (DPOAE). We used a Madsen Celesta 503 equipment for the otoacoustic measures.

Results: We observed that the incidence of high risk indicators for hearing loss in the complete population of newborns studied is similar as the incidence described in the literature.

We registered a significant difference between the incidence rates of ototoxicity (58 % vs. 35 %) and hyperbilirrubinemia (35 % vs. 16 %) between newborns from public centers and newborns from private centers.

The incidence of other high risk factors for hearing loss had no significant difference in private and public centers.

Conclusions: We conclude that, although the global incidence of high risk indicators for hearing loss in neurosensorial hypoacusia has no difference between the population of newborns studied and newborns from other countries, we can remark the significant difference of incidence of high risk indicators between children from public and private centers, evidencing the uneffective health care policies to prevent hearing loss in public centers from a non developed country.

Experiences in Cochlear Implantation (G5)

G5 – O1

Pediatric speech recognition at one year post implantation

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Objectives: As part of the Childhood Development after Cochlear Implantation (CDaCI) study, the Pediatric Speech Intelligibility (PSI) test is used to track developing speech recognition skills in children as young as three years. PSI outcomes are reported for 45 implanted children (CI, mean age at baseline = 3.2 years) and 45 normal hearing controls (NH, mean age at baseline = 3.1 years) reaching 12 months of follow-up.

Methods: Children were evaluated at baseline, 6-month and12-month follow-up intervals. Children meeting minimum age (3 years) and performance (ESP category 3 or 4) criteria were assessed using PSI words and sentences in quiet. Children achieving 80 % or greater sentence identification in quiet were further evaluated in single-talker competition at message-to-competition ratios (MCRs) ranging from +10 to – 10 dB.

Results: Nearly 70 % of CI children and all NH children showed closed-set word and sentence recognition in quiet by 12 months follow-up. Twenty-seven (60 %) of CI children met criteria for assessment in competition, yielding mean scores of 79 % at +10 MCR, 59 % at 0 MCR and 35 % at –10 MCR, compared to means of 99 %, 91 %, and 53 % at +10, 0 and –10 MCR, respectively, for the 45 NH controls. Seven CI children achieved scores of greater than 50 % at –10 MCR, the most difficult listening condition.

Conclusions: By 12 months, more than more than half of CI children could identify closed-set sentences in some degree of competition, with some CI children performing comparably to normally hearing peers. [Supported by NIH-NIDCD R01DC004797].

G5 – O2

Outcome of cochlear implantation in paediatric patients

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Cochlear implantation have been considered beneficial in a selected group of paediatric patients. Although audiological criteria have been well defined in those patients, results of various centers are not always identical. Regarding audiological performans, speech devolopment and attendance of mainstream education system, patients have found to be quite variable.

In this study paediatric patients implanted at Ýzmir Teaching Hospital CI Center would be throughly evaluated. 419 patients have been implanted at our center between March 1998 – October 2005. 294 of them were aged between 14 months – 16 years. In 14 postlingual patients open set speech performance could be obtained. In 7 perilingual and 201prelingual cases results were quite variable.

Audilogical development and speech performance were satisfactory in 219 patients (according to CAP and SIR). 30 of the children outof 94 who are attended our Implanted Children Training Center could be attended to a main-stream school. Also 42 of our children who are CI users for 4 years can communicate by telephone.

Age at implantation and duration of implant usage were found to be the most important factors influencing the outcome of implant.

G5 – O3

Auditory neuropathy: clinical picture and auditory test results as a new syndrome

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Objectives: To describe the clinical picture of the patients with the key clinical feature of hearing loss for pure tones and reduction in speech discrimination out of proportion to the pure tone loss, having some of the criteria of auditory neuropathy (i.e. normal otoacoustic emissions, OAE, and abnormal auditory brainstem evoked potentials, ABR) and lacking others (e. g. present auditory reflexes).

Methods: During 1997–2005, in a retrospective study, patients' records were reviewed and the results of OAE and ABR and pure tone audiometry (PTA) were tabulated as well as speech discrimination scores (SDS), measured in all patients using a standardized list of 25 monosyllabic Farsi words at MCL in quiet.

Results: Both ears of 9 patients (5 males and 4 females) comprised the study population. Mean age at the onset was 15.2 ± 3.5. Hearing thresholds were measured at 250 to 8000 Hz at octave intervals. SDS had a mean±SD of 29.2 ± 30.7. A strong significant correlation was noted between SDS and hearing threshold. Six samples (33 %) had auditory reflexes. All of the patients were suffering from different degrees of tinnitus. Four patients were able to hear music, without understanding the words of the singer, although the SDS in all of them was no more than 10.

Conclusions: Reviewing the medical records revealed deterioration of hearing and speech discrimination over time. Although in most of the cases the hearing loss had been more apparent in the lower frequencies, a stronger correlation was found between SDS and hearing threshold at higher frequencies. These patients may not benefit from hearing aids, as the outer hair cells are functional and amplification doesn't seem to help; though, it was tried for all.

G5 – O4

Intelligibility in hearing aid and cochlear implant users

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Objectives: To compare speech intelligibility in children using cochlear implants (CIs) with that of children using hearing aids (HAs).

Methods: Beginner's Intelligibility Test (BIT) scores were analyzed for 100 (CI=71,HA=29) children within a chronological age (CA) range of 58–150 months and 78 (CI=57,HA=21) children within a device use duration (DD) range of 33–108 months. Two ANCOVA models compared the association of BIT scores with CA or DD in CI versus HA users. PTA thresholds, gender, and communication mode were included to control for potential confounders.

Results: Both ANCOVAs demonstrated no three-way interaction among age, communication mode, or device group; and no significant effects of gender or PTA threshold on BIT scores. The final model with CA as an independent variable demonstrated higher BIT scores among CI users and among children using oral communication (OC) versus total communication (TC). The final model with DD as an independent variable revealed a significant interaction between device group and communication mode. HA users using OC had higher BIT scores than their TC peers. There was no such difference for the CI users, who outperformed the HA users. Regression analysis demonstrated that CI users (mean PTA>110dBHL) tended to have better BIT scores than even the best-performing HA group (OC with PTA thresholds 90–100dbHL).

Conclusions: CI users perform similarly to the best HA users, with better intelligibility over similar chronological ages and durations of device use. HA users appear to benefit more from OC than CI users.

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G5 – O5

Clinical and surgical correlates of auditory and language outcomes in the multicenter CDaCI study

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Objectives: To assess the impact of clinical and surgical factors on early auditory and language outcomes in young children with cochlear implants.

Methods: The Childhood Development after Cochlear Implantation (CDaCI) Study is a multicenter, prospective cohort study using normal hearing age-mates as controls (Eisenberg et al). Participants are enrolled prior to CI between ages 9mo-5y or as normal hearing (NH) controls of similar age. Outcome measures are performed in 4 domains: A. Oral language level; B. Speech recognition capabilities; C. Psychosocial & behavioral correlates of oral communication; D. Parental proxy of quality of life (QoL).

Results: A. There are large differences in language levels between the deaf (CI) and NH children at baseline. Baseline differences in cognition are also observed. B. At 1 year, approximately half of the CI group demonstrated closed-set word and sentence identification. C. Baseline differences in psychosocial measures include more time spent by deaf children in solitary play with objects, not interacting with caregivers. D. Quality of life scores appear to correlate most strongly with the child's age.

Conclusions: Preliminary results indicate that measures utilized in the CDaCI study are sensitive to differences between the deaf (CI) cohort and NH controls, and are able to detect early changes in these disparities after implantation. Using multivariate analysis, we will provide an initial correlation of clinical and surgical factors with these outcomes.

References

Eisenberg LS et al Speech Recognition at 1-year Follow-up in the Childhood Development after Cochlear Implantation (CDaCI) Study: Methods and Preliminary Findings. Submitted to Audiology and Otology

G5 – O6

Predicting performance based on traditional pre-operative testing: Results of the US Med El bilateral cochlear implant trial

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Bilateral cochlear implantation is an increasingly popular choice for rehabilitation of binaural hearing loss. As part of the Med El U. S. multi-center clinical trial investigating the benefit of bilateral cochlear implantation, patients underwent extensive pre-operative and post-operative testing including hearing in noise, sound localization and distance perception testing. With patients being implanted with more residual hearing, attention has been directed to whether the "better" or "worse" hearing ear should be implanted. Some patients opt for the worse ear to be implanted so that there better hearing ear is preserved, while others opt to implant the better hearing ear with the hopes of improved performance. The bilateral study gives us a unique opportunity to examine whether the traditional variables used to predict the potentially better performing ear are accurate. Pre-operative pure-tone testing, discrimination, discrimination of CUNY sentences, CNC words and other variables (hearing aid use, length of deafness) will be compared to post-operative performance in a longitudinal study over a 1 year period. Implications regarding implanting the better or worse hearing ear in patients with residual hearing are discussed.

G5 – O7

Cochlear implantation in children- insights of 15 years of experience

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Objectives: Since its start in 1992, more than 250 deaf children were supplied with a Cochlear implant at the CI- Center Salzburg. Many of them have now grown up to adolescents and young adults. For some the transition from school to work has already taken place. The purpose of this study was to evaluate their educational status, out of school education, vocational training, and employment status as a critical evaluation of CI in children.

Methods: Candidates for this survey were altogether 45 adolescents and 19 adults, all Austrians, implanted in Salzburg, ranging between 12–21 years (when interviewed), pre- perilingual deafened and with at least 3 years of hearing experience with their CI. They and their parents were asked to complete structured paper and pencil interviews. Normal hearing contemporaries (age- matched) with their parents serve(d) as control groups. Additionally, all adolescents up to 17 years, their parents and their teachers complete(d) the `Strengths and Difficulties Questionnaire' (SDQ).

Results: Preliminary results from 40 participants (27 adolescents and 13 adults) are currently available. Of these, 86 % attend(ed) mainstream- schools, and 25 % are (were) in secondary grammar schools. From the 11 individuals no longer attending school, one presently studies at the university, six do regular apprenticeships, three are employed and one is unemployed. All are wearing their CI continuously at a daily basis. The results of the SDQ revealed that the prevalence rate of mental health disorders is not increased for adolescents with CI, compared to hearing contemporaries (self $p = 0.61$; $p = 0.40$; parents $p = 0.77$; $p = 0.16$).

G5 – O8

The domain of hearing threshold in cochlear implanted pre-lingually children

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Objectives: The aim of this study is to find the effect of age at the time of implantation on hearing threshold of these children.

Methods: In this study a cohort of 109 children were followed from the time of implantation until now. The mean hearing threshold (HT) at octave intervals from 125 to 8000 Hz at different periods from the operation time were compared between those patients whose ages at the time of implantation were less than 24 months and those whose ages were equal or greater than 24 months.

Results: The mean age of patients at the time of implantation was 38.9, and a half of them had less than 28 months at that time. There was no difference in mean HT between the two age groups across different measurement periods. Of these patients 80 cases (73.4 %) had received Clarion and the remaining 29 cases (26.4 %) Nucleus devices, Clarion patients were younger than Nucleus patients at the time of implantation (31.4 vs. 59.6 months). Studied in a multiple regression model, device type was a sole significant predictor of mean HT at the first and third months after implantation, where age replaced it at the sixth month.

Conclusions: These results suggests that what had been found in other studies as a favourable effect of lower age at the time of implantation on speech perception can not be explained by a better hearing and there are other important factors, like rehabilitation programs beginning at a lower age, that should explain those finding.

G5 – P9

Blink reflex and auditory speech perception in prelingually cochlear-implanted children

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Objective: To demonstrate that the blink reflex or auropalpebral reflex evaluation can be used as a prognostic factor for the assessment of auditory and speech perception levels in prelingually cochlear-implanted children.

Material and methods: In an observational, analytical, prospective study conducted at a single cochlear implant rehabilitation center in 85 prelingually cochlear-implanted children, the presence or absence of the blink reflex (BR) was evaluated and the results of auditory and speech perception tests were compared between reflex-positive (R+) and reflex-negative (R-) patients. To obtain the BR, four electrodes were applied in both the Nucleus and MED-EL systems and then stimulated by means of current levels higher than the previously detected most comfortable level of the patient until the reflex appeared. Auditory and speech perception levels were measured using the vowels-confusion test and the categorization of auditory perception scale.

Results: The mean results of auditory and speech perception tests were significantly higher in R+ compared to R- patients.

Conclusion: The results of this study show that R- prelingually cochlear-implanted children are not optimal candidates for cochlear implantation. However, if this group are implanted, other rehabilitation methods should be incorporated into their rehabilitation program in order to achieve better results and maximize the efficacy of their prosthesis.

G5 – P10

Babbling after implantation between 5 and 20 months

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Objectives: To describe the babbling development of early implanted children.

Methods: This study reports on a cohort of 10 children with congenital deafness who received an implant between 5 and 20 months of age. They were followed longitudinally over a period of at least 4 years to assess their speech and language development. Monthly video recordings of spontaneous speech production were taken at home. They were analysed at the segmental, syllabic and intersyllabic level. Hearing peers ("NH children") and hearing impaired children with hearing aids ("HI children") served as positive and negative controls.

Results: At the segmental level, it was shown that the same vowel and consonant inventories were produced by the CI-children when compared to NH children and this was unlike the HI children.

At the syllabic level, the same consonant-vowel co-occurences were retrieved in the CI-group as in the NH group, again in contrast to the HI group.

At the intersyllabic level, the CI-children appeared to produce less variegation. In case of variegation, they produced less consonant variegation and in case of consonant variegation they produced less combined variegation in both place and manner of articulation.

Conclusions: These results seem to indicate that cochlear implants, when given early, are capable of providing sufficient auditory input to allow speech and language development to become near to normal. Yet the input may be just insufficient to provide all the fine-grained details necessary for a highly variable articulatory production. New CI developments with higher sampling and stimulation frequencies (like in the Clarion and the Digisonic devices) may cope with this issue.

G5 – O11

An investigation into cochlear implant use in a paediatric population

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Objectives: The aim of the study was to identify the factors that affect cochlear implant use in a paediatric cochlear implant service. These could then be used as long term predictors of good and poor cochlear implant use.

Methods: The Yorkshire Cochlear Implant Service supports a caseload of around 165 implanted children. A retrospective study of cochlear implant use was carried out, in particular investigating good use, poor use and non-use. This was established from information given at programming sessions and outreach visits from the team's Teacher of the Deaf. In addition to information from the parental and teacher versions of the MAIS administered at 12 months and 3 years post-implantation. The CAP score and SIR rating were also obtained to at these intervals.

Results: At the present time, the service supports 145 good users (88 %), 8 poor users (5 %) and 12 non-users (7 %). Good users were defined as those children who always wear their device all waking hours, poor users were those who occasionally did and non-users were those who never or rarely did. The relationship of use to age at implant, duration of deafness, educational placement, mode of communication used and level of functional listening skills achieved will be discussed.

Conclusions: Future service development in relation to these findings with regards to the counselling of parents, the advice given to education services and how this relates to the use of the Children's Implant Profile (ChIP) in the assessment phase will be covered.

G5 – P12

Production of Mandarin tone by children with normal hearing

G Plant

MED-EL Medical Electronics, Austria

Objectives: To investigate production of Mandarin tone by children with normal hearing. The results of the study can be used as baseline data against which to measure tone production by children with cochlear implants.

Methods: Recordings were made of 36 eight-year-old children (19 girls and 17 boys) with normal hearing from Beijing, who speak Mandarin Chinese as their first language. The children were recorded producing the four tones of Mandarin Chinese in a [ma] syllable in isolation, and in simple sentences. The pitch movement for each utterance was measured using a computer-based speech analysis system.

Results: All of the speakers were able to produce the four tones consistently. The range of FO for the four tones for any individual speaker was around one octave. The frequency range across all speakers was from approximately 150–450 Hz. In producing Tone 3 in isolation, and in a meaningful sentence, the children followed the Tone Sandhi rules found for adult speakers. Some small gender differences were also noted.

Conclusions: The ramification of these results for children with cochlear implants will be discussed in detail. The need to consider access to cues for modelling and feedback will also be discussed. Suggestions will be made for further research in this area.

G5 – O13

Age at CI and performance in children prelingually deaf

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Multichannel CI have resulted to be effective for children with congenital and acquired deafness.

The results show that early implantation can minimize most of the adverse effects of auditory deprivation.

Objectives: The aim of the present study was to examine auditory development in relation with Speech Perception in children as a function of age at the implant.

Methods: We evaluated 4 groups of children differing in age at implantation. They were 40 profoundly hearing-impaired children who received a Nucleus CI between ages: 1 year and 8 months to 2 years and 11 months, 3 years to 5 years and 11 months , 6 years to 8 years and 11 months and 9 years to 11 years and 11 months. All of them had no additional disorders and receive similar auditory and educational placement, communication mode, attendance to evaluations and mapping.

Auditory development was assessed using the Early Speech Perception battery (Latin American Protocol) which was administered pre-implant and 6, 12 and 18 months post-implant. Children were evaluated with age appropriate vowel, consonants, and word and sentence tests during follow-up evaluations.

Results: These groups of cochlear implanted children demonstrated significant postimplant improvement on the speech perception tests. Rate of development in the younger group was better.

Conclusions: Children implanted before the age of 3 years demonstrate better speech perception skills than those implanted after that age.

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G5 – O14

Literacy outcomes after cochlear implantation in childhood

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Objectives: Previous research has suggested that cochlear implantation has a positive impact on the development of speech and language in prelingually deafened children, as well as on later development of literacy. The objective of the research was to conduct a comprehensive investigation of literacy after cochlear implantation.

Methods: Participants from one pediatric CI centre were enrolled in the study if they met the following criteria: cochlear implant use for at least one year, rehabilitation program focused on oral language, English instruction at school, and absence of additional disabilities. A test protocol consisting of comprehensive measures of literacy (word reading, decoding, spelling, reading comprehension) as well as intelligence, language, receptive vocabulary and phonological processing was administered.

Results: Age at implantation varied from 1.01 to 15.86 years. Assessment results indicated a wide range of skills across all dimensions of literacy. These skills were related to age at implantation, as well as to current language and cognitive abilities. For individuals who, as children, were implanted at school age, literacy levels were also related to pre-implant hearing, language and cognitive abilities.

Conclusion: This research extends previous findings to include comprehensive indices of literacy. These findings have implications for rehabilitation, and can guide candidacy decisions and counselling.

G5 – P15

Perception of familiar melodies by Taiwanese pediatric cochlear implant recipients who speak a tonal language

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Objectives: To investigate the perceptual accuracy of Taiwanese pediatric cochlear implant (CI) recipients who speak a tonal language for familiar melody recognition and speech perception. This study examines the relative contributions of pitch, rhythm and verbal cues to melody recognition, as well as relations between perception of pitch and tonal elements of Mandarin.

Methods: Thirty prelingually-deafened Taiwanese CI recipients (ages 7–15) and 30 normal-hearing (NH) Taiwanese children were tested on closed-set tasks for familiar melody, Mandarin tone, and Mandarin word recognition. The stimuli for the melody recognition task were presented in three conditions: 1) pitch only, with isochronous rhythm, 2) rhythm plus pitch, and 3) lyrics, rhythm, and pitch.

Results: The NH children performed with greater accuracy than the CI recipients on melody recognition ($p < .0001$). The CI recipients performed significantly more accurately in the Lyrics condition of the melody recognition than on the Isochronous and the Rhythm conditions ($p < .0001$ for both comparisons). Their accuracy on the Rhythm condition was significantly greater than chance level (33 %; $p < .05$), and more accurate than for the Isochronous condition ($p < .0001$). Significant correlations were found between the Isochronous condition and Mandarin tone recognition, and between the Rhythm condition and the Mandarin word recognition.

Conclusions: These CI recipients showed differential abilities in melody recognition depending upon those structural components (pitch, rhythm and lyrics) available. Lyrics provided the most salient cue for familiar melody recognition; rhythmic cues improved performance, but not to normal levels of perceptual accuracy. Significant relations were found between perception of melody and tonal speech.

G5 – P16

Outcomes among three siblings implanted below 3 years of age

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Objectives: Early identification of hearing loss has resulted in lowering the age that parents seek cochlear implant candidacy. Studies investigating early implantation have restrictive criteria to reduce variables that can influence outcomes. This study compares the auditory, speech and language abilities of three siblings with prelingual bilateral severe/profound sensorineural hearing loss who underwent cochlear implantation before 3 years of age.

Methods: Retrospective chart review of siblings unilaterally implanted with COMBI 40+ at 2 years 9 months, 11 months, and 6 months of age. They utilize CIS+ coding strategy, receive auditory/oral intervention services, and have no additional medical disabilities. Comparison of pre- and post-operative hearing thresholds, speech perception scores, expressive and receptive language, and speech production outcomes conducted as part of routine clinical practice up to three years following activation.

Results: The children demonstrated improved scores when compared with scores obtained pre-operatively and at various post-implant intervals. The youngest implanted child has reached age-appropriate skills at 18 months of age; however, there are limitations to the type/depth of measures available to track progress for these very young children. At 3 years post, her brothers exhibit delays in some areas compared with their normal hearing peers.

Conclusions: The outcomes for these three siblings are consistent with previous studies indicating that early implantation facilitates improved development of auditory, speech and language abilities. A distinct advantage may be afforded to children implanted below 12 months of age, particularly for skills necessary for receptive and expressive language. Further longitudinal studies for children implanted below 12 months are necessitated.

G5 – P17

Cochlear implants in children from bilingual and monolingual homes

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Objectives: To evaluate the impact of daily exposure to a second language on outcomes in children with cochlear implants.

Methods: Post-operative speech perception and speech/language measures achieved by children with cochlear implants who reside in bi-lingual homes (homes where English is the second language of the parents) were compared to those achieved by children with cochlear implants who reside in monolingual homes. The two groups were matched on several variables including; age at implantation, normal cochlear anatomy, and educational setting. All children received their cochlear implant prior to age five. Second languages utilized by parents included French, Arabic, Spanish, Gujarati, Marathi, and Chinese. Parents of the bilingual group were surveyed to determine if the use of two languages at home was related to performance with the device.

Results: Children from bilingual homes who receive a cochlear implant prior to age 5 appear to develop proficiency in the majority language at rates comparable to those of implanted children who reside in monolingual homes.

Conclusions: Use of a minority language at home does not significantly impede development of the majority language in children who receive cochlear implants prior to age five.

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G5 – P18

Children with cochlear implants in conversation with normally hearing peers

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In a conversation where one of the participants is a deaf person with a cochlear implant (CI) the risk for conversational breakdowns is heightened, due to the speech perception deficit and impaired speech intelligibility of the person with CI. Influencing factors are the degree of hearing and intelligibility problems and the level of cognitive and linguistic ability in the person with CI. The type of context may also be of importance. The most obvious evidence of problems in interaction is conversational repairs. Monitoring how requests for clarification and repairs are formulated is one important way to help children with hearing impairment achieve smoother interaction. The purpose of this study is to investigate repairs in two types of conversational tasks where one of the conversational partners is an adolescent with CI. One task is a referential communication task requiring description of faces. The other task involves viewing and discussing a film showing different scenes in a school setting. 6 interactions between an adolescent with CI and a friend with normal hearing in the age range 14–18 years old were videorecorded in the two tasks. The dialogues were transcribed. All cases of repairs were identified and coded. In our presentation we will present results related to the frequency of different types of repairs in each participant and context. The results will be discussed in relation to the demands of the two tasks and to the cognitive and linguistic abilities of the children with CI. Of particular interest was to identify which repair strategies are more successful.

G5 – O19

Experiences of the southern cochlear implant program

N Heslop

Southern Cochlear Implant Programme, Christchurch, New Zealand

New Zealand is a small country in the South Pacific with a population of approximately 4 million mostly European people but with a significant indigenous Maori population, and increasing numbers of immigrant Pacific and South East Asian communities.

The Southern Cochlear Implant Programme based in Christchurch is one of 2 cochlear implant programmes in the country. This brief presentation provides an overview of cochlear implant services in New Zealand and in particular the experiences of the Southern Cochlear Implant Programme.

Nationally the Ministry of Health in New Zealand publicly-funds 27 implants per annum. On a per capita basis this number is consistent with other programmes in Australasia. However demand always exceeds supply each year, and with

a relatively poor private health insurance market many candidates must fund the entire cost of the procedure themselves or remain on a 4 or 5 year waiting list. Improving technology, changing candidacy criteria, and trends toward bilateral implantation are likely to see New Zealand fall behind international standards for "best practice" because of this funding crisis. Further, New Zealand does not yet operate a national universal neonatal screening programme, though there are plans to implement this within the next 2–3 years and the on-stream effect on an already under-funded sector is not clear.

Despite these funding and other issues, New Zealand has good training and infrastructure in the fields of Audiology, Otolaryngology, and Rehabilitation/Habilitation, meaning that those able to access cochlear implant services benefit from a reasonably high standard of care.

Audiological Outcome of Bilateral Cochlear Implantation (G6)

G6 – O1

Adult bilateral cochlear implant outcomes

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Objectives: Evaluate bilateral benefit of cochlear implants in adults seen at UT Southwestern Medical Center.

Methods: Retrospective review was conducted of adult patient performance with bilateral cochlear implants. Test results obtained monaurally and binaurally pre-and post-implantation will be presented. Procedures used to evaluate speech perception included HINT, CNC, CUNY and BKB lists presented to each ear separately as well as binaurally. Speech perception ability was assessed in quiet and in noise. In addition, pre- and post-implant patient questionnaires exploring perceived benefit (APHAB, LOCATE, Ontario Health Utility Index, Cochlear Questionnaire, Med-El Questionnaire) were completed.

Results: This review details the performance of 20 adult patients who received Nucleus (N = 14), Med El (N = 5) and Clarion (N = 1) devices. 16 of the patients were implanted simultaneously and 4 sequentially. Both quantitative performance as measured by speech perception tasks and qualitative information obtained from questionnaires indicate improved outcomes with binaural stimulation. In addition to the cumulative date, case presentations of selected sequential candidates with greater than 5 years between the first and second implantation will be presented.

G6 – O2

Bilateral implantation in adults: results from 20 cases

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Objectives: To study the benefits of bilateral cochlear implantation compared to unilateral implantation in terms of speech understanding in noise.

Methods: 20 post lingual adults were studied since 2003. 17 of them were implanted simultaneously during a single surgery and three of them sequentially, with an interval between surgeries between one and three years. The subjects were tested first unilaterally with their preferred implant, before being tested in the bilateral condition. For each condition the following tests were performed:

– In quiet: 10 words and 10 sentences presented in natural voice from the front and the back at 60 dB SPL, without lip reading.

– In noise: same tests with background noise coming from left, right, back and front simultaneously. The type of noise used was cocktail party presented at 60 dB SPL. The loudspeakers were located 1.5 metres away from the subject.

Results: Testing showed a clear improvement in speech comprehension in noise in the bilateral condition compared to the preferred unilateral condition. On a subjective level, subjects reported a better listening comfort, less fatigue and better localisation of the sound source when listening in the bilateral condition. In addition, some bilateral users reported better body balance.

Conclusions: Bilateral implantation in adults appears to be more beneficial than unilateral implantation, particularly for speech comprehension in noise. More data and further statistical analysis are necessary to draw conclusions but these encouraging results indicate that bilateral implantation in adults should gain more importance in the future.

G6 – O3

Review of clinical outcomes in adult bilateral cochlear implant recipients following 3 years of implantation

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Objectives: To assess the benefits of bilateral cochlear implantation with the MED-EL COMBI 40+ device in a group of 9 adult patients with post lingual onset of deafness.

Study Design: Longitudingal, single-center study examining speech perception and surgical outcomes in 9 adults who underwent bilateral cochlear implantation at UNC Hospitals. A review of patient medical charts was performed to assess medical factors and outcomes.

Methods: Nine post-lingually deafened adult patients with a short duration of deafness were implanted bilaterally with the MED-EL COMBI 40+ cochlear implant. Speech perception was tested preoperatively and at regular intervals after

implantation using CNC words and CUNY sentences in quiet and varying noise conditions presented via direct audio input.

Results: Operating time, complication rate, and length of hospitalization was similar to that of patients undergoing unilateral cochlear implantation. Speech perception measures over the two-year period suggest a general trend in overall functional performance. In addition, head shadow effect is evident each of the six data points, binaural summation was evident at most data points; squelch, while less robust, was evident in averaged data at 1-year, 2-years, and 3-years post activation time points.

Conclusions: Outcomes are consistent with improved functional benefits of bilateral cochlear implantation over three years of use. Based on this subject group, surgical risk and complications are comparable to those of unilateral implantation. Further study is needed to fully quantify these benefits.

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G6 – O4

Sound localisation for children with bilateral cochlear implants

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Objectives: To investigate the development of sound localisation abilities for young children with bilateral cochlear implants.

Methods: Sound localisation in the horizontal plane was tested on a number of young children with bilateral cochlear implants. So far we have data from 15 children out of the 70 implanted. The test system (software by Prof. Mark Lutman, ISVR, University of Southampton) uses pink noise bursts presented randomly from a set of 5 loudspeakers in a 180° frontal arc. Presentation level was 70 dB SPL +/- 5 dB. The distance from the patient to the loudspeaker was 0.8 m in the present setting. The level and the spectrum of the signal were randomly varied to avoid speaker specific cues. Each test occasion contained 10 stimulations, 2 from each loudspeaker. The child was instructed to point towards the loudspeaker from which the signal was delivered. Positive feedback was given to the child, irrespective of the response.

Results: We will present the results from the measurements collected up to spring 2006.

Conclusion: From the initial measurements we conclude that some of the young children get sound localisation abilities within the first 2 years of binaural listening.

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G6 – O5

Simultaneous bilateral implantation in adults: is the expected ear always the better ear?

JB Roberson Jr, MM Inserra, L Tonokawa, LD Kunda

California Ear Institute & Let Them Hear Foundation, USA

Objectives: To evaluate if the expected preoperative ear is always the higher performing ear after simultaneous bilateral cochlear implantation

Methods: Retrospective cohort.

Results: Nine patients (age 19–68) underwent simultaneous bilateral cochlear implantation. The etiologies of hearing loss were progressive loss (56 %), genetic loss with sudden decline (22 %), sudden sequential hearing loss (11 %), and meningitis (11 %). The better preoperative ear was determined by length of hearing loss, pure tone average, and patient preference. Postoperative performance was evaluated by HINT and CNC testing. Two out of nine patients (22 %) had significantly better hearing in what was considered the worse hearing ear preoperatively. The difference in CNC word scores between better and worse implanted ear at 6 months were 23 and 26 %.

Conclusions: The better candidate ear cannot always be accurately determined as shown by 22 % of the patients in this cohort. With bilateral implantation, the better performing ear is always assured to be implanted.

G6 – O6

Sequential bilateral implantation in children: effect of timing between implants and hearing aid

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California Ear Institute & Let Them Hear Foundation, USA

Objectives: To compare performance of the second ear with respect to the first ear in patients receiving sequential bilateral cochlear implants. Performance of the second ear was also compared with the usage or not of a hearing device between surgeries.

Methods: Retrospective cohort.

Results: Twenty patients underwent sequential bilateral cochlear implantation. The mean age at first and second implantation was 2.7 and 7.0 years, respectively, with a mean interval of 4.3 years. A ratio of word scores at 6 months after second implantation was used to evaluate performance of the second side with respect to the first. Twelve of 20 subjects were able to perform CNC testing to obtain the word ratio. The mean ratio was 0.64. Both a longer interval (>3.5 yrs) between implantation and lack of hearing device usage prior to second implantation correlated with a lower word ratio.

Conclusions: In sequential bilateral cochlear implantation, an interval greater than 3.5 years and no hearing aid usage in the contralateral ear tended to correlate with less robust performance of the second ear in comparison with the first ear.

G6 – O7

Longitudinal audiological follow-up of children with bilateral cochlear implants

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Introduction: In our department 51 patients have been bilaterally implanted since 1997.

Objectives: 1.) To document the development of the auditory and language skills of bilaterally implanted children. 2.) To evaluate the influence of the age at implantations on auditory performance measured after the second implantation.

Material and Methods: 10 children chosen for this longitudinal study were followed for at least 2 years. All children have been implanted sequentially with the Nucleus-Nucleus or Nucleus-Laura CI combinations. The age at implantation ranged 15–129 months for the first implant and 51–157 months for the second implant.

Results: 1.) In our group there seems to exist a definitive critical period for obtaining additional benefits in speech understanding with bilateral implantations compared to unilateral implantations. Children implanted with the second implant after the age of 10–12 years tend to show no additional benefits in speech understanding. 2.) Contrary to what had been reported before, after approximately 18 months the results of speech understanding obtained with the second implant do not differ significantly from the results obtained with the first one. 3.) Average maximal speech understanding result obtained with the second implant at 3 month post-op was 57 % (monosyllabic CVC open-set-identification-task in quiet), that is much higher than the matched average results at 3 months obtained with the first implant. This indicates the priming effects of the first cochlear implant on the central auditory system.

Conclusions: Bilateral cochlear implantation should be performed at the earliest possible age and with the shortest possible time interval.

G6 – P8

Clinical outcomes in adult bilateral cochlear implantation

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Objectives: (1) Determine the clinical outcomes following bilateral cochlear implant (CI) surgery in adults, (2) Quantify the speech perception benefits of bilateral cochlear implantation in quiet and in noise, and (3) Compare the perceived spatial hearing benefits in patients with bilateral versus unilateral CIs.

Methods: Post-lingually deafened adults who underwent bilateral CI surgery and matched unilateral CI patients were recruited for this study. A retrospective chart review was also performed. Speech perception ability was measured in the CI only condition using CNC words in quiet, and HINT sentences in quiet and noise. Bilateral CI users were tested in the unilateral as well as the bilateral condition. All subjects completed a modified Speech, Spatial and Qualities of Hearing Scale (SSQ) (Gatehouse and Noble, 2004) to determine perceived spatial hearing benefits.

Results: No major perioperative complications were observed. Severe vertigo or dysequilibrium was only seen in one subject who developed benign paroxysmal positional vertigo 3 months postoperatively from his second sequential implant. Bilaterally implanted patients demonstrated their overall best performance in the bilateral cochlear implant condition. For individual subjects improvements in speech perception ability were observed both in quiet and in noise suggesting both binaural summation and binaural squelch benefits. The results of perceived spatial hearing measures using the SSQ will be presented for both bilateral and a cohort of unilateral CI patients.

Conclusions: Early data suggest that bilateral cochlear implantation provides adult patients with improvements in both speech perception and perceived spatial hearing when compared with unilateral implantation.

G6 – P9

Spatial hearing performance of bilateral implant children

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With the revolutionary change from traditional unilateral to bilateral implantation in addressing the problem of deafness, the issue of cost and benefit matters a lot in a developing country like the Philippines where implants are being shouldered by the patient. With growing inclination towards bilateral implant amongst deaf individuals, this paper seeks to explore the benefits of having bilateral implants especially on the aspect of spatial hearing abilities of children. All children implanted bilaterally before the age of seven shall be evaluated using the Ling Six Sounds as stimulus, presented through four speakers located 90º away from each other. Data gathering shall focus on (1) sound localization abilities, (2) right/left discrimination and (3) frequency effects on spatial hearing. To establish sound localization abilities, sound stimulus will be randomly presented between the four speakers, computing for the degree of correct response for each study participant. With right/left discrimination, stimulus shall be presented on either speakers positioned one meter away from the right and left ear. Subsequently, differences, or lack of it, shall be evaluated amongst the six Ling Sounds during the conduct of the other tests to evaluate effects of stimulus among participants on both tasks.

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Offeciers E, Morera C, Muller J, Huarte A, Shallop J, Cavalle L (2005) International consensus on bilateral cochlear implants and bimodal stimulation. Acta Otolaryngol 125(9): 918–919

G6 – P10

Auditory localisation with bilateral Med-el Combi-40+ cochlear implant users

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Objectives: To quantify binaural benefit for auditory localisation in the horizontal plane by bilateral users of the Med-El Combi 40+ device; to determine whether the use of a CROS aid with one implant improved localisation; to assess changes in monaural localisation before and after implantation with a second device.

Methods: Six CI users were tested before and after implantation with a second device. Horizontal sound localisation was assessed in an anechoic room with an 11-loudspeaker array under two test conditions: monaural CI and monaural CI + CROS aid. Subjects were subsequently tested in 3 conditions after receiving the second implant: right CI, left CI and bilateral CI. The test protocol and stimuli are described in Verschuur et al. (2005).

Results: Mean localisation error with bilateral implants was 23°, compared to 70° for monaural implant conditions (chance performance was 65°). Binaural performance was significantly better than monaural performance for all subjects and for all stimulus types. There was no significant difference between the normal monaural and CROS aid conditions.

Conclusions: Bilateral cochlear implantation with the Med-El Combi-40+ device provides marked improvement in horizontal localization abilities. Monaural localisation was at chance and did not change after implantation with a second device. There was no benefit to localisation with a CROS aid.

References

Verschuur CA, Lutman ME, Ramsden R, Greenham P, O'Driscoll M (2005) Auditory localization abilities in bilateral cochlear implant recipients. Otol Neurotol 26: 965–971

G6 – P11

Bilateral cochlear implantation in comparatively long surgical interval

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Objective: More and more patients have received bilateral cochlear implantation now. Most of the implantees received the second implantation within one year after the first CI. Due to the existence of auditory deprivation, it is unknown whether the bilateral CIs implemented with a comparative long surgical interval will get favorable effects and whether the auditory center still has enough plasticity.

Methods: Three bilateral CI recipients with surgical interval of longer than 2 years, at People's hospital of Peking University between 2002 and 2005, were included in this study. Assessment of hearing perception and unilateral, bilateral speech discrimination score in quiet and noise are administrated in all the three recipients, one of whom was evaluated with the recognition to GAP in each ear and homochronous speech discrimination respectively. **Results:** Comparing with unilateral implant, only one of three patients had better performances both in quiet and noise; one of the other two patients showed no significant difference both in quiet and noise. The other had better results in quiet while no significant difference in noise. All the three patients showed significant improvements on recognition of Chinese four-tone intonation.

Conclusions: Despite of the existence of acoustic deprivation resulting from comparatively long surgical interval, the auditory center still has considerable plasticity. After a relatively long-term training, bilateral implantation results in significant improvements. But the invasive visual deprivation to auditory perception resulting from lip-reading is hard to restore. Recipients with MED-EL COMBI 40+ show significant improvements on recognition of Chinese four-tone intonation.

G6 – P12

Long term evaluation of sequential bilateral cochlear implantation

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Objectives: The Midlands Adult Cochlear Implant Programme contributed to the recently published UK study investigating the results of sequential bilateral cochlear implantation of the Nucleus 24 device*. Study results indicated that sequential cochlear implantation with long delays between ears can result in poorer second ear performance, limiting the degree of bilateral benefit that can be obtained by these users. The aim of this study is to evaluate the longer-term bilateral benefit for subjects who received their second implant at least 4 years ago as part of this study, including tests of speech perception and subjective evaluation of benefit.

Methods: Subjects are sequentially implanted adults from the Birmingham Programme and are bilateral users of the Nucleus 24 Cochlear Implant System. They received their second device within the original UK study*. All were established cochlear implant users before receiving their second device. This study is a repeated measures design, with additional questionnaire to establish subjective benefit.

Results and Conclusions: Results will be presented comparing recent open set speech perception results in the quiet and in three noise conditions with results obtained at 9months post-second implant. Subjects own ideas of benefit established via questionnaire will also be presented. Conclusions will be drawn as to whether in cases of sequential bilateral cochlear implantation, bilateral benefit increases as the user becomes more experienced in bilateral listening.

References

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G6 – P13

A case study of a bilateral sequentially implanted Meniere's patient

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Objectives: To describe the outcomes of sequential bilateral implantation of a 45 year old man with Meniere's disease.

Methods: This patient had a 26 year history of Meniere's disease and had no functional hearing in his left ear for three years prior to implantation. He had good hearing aid benefit in his right ear until approximately one year before surgery. Fluctuations from Meniere's disease made communication extremely difficult. The left (poorer) ear was implanted with an Advanced Bionics Hi Res 90K in October 2005. He was fitted with an Auria and switched on in Hi Resolution. His right ear was implanted five months later with the same device.

Results: Prior to implantation, this patient scored 20 % in the right (better) ear and 0 % (poorer) ear on BKB sentences, presented by audition alone. Three months post-implant, he scored 87 % with the left implant alone on BKB sentences and AB Word lists. Within one week of switch-on, he was able to use the telephone. At three months post-implant, telephone use is well established and he has significant music appreciation. Performance at six months post initial implant, and outcomes of the second implanted ear will be discussed further.

Conclusions: Bilateral implantation is becoming more widespread. Furthermore, this patient's performances exceeded previously established expectations, with significant music perception and telephone use. While this is one case study, it demonstrates the implications of implanting an adult with extremely impaired discrimination and outlines the direction for future expectations with bilateral implantation and technological advances.

G6 – O14

Speech performances in bilateral adult users of Med-el cochlear implants

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Objective: To investigate performances in adult subjects bilaterally and simultaneously implanted with MED-EL COMBI 40/40+ cochlear implants.

Methods: Thirty-for postlingually profound deafened adults have been implanted, in a single stage surgery with simultaneous activation of the two processors. Subjects were evaluated at 3,6 and 12 months after switch-on. Speech perception tests (disyllabic words) were performed in quiet and noise (signal-to-noise ratio: + 15 and + 5 dB), with speech and noise coming from the front. Test of localization were performed in quiet and in noise with 5 loudspeakers set up in frontal horizontal plane. Subjective benefit was evaluated using GBI questionnaire.

Results: Analyze of individual data showed that 77 % of patients had better results with bilateral implantation compared to unilateral best performances in quiet and 57 % in noise. Bilateral implantation improves speech performances even in case of long duration of hearing. GBI questionnaire evidenced an important improvement in quality of life with bilateral implantation. In case of asymmetric post-operative performances, no difference was found between the better ear and the poorer ear in term of preoperative speech performances, duration of deafness, duration of hearing aids and number of activated electrodes.

Conclusion: Bilateral implantation improves speech performances in quiet and in noise for most of patients, even in case of long duration of hearing. The main question remain to predict, before the implantation, the best responsive ear.

G6 – P15

Bilateral cochlear implantation – A case in need for meningitic patients

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Objectives: Outcome report of 4 patients with ossification treated by sequential bilateral cochlear implantation.

Methods: Severe hearing loss following meningitis poses a number of dilemmas. We highlight our experience of four adult patients, all deafened by pneumococcal meningitis, who subsequently received bilateral implants. All four patients had ossified cochleas and initially underwent unilateral surgery which initially did not produce satisfactory stimulation. Sequential second side surgery was performed following counselling.

Results: Overall a 'full' insertion was only possible in 1 out of 8 ears and an apical drill out was necessary in 4 ears. A variable number of useable electrodes were available for programming. All 4 patients have a 'better' ear and only use a single implant. All are users and have good quality of life outcomes.

Conclusion: In the United Kingdom patients are usually funded for only one implant based on health economics. In reviewing our experience in such cases it is evident that preoperative imaging and audiological testing alone may not identify the 'better' ear on which to operate. If only one ear were implanted there is a potential risk of a patient becoming a 'non-user'.

We recommend that
– all meningitic patients are seen 'urgently'.
– more robust objective tests are needed to try and identify a 'better' ear.
– from our experience we would support the view that all meningitic patients should be considered for simultaneous bilateral cochlear implantation especially following pneumococcal infections.

G6 – P16

Development after bilateral implantation: Special cases

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Objectives: More and more patients will benefit from bilateral implantation. The aim of this presentation is to show outcomes after bilateral implantation in two not just common cases.

Methods: Enrolled are two patients: A teenager, sequentially implanted with two different types of implants using completely different speech coding strategies, first operation at age eight, second at age fourteen. Baseline assessment was performed prior to the second implantation. Follow-up assessments were performed six months after the first fitting of the second implant using the "Freiburger Monosyllable Test" and the "Oldenburger sentence test". The second patient was sequentially implanted afer meningitis, which caused partially ossification on both cochlears. The time gap between the implantations was three years. In the first implanted ear are ten in the second one twenty two electrodes available for stimulation. Assessments were performed as described in case one.

Results: Type of implant and different speech coding strategy after bilateral implantation had a considerable positive impact on speech understanding performance in the first case as well as the number of electrodes available for stimulation in the second case.

Conclusions: Both cases demonstrate that, far from generalisation, it is necessary to consider every single case especially concerning bilateral implantation.

G6 – O17

Bilateral cochlear implantation in deaf-blind users

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Objectives: For the deaf-blind, restoration of localization capacities is as important as restoration of speech perception capacities. Surprisingly, bilateral cochlear implantation is still infrequent in deaf-blind candidates. This project proposes an ongoing clinical study aiming at documenting auditory benefits of bilateral cochlear implantation in deaf-blind users.

Methods: A not-randomized controlled clinical trial where binaural is compared to monaural listening in the same subject was implemented. Speech perception (HINT test) and localization abilities (front 180° horizontal array of 11 speakers) were assessed immediately after binaural adjustment, and after three, six, and then every six months of use of the devices up until stabilization of performance is observed. Interviews were done at the end of the follow-up to assess the subjective benefits of binaural implant use in everyday life.

Results: Only one subject did not show any gain from binaural hearing. This subject was a teenager whose bilateral implantation was sequentially performed with a 10 years gap. While subjective reports were in favour of a binaural advantage from the first days for the other subjects, these gains were not objectivable up until twelve months for some. Speech perception in quiet reached normal range of performance (80–100 %). Performance in noise also appears quite high (63–91 %) and is comparable to the best cochlear implant users. Localization capacities improved for both HF and LF filtered stimuli, so both interaural time and intensity difference cues appear effective to support localization. These capacities did not reach the normal range.

G6 – O18

Analysis of the "software"-fitting parameters at bilaterally implanted CI users

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Aim of this study is the analysis of speech perception, sound localization and restoration of spatial hearing by means of a special measurement located in an anechoic chamber depending on the "software"-fitting parameters of CI's sound processors and the fitting procedure of bilaterally implanted CI users. All the patients used MED-EL COMBI 40 or COMBI 40+ implants and the standard MED-EL CIS+ strategy. According to this study, CI users improve or restore their spatial hearing because of the ability to use their better ear for changing circumstances (bilateral benefit) and the ability to combine the sound signals from both ears (binaural advantage). The bilateral fitting procedure works as follows: for each ear separately (THR, MCL, Maplaw, etc.), everyday map, obtained during clinical device fitting on each side individually, the patient can subsequently adjust the loudness on each side to a comfortable level and to get an azimuth 0°. To achieve further improvements of speech perception and sound localization in horizontal plane, dependencies of bilateral hearing on pulse rate (variation of pulse width), channel number (variation of numbers of activated channels), MCL (MCL adjustment channel by channel), Maplaw (loudness adjustment on each side) and frequency range covered (5,5 kHz – 8,5 kHz) are examined. To have equal microphone sensitivity across all subjects with respect to the sound pressure level used in the test, the AGC is set to maximum sensitivity. The achieved results represent in detail the influence of the "software"-fitting parameter and the significance of each parameter for improving binaural hearing.

G6 – P19

Binaural perception with the Digisonic SP binaural

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Objectives: The authors present a new technique for the rehabilitation of profoundly deaf adult patients by cochlear electrical stimulation. Usually, one ear is implanted. Bilateral cochlear implantation experiences have been reported by the literature recently. Despite the significant benefit, the cost of a bilateral implantation is a disadvantage.

In order to reduce the cost, we have started in 2004 the evaluation of a binaural cochlear implant in collaboration with Neurelec company. The Digisonic SP Binaural is a 24 channels cochlear implant with two electrodes array. The first is introduced in the ipsi-lateral cochlea with 12 electrodes. The longer second electrodes array is running under the galea for the stimulation of the contro-lateral ear with 12 electrodes. One speech processor does the signal processing. A specific stimulation pattern is used. The easy surgical procedure will be presented.

Results: The results on 8 patients shows an improvement of 8dB in tonal audiometry with the binaural hearing and a gain of 19,5 % in vocal audiometry. Also an improvement of localisation with one microphone is seen.

Conclusion: The Digisonic SP Binaural is a safe, reliable and an efficient solution for the binaural rehabilitation. It's a cost-effective solution in patient where bilateral implantation is not possible. A larger population is necessary to confirm theses preliminary results. The possibility to add a second contro-lateral microphone will be presented.

G6 – O20

Bilateral HiRes 90K benefit: U. S. multi-center study

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Objectives: A University of Iowa study has reported that bilaterally implanted adults demonstrated significant improvement in speech-in-noise scores with HiRes sound processing after only one month of use compared to their scores after long-term experience with CIS (Dunn et al. 2006). This in-progress multicenter study aims to replicate these findings in a larger group of newly implanted postlinguistically deafened adults who receive two HiRes 90K implants during the same surgery.

Methods: A prospective counterbalanced between- and within-subjects design is used to evaluate bilateral listening benefits and to compare sound processing modes (CIS vs. HiRes). The study uses a six-month crossover design (three months with each processing mode) with an additional one-month period in which subjects re-evaluate the two processing modes (two weeks with each mode) and indicate a preference. Subjects then are evaluated at one and four months after using their preferred mode.

Results: A unique aspect of the study is use of a direct-connect (DC) system for postimplant testing. The system was developed by the House Ear Institute and eliminates the need for a sound booth or a speaker array. Left-ear and right-ear head-related transfer functions appropriate to the selected source location are applied to the selected signal and presented via direct connection to the auxiliary input of the Auria sound processor.

Conclusions: Initial study data indicate that bilateral implantation is advantageous and that sound processing may have a significant effect on bilateral benefit, consistent with the Iowa results.

Neural Response Measurements (G7)

G7 – O1

Changes in t-NRT over time

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Objectives: The use of NRT measurements has become widely spread to ascertain the integrity of the neural/electrode interface as well as for assisting in the setting of thresholds and most comfortable levels. While the stabilization of programming levels has been described extensively, information regarding changes in t-NRT over time is limited. The purpose of this retrospective study was to assess the evolution of t-NRT over time in the different cochlear segments.

Methods: The records of 56 children that were implanted with the Nucleus 24CI in the Chaim Sheba medical center, between the years 2002–2005 were analyzed. NRT measurements were carried out intra-operatively and then repeated at several time-points during post-operative programming sessions, up to 18 months post initial stimulation. Levels were analyzed according to the three cochlear segments: apical, medial and basal.

Results: Changes over time in t-NRT were evident mainly between the intra-operative and the initial post-operative measurement and in the order of 10 (±7.8 s.d.) clinical units in the consecutive sessions during the study follow-up. In most cases levels in the apical segment were lower than those in the medial and basal ones. A different t-NRT profile was observed in different etiologies; however, this observation needs further substantiation in a larger group of children.

Conclusions: As changes in t-NRT over time were found, the use of t-NRTs for programming requires repeated post-operative NRT measurements, especially in difficult to test children.

G7 – O2

Correlation of NRT / map-mismatch and speech understanding

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Objectives: Neural Response Telemetry (NRT) is an elegant method for fast auditory evoked potential recording in Cochlea Implant patients. NRT therefore offers the opportunity of objective threshold estimation for speech processor fitting in very young children. A disadvantage of NRT, however, is that there always is a mismatch between NRT-thresholds and speech processor map T-values. We investigated this threshold mismatch and looked for possible reasons.

Methods: In 40 adult patients, using a Cochlear CI24-System, three Tests were performed:
– psycho acoustic map-threshold determination
– NRT-threshold determination
– speech discrimination, using *Freiburger* monosyllable words at 70 dB SPL

To avoid influences of electrode position, the statistics were restricted only to measurements of electrode 10, just in the middle of the electrode array.

Results:
– NRT thresholds and map thresholds prove to have large inter individual variability.
– Also the gap between map threshold and NRT threshold varies extremely.
– This gap reveals a clear correlation to monosyllable speech understanding score.

Conclusions: The found correlation between speech understanding score and NRT/map threshold mismatch reveals, that the error of map threshold estimation, using NRT threshold, is no random error. There is a law behind this mismatch. Individual different integration and summation effects within the hearing pathways most probably are the reasons for this threshold mismatch.

G7 – O3

AutoNRT in implanting the severely malformed cochlea

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Objectives: With the implementation of autoNRT, very young and difficult to program patients have been able to achieve usable MAPs much faster. The current study evaluates results of the autoNRT and its implications on both surgical placement and programming in children with severely malformed cochleae.

Methods: Four children with significant cochlear malformations, aged 13–22 months, were implanted with 5 Cochlear Nucleus Freedom straight electrode implants, with one child receiving bilateral sequential implants. In addition to hearing loss, two children also had other significant developmental delays. AutoNRT data was obtained intra-operatively and over the next several months at mapping appointments. Intra-operative findings and postoperative clinical data were evaluated in reference to autoNRT data.

Results: AutoNRT helped determine appropriate intra-operative placement of the electrode array. Data will be presented regarding benefit from cochlear implantation in severely malformed cochleae both by electrical testing and clinical surveillance. Long-term autoNRT responses will be reviewed and compared to responses at implantation and initial stimulation.

Conclusions: AutoNRT is an effective tool to assist in implanting and programming the child with a severely malformed cochlea.

G7 – P4

Surgeon performed auto-NRT: an aid to cochlear implant mapping

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Objectives: To describe the method and outcome of surgeon performed Auto-NRT measurements in the operating room at the time of Cochlear Implantation as a means of streamlining cochlear implant programming.

Methods: Auto-NRT was performed in the O. R. for adults (n = 9) and children (n = 8) implanted with the Nucleus Freedom cochlear implant. A mean of 14 electrodes per subject was measured.

Auto-NRT results were compared to T and C-levels measured at the initial hook-up. Intra-operative results were also compared to Auto-NRT obtained following the initial activation of the first map.

Results: Intra-operative Auto-NRT was obtained for 15 of 17 subjects.

Intra-operative Auto-NRT for the adults are similar to C-levels measured on their initial activation. These results are dependent on the rate of stimulation. NRT results are 50 to 30 levels above T-levels.

The mean Auto-NRT obtained at hook-up are 18 clinical units below those measured in the O. R.

Conclusions: Auto-NRT is easy and fast, therefore can be completed in the O. R. Results were obtained for 88 % of the subjects. NRT confirms that the implant is working prior to leaving the OR. These results are particularly helpful in creating maps for children when limited behavioral results are obtained. For some subjects, Auto-NRT can not be completed at the initial hook-up. Stimulation may be too loud. Adults with long lengths of auditory deprivation or those with congenital losses, NRT may provide valuable information. NRT helps to speed the programming process. NRT helps to determine which electrodes should be measured for streamline programming for more accurate maps.

G7 – P5

Speech processor fitting in very young children using Nucleus NRT based maps

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Objectives: To evaluated a NRT based fitting procedure concerning it's applicability in very young children and to compare NRT based maps with conventionally created programmes.

Methods: A two phase study design: During phase I10 children implanted with a Nucleus device and with at least 6 month of implant experience were re-programmed according to the NRT based method. Results between the two programmes were compared intra individually. During phase II two groups of 10 children each were implanted with a Nucleus 24 System. One group of children was programmed behaviourally and the other group with the NRT based method. The development in speech recognition and production was monitored at 3, 6 and 12 month after first fitting. The results were compared between the two groups and the time effort was recorded.

Results: Phase I: results demonstrate that all children had equal or improved performance after being switched to a NRT map. Programs for all children could be created within 30 minutes. Including the NRT recordings the whole fitting procedure only took one hour. Phase II: all children could be fitted with an NRT based map. Speech perception results and questionnaires seem to demonstrate that these children improve their speech and language skills earlier than behaviourally fitted children. A fitting session only takes less than 20 minutes.

Conclusions: This study demonstrates that NRT based fitting can reliably be used with very young children, that it is time efficient and beneficial in terms of speech and language development.

G7 – P6

Correlations of speech recognition scores with NRT measurements

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Objectives: The objective of this study is to evaluate whether NRT measures can be correlated with speech perception scores.

Method: 20 adult subjects with post-linguistic onset of bilateral severe-to-profound SNHL were implanted with the Freedom implant. They were fitted with two MAPs, an ACE MAP (900 pps/channel) and an ACE (RE) MAP (2400 pps/channel). After 3 months speech test (Spanish bi-syllabics words in quiet and sentences in noise) were performed and the patients preferred MAP was identified. During the trial the following NRT measurements were performed: amplitude growth functions (AGF), recovery functions and rate adaptation at 250, 500, 2000, 4000, 8000 pps.

Results: The mean age of the participating subjects is 54.5 ± 15 years. The duration of severe to profound deafness is 6.33 ± 6 years, with mix aetiologies. Speech scores at 3 months showed that only 1 of the 20 performed better with an ACE (RE) compared to ACE.

Data were stratified according to speech perception scores (Bi-syllabic word scores Group 1 ≤50 %; Group2 >50 %). Group1 and 2 had similar age distribution but Group 1 had longer duration of deafness and more patients with unknown aetiology. Preliminary NRT results show that Group2 had steeper slopes of the AGF than Group1. Time constants of recovery functions and rate adaptation will be analysed in the light of speech perception performance and subjective rate preference.

Conclusion: The majority of patients have better results with the low rate ACE strategy. Correlates of NRT measurements with speech perception will be presented.

G7 – P7

Intra-operative TECAP measurement using AutoNRT

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The telemetric recording of electrically evoked compound action potentials (TECAP) via the cochlear implant (CI) has been developed from a research tool to a valuable clinical method. The leading CI-manufacturer support this technique in their current systems.

The intra-operative TECAP measurement does not only serve as an indicator for the operativeness of the system and the excitability of the auditory nerve, but can also assist the choice of stimulation parameters during 1.fit. With an adequate software support the TECAP recording does not prolong the surgery, as it is done smoothly while the surgeon closes the incision.

Cochlear introduced with AutoNRT an algorithm that allows the fully automatic TECAP threshold detection. The AutoNRT measurements lead considerably faster to a threshold profile of all electrodes than the standard method using amplitude growth functions.

Post operative a good threshold reproducibility was demonstrated for measurements at the same day. Intra-operative recorded thresholds are generally higher than those measured in the course of 1.fit. The measuring time is influenced by the electrode impedance. Electrodes with high impedances are frequently associated with larger artefacts than stimulation electrodes with low impedances. A conditioning of the electrodes prior to the first measurements leads to less problems with the stimulation artefact and faster results. We could demonstrate that this conditioning by stimulation with a relatively high current as well when the electrode is inserted into the cochlear,

as before the operation in physiological saline improves the measuring conditions.

G7 – P8

AutoNRT intraoperative measurements for CI fitting: Preliminary results

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Objectives: Intraoperative NRT measurements can help in creating initial maps. Thresholds do not usually map with T or C values, but they help defining the map morphology. AutoNRT has been recently introduced by Cochlear. In our patients we have found a high variability in thresholds between intraop and postop measurents, higher than with standard NRT, and the most important, morphology has also a great variability. The objective of this study is to determine the reliability of AutoNRT for initial fitting and compare it with conventional NRT.

Methods: 10 patients implanted with Cochlear Freedom implants have been studied. Intraoperative AutoNRT and standard NRT measurements were taken for 9 electrodes. For standard NRT, N1P1 peaks were manually set and extrapolated T-NRT was obtained. AutoNRT and standard NRT thresholds were compared for each electrode.

Results: A priori, AutoNRT should be much better since it obtains the visual T-NRT, and is more comfortable for patients since it does not need to stimulate at high current levels. Results show that AutoNRT is only reliable when good NRT responses are present. This is because NRT response validation is quite weak, accepting as good responses waves that would be usually discarded. The other problem is that it is designed to automatically optimize parameters, meaning that you can have thresholds obtained with different parameters for some electrodes, making them unreliable.

Conclusions: AutoNRT is a good approach but still needs improvements, specially response validation, to be reliable. Current AutoNRT technique requires to manually revise the waves, increasing first fitting time.

G7 – P9

Electrode impedance in children using the Nucleus 24 CI

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The aim of this study was to measure impedance variations in a series of time intervals, in Common Ground Mode in children using the N24 Contour Cochlear Implant System.

Data were collected for ten children: intraoperatively, during tune up, one, two, six twelve and twenty four months later.

In general, impedances increased from the intraoperative to the tune up session, decreased for the first month and were then relatively stable in other periods. This behavior was observed when using corrected and uncorrected data for differences in electrode surface area.

Impedance variations in relation with electrode position were not statistically significant.

Impedances were influenced by whether the electrodes were stimulated or unstimulated in the speech processor maps. The impedances of the unstimulated electrodes, were relatively unchanged after the tune-up session, when compared with the variations observed in stimulated electrodes.

The data suggest that impedance variations could be due to changes in the resistive characteristics of the medium surrounding the electrodes and also to the effect of electrical stimulation.

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G7 – P10

The effect of simultaneous pulses on vowel perception

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Objective: The goal was to test the hypothesis that the use of simultaneous pulses on formant electrodes and sequential pulses on background electrodes would enhance the ability of implantees to correctly identify vowels in background stimulation.

Methods: Two volunteers who use the Percutaneous Nucleus Contour system participated. Subjects were trained to identify four synthetic vowels that were constructed using pulses on 11 electrodes, of which 2 were designated as formant electrodes and had higher current levels. They were then tested in various more difficult conditions in which the temporal offset of the formant electrodes was varied (including zero offset) while maintaining a constant temporal offset among the background electrodes.

Results: For both subjects, their ability to correctly identify the vowels was significantly affected by the temporal offset of the formant electrodes. In neither case was the pattern of results consistent with the hypothesis that the subject could use the differences in temporal offset to perceptually separate the vowel formants from the background stimulation. In both cases, the results were consistent with the perceived spectral shape of the vowels being distorted by direct current summation.

Conclusions: Simultaneous or overlapping current pulses have the potential to seriously distort the perception of vowels due to direct current summation. There was no evidence of subjects being able to perceptually use differences in temporal offset in this experiment.

This research was supported by Cochlear Corp, Aston University, and The Australian National Health and Medical Research Council.

G7 – P11

Conditioning effects of high-level sweeps on intra-operatively measured ECAP

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Objectives: The discrepance between intraoperative objective measures and postoperative results is a big drawback for 'the use of intraoperative measured electrophysiologic data in objective fitting'. Usually, postoperatively measured ECAP-thresholds and electrode impedances are much lower. In order to reduce these discrepancies the introduction of conditioning sweeps was proposed recently. We investigated the effect of high-level pulse trains on electrode impedances and electrically evoked compound action potential (ECAP).

Methods: Electrode impedances and ECAP were measured in twelve patients implanted with a Nucleus System 4 during surgery before and after applying 200 sweeps of 500 ms duration at 230 current units. Five electrodes (1,6,11,16, and 21 from basal) were investigated.

Results: Electrode impedances were reduced for all investigated electrodes. ECAP-thresholds as measured with the Auto-NRT mode were substantially affected by the conditioning sweeps: In most of the patients a decrease was observed for the ECAP-thresholds. In three patients no significant reduction of ECAP-threshold was observed.

Conclusions: Until now, it is not clear wether the conditioning is only a physical effect regarding the electrode surface or physiological properties contribute. However, evidently high-level conditioning reduces the intraoperatively measured ECAP-threshold and electrode impedances. Therefore, cochlear implant fitting on the basis of objective measures is enhanced.

G7 – O12

Can ECAP measures predict preference for ACE stimulation rates?

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Objectives: To investigate the correlations between subjective preference for ACE stimulation rates and speech perception and ECAP measures.

Methods: Thirty deaf adults received the Nucleusâ FreedomTM Implant. Patients were initially fitted for three months with the ACE1200 strategy. Speech performance with the ACE strategy was investigated at 500 (A), 1200 (B) and 3500 (C) pps/channel using an ABC-C`B`A` design with 6 weeks period during the ABC phase and 2 weeks during the C'B'A' phase. At the end of each period speech tests were performed. Patients were asked to complete a comparative questionnaire, in order to determine the individual subjective rate preference. In all recipients ECAP measurements were performed using Neural Response Telemetry (NRTTM). Time constants of 'NRT recovery functions' and 'NRT rate adaptation', and spatial constants of 'NRT spread of excitation' measurements were calculated and correlated with rate preference and speech performance results.

Results: Preliminary group scores (n = 13) indicate no differences in performance for the different rates tested, although marked individual differences were observed. The majority of subjects preferred 1200pps/channel. Preliminary NRT data indicate that the current levels influence time- and spatial constants. Correlations between NRT measures and rate preference/performance for the whole group (n = 30) will be presented.

Conclusions: Preliminary group results suggest that there is no difference in speech performance for the ACE strategy at rates ranging from 500pps to 3500pps/channel. On the other hand performance differences may exist between rates for individual subjects. This reinforces the view that the choice of stimulation rate needs to be individually customised.

G7 – P13

Relationship between AutoNRT, ESRT and behavioural T &C levels with the Nucleus Freedom cochlear implant – preliminary results

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Objective: Clinical studies confirm that NRT threshold lies between T & C levels, and that the Electrical Stapedius Reflex Thresholds (ESRT) is best correlated to the C levels. In Nucleus system 3 NRT and ESR threshold levels were commonly used to set program levels in 900Hz map.

The Freedom (system 4) offers new characteristics including higher stimulation rates and Auto NRT. The aim of this study was to verify the offset profile along the electrode array with higher stimulation rates using the Auto NRT and ESRT over six months period.

Subjects: All patients implanted with the Nucleus Freedom system that were able to set reliable subjective counted thresholds and reliable judgement of comfort levels were included in the study.

Design: Auto NRT thresholds and ESRT were recorded at regular intervals over 6 months in electrodes 3, 5, 10, 15, 20 and 22. The corresponding behavioural T & C levels were measured at the same visits in various stimulation rates. Additionally, offset correlation between the overall threshold profile using live voice, based on a profile derived from the Auto NRT thresholds was assessed at the various stimulation rates.

Results: preliminary results of 15 subjects will be presented.

G7 – P14

ECAP threshold estimation with AutoNRT of the Nucleus Freedom system

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Objectives: The Nucleus Freedom cochlear implant system includes a completely automatic algorithm (AutoNRT) for the measurement of the Electrically evoked Compound Action Potential (ECAP) and determination of ECAP thresholds. This study evaluates relations between ECAP thresholds and behavioural thresholds at different time intervals to assess the usability of AutoNRT for fitting.

Methods: Postlingually deafened adults implanted with the Nucleus Freedom cochlear implant are included in this study. ECAPs are measured intraoperatively and postoperatively at different intervals. AutoNRT is performed at 5 electrodes using stimulation rates of 80 pps and 250 pps. Behavioural thresholds are obtained for 900 pps/channel stimulation at the same electrodes.

Results: Preliminary results in 16 patients show that intraoperatively, AutoNRT can determine ECAP thresholds in most patients. At first fitting ECAP thresholds can be obtained only in about 50 % of the patients due to uncomfortable loudness sensations. At later postoperative intervals ECAP threshold detection rates increase. Correlation coefficients between ECAP thresholds and behavioural thresholds differ across electrodes. Correlations between ECAP threshold profiles and behavioural threshold profiles vary amongst patients.

Conclusions: Preliminary results demonstrate good usability of AutoNRT of the Nucleus Freedom system for ECAP threshold determination shortening the recording and analysis time compared to nonautomatic ECAP measurements with conventional NRT. Results will be obtained in more patients and on additional electrodes to better assess the usability of AutoNRT threshold profiles for fitting Nucleus Freedom cochlear implant patients.

References

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G7 – P15

Determination of perceptual channels created by current steering

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Objectives: The Advanced Bionics cochlear implant devices are designed with independent current sources for each of the 16 contacts. This allows "steering" current between adjacent contacts, creating different stimulation sites depending on the ratio of current distribution.

The aim of this study was to investigate whether the intermediate channels lead to additional pitch percepts and to verify whether this correlates to performance scores in various speech tests. In particular if it correlates to more difficult tasks as consonant confusion matrix scores.

Methods: A group of adult CII-Bionic Ear® or HiRes90KTM cochlear implant users, with more than three months HiRes experience, were enrolled in the study. The number of perceptual channels was determined based on a pitch ranking task using a special research program. In addition the subjects underwent a test battery including a consonant confusion test to evaluate their performance with the HiRes strategy.

Results: A wide range of number of perceptual channels was found: the poorest subject could not rank the physical contacts, whereas the best performer had 110 channels between just one electrode pair. There was no correlation between the number of perceptual channels and demographical data. The subject with the lowest performance in the speech perception test also achieved the lowest number of perceptual channels. Detailed data on the correlation between results in the consonant confusion test and the number of perceptual channels will be presented.

Conclusion: Current Steering between adjacent electrodes allows the creation of additional pitch percepts.

G7 – P16

Sinusoidal analysis of audio for current steering strategies in cochlear implants

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Objectives: Current speech processing strategies for cochlear implants are based on decomposing the audio signals into multiple frequency bands, each one associated with one electrode [Nogueira, 2005]. However, these bands are relatively wide to accurately encode tonal components of audio signals [Geurts, 2004]. The CII® and HiRes90K® implants of Advanced Bionics Corporation have the ability to share the stimulation current between two contacts (Current Steering). By stimulating two bounding electrodes with different weights, the perception of different pitches is possible (Virtual Channels) [Townsend, 1987]. However, temporal pitch is also important to perceive frequencies [McKay, 2000].

Signal processing strategies for cochlear implants should, therefore, be able to analyze the time-frequency features of the audio signals while also exploiting the time frequency features of the implant.

Methods: A new signal processing strategy, based on the principle of parametric coding has been designed. Parametric representations of audio signals are based on model assumptions for the signal source and signal perception. Using sinusoidal modelling, a fine frequency resolution as well as a good temporal resolution can be reached.

Results: In a pilot study with five Clarion® recipients, the performance in speech intelligibility and pitch discrimination was evaluated in a chronical trial.

Conclusions: First results have shown similar performance between the HiResolution® strategy and the new strategy, further improvements on the above mentioned algorithm are expected to enhance speech perception.

References

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G7 – O17

Do users benefit from intermediate channels created by current steering?

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The goal of this ongoing study is to investigate the influence of improving spectral resolution by the use of intermediate channels beyond of what is possible with physical channels. Intermediate channels are created by steering the current between two physical contacts thus creating a current focus in the area between two contacts. Recent studies showed that cochlear implant users can perceive distinct pitches from so called intermediate channels.

Two possibilities of utilizing current steering will be discussed: a) increasing the total number of channels by a combination of physical and intermediate channels and process the acoustic signal with a maxima selection approach; b) decompose the acoustic signal into its primary sinusoid components and exactly represent the frequency of each sinusoid by steering the current between two physical contacts. Both strategies were implemented on the body worn Platinum Series Sound Processor. A subgroup also tried the new Auria+, a behind-the-ear processor developed especially for improvement of the spectral resolution. Data of more than 15 subjects will be presented who were fitted with and used the current steering strategy for at least one month.

Preliminary results show improvements in speech perception tests in noise as well as in a behavioural questionnaire on sound quality. Some subjects report better music appreciation. Only one subject dislikes the new strategy.

From these early data it can be assumed that current steering offers the potential to improve sound quality and performance especially in challenging listening situations.

G7 – P18

Effect of increased IIDR in the Nucleus Freedom CI system

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Objectives: Previous Nucleus CI systems have had a limited instantaneous input dynamic range (IIDR) of 30 dB which has adversely affected Nucleus recipients' ability to perceive soft speech (Donaldson et al., 2003). Studies have shown that perception of soft speech can be significantly improved for Nucleus recipients by raising Ts (Skinner et al., 1999) and by increasing the processor's sensitivity control (James et al., 2003). With the Freedom system, the IIDR can be increased to 45 dB. This study's objective was to determine if a map using an increased IIDR (40 dB) could improve Freedom recipients' recognition of soft speech over that of a 30 dB IIDR map optimized for perception of soft speech by raising Ts.

Methods: Ten newly implanted adults participated. Two maps were created for each participant that differed only in IIDR and Ts. After listening with both maps for at least one month, speech recognition testing was performed.

Results: Results revealed significantly higher group mean scores for CNC words presented at 50 dB SPL and significantly lower sound-field thresholds with the 40 compared to the 30 IIDR map. No significant differences were seen in scores obtained with the two maps for sentences in noise (65 dB SPL) or for sentences in quiet (50 dB SPL). Ceiling effects likely contributed to the non-significant finding for sentences in quiet. Most participants subjectively preferred the 40 dB IIDR map.

Conclusions: The increased IIDR of the Freedom system allows better perception of soft speech with no detriment to perception in noise.

G7 – P19

Determination of perceptual channels

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Objective: The aim of this study was to estimate the, minimum, maximum and average number of perceptual channels across the electrode array and at apical, mid or basal locations, determine whether the number of perceptual channels correlates with subject demographics, program parameters or speech recognition outcomes and to use perceptual channel distribution to delete electrodes from sparse areas.

Methods: 12 adults or adolescents implanted with CII or HiRes90K Bionic Ear were included in the study. The individuals who are capable of providing feedback regarding their auditory perceptions of both pitch and speech and have some memory for normal sound were preferred. Research software (BEDCS) by Advanced Bionics was used. In the pitch scaling procedure adjacent electrode pairs at three different sites were stimulated to find the smallest perceived pitch difference via adaptive psychophysical procedure. Patient performance was evaluated by CAP (Categories of Auditory Performance), monosyllabic word test (60dB SPL), entence test (60dB SPL) in quiet and in noise(+10dB S/N), for subjects with < 3 months CI experience, the session is repeated after more than one year experience.

The minimum, maximum and average number of perceptual channels across the electrode array and at apical, medial and basal locations was determined. It has also been investigated whether the number of perceptual channels correlates with subject demographics, program parameters and speech recognition outcomes.

References

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G7 – O20

Within subject study of perceptual channels and HiRes 120

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Objectives: Recent data indicate that some adult cochlear implant recipients can hear multiple pitches when current is steered between two electrode contacts (Donaldson et al., 2005). This within-subject study was designed to 1) evaluate the number of perceptual channels (or different pitches) that can be resolved, 2) assess variability of results with test-retest measures, and 3) compare perceptual channel results with speech recognition performance in subjects using the HiRes 120 sound processing strategy.

Methods: Subjects had received either the CII or 90k device. During two test sessions, electrode pairs were loudness balanced and pitch ranked. Subjects identified the electrode with the higher pitch while current was varied proportionally between electrodes in each pair. During additional test sessions, subjects were administered speech recognition measures with their standard HiRes strategy and following use of the HiRes 120 strategy. Test materials included one and multiple-speaker sentence material at soft and average conversational levels in quiet and an adaptive noise procedure.

Results: Preliminary data indicate that 1) a large number of subjects have additional perceptual channels across the electrode array, and 2) the number of perceptual channels can vary when assessed over time. The comparison between the perceptual channel experiments and speech recognition scores in subjects using the HiRes 120 strategy is in progress, however initial subject reports suggest improvements in everyday listening.

Conclusions: Subjects can perceive multiple pitches between adjacent electrodes. The advantages of additional perceptual channels created using current steering in the HiRes 120 strategy is under investigation and will be reported.

G7 – P21

Asymmetric pulses in cochlear implant stimulation: what polarity should we use?

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Objectives: Commercially available cochlear implants stimulate the auditory nerve (AN) with trains of symmetric biphasic pulses, consisting of a negative (cathodic) phase immediately or shortly followed by a positive (anodic) phase. The cathodic phase is commonly believed to be the most "effective" phase, i.e. producing most of the AN excitation, although there is no evidence for this in humans. Investigating the relative effects of stimulus polarities in cochlear implants is particularly relevant to the design of novel speech-processing strategies using asymmetric pulses (where the influence of one polarity is reduced compared to the other).

Methods: Two psychophysical experiments involving 8 users of the CII/HiRes cochlear implant were designed to study these relative effects. In experiment 1, temporal pitch discrimination abilities of subjects were measured at several rates for three different pulse shapes, namely biphasic, alternating-monophasic (where the second phase of each pulse is delayed to be mid-way between two subsequent pulses) and delayed pseudomonophasic (identical to alternating-monophasic except that the second phase has a lower amplitude and a longer duration). In experiment 2, several masking period patterns were measured. The masker was a 76 pps delayed pseudomonophasic pulse train, either anodic or cathodic. The signal was a 76 pps biphasic pulse train that was either presented 1 ms after the short/high phase or 1 ms after the long/low phase of the masker.

Results: The results suggest that the anodic phase is more efficient than the cathodic one.

Conclusions: To minimise power consumption, the high-amplitude phase of asymmetric pulse shapes such as the delayed pseudomonophasic waveform should be anodic.

G7 – P22

Artefact reduction in neural response imaging via a triphasic stimulation signal

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Intracochlear measurements of the evoked compound action potential (ECAP) are commonly used in the clinical routine. Following electrical stimulation some residual charge remains on the contacts and in the tissue close to the contacts. Given the relatively high gains required to measure small physiological responses, the potential arising from this charge drives the implant's recording amplifier into saturation. In addition, residual charge decays with a similar time scale to neural response waveforms, resulting in artefact that can distort or completely obscure any measured neural signal. It is known that the residual charge could be reduced by introducing a third phase to the stimulus.

The "Bionic Ear Data Collection System" (BEDCS) research software for the Advanced Bionics CII and HiRes90K implants allows the recording of ECAPs, known as Neural Response Imaging (NRI), and may be performed with highly flexible stimulation patterns.

15 post-lingual deafened adults participated in this study. Artefact reduction accomplished via the forward masking approach was compared with reduction via a third phase following the normal probe biphasic stimulation waveform.

Addition of a third phase to the probe waveform was shown to produce benefit in 90 % of the measurements made. Thereby only small changes in loudness were observed. Residual artefact was reduced to levels below many real-life NRI responses amplitudes hence should lead to more accurate and more easily interpreted NRI measurements. The influence of the third phase on NRI amplitude was found to be around 30 to 40 %, however in extreme cases it may be more.

G7 – P23

Speech processor fitting in very young children using Nucleus NRT based maps

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Objectives: To evaluated a NRT based fitting procedure concerning it's applicability in very young children and to compare NRT based maps with conventionally created programmes.

Methods: A two phase study design: During phase I10 children implanted with a Nucleus device and with at least 6 month of implant experience were re-programmed according to the NRT based method. Results between the two programmes were compared intra individually. During phase II two groups of 10 children each were implanted with a Nucleus 24 System. One group of children was programmed behaviourally and the other group with the NRT based method. The development in speech recognition and production was monitored at 3, 6 and 12 month after first fitting. The results were compared between the two groups and the time effort was recorded.

Results: Phase I: results demonstrate that all children had equal or improved performance after being switched to a NRT map. Programs for all children could be created within 30 minutes. Including the NRT recordings the whole fitting procedure only took one hour. Phase II: all children could be fitted with an NRT based map. Speech perception results and questionnaires seem to demonstrate that these children improve their speech and language skills earlier than behaviourally fitted children. A fitting session only takes less than 20 minutes.

Conclusions: This study demonstrates that NRT based fitting can reliably be used with very young children, that it is time efficient and beneficial in terms of speech and language development.

G7 – P24

Preliminary evaluation of phase-lock coding for cochlear implants

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Objectives: A new speech coding for cochlear implants was developed: the **p**hase-**l**ock **s**trategy (PLS). This strategy aims to enhance the perception of acoustic fine-structure. In PLS, the biphasic pulses are presented immediately after the presence of a zero-crossing of the acoustic signal.

Methods: A preliminary evaluation of pitch perception with PLS was performed in four CI users. Stimulus presentation was conducted using the Advanced Bionics SPAIDE research platform. This platform enables testing of an experimental speech coding strategy, while the user is connected to the computer. Two frequency discrimination tests were conducted: [1] with pure tones, and [2] with harmonic complex tones.

Results: When rating the pitch of a 330-Hz pure tone to that of a 933-Hz pure tone, subjects performed on average 83 % (s.d. 21 %) correct when using HiRes, and 81 % (s.d. 21 %) for PLS. For complex tones these scores were 56 % (s.d. 29 %) for Hires, and 70 % (s.d. 30 %) for PLS. One subject performed near 100 % for both strategies; one subject performed near chance level (50 %) for all tests; and for two subjects the performance for complex tones improved clearly when using PLS.

Conclusion: These pilot experiments suggest that PLS may improve pitch perception of harmonic complex stimuli.

G7 – O25

Banded neural response imaging using HI-Res sound processing

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Objectives: The goal of this study was to define the relationship between single channel and banded–NRI ECAP responses with the intent of developing clinical guidelines to assist in programming the Hi-Res system.

Methods: Thirteen adults implanted with the Clarion CII or 90K device were participants in this study. Psychophysical loudness assessments were made for each band using the standard Soundwave speech-burst stimuli. Loudness responses were ranked in an ascending manner using a standard scaling protocol from threshold to loud in eight steps. An automated data acquisition interface was used to collect all the data. Growth functions were first obtained for each band of four electrodes using the simultaneous stimuli followed by one single-channel growth function measured from one of the two middle electrodes in each band. The recording electrodes for the single channel and banded stimuli were held constant for each band.

Results: Banded NRI responses were obtained easily in all subjects even when single-channel NRI responses could not be measured on some electrodes or when the single channel measure was poor. Additionally, the growth ranges of the Banded NRI measure exhibited greater overlap with subjective measures when compared to single channel NRI.

Conclusions: Results confirm previously reported findings and demonstrate the usefulness of banded NRI in device programming of the Advanced Bionics Hi-Res cochlear implant system.

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G7 – P26

Loudness of partially-tripolar stimulation: model and data

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Objectives: To understand the effects of limiting current spread with multi-electrode stimulation in a biophysical model and in cochlear implant patients.

Methods: In a biophysical model, electrodes and neurons were arranged along parallel lines. For a given electrode, an effective spatial activation pattern was computed by assuming a homogeneous medium; activation from multiple electrodes was summed linearly. The degree of tripolar compensation (s) was varied between 0 (monopolar) and 1 (tripolar). Equal-threshold and equal-loudness contours were generated as a function of tripolar compensation for seven patients using the HiRes90K/CII cochlear implant with (n = 3) and without (n = 4) an electrode positioner designed to reduce electrode-to-tissue distances.

Results: In both the model and the patients, current needed for near-threshold activation was predicted by the field summation approximation: I=I0/(1+sK), with fitted constants I0 (monopolar threshold) and K (interaction coefficient). K was smaller for in the model for closer electrode-to-tissue distances and for patients with the positioner. Equal-loudness contours of 5 patients were predicted by the model. Loudness contours of 2 patients, both with positioner, significantly deviated from the field summation approximation. These cases closely resembled the model for small electrode-to-tissue distance, where neurons within the controlled current field were driven to saturation.

Conclusion: The biophysical model suggests partially-tripolar stimulation can be used to control current spread and to reduce the neural activation patterns observed with monopolar stimulation, while still achieving normal growth of loudness. The effects and potential benefits of partially-tripolar stimulation may be greatest for patients with larger electrode-to-tissue distances (i.e. non-positioner patients).

G7 – P27

Current steering: New model insights

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Objectives: Psycho-physical data suggests that it is possible to create intermediate percepts between electrode contacts by simultaneous stimulation of both contacts. This principle is also called current steering (CS). This study investigates the neural excitation patterns during CS in terms of pitch and loudness changes.

Methods: The CS stimulation patterns are modeled with a realistic 3D spiral computer model of the human cochlea implanted with a HiFocus implant combined with an active nerve fiber model. The latter uses human kinetics and a realistic double cable model representation of the sparsely myelinated human cell body. The model indicates which fibers are excited at certain current strengths.

Results: At the basal end of the cochlea, with the contacts along the lateral wall, the frequency glides smoothly from one percept to the next at a constant loudness. When the contacts are placed against the medial wall, the improved special selectivity makes that at low current levels the percept jumps between the electrode contacts without intermediate percepts. At high current levels the CS principle works also with lateral electrodes although there are loudness changes. In the apex, lateral contacts show irregularities in both frequency and loudness of the virtual channels. With medial contacts the pitch is controllable although their is no constant loudness.

Conclusions: Current steering only works predictably for contacts with limited spatial selectivity. At high current levels variations in pitch and loudness frequently occur simultaneously.

G7 – P28

Perceptual dimensions of current steered electrodes

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Objective: Simultaneous stimulation of multiple electrodes causes their individual electrical fields to sum in the cochlea. One application of this field superposition principle is to redistribute a given current pulse over two electrodes, and continuously vary the current fraction. This likely causes the peak of the electrical field to continuously shift between the two electrodes, since this technique is able to elicit multiple pitch percepts [1]. Therefore current steering may provide an improved site-of-excitation cue, and eventually lead to better frequency resolution, speech understanding and music appreciation. Initial psychoacoustic evaluations concentrated on loudness and intermediate pitch [1]. This study evaluates whether current steered pulse trains result in a different hearing sensation than sequential pulse trains.

Methods: A psychoacoustic technique known as multidimensional scaling was used. Subjects listened to pairs of stimuli only differing in their current steering coefficient or stimulation mode (simultaneous or sequential). Stimuli were initially loudness balanced, and a mild amount of amplitude roving was applied. The subjects indicated on continuous scale how different the stimuli sounded to them. The resulting dissimilarity numbers are interpreted as distances in a multidimensional space. Ten adult CII/HR90K users participated in the study.

Results: MDS analysis shows that simultaneous stimulation can evoke different percepts than sequential stimulation. Results depend on subject, position and loudness.

Conclusions: Simultaneous stimulation is a promising technique for better control over the neural interface.

References

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G7 – P29

ASSR thresholds pre and post cochlear implant surgery

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A cochlear implant is a prosthetic device designed to provide hearing to patients with severe to profound sensorineural hearing loss. A portion of the device, is surgically placed in the mastoid portion of the temporal bone. An electrode array extending from the implant package is inserted into the cochlea.

With the current developed technology, ASSR is becoming a valuables tool for evaluation hearing thresholds of young infants and those difficult to test children using behavioral investigations. Comparative study of changing in ASSR threshold pre and post cochlear implant, before and after the implants was switch on. This study was conducted on 9 young children who were implanted by two different experts' surgeons using four different cochlear implants models made by med-del and cochlear nucleus.

The results show a significant drop in hearing thresholds in the first month after the surgery. The drop in ASSR threshold for 6 patients recovered gradually within two months. Two patients ASSR threshold partially recovered mainly at low frequency. Several interacting factors and applications of the results will be discussed.

Bone Anchored Hearing Aids (G8)

G8 – O1

Results with self-tapping implants for BAHA

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Objectives: One aim of this study was to compare the implant stability at insertion between the standard and the new implants using resonance frequency analysis, RFA. A second aim was to compare the frequency of implant losses between the two groups.

Material and Methods: A new implant for the BAHA has been designed and has been tested. The tip of the implant has been provided with cutting edges. This means that when the implant seat has been prepared using the spiral drill with countersink no tapping is needed. The new implant is inserted directly. The insertion torque has been measured. Fifty consecutive patients have been provided with this new implant and the results have been compared with that of a matched group of patients who got implants placed in the standard way.

Results: In the study no implant placed in the conventional way was lost. Two implants in the self-tapping group were lost. One was in an 11 year old boy. A 4 mm implant was inserted as an one stage procedure. When the BAHA was fitted four weeks after surgery the boy experienced pain indicating non-integration. Four weeks later the implant was extruded. The other loss was in an elderly diabetic man who also had been a heavy smoker for many years.

There was no difference in implant stability.

Conclusion: Self-tapping implants for BAHA facilitates the surgery. Failure rate is about the same. Early loading of BAHA implants in children could be questioned.

G8 – O2

Skull vibration measurements with the BAHA

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Objectives: To measure the skull vibration characteristics of the BAHA in plastic, dried, and for the first time, live human skulls, and to compare different models of the BAHA.

Methods: Using a laser Doppler vibrometer, vibration responses with sound input of 70–80 dB SPL were measured on unloaded BAHAs, a dry skull, a plastic skull, and on the abutments of three live BAHA-fitted patients. Responses at different volume settings and distances from the vibrator were also tested. Frequency responses were calculated for displacement, velocity, and acceleration.

Results: Unloaded BAHA accelerations were about 30–50 dB higher than live head accelerations. Live head accelerations were similar to dry skulls in frequencies above 500 Hz, but much higher than the plastic skull responses. Live head responses were more damped. The Cordelle II® outperformed the other two processors by about 20 dB. The Classic 300® had better low frequency responses than the Compact®. The volume settings had little effect on vibration output overall. Acceleration peak was at approximately 2.5 kHz for all conditions.

Conclusions: The BAHA processors differ in the output acceleration they can achieve with differing loads. The volume control setting has little impact on accelerations produced for most processors. The live head responses are similar to the dry skull above 500 Hz.

G8 – O3

Do pre-implant BAHA sound field thresholds predict post-implant thresholds?

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Objectives: To determine if measurements of sound field threshold with the BAHA headband and bite-bar obtained prior

to BAHA implantation accurately predict post-implant sound field results. To compare the bite bar and the headband.

Methods: Sound field thresholds with the bite bar and the BAHA headband were performed prior to surgery in 20 patients. The same cohort was tested post-surgery with the BAHA coupled to the abutment. A comparison of results with pre-operative predictions was made.

Results: There was very good correlation between the pre-implant and post-implant sound field thresholds. In general, the bite-bar and headband results were very similar. However, there were some discrepancies at the higher frequencies. The bite-bar results were affected by placement of the bite bar in the incisors or the molars.

Conclusion: The pre-operative assessment of expected results for BAHA surgery is generally an accurate predictor of operative results. There are some high frequency differences in the results obtained with the bite bar compared to those with the headband.

G8 – O4

The Baha applied in subjects with unilateral conductive hearing loss

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Objective: Recently, we reported on the application of the BAHA in subjects with an acquired unilateral conductive hearing loss (Hol et al., 2005). We elaborated on the localization abilities of this group which were not fully understood. Results of 8 successive patients proved to be comparable for the aided and unaided situation. This could not be explained by loudness differences due to acoustic head shadow nor the test environment. It is suggested that the ear with the conductive hearing loss plays a part even in the unaided situation. The objective of this study was to assess the benefit of the BAHA in subjects with congenital unilateral conductive hearing loss.

Methods: 14 patients were included with an age ranging from 6 to 33 years. Binaural hearing was assessed in the sound field by comparing aided and unaided scores obtained with a sound localization test and a speech recognition in noise test with spatially separated sound and noise sources.

Results: The evaluations showed that sound localization improved significantly in the majority of the subjects. The binaural advantage, studied with speech-in-noise tests proved to in the same range as that of normal hearing controls, listening monaurally versus binaurally. For subjects implanted at a relatively high age, results were ambiguous. It is suggested that there is an upper age limit for this BAHA application.

Conclusions: fitting the BAHA in patients with congenital unilateral conductive hearing loss will render an improvement in binaural hearing, although a timing issue may be present.

G8 – O5

Predictive factors improving the benefit of BAHA application in patients with single sided deafness

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Introduction: At our centre not more than 20–30 % of the patients with single sided deafness (SSD) are qualified for the BAHA. However, even with very careful and conservative selection criteria, the percentage of non-wearers reaches 20 %.

Objectives: The aim of the study was to identify the most important factors predictive for successful application of the BAHA system in SSD patients.

Material and Methods: Basic epidemiological, etiological, medical and audiological data of 115 patients with SSD (32 effectively implanted with the BAHA) were retrospectively collected from the medical records and from the customized questionnaires, based on the validated APHAB, Glasgow, Oldenburger & Entific lists (responder rate in the BAHA population was >80 %). 178 different parameters have been collected for every subject. The outcome measures were the satisfaction scores and the intensity of the BAHA use. Statistical methods, including multiple regression analysis, were employed to evaluate the influence of different parameters on the outcome measures ("Patient Profiling").

Results: Significant correlations with the outcome measures were found for e. g. the patient's age and social status, aetiology of the hearing loss, problems encountered in particular listening situations and initial complaints (e. g. localization problems, tinnitus, hyperacusis, etc.).

Conclusion: Outcome of the BAHA application in SSD patients depends on multiple factors reaching beyond the purely audiological criteria. Therefore the "Patient Profiling", taking into consideration also other factors (economic, social, professional, etc.), can substantially help in the identification of potentially best candidates for the successful BAHA application in SSD.

Acknowledgement: This study was sponsored by Cochlear AG.

G8 – O6

Frequency of skin necroses after BAHA surgery

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Objectives: The aim of the study was to evaluate the frequency of necrosis of the skin around the BAHA-coupling in the immediate postoperative period and during the first years of follow up.

Material and Methods: During a three year period 144 patients were operated upon. Age varied from 2–85 years. There were 79 women and 65 men. In one group a new

BAHA-dermatome was used and in the other the thinning of the flap was made with a blade.

The frequency and seize of skin necroses during the first six postoperative weeks was registered. The same groups of patients were followed for 1–4 years and the frequency and distribution of adverse skin reactions was noted.

Results: The frequency of early necroses was higher in the "blade" group as compared to the BAHA-dermatome group. The frequency of late adverse skin problems was found to be 4.1 % in the Dermatome group as compared to 5.8 % in the other group.

Conclusion: Thinning of the skin around the BAHA coupling is of utmost importance for a lasting reaction free skin penetration. The BAHA-dermatome is a very useful tool to achieve this goal. No increased risk of early necroses was found.

G8 – O7

Loss of vibration amplitude across the BAHA snap coupling

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Objectives: To measure if the snap coupling is an efficient coupling device for the BAHA transducer.

Methods: A laser Doppler vibrometer was used to measure vibrations on the output stem and three points on the abutment of the BAHA. The BAHA was coupled to a dry skull through a plexiglass bite bar screwed to the skull. The impedance load was varied by fixing the skull. A control loose coupling was measured. Five BAHA Compacts® were measured.

Results: There was little loss across the BAHA snap coupling. At frequencies above 500 Hz, there was no more that 5dB loss at any frequency. Changing the impedance load by fixing the skull did not change the loss across the coupling.

Conclusion: The snap coupling is an efficient means of transmitting vibrations to the skull. There is little loss of vibration attenuation across it. BAHA amplification gain cannot be achieved by further optimizing this interface.

G8 – O8

A comparative analysis of office versus Operation room Insertion of the BAHA

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Introduction: The Bone Anchored Cochlear Stimulator (BAHA) is indicated for patients with unilateral deafness and/or an irreversible conductive hearing loss. The insertion of this device is usually performed in the operating room (OR) under IV sedation or general anesthesia. We suggest that the placement of the abutment can occur easily and safely in the clinic setting, reducing time and costs for both the patient and physician.

Study Design: Retrospective study.

Material and Methods: 14 patients requiring 15 devices (1 bilateral) were implanted with the BAHA device in the outpatient clinic and another 8 patients were implanted in the OR. All office procedures were done under local anesthesia; OR procedures used either general anesthesia or IV sedation. Follow-up occurred over 18 months. Time required, cost of the procedure, and other logistical concerns between OR and office-based insertion were evaluated and compared.

Results: When performed in the office, patient fees were reduced by 31 %, and patient's time investment was reduced 73 %. Physician time was reduced by 50 %. Following office-based insertion, patients were able to return to their normal routine immediately after the procedure, and no chaperone or designated driver was required. No infection or complications occurred in either group.

Conclusion: BAHA insertion in the clinic setting is safe and cost-effective, saving the patient and physician significant time and resources.

G8 – O9

The Bradford BAHA programme – impact of the multidisciplinary team

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Objectives: Assess implant survival, skin reaction and patient satisfaction in patients following the introduction of a multidisciplinary (MDT) team in 1997.

Method: Prospective / retrospective analysis of 80 patients treated at Bradford Royal Infirmary (1991–2005). Implant survival / failures were recorded along with abutment skin reaction. Patient satisfaction and quality of life was assessed using a questionnaire. Analysis and audit of patients treated pre and post introduction of Multidisciplinary Team approach to treatment.

Results: 12 out of 80 implants failed giving an overall failure rate of 15 %. Kaplan-Meier survival curves show a steady decrease in implant survival. Some failure was obviously due to trauma and poor primary integration. The remainder due to infection and unknown causes.

The MDT has had a positive effect on implant survival (8 %) and on skin reactions, with a higher proportion of patients with no reaction (56 % Pre-MDT; 84 % Post-MDT) after its introduction.

There was a 92.5 % response rate to the questionnaire. Overall patient satisfaction was high both before and after the introduction of the MDT. Patients have been treated because of congenital atresia, CSOM, Otosclerosis and single sided deafness (SSD).

Conclusions: BAHA is a safe and effective treatment. Complication rates and patient satisfaction are comparable with most other centres. A multidisciplinary team approach appears to have a positive effect on outcomes, particularly reduced skin reactions and increased implant survival. It is to be recommended that units should consider a MDT model when offering a bone anchored hearing aid service.

Otoprotection (F9)

F9 – O1

Trauma initiated cell death in the cochlea

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Apoptosis is a selective cell suicide process that plays a pivotal role during development and in the homeostasis of the adult nervous system. It can be triggered by a wide variety of cellular stresses, including insertion of electrodes in the cochlea, extracellular events leading to cell death receptor activation as well as trophic factor deprived neuronal cell death. In the auditory system, trophic factor deprived-spiral ganglion neurons (SGNs) died through an apoptotic process (Lallemend F. et al., J. Neurochem. 2003) whereas the significance of trophic support derived from both pre- and postsynaptic cells in neuronal survival has been already highlighted several decades ago. Substantial progress has been made recently in understanding the intracellular signals recruited by neurotrophic factors to prevent SGN cell death. Neurotrophins signal through the activation of at least two intracellular signal pathways implicated in promotion of neuronal survival: the Ras-MAP kinase (ERK pathway) and the phosphatidylinositol-3-OH kinase (PI3K)-protein kinase B (PKB, Akt) pathway. PKC activation by PMA induces the survival and neuritogenesis of postnatal rat spiral ganglion neurons *in vitro*. We have next demonstrated intracellular pathways mediating the trophic signaling of PKC. Activation of PKC in spiral ganglion cultures has the potential to promote SGN neuritogenesis and survival by preventing apoptosis against TFD-induced cell death trough two signaling pathways, that are PI3K and MAPK/ERKs pathways. Understanding of the molecular basis of neuronal survival and neuritogenesis in the cochlea might help to design valuable tool to preserve the cochlear integrity when traumatizing the inner ear.

F9 – O2

The role of inflammation and inflammatory mediators in post implantation hearing loss

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Objective: Develop a rational pharmacologic strategy for improving hearing preservation surgery.

Background and significance: Over the past 15 years the indication for cochlear implantation has been progressively expanded to include patients with large amounts of residual hearing. Loss of residual hearing previously during implant surgery may be related to multiple mechanisms ranging from pure mechanical insertion trauma to activation of inflammatory and cell death pathways. Control of these factors can be divided into improvement in surgical technique, improvement of electrode structure and modification of inflammation pathways. Understanding these factors will allow for the development of reliable techniques to consistently preserve hearing during implant surgery.

Methods: Adult mice underwent a cochleostomy and injection of a fluid bolus that was equivalent to a 25 % change in total perilymph volume. At 6, 24 and 72 hours mRNA was extracted from the inner ear of mice and stored in RNase free conditions. Microarrays for transcription factors, heat shock proteins, inflammatory mediators and cell death mediators were used to determine the expression and regulation of genes that may signal pending loss of function in the inner ear. Control tissue consisted of mRNA from untreated mice. Identified genes were confirmed by quantitative RT PCR and analyzed through bioinformatic approaches to identify regulatory networks.

Results: Hydraulic trauma induced numerous genes that are potential targets for the prevention of delayed hearing loss. Key gene families identified were anti oxidant genes, genes linked to TNF alpha signaling, jnk and downstream mediators of cell death, heat shock proteins and a variety of non specific transcription factors. We have tested a variety of TNF alpha inhibitors using this trauma model and found that we can prevent hydraulic trauma to the inner ear.

F9 – O3

The role of inflammation and inflammatory mediators in post implantation hearing loss

H Staecker

Department of Otolaryngology Head and Neck Surgery,
University of Kansas Medical Center, Kansas City, USA

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Results: Hydraulic trauma induced numerous genes that are potential targets for the prevention of delayed hearing loss. Key gene families identified were anti oxidant genes and genes linked to TNF alpha signaling.

Summary: Using an animal model of electrode insertion trauma we have identified several key mediators of cochlear trauma. Correlating these to regulatory networks using bioinformatics we can derive a series of compounds that may be useful for preventing hearing loss related to implant insertion.

F9 – O4

Protection against trauma-induced hearing loss by an inhibitor of the MAPK/JNK cell death signal cascade

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Objective: Test the ability of D-JNKI-1 to prevent cochlear implant electrode trauma induced hearing loss in an animal model.

Method: Guinea pigs were tested before and after electrode insertion trauma by pure tone evoked ABR and DPOAE recordings. D-JNKI-1 peptide in artificial perilymph (AP) was delivered locally to the cochlea immediately following electrode trauma and over 7 days. Controls were the contralateral ears of untreated trauma animals, animals perfused with D-JNKI-1 not exposed to trauma and trauma animals treated with AP.

Results: There was no increase in the hearing thresholds of either the control, contralateral ears of the untreated-electrode insertion trauma animals or in the ears of the animals perfused with D-JNKI-1 peptide without trauma. There was a progressive increase in hearing thresholds following electrode insertion trauma in the untreated animals and in animals that received AP. This progressive increase in hearing thresholds following electrode insertion trauma was prevented by scala tympani perfusion of a 10 mM solution of D-JNKI-1 in AP. The 1 month follow up of these animals found that the hearing preserved by D-JNKI-1 treatment was stable. The results of double stained surface preparations of organ of Corti specimens indicate a pattern of trauma induced hair cell loss that involves both necrosis and apoptosis.

Conclusion: D-JNKI-1 treatment protected against electrode trauma induced hearing loss in our animal model. This type of therapeutic approach may have clinical relevance when hearing conservation is desirable during cochlear implantation.

Supported by grants from NOHR and MED-EL, Medical Electronics GmbH, Innsbruck, Austria.

F9 – O5

Protection against hearing loss by growth factor and antioxidant therapy

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Objective: Define an intervention strategy to reduce environmentally-induced hearing impairment and sensory cell loss, and to reduce auditory nerve degeneration that follows sensory cell loss.

Methods: Guinea pig hair cells were damaged or completely eliminated by exposure to intense noise or ototoxic drugs, free radical formation was measured and the effects of various antioxidants and neurotrophic factors, administered prior to and/or follow cochlear damage, were assessed for efficacy in preventing sensory cell and auditory nerve cell death.

Results: Free radicals are formed in the organ of Corti and spiral ganglion cells (SGC) following damage. SGC degeneration could be prevented with local neurotrophic factors and antioxidants, administered locally or systemically. Both sensory cell damage following noise stress and SGC degeneration following deafness could also be prevented by delayed treatment; and the enhanced SGC survival witnessed remained long after cessation of treatment.

Conclusion: Systemic administration of antioxidants may be useful in the prevention of sensory cell loss associated with implant surgery and the loss of auditory nerve following sensory cell loss.

Acknowlegments: Supported by NIH DC03820, GM/UAW and the Ruth & Lynn Townsend Professorship.

F9 – O6

Auditory neurons: Restorative therapy

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Objectives: Relief of neural deafness through electric stimulation may be restrained by secondary neural degeneration due to hair cell loss. Induced enhancement of the neural population is a conceivable and challenging future. Cochlear receptors and neuron supply have been thought to be terminally differentiated. New findings of regenerative capacity of CNS neurons have challenged the old concept that neurons not undergo renewal during life, underestimating the potential for constitutive or inductive replacement of these cell components (Reynolds and Weiss, 1992; Magavi et al., 2000; Li et al. 2003; Izumikawa et al., 2005).

Methods: We reported in vitro-studies of adult mammalian cochlea including man, that neural progenitors may exist that undergo proliferation and differentiation into mature elongating neurons (Rask-Andersen et al., 2005). Bipolar cells (type I and II afferents) send neural projections to the spiral lamina and brain stem. Physical interaction may provide trophic supply between cells and could partly explain the slow and incomplete antegrade/retrograde degeneration of human auditory neurons, especially in the low frequency region.

Results: Present study shows that the generation of higher-order neural network developed from adult regenerating auditory neurons grown in vitro. In a series of cellular events which included sprouting, directed axonal growth cells clustered and formed a “ganglionic” structure.

Conclusions: A better understanding of the molecular background of these spectacular events may be helpful in designing future cell therapies for regeneration of inner ear neuronal structures.

F9 – O7

Regeneration of the human auditory nerve: A study using video microscopy and SEM of in vitro regenerated auditory nerve growth cones

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Objectives: Relief of neural deafness through electric stimulation may be restrained by secondary neural degeneration due to hair cell loss. New findings of regenerative capacity of CNS neurons have challenged the old concept that neurons not undergo renewal during life, underestimating the potential for constitutive or inductive replacement of these cell components (Reynolds and Weiss, 1992; Magavi et al., 2000). Recently we reported, using in vitro-studies of adult mammalian cochlea including man, that neural progenitors may exist that undergo proliferation and differentiation into mature elongating neurons (Rask-Andersen et al., 2005). These results suggested that the adult auditory system may have the potential to undergo self-renewal and regeneration.

Methods: Here we analysed, using high resolution SEM, the fine structure of nerve growth cones (GCs) in regenerating adult auditory neurons developed either via EGF and bFGF expanded neurospheres or directly from sprouting spherocytes obtained from dissociated spiral ganglion tissue and differentiated in neurotrophins (BDNF and NT-3) and nerve growth factors (GDNF). These studies were combined with TLVM to assess and probe axon kinesis.

Results: Images taken at high magnification displayed that lamellipodia membrane of expanding nerve GCs are decorated with surface specializations assumed to explain their crawling. Filopodia/mikrospikes were devoid of these emerging structures but showed circular adhesions providing anchorage of the navigating axon. Neurons and GCs expressed receptors for guidance molecules and ligand-based stimulation resulted in turning response.

Conclusions: The approach may be used for ensuing tentative steering of cochlear neurons to induce regenerative processes in the human cochlea.

F9 – O8

Hearing preservation with steroids in cochlea-implanted guinea pigs

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Threshold shifts caused by electrode implantation can be diminished by local administration of a crystalline suspension of triamcinolone into the hearing cochlea before implantation (ARO Abstr. 1198, 2005). In the present study, the effect of non-crystalline triamcinolone and dexamethasone on implanted guinea pig cochleae was investigated. Three groups of guinea pigs were implanted with a guinea pig electrode (MedEl) through a cochleostomy in the basal turn of the cochlea. 3 µl of triamcinolone (1st group), dexamethasone (2nd group) or artificial perilymph (AP) as a control (3rd group) was infused with a micro-syringe before implantation. The other ears received the same treatment omitting implantation (additional controls). Hearing loss (HL) was tested before and after drug/AP application for 2 month postoperatively by measuring click-evoked compound action potentials (CAPs) and frequency-specific CAP-audiograms via electrodes implanted near the round window. CAP-thresholds revealed a HL of 10–50 dB after electrode insertion in all groups. HL was smallest in Dexamethasone-treated animals. 7–28 days post-implantation a recovery of thresholds with no difference between steroid and control groups was observed. Frequency-specific CAP-audiograms showed highest HL in the high frequency range (>11 kHz), whereas middle and low frequencies were less affected. Recovery was found in all groups but was more pronounced in the steroid groups. After 2 months, recovery of steroid-treated animals exceeded that of control animals. The results indicate that a one-shot local application of steroids is capable of reducing progressive hearing loss caused by electrode insertion trauma up to two month post implantation. Supported by DFG & MedEl.

F9 – O9

Trauma-induced hearing loss, corticosteroids: Otoprotection

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Objective: Test the ability of local delivery of dexamethasone to prevent or lessen the loss of hearing threshold caused by electrode insertion trauma in an animal model.

Method: Adult pigmented guinea pigs were the experimental animal; dexamethasone was delivered into the scala tympani immediately following insertion and withdrawal of an electrode analog via a cochleostomy at the base of the cochlea; hearing was tested by both ABR and DPOAE tests with Intelligent Hearing System hardware and software; the effect of trauma on a cellular level was assessed from stained whole mount preparations of the organ of Corti.

Results: Electrode insertion trauma caused both an initial and a progressive loss of hearing. Whole mount preparations showed apoptosis of damaged hair cells in a site distant from the site of insertion trauma. Treatment with high dose dexamethasone immediately after electrode trauma decreased the initial loss and prevented most of the progressive loss of hearing caused by electrode insertion trauma when compared to the pattern of hearing loss that occurred in both untreated animals and artificial perilymph treated animals.

Conclusion: High dose dexamethasone therapy when delivered directly to the cochlea is an effective otoprotective

therapy in our animal model of cochlear implantation induced hearing loss. This therapeutic approach may have clinical application in patients where hearing conservation is important.

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Supported by a research grant from MED-EL, Innsbruck, Austria

Education (Z9)

Z9 – O1

STEPS: From hearing to talking – A package for families and professionals

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STEPS is a package developed to help families in supporting the progress of young deaf children in the STEPS from hearing to talking. It consists of a modular DVD, handbook, individual record book and poster, which can be used by families and by the professionals working with them. Each of the seven STEPS is illustrated on the DVD by families talking about their experiences and how they supported their child at home through the STEPS from hearing to talking. The individual record books enable families to identify and monitor their child's progress. The key principles are:

- Early communication skills underpin the development of spoken language. Good communication skills pre-implant are a strong indicator of success, post implant
- The quality of the relationship between the child and his/her principal caretakers and their experiences in their everyday environment are central to the way they learn
- For all children, spoken language takes time to develop.

Early feedback from teachers and therapists shows that STEPS provides a practical and pragmatic resource which can be used effectively with groups and individuals.

Development supported by Advanced Bionics.

Z9 – O2

Language skills of school-aged children with cochlear implants

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Objectives: The purpose of this study was to examine the impact that long-term use of a cochlear implant has on the language development of school-aged children.

Methods: Language skills of fifty children who received a cochlear implant at the Indiana University School of Medicine were examined. The Reynell Developmental Language Scales (RDLS), the Clinical Evaluation of Language Fundamentals (CELF-4), and the Peabody Picture Vocabulary Test (PPVT) were used as language assessment materials. Additionally, the Hearing in Noise Test (HINT) and the Phonetically Balanced Kindergarten (PBK) tests were used to assess speech perception skills.

Results: Preliminary analyses have suggested that for children who develop language at near-normal rates and also had language skills slightly below those of their hearing peers after receiving a cochlear implant, eventually developed language skills at normal or above normal levels. However, pediatric cochlear implant recipients who had normal or near-normal rates of language growth, but were well below normal language levels during the early years of cochlear implant use, struggled to develop language skills in order to keep pace with their normal-hearing peers in later school years. Additionally, the level speech perception skills were not associated with language skills or language development.

Conclusions: The findings from this study provide further evidence that early intervention is crucial for the continued development of language skills after cochlear implantation. It will be necessary to determine the factors that lead to the observed variability in performance in order to assist cochlear implant recipients with language delays.

Z9 – O3

Language competence – Bilingualism children with cochlear implants

G Diller

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Objectives: Acquisition of hearing and language in children with cochlear implants in relation to monolingual or bilingual educational support.

Population: Children with cochlear implant in monolingual and bilingual environments.

Methods: Comparison of matched peer-groups (n = 26) following factors as age, age at implantation, cognitive skills, threshold with CI, audiometric level, language acquisition level, educational placement, assessment of language skills, language of the parents, method of therapy.

Results: Monolingual educated children with cochlear implant had a development of hearing skills similar to normal hearing children. Significantly less of the bilingual educated children developed hearing skills similar.

Monolingual educated children with cochlear implant had a language acquisition similar to normal hearing children. None of the bilingual educated children reached this level. Most of the bilingual educated children with CI are involved in special education environments. We found no relation to the age, age at implantation, cognitive skills, threshold with CI and audiometric level.

Conclusion: Obviously the age of implantation, the threshold, speech audiograms seems to be not useful to predict the development of language competence for bilingualism children with CI. For example in the first stage the prosodic elements play an important role. Last but not least we have to pay attention to the culture aspects of families with other languages.

Z9 – P4

Verbal and non verbal communication strategies of an implanted child with his hearing twin and parents

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Objectives: Quantitative genetic designs, such as the twin method, can be used to explore genetic and environmental contributions to individual differences in rate and outcomes of language development and thus elucidate the contribution of nature and nurture to individual differences in language ability. In this context, we have asked us how genetic and environmental factors could affect our expectation on language outcomes in children with cochlear implant and, so, how much this factors had to be accounted in clinical evaluation and in prognostic considerations.

Methods: First we have assessed the linguistic abilities of a four years old implanted deaf child, after two years of CI use, and of his hearing twin, using language evaluation protocol of the ENT Department of Rome University; then we have videotaped four different communication situations – children alone and children/parents at home and in the clinic – to examine verbal and non verbal strategies of communication between children and between children and parents.

Results: The typology of communication strategies and styles and the relationship between language competence and strategies used were studied and a significant correlation was found.

Conclusions: Although these results are preliminary, we retain that a multivariate analysis of communicative use of language, with his concern with families and environment features, could be a power evaluation instrument to predict, together with the other clinical tests – audiological, neuroradiological, linguistic, neuropsicological – cochlear implantation possible outcomes and to quantify the real benefits in every day life.

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Z9 – O5

Socialisation of CI children over the past 10 years – expectation reached?

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The outcome in early implanted children is measured by the good open speech understanding in quite. Bilateral implantation is requested increasingly because of the bad communication abilities with unilateral Cochlear Implants (CI) in normal hearing situations. Especially teens with CI are faced with increasing demands in the mainstreamed high schools and the changing challenges in the communication with their peers.

Two years ago we created a so called "hearing camp" (Hörcamp) in order to rehabilitate the communication strategies of the CI teens. They should be enabled to follow up their mainstreamed schools. However with a successful school career the integration within the society is not associated.

We send out a questionnaires to 800 children, implanted before the age of 12 years and a second questionnaire to their parents. The questions focused on the auditory technical possibilities in the schools and at home, to the possibilities of assistance from parents, teachers and friends and to the reality, seen from the patients itself and their parents, of their grade of integration. We will report on the results.

Z9 – O6

Non-word discrimination skills in deaf infants

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Objective: Currently, there is little known about the speech discrimination capacities of deaf infants with cochlear implants. We present preliminary data from an ongoing longitudinal study that uses a novel paradigm to assess speech discrimination skills of infants enrolled in a CI program.

Methods: To date, 12 infants have been tested prior to implantation, and a number of these have been tested at various post-implant intervals using a variant of the Visual Habituation (VH) procedure. Infants were first habituated to audiovisual repetitions of a non-word prior to the test phase. The test phase consisted of "old" trials in which repetitions of the habituated non-word were presented, and "alternating" trials in which a novel non-word alternated with the habituated non-word. Looking time during each trial was measured on-line by blinded experimenters. A looking time preference for the alternating trials was taken as evidence that the infant is capable of discriminating the two non-words.

Results: None of the infants tested prior to implantation showed evidence of non-word discrimination, nor did the group of infants show significant discrimination on average. The preliminary post-implant data suggest a highly variable non-word discrimination capacity emerging during the first months after implantation.

Conclusion: Most deaf infants do not show discrimination of non-words shortly after implantation. Additional longitudinal data will provide more information on when after implantation deaf infants will show more robust speech discrimination skills.

Z9 – O7

Listening, phonological awareness and speaking skills of CI users

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Objectives:

1. Establish a series of valid tasks for the measurement of phonological awareness (PA) for pediatric, CI users.

2. Examine the rage of phonological awareness skills in children with more that 3 years of CI experience.

3. Determine the relationship between speech perception, speech production and phonological awareness in Pediatric, CI users.

Methods: Participants met the following criteria: prelingual, bilateral hearing loss with no other identified cognitive or learning disability, they received a cochlear implant at the University of Iowa Hospital and Clinics before the age of seven, they had at least 3 years of cochlear implant experience, and they were under the age of 18. Participants completed a series of phonological processing tasks ranging from rhyme determination from photos, to elision, synthesis, nonword repetition, digit repetition. Tasks were presented using auditory/visual modalties. Additional speech perception and production tests, and word reading comprehension tests were given.

Results: Indicated that the PA tasks that were most predictive of reading performance for CI users included rhyme determination, elision, blending words, and nonword repetition. Additionally there was a large range of variability of PA for these children, and a strong relationship between speech perception, speech production and reading skills.

Conclusions: Phonological Awareness can be validly measured in CI children and furthermore this skill is predictive of reading skill in this group. Thus it is important to begin incorporating PA assessment and training into the educational programs of these children.

Z9 – O8

Educational follow up of 24 children with cochlear implants

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Objectives: This paper reports on an ongoing follow-up study (2004–2007) of 24 children with cochlear implants, aged 7-11 in primary schools. The children were implanted in the period 1996–1998, and our first observation data were collected in 1999/2000. Average age at implantation was 3,2. The study is focusing on levels of integration, academic and social participation and what kind of resources, communicative modes or semiotic tools are available and in use in the variety of activities in the classroom.

Since 1997, deaf pupils in compulsory school in Norway have had an individual legal right to a bilingual education. Their right is not limited to placement in certain specialized schools. Our study includes both pupils following a bilingual program and those who are not.

Methods: The data consists mainly of video recordings, field notes and interviews with principles and teachers from seventeen primary school classrooms throughout Norway.

Results: To date we have found that education both within bilingual and monolingual classrooms is highly multimodal in a visually-oriented and patterned way, depending on the activities and resources available. The everyday life in classrooms consists of a range of different learning activities that are more or less challenging for pupils with cochlear implants when it comes to participation and learning.

Conclusions: An insightful use of two languages, visual and auditory modalities and visual semiotic tools seem to be important resources for facilitating an effective and inclusive educational practice for pupils with cochlear implants.

Z9 – O9

Educational development of implanted children in Latin America

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Objectives: In Latin America (LA) there are similar demographic, economic and social problems, but also differences in the availability of resources between the richer and the poorer countries of the region. The fast growing of CI programs in LA imply a challenge for professionals involved in the follow-up of implanted children. Because of that, the purpose of this study was to evaluate their actual educational situation and to propose strategies to improve their whole development.

Methods: The results of two surveys (1998–2001 and 2001–2004; 60 CI centres; 16 Latin American countries) demonstrate that most of deaf children traditionally attend special schools, but also that CI changed the educational patterns towards a tendency to the mainstream setting. Based on that, we carry out another survey to explore the therapy received; communication options; school placement; type of services; easiness to access them; parent's attitudes; development levels of communicative and educational skills; school-teachers involvement; school-teachers/therapists relationships and socio-cultural, economical and educational aspects.

Results: The outcomes show a lack of well-trained specialized personnel and of guidance programs for parents, shortage of educational policies and deficiency of school-teachers interested in the needs of implanted children, as factors linked with their educational development and therefore with their possibility of communicative success.

Conclusions: We discuss and suggest new educational policies and programs to train therapists and to support the parent's and school-teachers involvement, emphasizing the need to sketch common strategies with Spanish as a common language in LA, to improve the actual situation from an international perspective.

Z9 – O10

Speech identification in Spanish-speaking children with cochlear implant

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Objectives: Auditory perception and speech identification in 71 Spanish-speaking children over the first three years of experience with their cochlear prostheses were studied. The main objective is to investigate the influence of the age at implantation on the results obtained, and to compare our results with those of similar cases involving other languages such as English and German.

Methods: Children who participated in this study, were selected from among 175 patients. Children were divided into

5 groups according to their age at implantation from 12 months to 17 years old and categorized taking into account their auditory and productive skills at the moment this study was performed. Tests of suprasegmental features, segmental features such as vowel recognition, vowel discrimination, vowel transitions, every-day use verbal comprehension, spontaneous language production and communication via telephone were administered using spoken language.

Results: Average scores for most of the children showed improvements after one-year of experience with the cochlear implant. However, the rate of progress is not the same for the different groups: higher scores were obtained for children implant between 36 months to 4 years, 11 months old. This group also shows a smaller gap when comparing their language acquisition rate with that for normal-hearing children. Comparisons between our results with Spanish-speaking children and those provided to us of English and German-speaking children were made.

Conclusions: Earlier implantation would result in a fast rate of growth in language acquisition. The rate of language development in Spanish-speaking children might be slightly higher than in English or German, probably due to the Spanish vowel system.

Z9 – P11

Cochlear implants and English as a second language: Outcomes

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Objectives: In children with cochlear implants from families whose dominant language is not English, the influence of psychosocial, device, and auditory factors on academic and communicative performance was examined.

Methods: The charts for five children with cochlear implants from families in which English was a second language were reviewed. The educational and communicative outcomes examined included math and reading achievement, cochlear-implant aided word recognition performance, receptive and expressive language ability, main mode of communication, and speechreading ability.

Results: All three children with good academic and communicative outcomes had a parent with good English proficiency. In contrast, the outcomes were poor on all measures for a child with a parent with limited English proficiency. This child also demonstrated behavioral problems and had low parental participation in the rehabilitative and educational process. The one child at risk on the basis of three factors (parental English proficiency, behavior, and parental participation) was the child with the worst academic and communicative performance.

Conclusions: Health professionals should be prepared to offer alternatives to parents with limited English proficiency to enhance parental participation and confidence in the cochlear implant rehabilitative and educational process.

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Z9 – O12

Cochlear implants and FM: Technology and educational considerations

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Abstract: Cochlear implant technology faces some of the same challenges as hearing aids in most listening environments: background noise, distance between listener and speaker and reverberation. FM technology continues to advance and now provides an option to consider for CI users in addressing those challenges. In the educational setting, there are a variety of factors that must be considered when combining the two technologies.

Summary: Current FM technology options for cochlear implant processors will be presented as well as a look at future trends. CI users often complain of listening difficulty due to noise in their immediate environment, distance between listener and speaker and poor room acoustics. By utilizing FM technology as a part of the CI system, it is possible under the right circumstances to assist the CI user with overcoming these issues to a large degree. Historically, there have been some critical problems when coupling the two devices but now those issues have been resolved, for the most part. With the move towards all ear level devices, it is now easier than ever to consider incorporating FM with CI.

Issues faced in the school and nonschool environment will also be addressed.

Expected Educational Outcomes: Following the session, attendees will be able to:

1. Identify the different versions of cochlear implant technology.
2. Identify the different FM technology options that are compatible with cochlear implant technology.
3. Select appropriate FM technologies to meet individual patient needs.

Z9 – O13

Verifying FM benefit in children with cochlear implants

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Objective: The technology to couple FM systems to cochlear implants has been avaliable for several years. In England, FM systems are typically purchased by the school system and sent to the Cochlear Implant Center to be fit to the child's speech processor. It is essential to verify that the FM

system is providing sufficient benefit over background noise, distance and poor acoustics, while allowing sufficient input from the speech processor microphone. No definitive protocols have yet been established to verify benefit. At the Royal National Throat, Nose and Ear Hospital (RNTNE), a protocol for verifying benefit is being trialled. The objective of this project is to establish a protocol for FM fitting that allows the audiologist to measure the benefit received by the child.

Methods: Children are tested in various conditions with the cochlear implant and the FM system. These conditions include: cochlear implant in quiet, cochlear implant in noise, FM in noise and FM in quiet. Results are used to set up the FM to provide optimum benefit for noisy classroom situations. Interestingly, our results indicate that using a child's 'everyday' program with the FM may not provided enough FM benefit. A special program may need to be created for FM use only. However, this program may not be suitable for all-day classroom use, requiring the teacher to switch between programs. Case studies will be used to demonstrate these findings. An innovative teacher questionnaire has been developed to follow-up with the school.

Z9 – O14

A model for providing outreach services to early intervention specialists

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Objective: There is a need for improved communication between professionals who work with children with hearing impairments in order to maximize outcomes with a cochlear implant (Sorkin and Zwolan, 2004). This presentation describes ways outreach programs can improve the timeliness and quality of care provided to children with cochlear implants and demonstrates ways to educate and train professionals to better serve the rehabilitative needs of children with cochlear implants.

Methods: The Sound Support program is a grant supported by the University of Michigan and the State of Michigan's Department of Community Health. Sound Support has provided on-site training to more than 100 school personnel, has organized numerous on-site and internet workshops for families and medical professionals, and has facilitated networking among various professionals in the field.

Results: Early results indicate an increased understanding of the needs of hearing impaired children and improvement in the quality and availability of services received by hearing impaired children in the state of Michigan.

Conclusions: Outreach programs can be used to facilitate a greater understanding of the needs of children who are deaf or hard of hearing, have the potential to decrease the age at which children are diagnosed with a hearing loss, to decrease the age at which they receive intervention, and to have a profound effect on outcomes obtained with children with hearing impairments, particularly those who use cochlear implants.

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Z9 – P15

Validation of LittlEars questionnaire for Serbian language in normal hearing children under age of two

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Objectives: To validate the LittleEars Questionnaire for Serbian language compared to German original and to check if auditory performance in infants is language specific in normal hearing children. The study was a part of international LittlEars project run by MED-EL research team.

Methods: LittlEars Questionnaire consisting of 35 questions regarding receptive and semantic auditory behavior as well as expressive vocal behavior in normal hearing children up to 24 months of age. Parents of normal hearing babies and infants under age of two were included in this study (N = 238) The Questionnaire was answered by parents following instructions of the pediatrician or ENT doctor in well baby clinic or ENT department.

Results: The answers to all 35 questions in 238 children, aged 0–24 months were analyzed for age-appropriate auditory development and compared to German study. The analysis consisted of correlation with age (Pearsons Correlation – r), Dificulty index (p), Discrimination coefficient: point biserial correlation (r pbs) and part to whole corrected Discrimaination coefficient (r corr), regression curve etc. No statistical significant difference between Serbian and German study was shown.

Conclusions: Early auditory development in normal hearing children under age of 24 months is not language specific as have been shown by comparative application of LittleEars Questionnaire for Serbian and German children. It is very important for further application of the Questionnaire in hearing impaired children with either cochlear implants or hearing aids to follow development of auditory skills for hearing age under two, because it enables cross national comparison of the results of cochlear implantation.

Z9 – P16

The use of peabody picture vocabulary test – Croatian with deaf students

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Objectives: The present study was undertaken to determine the degree to which Peabody Picture Vocabulary Test-Croatian is reliable assessment tool when used with deaf participants. The aim was to compare the communication outcomes between students with aided residual hearing and students with cochlear implants.

Methods: Ten deaf participants age 12 to 18 were divided into two groups. Each group was composed of 5 students with a mean unaided pure-tone average thresholds of 110 dB HL. The PPVT-C is individually administered, norm-referenced.The examinee's task is to select the picture considered to best illustrate the meaning of a stimulus word presented orally by the examiner.

Results: Results show that the language delay resulting from auditory deprivation is smaller in students with CI which is strong argument for early implantation of deaf children.

Conclusions: The findings from this study indicate that educators, speech-language pathologists, and diagnosticians need to be highly cautious when interpreting the results of vocabulary tests, and when using those results in developing educational goals.

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Z9 – P17

Mainstreaming of bilingual CI children in a developing country

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Despite the adverse environment in a developing country, lack of professionals, conflicting issue of bilingualism, and the different approaches in habilitation, cochlear implanted children are effectively trained and mainstreamed into regular schools.

In our study, the first 8 CI children under our care, implanted at the ages from 2 to 6 years old, were enrolled into regular schools without any special educational help within the mainstream schools. The study shows that all children are still in the mainstreamed environment. Some of the children still need regular speech therapy in addition to the academic approach offered by the regular schools.

All children are entirely language oriented. They are able to communicate in both local language and the taught rehabilitation and mainstream school language English.

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Z9 – O18

Nottingham Early Assessment Package: expectations of progress in young implanted children

S Archbold

The Ear Foundation, Nottingham, UK, Advisor, Nottingham Cochlear Implant Programme

Nottingham Early Assessment Package, (NEAP) provides a framework for parents, teachers and speech and language therapists to monitor progress in young deaf children in the areas of:

- Communication and language
- Speech perception
- Speech production

With earlier diagnosis the assessment of young deaf infants becomes crucial in order to make informed decisions about their management. It is also important to assess these infants in their everyday environment where they spend most of their time and to engage parents and teachers of the deaf in their management and the monitoring of their progress.

It is available on CD-Rom and in a number of languages. Assessments include questionnaires, criterion-referenced profiles, and video analyses, to enable evaluation to be carried out in non-clinical settings, and with very young children. Outcomes will be given in the measures from a large number of children which will assist in identifying where a child may be experiencing problems and need further, more specialist assessment. Up to 40 % of deaf children are likely to have another problem and it is essential that we are able to identify early after implantation where there may be an additional difficulty.

With thanks to Cochlear Europe for sponsorship of the production of the package.

Worldwide Experiences in Cochlear Implants (Z10)

Z10 – O1

History and development of cochlear implant

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Objectives: Cochlear Implants has been widely used in auditory rehabilitation of profoundly deaf patients. The development of Cochlear Implants is one of the greatest achievements in Medical research of recent times. The idea of electrical stimulation of hearing first started in late 18th century, when Alessandro Volta the Italian physicist who stimulated his own ears. We like to remind all the important developmental steps from late 18th century till the development of Cochlear Implant.

Methods: A review of literature and History of Medicine.

Results: All the important dates and events in breakthrough of invention of Cochlear Implant will be presented.

Reference

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Z10 – O2

Why don't all patients receive cochlear mplants?

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Objectives: To investigate changing referral patterns of patients over time, and to examine why a significant proportion do not go on to receiving an implant.

Methods: The number of referrals and operations for adults and children was examined over the last 11 years. Files of adult patients who were referred but did not go through to receive an implant were examined for the last 3 years. The reasons for not proceeding were identified, and grouped into audiological, medical and personal reasons. Files were further examined to determine how far patients progressed with assessments, before the decision not to implant.

Results: A continuing increase in referral and operation numbers was observed over time, with numbers levelling off in the last 3 years. A larger proportion of children referred received implants compared to adults. Over 60 % of adults referred did not receive an implant. More post-lingually deaf patients progressed further with assessments than pre-lingual. The most common reasons for not receiving an implant were audiologically based. These included unaided or aided thresholds or speech perception being too good, or auditory experience of patients being too limited to benefit from an implant.

Conclusions: Audiological assessment of patients in particular is becoming increasingly complex and time consuming, with more relaxed selection criteria and more patients with significant residual hearing. This impacts on financial and staffing resources. The increasing number of referrals suggests that there is better awareness of cochlear implants among professionals, however not all people referred are suitable candidates at the time of the referral.

Z10 – P3

Expanding selection criteria study

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[2]RNTNE, UK
[3]South of England Cochlear Implant Programme, UK
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Objectives: Current selection criteria for implantation in Birmingham are set at maximum 30 % open set speech perception for recorded sentences in quiet in the best aided condition. This is conservative in comparison to other countries especially US where it is < 60 %. A recent study described a statistical method to set new criteria based on the first quartile of post-operative performance of Adult CI subjects1,2. Based on the first quartile of performance in Birmingham, this study expands current selection criteria to 50 % pre-operative performance giving a 75 % chance of improved performance in speech testing compared to pre-operative scores.

Methods: Eight subjects were implanted with the Nucleus Contour Advance in the poorer performing ear and optimally aided in the better ear using the loudness balancing procedure described by Ching et al3. Subjects were tested pre-op and post-op using speech testing in quiet and noise and quality of life measures at 3 and 6 months post switch-on.

Results: Performance data is presented from 8 patients.

Conclusions: The process of expanding traditional selection criteria and the clinical implications for the Birmingham Team will be discussed.

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Z10 – O4

Cochlear implantation – is younger better? An overview of the evidence

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Objectives: Since cochlear implants were approved in 1990 by the FDA for use with children, they have moved the minimum age for implantation firstly from 2 years, to 18 months, and then in 2000 to 12 months of age. Currently there are selected research centers implanting children younger than 12 months in the US and around the world, however many countries including Australia do not have a regulated age for implantation. The aim of this paper was to review the evidence available and to conclude, “Is younger better and if so, how young is young enough”?

Results: Various papers analyzing outcomes with cochlear implants by age of implantation were reviewed and the conclusions were collated for discussion.

Conclusions: From the review of the literature there is a significant amount of information available detailing the benefits that infants and toddlers receive from using cochlear implants from a very young age, in terms of auditory, language and speech development. The research overview presented illustrates this positive benefit from cochlear implants in very young children and concludes that the shorter the auditory deprivation the lesser the negative impact on the development of hearing, speech and language skills. The question remains however, “Is cochlear implantation in congenitally deaf children at 12 months of age young enough to see the full benefits from CI in terms of auditory skills and speech and language development in the majority of such candidates?”

Z10 – O5

Prospective benefits of deep electrode insertion for children with CI

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Objective: The advantage of deep electrode insertion for adults with CI has been demonstrated in several studies (Büchner *et al* 2004, Hochmair *et al* 2003, Boeheim *et al* 2002).

Results: Benefits include extended pitch domain, reduced channel interaction due to greater channel separation from base to apex, and better performance in noise with the apical electrode activated.

Measures of benefit have been established by focusing on the contribution of the apical region to the performance of the patient in noisy and quiet environments. Without the apical electrode switched on, patients performed poorer in clinical testing.

Adult benefits suggest that young and very young children will also benefit from the apical stimulation of the coch-

lea. Additional benefits for children may be related to the neural activation of central processes that is initiated by peripheral electrical stimulation.

Conclusion: It has been demonstrated that stimulation of the auditory nerve through a cochlear implant within the critical time window of auditory development (within the first 4 years of age) initiates fastest functional maturation of the auditory cortex (Sharma et al, 2005). Stimulation of larger portions of the auditory nerve, as achieved in deep electrode insertions, would activate a larger area of the auditory cortex. Deep electrode insertions would therefore provide a better starting point for cortical development in prelingually deaf children.

Z10 – P6

Prevention versus intervention: Early interaction and small talk

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[2]The Ear Foundation, UK
[3]Birmingham Paediatric CI Programme, UK

Objectives: Children with permanent sensorineural deafness are now being identified in the first few months of life, due to the increasing use of newborn hearing screening worldwide. Earlier identification and therefore earlier access to hearing aids, cochlear implants and habilitation is a positive development. However there are concerns about the impact of early diagnosis and the lack of appropriate resources and materials available for the families of these babies. Professionals have expressed concerns that families of early-identified deaf babies are unaware of how they, as parents, play a pivotal part in promoting early spoken language opportunities. In addition, relatively few professionals are experienced in working with families of deaf infants in the first weeks and months of life.

Methods: Cochlear Europe and The Ear Foundation have been working together to produce the Small Talk for families of newly identified babies and a training day for those professionals who support them.

Results: This package aims to help prevent the breakdown of parent-baby interactions, thereby reducing the need for intervention at the infant's pre-verbal stage.

Conclusion: This presentation will place the Small Talk package in the context of early intervention practises and the Newborn Hearing Screening Programme in the UK. It will provide an overview of the DVD and booklet resource and evaluate the impact of the nationwide training days that have taken place at most of the paediatric cochlear implant programmes throughout the UK.

Z10 – P7

Case study of a patient with partial insertion of the MED-EL Pulsar CI100 standard electrode array

A Scott, C Polite, LR Lustig

University of California San Francisco, United States

Objectives: To evaluate outcomes in an adult, post-lingually deafened patient with a MED-EL Pulsar CI100 Standard Electrode Array.

Methods: Case study of a single patient using observational, audiometric, programming and subjective patient report data. Program parameters, audiometric thresholds, speech perception outcomes, subjective feedback on cochlear implant benefit in cochlear implant only and bimodal (Cochlear implant in implanted ear and hearing aid in contralateral ear) conditions.

Results: Intraoperatively the patient had a severely ossified cochlea and only a partial insertion could be achieved. Post-operative imaging revealed three intracochlear electrodes. One month post-operative cochlear implant thresholds were within the speech range from 250 Hz to 6000 Hz recorded in the sound field. Speech Detection Threshold (SDT) was 30 dB HL and consistent with pure tone thresholds. Early Speech Perception (ESP) test, low verbal version, results showed gross pattern perception (i.e. consistent identification of monosyllable vs. trochee words). Data will be collected at regular intervals through six months post-cochlear implant activation and presented in this paper.

Conclusions: Patient receives limited benefit in the cochlear implant only listening condition as a result of the limited number of usable electrodes after one month of device use. Testing over time may reveal if patient has bimodal benefit.

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Z10 –P8

Cochlear implantation in severe traumatic brain injured patient

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Objectives: To report clinical experiences with multichannel cochlear implantation(CI) in severe brain damage patient by traffic accident.

Methods: Multichannel CI was performed in a 33 year old man who sustained sensorineural deafness in both ears and left hemiplegia with bilateral transverse temporal bone fractures and severe right frontotemporal lobe damage, which resulted from a traffic accident 7 years ago. Left ear deafness and left hemiplegia had developed with the accident, and he experienced the hearing loss in right ear 4 years later. CI was done on his right ear.

Results: CT scan of the temporal bones showed bilateral transverse temporal bone fractures and cranioplasty on right temporoparietal area, and MRI revealed extensive cystic encephalomalacia in right cerebral hemisphere. We selected the right ear for CI because the right cochlear function was remained after accident. At surgery, fibrous band and fracture line was seen on the right tympanic cavity, which caused by previous temporal bone fracture. Cochleostomy was per-

formed by drilling and we inserted the Nucleus® CI 24M electrode without difficulty. Perioperative NRT were well recorded and postoperative temporal bone X-ray revealed well positioned electrodes.

Conclusions: This case present that CI is a good auditory management in the patients who suffer bilateral profound deafness with severe brain damage, but appropriate preoperative evaluations are required.

Z10 – P9

Curious about sound after years of silence

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Objectives: To explore objective and subjective outcome measures for a non ideal cochlear implant candidate. The candidate became profoundly deaf pre lingually, but communicated orally and presented for cochlear implant assessment aged 57 years.

Methods: A retrospective case study looking at measures of speech understanding of sentences with lip reading (CUNY sentences) and quality of life changes will be presented.

Results: The patient wears his implant consistently. He greatly enjoys having an increased awareness of his environment, which has improved over time. At five years post implant he scored 40 % on an environmental sounds test pre implant score of 0 %. He is more able to control the volume of his voice and is also quieter when he goes about his daily activities with his cochlear implant. He socialises more with his hearing family than he did pre implant and now attends musical concerts and enjoys the sound he hears. He has not noticed any improvement in his ability to understand speech. However testing on the CUNY sentences indicate that some progress has been achieved. At one and five years post implant he scored 23 % and 38 % respectively.

Conclusions: If a similar candidate presented today for a cochlear implant we would be unlikely to consider them due to the duration of profound hearing loss. However, the above results suggest that it is not appropriate to refuse someone a cochlear implant on the basis of their case history alone, as benefit can be gained.

Z10 – P10

Newborn hearing screening in Belgrade

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Prevalence of sensorineural hearing loss is 1–3 per 1000 newborns. Transient evoked otoacoustic emission (TEOAE) and automated auditory brain stem responses (AABR) are most frequently used methods in newborn hearing screening programs.

The aim of this study was to examine hearing function in newborns with and without risk factor for hearing loss. We were investigated accuracy and feasibility of two automated technologies: transient otoacoustic emissions (TEOAE) and auditory brain stem response (AABR) in early detection of hearing loss. Also we want to give our contribution to implementation of universal newborn hearing screening in our surroundings.

In prospective study, 907 newborns were tested on both ears with transient evoked otoacoustic emissions (TEOAE) using Echo-Screen Fischer-Zoth. If results were “refer” we were performed automated brain stem response (AABR). Two stage screening protocol were used, with two screening technologies (TEOAE, AABR).

Results showed that first screening pass 86,30 % of the newborns and 99,34 % the second. 0,66 % of newborns had pozitiv screening results for hearing loss. They were referred for additional audolologic tests (OAE, timpanometry, and ABR) for confirming or excluding hearing loss. Audiologic examination was performed up to third month of life. We confirmed unilateral sensorineural hearing loss in two babies. Average test time per ear was 27,21 s for TEOAE and 135,25 s for AABR.

We believe that TEOAE, AABR tests are confidential, noninvasive, and feasible methods and can help to detect hearing impairment.

Z10 – P11

From NHS to CI – dilemmas and pitfalls

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Objectives: There is no doubt about necessity of NHS in spite of it’s limitations. This program is closely linked with CI and it is expected from it to facilitate early implantation. Problem of acquired and/or progressive hearing impairment remain the subject of additional follow up afterwards. Retro cochlear deafness cannot be detected by TOAE screening which involves AABR in screening program. The aim that we have today is to make NHS efficient, higly sensitive and reliable. When you ones implement NHS you face additional problems and questions. How to stimulate parents for retesting of hearing? Is it final medical interpretation of screening results concerning hearing impairment enough to explain how serious problem is? Is it acceptable and realistic age dynamics in detection of hearing impairment and CI time which is set as a standard now?

Methods: NHS in Clinic centre Banja Luka exists from year 2004 with coverage of more than 95 % in the region. We used two-stage method by protocol. Analysis of results of more than 3000 newborns were presented.

Results: We presented total number of children who failed screening procedure. There is a number of children who faild to pass clinica audiological assessment. Also we presented average age of children for CI.

Conclusions: Total number of children with profound congenital hearing loss fit with average of other countries. There is a substantial number of children who fail to perform retest and final clinical assessment. Medical conclusion from screening results often is not enough to persuade parents they have hearing impaired child.

Z10 – O12

10 years cochlear implantation in Croatia

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Objective: Cochlear implantation started in Croatia in June 1996, in our ENT department. Cochlear implants (CI) are hearing devices that compensate for damaged or non-functional parts of the inner ear. They are effective for patients whose cochlear structures are damaged (diseases, congenital problems, trauma, or other causes), but whose auditory nerves remain intact. Early implantation with CI can provide significant advantages in speech and language development. Evidence indicates that implantation at the age of 12 months, combined with intensive post-implantation therapy, clearly helps children develop necessary speech, language, and developmental skills. This advantage can not be overestimated in its long term effects, including significantly improved performance in school and social comfort with peers.

Methods: We performed successfully 233 cochlear implantations by a mastoid and facial recess approach.

Results: 233 CI in the past 10 years were implanted. Most of the patients (125) were in the age 1–5 years. 56 were in the age 6–10 years, and 30 in the age 11–18 years. Other were implanted at age above 18 years.

Conclusions: Cochlear implantation requires medical, audiological and psychological evaluation. Over the years, inclusion and exclusion criteria have gradually changed with growing knowledge. However, the earlier the implantation, the better the result, especially in prelingually deaf individuals. Adequate rehabilitation is most crucial for the children to maximize the benefits of cochlear implantation. Although cochlear implants do not restore normal hearing, they can provide a sense of sound, give some auditory understanding of the environment, and help patients to understand speech.

Z10 – O13

Development of cochlear implantation in Lithuania

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More than 69 CI implantations were performed in Lithuania during the last 6 years. 69 of the subjects provided with CI are children. The majority of the implanted children (61) are in the age between 1 and 6 years.

Methods: 56 implanted children in the age between 1 and 7 years. Listening abilities of the children were obtained before the implantation, during the first fitting of CI and 3, 6, 12 and 24 months after the implantation. The measuring was performed according to the Nottingham listening progress test (LiP). We evaluated the quality of life of all the families of the CI users. The special detailed questionnaire for parents of deaf and hearing impaired children has been used for this purpose. The questionnaire consisted of 85 structured items. The parent were asked to give a grade between 1 and 10 regarding the expected improvement of the listening and speaking abilities of their children (VAS).

Results: The evaluation of the LiP test results shows clear tendency of improving capabilities of implanted children to percept their acoustical environment and to understand speech. Every child is different and every parent has his own experiences and opinions. The same tendentions can be found in the results of the studies, which will be presented. The grade of parents expectations fulfilling are above 5 in nearly all the cases. This score depends on the interval after the implantation and is increasing with every year.

Z10 – O14

Cochlear implant in ENT department Timisoara

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Objectives: A cochlear implant is an electronic device designed to help severely to profoundly deaf individuals who gain little or no benefit from hearing aids. This paper reviews the patient's selection criteria and the therapeutically possibilities of patients with sensorineural hearing loss, from January 2003 – December 2005. In our ENT Department, between January 2003 and December 2005, a number of 24 cochlear implants have been operated, 2 cases were postlingual hearing losses, and the rest were prelingual hearing losses, 23 MedEl, 14 Combi 40+ and 9 PULSARci 100 and 1 Nucleus 24 K.

Methods: Between January 2003-December 2005, 24 patients (between 12 months and 25 years old) were implanted in ENT Department Timisoara. Two cases were postlingual hearing losses, and 22 were prelingual hearing losses. It's recommended that the period of hearing loss should not exceed more than 1/3 of patient's age in cases of postlingual hearing losses.

Results: There were no intra or postoperative complications: facial nerve palsy, meningitis or flap necrosis. In one case identification of the cochlear canal was not possible, in spite of normal aspect at CT scan; controlateral ear was implanted with success. Sooner the cochlear implantation is performed better the benefits are. After the age of 6 years the benefits are minimal.

Conclusions: Cochlear implant represents a modern therapeutically method for severely to profoundly deaf individuals who gain little or no benefit from hearing aids. In Romania there is a National Program regarding cochlear implantation. ENT Department, University of Timisoara, became Cochlear Implantation National Centre from January 2003.

Z10 – O15

Outcomes in patients with Med El cochlear implant in Iasi, Romania

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The Romanian national cochlear implant programme has been started in 2002. In our clinic the first cochlear implant was made in 2000.

We implanted in the last two years 6 patients with MedEl devices (3 children in the national programme and 3 privat patients), each of them having different performances. Everyone started from different conditions and expectations.

The age of the patients was between 3 and 35 years old and the onset of the hearing loss was as well prelingualy and postlingualy (sudden and progressive deafness). There are 3 patients implanted with Pulsar CI 100 and 3 with Combi 40+, five of them wear TEMPO+ processor and one CIS PRO+. We have had no medical or surgical complications. We analyse the outcomes for these patients in correlation with the THR, MCL values and the ART results in evolution and, on the other hand, with the free field audiograms and speech therapeut evaluations. All of our patients profit from their implants having the expected results.

Z10 – P16

Assessment of the cochlear implanted children

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Objectives: After the CI surgery, the most difficult step is the speech rehabilitation, involving a considerable effort from the speech therapist but also from the patients' family, who must learn together with the patient in order to continue the rehabilitation exercises at home. We had monitories their evolution in the first 2 years following the surgery.

Methods: We used the Teentrax test provided by MED-EL to a group of school age children, prelingual hearing impaired, implanted in the last 2 years, digital hearing aided in the early childhood, and who begin to learn to speech before the age of 3 years.

This test consists in reading a text in a determinate time. After that we calculate the percentage of the correct recognized words in order to establish a score.

Results: The initial values weren't too good, but the score increase during the study and the patients' evolution was satisfactory. Our study is only at the beginning but we hope that in the future the results will be comparative with the literature.

Conclusions: A child implanted after the age of 6–8 years has lower chances to recover comparing to children implanted at the age of 2 or 4 but their evolution makes us to believe that cochlear implant was a the only real chance for them.

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Z10 – P17

Cochlear implantation in Armenia: first steps

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Objectives: This study is designed to present the Armenian cochlear implant project and the results of the first cochlear implant surgeries in Armenia.

Methods: The Armenian Cochlear Implants project was established in 2003 in collaboration with UCLA, USA. In March 2004 on the basis of Medical Center "EREBOUNI" for the first time in Armenia 3 CI surgeries were held. Currently 13 operations were held. 11 patients were prelingual deaf children (at 1,5–4,5 age) and 2 patients – postlingual deaf (at 19 and 21 age). Etiology, duration of deafness, preoperative evaluation, patient selection parameters, surgical findings, postoperative audiological and speech therapy rehabilitation works and development of hearing in patients who were implanted will be presented.

Results: Immediately after switching-on the speech processors the reactions on sorrounding voices noticed. Post implantation, all patients had hearing and speech rehabilitation. Hearing level was 25–35 dB for all implanted patients. Currently patients are completely comprehending and understanding the conversation with them. They already use speech as a communication means. In postlingual adults the results demonstrate a significant improvement in speech understanding on sentences and monosyllables, a clear benefit in localization.

Conclusions: Cochlear implantation in patients with bilateral deafness is decisive method at rehabilitation as it helps them to develop verbal language and normal audition. Cochlear Implant made a difference in the life of the patients and their families. A deposit of effective cochlear implantation is early detection and diagnosis of the hearing loss. It's extremely important to begin the universal hearing screening program in Armenia.

Z10 – P18

Overview of cochlear implantation in India – challenges and solutions for the developing world

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Cochlear Implantation in India has undergone several challenges & tribulations. Unlike most countries the entire cost of the device & surgery is borne by the patient. Added to this is the difficulty posed by a multicultural, multilingual society where there are 22 official languages & over 200 dialects. Another problem unique to India is the long distances, the patient has to travel to reach his CI clinic. Despite these challenges, Implantation is increasing exponentially in India. This paper looks at these various issues and offers solutions. The "Indian model" can serve as an useful model for many developing countries.

Z10 – P19

Cochlear implantation in a developing country

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Objectives: Develop an adult and pediatric cochlear implant program in a developing country with assistance from an established cochlear implant program.

Methods: A full time Otolaryngology missionary in a third world African country was identified who had already established a program to dispense solar powered hearing aids and identify patients with hearing loss. Through the internet-based teleconferencing program, WebEx, audiology technicians in the developing country received instruction familiarizing them with software and hardware needed for cochlear implant programming. The in country Otolaryngologist and his staff selected potential patients. Two patients underwent cochlear implantation during an initial trip in August 2005. One patient was programmed in November 2005 while being closely observed via WebEx from the US. A second trip is planned for March 2006 at which time two additional patients will be implanted. Surgeons in the developing country are being educated about cochlear implant surgical techniques in the temporal bone laboratory and will perform the surgery in March 2006.

Results: Multiple technical obstacles needed to be overcome to allow internet linkage via satellite connection in the developing country. Initial surgical attempts were complicated by power outages, drill failure, microscope failure and infections. The second cochlear implant patient required explantation due to persistent Pseudomonal infection. The initial cochlear implant patient has had her implant programmed and finds the device extremely beneficial.

Conclusions: Establishment of a cochlear implant program in a third world country is possible with significant corporate and clinical support. Significant and often unexpected difficulties should be anticipated during this process.

Z10 – P20

Remote programming and support of cochlear implantation via internet connectivity

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Objectives: Develop and support an adult and pediatric cochlear implant program via internet connection.

Methods: WebEx, an internet teleconferencing system, was used to educate physicians, audiology technicians and support personnel about cochlear implants, cochlear implant programming and the associated hardware and software in a developing African country. WebEx, in addition to teleconferencing, allows either remote control of a computer via the internet or observation of the computer remotely while maintaining audio and visual contact. Initial stimulation of a Med-El Combi 40+ cochlear implant was performed via internet connection with significant support from Audiologists in the US. Troubleshooting of problems encountered in the programming process took place through the internet connection. Subsequent follow-up was also accomplished via the internet connection. WebEx allows either remote control of a computer via the internet or observation of the computer remotely.

Results: Significant technical problems were encountered in establishing a WebEx linkage between the US and the developing African hospital. These problems were thought to be due to the satellite internet connection at the African hospital. With persistence and technical assistance, these problems were overcome. In the end, successful initial stimulation of the cochlear implant and subsequent follow-up were accomplished.

Conclusions: Remote programming and support of cochlear implants via internet connection with WebEx is possible. This connectivity greatly extends the potential for cochlear implantation around the world.

Z10 – O21

Experience on medical supports to multiple cochlear implantation centers

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Objective: To find out an effective working mode on cochlear implantation in China which should meet the fast growing needs of cochlear implantation in China, decrease the differences in experiences and technical conditions and ensure the qualities and safeties.

Methods: This paper reviewed the author's experience on medical supports to multiple cochlear implantation centers between December 1997 and August 2005. 25 hospitals, 14 public or private rehabilitation centers and 434 children CI users with severe to profound deafness were included in this study.

Results: After 0.5–7.5 years of technical training, support and cooperation, all the 25 hospitals could perform the pre-operational evaluations and select the candidates properly according to the criteria of pre-operational audiological evaluations and radiological evaluations. 434 children with severe to profound deafness (435 ears) were successfully implanted with CI in primary surgeries. Implant malfunctions were found in 3 cases in 0.5–3.5 years after first implantation and revision surgeries were all succeed. No complications were found in the other 431 patients. 309 patients had accepted hearing and speech rehabilitations in local rehabilitation center for 0.3–5.0 years respectively. 125 patients accepted family rehabilitations. All 434 patients' hearing and speech performance were improved in different degrees.

Conclusion: With regular guidance and technical supports, the new cochlear implantation centers could avoid the problems caused by lack of experiences and technic skills which might impact the safety and effectiveness of the cochlear implantation. This working mode ensures cochlear implantation could perform in many hospitals with little expe-

rience and encourage the steady progress of cochlear implantation in China.

Z10 – P22

A review of service delivery at south of England cochlear implant centre 1990–2005

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Objectives: To review service development to meet the needs of the changing patient population at the South of England Cochlear Implant Centre (SOECIC).

Methods: SOECIC provides a regional service for severely and profoundly deaf adults and children in the Southern region of the United Kingdom and Channel Islands. Established in 1990 over 300 patients have received cochlear implants. Situated within the Institute of Sound and Vibration Research (ISVR) at the University of Southampton SOECIC benefits from being part of a high quality research establishment.

Results: In 1990 SOECIC's provision was for profoundly post-lingually deafened adults. The team consisted of a surgeon, a radiologist, a hearing therapist, audiological scientists and clerical support. During the first two years 7 patients were implanted with the Nucleus 22 device.

In 2005 the centre implanted 11 adults and 26 children. 8 of the children were under the age of 2. The team has expanded to 25 members with the addition of speech and language therapists, teachers of the deaf, paediatricians and a deaf advocate. Services for ophthalmology and genetic counseling are available where appropriate.

Conclusions: SOECIC has developed to meet the challenges of a changing population. It supports cochlear implantees with Advanced Bionics, Med-EL, Cochlear and Ineraid devices. We promote binaural hearing by use of bimodal or bilateral devices. We offer a post-meningitic fast track service including bilateral simultaneous cochlear implantation.

The team is about to move into new purpose built accommodation with state of the art audiological test facilities, rehabilitation and seminar rooms.

Z10 – P23

Cochlear implant in Thailand

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Objectives: To make known the current situation of Cochlear Implant in Thailand.

Methods: 1. Study how Thailand are involved in Program Prevention of Hearing Impairment & Deafness. 2. Study the rehabilitative approach for severe Sensory-Neural hearing loss in Thailand and how Cochlear Implant is implemented. 3. Study the way the Cochlear Implant being implemented – in different Centers. 4. How Cochlear Implant can be implemented efficiently in Thailand.

Results: Thailand has been the far front country in the region on program for 'Prevention of Hearing Impairment and Deafness' particularly the service at Neuro-oto-audiology Unit at ENT Dept. Siriraj Hopsital. The Bangkok Center has played the leading role in the setting up Program for hearing evaluation and hearing aids services at the National level by 'The Sirinthorn National Rehabilitation Center for Disable Persons' since 1991. The hearing aids were free even for mild bilateral hearing loss in children and for moderately severe hearing loss in adult. Anyhow, the service has limitation in profound hearing loss. Although we are aware of Cochlear Implants but it was not considered cost effective for low country budget. Until now 100 CI were operated in Thailand.

We now try to make CI program available at the National level particularly for this year to celebrate our King Bhumiphol 60 years accession on Throne. We hope at least 100 more CI will be implemented this year and will help make known the availability of the devices to help the Deaf not to be deaf.

Z10 – P24

Small incision technique for Med-El Combi 40+ implantation

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Objectives: 1) To present a technique for implanting the Med-El Combi 40+ using a small incision with minimal access. 2) To describe the short term post surgical outcomes in these patients.

Methods: Two patients (1 child and 1 adult) underwent a novel small incision technique for implantation of the Med-El Combi 40+ cochlear implant device. The short term outcomes in these two patients will be described and compared with previous experience using the standard implantation technique citing advantages and possible limitations. As these two patients had bilateral implantation utilizing different techniques on the two sides interesting comparisons can be made on the same individuals.

Results: The preliminary experience with a novel small incision technique for the Med-El Combi 40+ implantation shows encouraging results in terms of healing and initial performance of these patients.

Conclusions: This small incision technique may be offered to patients especially to those who wish to have bilateral implantations as this allows a less invasive approach, good cosmetics without sacrificing the safety and performance outcomes at least in the short term as seen in these two cases.

Outcome and Performance (G9)

G9 – O1

Recognition of auditory patterns in cochlear implant users

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Objectives: To establish the performance profile for children using cochlear implant (CI) in tasks of temporal order and sequence.

Methods: the Pitch Pattern Sequence Test (PPS) and Duration Pattern Sequence Test (DPS), at 60 dBNA, were applied in 43 children (28 females and 15 males) aged 7–11 yrs and 5 months, being 26 users of CI Combi® 40+ with the CIS strategy, 5 users of Nucleus® 24K and 12, Nucleus® 24M with the ACE strategy. The average deafness time was 36 months and the average time for CI use, 57 months. The subjects were asked to respond to 60 presented sequences of tones which differentiated in the frequency – high, 1430 Hz and low, 880 Hz, for the PPS test, and in the DPS test, for the duration – long, 500ms and short, 250ms through nonverbal (NV) and verbal (V) responses.

Results: The results showed a significant difference between the CI models. The children, users of CI Combi® 40+, presented a better performance for both tests and response modalities ($p < .0001$), with the results 76 %, 63 %, 45 % and 43 % for the NV PPS, V PPS, NV DPS and V DPS, respectively. For users of Nucleus® 24: 61 %, 46 %, 34 % and 30 % for the NV PPS, V PPS, NV DPS and V DPS, respectively. The multivaried logistic model was utilized.

Conclusion: This study evidenced a better performance for the Combi® 40+ implant, in relation to Nucleus® 24. Further studies which assess the auditory processing by means of PPS and DPS must be carried out, so as to thoroughly examine this issue.

G9 – P2

Continuous improvement in lexical tone perception as the number of channels increased

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Objective: To test our hypothesis that more channels is needed for lexical tonal perception in current cochlear implant.

Methods: A comparative analysis of both in acoustic simulations of cochlear implant (CI) devices and clinical cochlear implant users. Lexical tonal perception tests using 48 monosyllables in Mandarin Chinese were conducted in 32 native Mandarin speakers with normal hearing and 4 cochlear implant users. The performance of tonal perception was compared among the controlled factors, which were total channel number, number of channels allocated to the F0 spectrum. Simulated CI strategy that preserves fine structure was used as a comparison.

Results: The signal processing strategy using 16 channels – which is technically possible with current CI devices – produced better tonal perception than those using 12 or 8 channels. Increasing the number of fundamental channels did not improve tonal perception, and spectral shifts did not change tonal perception. The same results were observed in 4 cochlear implant users.

Conclusions: With reference to English phoneme recognition where performance usually did not improve after 6 or 8 channels, we found out a continuous improvement in lexical tone perception.

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G9 – P3

Behavioural assessment and use of accessories in every day situations

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The clinical routine as well as the technical development of the last years has shown that the hearing success of the cochlear implant users has continuously improved.

The goal of this ongoing survey was to evaluate if cochlear implant users need any accessories in their everyday life at home, at work or in certain social situations.

A group of 14 adult subjects implanted with the HiRes90K or CII implant system with more than six months of implant experience were recruited for the study so far. By the time of the presentation more than 20 subjects will be enrolled. In a single session a questionnaire was presented to the subject to assess different hearing situations like using the telephone or hearing music and which kind of accessories was used. The responses of the questionnaire were compared to objective data of the monosyllabic word test as well as the HSM-sentence test in quiet and in noise.

The first results show that the study participants using a behind the ear processor prefer to hear with the pinna microphone (T-Mic), which compensates for the use of accessories in most situations. Subjects wearing a body worn processor often use induction systems to get a better understanding on the telephone.

As a result of the manifold responses to single questions the evaluation of the whole study group has to be awaited to get a more detailed statement.

G9 – P4

Correlation between speech comprehension and width of spread excitation profiles

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Objectives: To find out if there is a correlation between objectively measured Spread of Excitation using electrically evoked compound action potential (ECAP) of the auditory nerve (Neural Response Telemetry, NRT) and speech comprehension for Nucleus 24 cochlear implant users.

Methods: Postoperative Spread of Excitation profiles were recorded for electrode number 5, 10, 18 in 35 Nucleus 24 users Monosyllabic words identification tests were performed in quiet and in noise.

Results: Clear Spread of Excitation profiles were received on every measured electrode for 28 patients, on 2 electrodes – for two patients, no response was received for four patients.

Conclusions: A correlations between profile width and monosyllabic word identification results for electrode 5 (high frequency region), electrode 10 (middle frequency region) and for electrode 18 (low frequency region) were discussed

Further research is planned to confirm these preliminary results for larger group of patients.

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G9 – P5

Pitch scaling versus spread of excitation in cochlear implant user

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Objectives: To evaluate possible dependence between width of Spread of Excitation and pitch scaling results in Nucleus 24 implant user.

Methods: Postoperative Spread of Excitation profiles recordings were made for electrode number 5, 10, 18 and pitch scaling along the implant electrode was performed for 58 years old female, Nucleus 24M user.

Results: Abnormally wide spread of excitation profiles, especially for electrode 5, accompanied with disturbed pitch estimation around electrode 5 was observed.

Conclusions: A clear dependence between abnormalities in width of Spread of Excitation profile and disturbances in pitch sensation for selected patient was confirmed. Further investigation in bigger group of Nucleus 24 implant users is planned to check if it is a general correlation.

A possible confirmation of mentioned correlation would provide an useful, objective tool to assess pattern of pitch perception evoked by stimulation through electrodes. Electrode related pattern of pitch perception might be important for optimization of number of active electrodes.

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G9 – O6

Spread of excitation function in meningitic and in non-meningitic deaf cochlear implant users

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Objective: This study aimed to describe the spread of excitation functions in post meningitic deaf and non-meningitic deaf patients after cochlear implantation.

Methods: Twelve meningitic subjects with a Nucleus 24 Double array Cochlear implant and twenty non-meningitic subjects with both Nucleus 24k and 24M were evaluated. Neural response telemetry using the NRT 3.1® software was performed intraoperatively in the electrode 10 (or an adjacent one) for the non-meningitic patients and for one basal array and one apical array electrode for the double array cochlear implant patients.

Results: Neural response was present with a much higher incidence in the non-meningitic patients than in the meningitic group. Spread of excitation functions could be recorded in all the electrodes with measurable neural responses in both groups. Spread of excitation functions showed an adequate pattern (sharp) of expected decrease in amplitude in the adjacent masked electrode responses in most of the patients of the non-meningitic deaf patients and a flat pattern in most of the the meningitic patients.

Conclusions: Meningitc patients show poorer selectivity of spectral response in the spread of excitation functions.

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G9 – P7

Demographics of cochlear implantation in the United States

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Objectives: To determine the demographic profile of cochlear implant recipients in the United States and assess how this population has changed over time. Of particular interest was utilization of cochlear implants as a function of age, place of residence, family income, and ethnicity.

Methods: Analysis of the Cochlear Americas registration database which includes recipients' date of implantation, birth date, and state of residence at time of implant. Additional data on family income and child's ethnicity was collected during parent surveys in 2003.

Results: Children age 5 and younger are now the largest single demographic for cochlear implants, comprising over one-fourth of all U. S. surgeries in 2005. Age of implantation for children continues to decline and was 21.5 months in 2005 for children implanted under 3 years. Minority children and those from low and moderate-income families were considerably under-represented. There was variability in pediatric utilization rates across the country. Over half of all individuals who could benefit from cochlear implantation are 65 years or older yet only 24 % of US recipients were in this age group in 2005.

Conclusions: Utilization of cochlear implants increased markedly among young children though not all have equivalent access. Factors that appear to have an impact on whether a child receives a cochlear implant are: family income, ethnicity, education/early intervention environment, and access to a cochlear implant program. Among adults, the rate of growth increased the most among those age 65 or older as candidacy expanded and reimbursement under Medicare increased.

G9 – P8

Evaluation of the Auria+ sound processor

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Objectives: The Auria+ behind-the-ear processor is designed to implement HiRes and HiRes 120, the enhanced version of HiRes sound processing with increased spectral resolution. The purpose of this multicenter investigation is to (1) compare speech recognition with standard HiRes fitted on subjects' own processors and on the Auria+, (2) compare speech recognition with standard HiRes and HiRes 120 on the Auria+, (3) monitor the battery operation time with the Auria+ and (4) obtain user feedback on use, comfort and new features (built-in telecoil and LED functionality).

Methods: Subjects consist of previously implanted adult CII or 90K users. Baseline speech recognition results with standard HiRes are obtained with the subjects' own processors and compared with performance on Auria+ one week later. Subjects are then fit with the HiRes 120 and return after one and three months of use for re-evaluation. In addition, subjects complete questionnaires at each visit about the clarity and quality of sound, music enjoyment, Auria+ comfort, ease of use and satisfaction with features, including battery life. Subjects are asked to state their preferences for the Auria+ or their own processor and for standard HiRes vs. HiRes 120.

Results and Conclusions: Initial results indicate that subjects prefer the Auria+ and HiRes 120. Battery operating time is substantially increased with the Auria+ compared with subjects' own processors (Auria or CII BTE). Subjects report the built-in telecoil is a useful feature in everyday listening situations. Results will be reported from approximately 40 subjects.

G9 – P9

Evaluation of HiRes® 120 in children

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Objectives: To compare benefit from HiRes 120 sound processing (which provides increased spectral resolution) to benefit from conventional HiRes sound processing in children.

Methods: Baseline data are obtained with HiRes in children 3 to 12 years of age who have been implanted with a CII or 90K device. Children then are fit with HiRes 120 and benefit is assessed after one and three months of HiRes 120 experience. Within-subjects comparisons are made between HiRes 120 and HiRes on a test battery that assesses speech perception, speech production, and sound quality. A parent questionnaire also evaluates benefit with both sound processing modes. Following testing at the three-month interval, children are refit with their original HiRes programs.

Results: The study is in progress. The current steering implemented in HiRes 120 offers the potential to perceive multiple and unique pitches which may contribute to improved cochlear implant performance.

Conclusions: It is expected that HiRes 120 will show superior performance in difficult listening tasks and enhanced sound quality and clarity for environmental sounds and music for some children.

G9 – O10

HiRes90K in children

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Objectives: To share the experience gathered in Bordeaux in implantation of young children with the HiRes90K device.

Methods: 25 subjects were studied, all implanted with a HiRes90K device, with a mean age at implantation of 40 months. To appropriately study their performance, they were divided into four groups. Group 1 consists in children implanted before two years old, group 2 consists in children implanted between two and four, group 3 consists in bilaterally implanted children, and group 4 consists in children implanted after four years old. The children were evaluated pre-implant, and every six months after surgery, using age appropriate test material.

Results: Group 1 subjects reach the ability to understand simple instructions without lip-reading on average after twelve months of implant use, whereas acquiring this skill takes more time for group 2. The bilateral group showed very encouraging results. Simultaneous bilateral implantation appeared more appropriate for children than sequential implantation, as acceptation of the second device can be an issue.

Conclusions: Those results reinforce the importance of immediate cochlear implantation after profound deafness diagnosis and sufficient initial auditory rehabilitation. Acquisition of early comprehension skills without lip-reading is possible within one year of device use for children implanted before two years old, which leads to better development of oral language. The future of cochlear implantation lies in implanting very young children (before four years old, ideally before two years old) and increasingly considering simultaneous bilateral implantation.

G9 – P11

Perceptual channels determination in CII and 90K users

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Objectives: Patient results with cochlear implants are linked to many variables, one being number of stimulating channels and consequently number of different pitches. A technique has been developed to create virtual channels between physical contacts by steering current between two physical channels, in order to improve spectral resolution. The aim of the study is: a) to correlate pitch resolution with audiological outcomes and subjective findings; b) to test potential of virtual channels implementation in users programs by combining physical and intermediate channels.

Methods: Study group consisted of 29 post-lingual adult patients implanted with CII and HiRes 90K. Audiological and subjective characteristics will be described. Intermediate channels were measured using research software at three sites: apical, medial and basal. 6 patients received the implemented strategy. Speech Perception Tests were: a) PB bisyllabic words and sentences in quiet; b) PB bisyllabic words and sentences in noise (S/N ratio +10–0), signal front and noise 90° right/left (ipsi and controlateral to CI).

Results: Channels resolution was correlated to cause of deafness: sudden hearing loss and Meniere's disease patients had better results compared to those with progressive hearing loss. Results for *speech perception in quiet* were not correlated with intermediate channel resolution. On the contrary analysis of results for S/N showed a good correlation with channel resolution ability. On average patients with good intermediate channel resolution showed better results at all SNRs and differences were statistically significant.

Conclusions: Results from current steering implementation will be discussed as case reports.

G9 – P12

Benefits of HiRes 120: Multicenter study results

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Objectives: HiRes 120 uses current steering to increase spectral resolution in HiRes sound processing. It is anticipated that HiRes 120 will provide better speech perception in difficult listening conditions and improve the overall quality of sound. This multicenter study is comparing performance with standard HiRes and HiRes 120 on a battery of outcome measures in adult subjects implanted previously with CII or 90K devices. Fifteen cochlear-implant centers in North America are participating in the study.

Methods: Baseline data are obtained with standard HiRes and compared with HiRes 120 results after one and three months of use. Performance is reassessed with HiRes at the three-month visit. Subjects are evaluated on a battery of recorded speech recognition tests presented at 60 dB SPL (monosyllabic words in quiet, sentences in noise at fixed presentation levels, adaptive sentence testing in noise). A computer-based test paradigm is used to assess the quality of sounds on a scale from 1 to 100. Everyday listening benefits are assessed at each visit with a questionnaire.

Results and Conclusions: The study is in progress. Longitudinal results will be available for approximately 30 subjects by the time of the conference. The current steering implemented in HiRes 120 offers the potential to perceive multiple and unique pitches, which may contribute to improved cochlear implant benefit, especially in background noise. Initial findings suggest that some subjects achieve higher speech recognition scores and improved sound quality with HiRes 120. Results will be analyzed to identify variables that predict improved performance with HiRes 120.

G9 – P13

Paediatric high resolution study: 3–36 months use

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Objectives: To evaluate the performance in implanted children using Clarion devices fitted in High Resolution Mode with 3 to 36 months of use.

Methods: The test battery used for the assessment of Speech Perception and Language Development (Italian) is described. Data is collected in relation to age at time of implantation (< 4 yrs and > 5 yrs), time of use and subsets (Erber categories). Study group consisted of 36 children using HiResolution mode, ranging from 11/2–15 yrs of age. A control group was set up consisting of 15 children using Standard Resolution Mode homogeneous for age and time of use.

Results: at 24 months children implanted before 4 yrs of age using HiRes mode showed better results both in recognition and comprehension (Hires mode recognition = 46 %, comprehension = 31 %; Standard Resolution recogni-

tion = 42 %; comprehension = 15 %). Children implanted above 5 yrs showed the same trend (Hires mode recognition = 49 %, comprehension = 61 %; Standard Resolution recognition = 43 %; comprehension = 21 %).

Conclusions: Results acquired to date would seem to show a tendency in HiRes users to reach Comprehension (Speech Perception skills) and Functional level (Language development) more quickly (≤ 12 months) than in the control group (SRM).

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G9 – O14

Patient performance with the Advanced Bionics HiRes 90K with HiFcus Helix electrode

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Objectives: The objectives of the study were to: 1) assess the safety of the HiRes 90K device with the HiFocus perimodiolar (Helix) electrode and 2) compare pre-operative performance using conventional amplification with post-implant performance.

Methods: Participants for this study were selected based on the Helix clinical trial inclusion criteria:

- 18 years of age or older
- Post-lingual onset (> 6 years of age) of severe or profound hearing loss
- Sensorineural hearing loss in both ears with a pure tone average of > 70 dB HL
- < 50 % open-set sentence score (HINT sentences) in the best-aided condition
- English language proficiency

Results: Forty-seven adult patients have been implanted with the Helix electrode at our center since October 2003. Full insertion of the Helix electrode was achieved in 46 patients. The one patient with an incomplete insertion had a structural anomaly of the cochlea identified on the pre-operative CT scan. No post-operative complications occurred. All post-operative X-rays showed perimodiolar positioning of the electrode array. Six-month and 1 year HINT sentence test and CNC word scores are presented.

Conclusions: This study demonstrates that perimodiolar positioning of the Helix electrode array can routinely be achieved without complications. No adverse events were encountered at our center. Patients demonstrated improved open-set speech recognition both in quiet and in noise after implantation.

G9 – P15

Two measures of high frequency consonant production

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Objectives: To develop a simple measure of evaluating production of high frequency consonants by children and adults with normal hearing or cochlear implants.

Methods: The adult measure requires speakers to record two passages. One passage includes a large number of high frequency consonants, while the other contains only voiced consonants. Measures of Long-Term-Average-Spectra (LTAS) were obtained for each speaker's reading of the two passages. The child's measure consisted of a simple rhyme presenting the target consonants in [ci] words. The LTAS for each consonant was measured and compared.

Results: Adult results showed that there were large differences in the LTAS measures for the two passages for normal-hearing speakers, but results were far more variable for speakers with cochlear implants. The children's results indicated that some of the children with cochlear implants, unlike those with normal hearing, were unable to produce a reliable contrast between the sibilants [s] and [sh]. Production difficulties were also noted for the affricates [dz] and [ch]. Duration cues were also found to be important in differentiating between the voiced and voiceless affricates.

Conclusions: The ramification of these results for children and adults with cochlear implants will be discussed in detail. The need to consider access to cues for modelling and feedback with children will also be discussed. Suggestions will be made for further research in this area.

G9 – P16

Outcomes in speech recognition and production, phonology and memory

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Objectives: Speech recognition measures have traditionally been used to assess the benefits of cochlear implantation in children. The underlying assumption is that access to auditory information will translate to improved oral communication skills. This study examined the relationship between speech perception abilities, speech production, phonological processing, and auditory memory in children with cochlear implants.

Methods: Participants included 20 individuals with two or more years of cochlear implant experience who were enrolled in oral rehabilitation programs. Age at implantation ranged from 1 to 15 years and participants were age 6 or older at assessment. Open-set word (PBK) and sentence (HINT-C) scores were extracted from the clinical charts for analysis. Cross-sectional assessment protocol included speech production using the Goldman Fristoe Test of Articulation and phonological processing and auditory memory with the Compre-

hensive Test of Phonological Processing and the Wechsler Intelligence Scale for Children-IV.

Results: Speech perception abilities ranged from open-set word scores of 20 % to 92 %. Relationships between speech perception, speech production, phonological processing and auditory memory will be reported.

Conclusions: The results of this study provide a profile of children's speech perception and speech production as well as phonological processing and auditory memory in children and adolescents with implant experience of up to 9 years. The relationship between these skills and auditory capacity has implications for rehabilitation.

G9 – P17

Speech recognition tests in noisy circumstances

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Everyday communication doesn't occur in a "sterile" environment, it is disturbed by many factors, such as noise, surrounding us. A hearing aid – and such a cochlear implant as well – must be programmed and fitted in a different manner when to be used in noisy or in a quiescent environment. That is why the control of speech understanding so important is.

The authors performed speech recognition tests on 15 cochlear implant users under different background noise conditions. The tests covered number, word, and sentence recognition tests.

The results showed that with intensifying background noise speech understanding worsened, still most of our cochlear implant users performed well in these circumstances. When fitting the speech processor, the primary goal should not be to reach the best pure tone threshold level, since it worsens the cochlear users' speech understanding performance in a noisy environment.

G9 – P18

Impaired hearing and nasalance

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Objectives: Information about influencing factors on the nasalance in the literature is very inconsistent. There are no exact objective nasalance measurements of patients with inner ear hearing losses or deafness in German-speaking countries.

Methods: The nasalance of 126 test persons with normal hearing, 28 carriers of a hearing aid and 26 individuals with a cochlear implant was examined with different test materials using the nasometer of Kay Elemetrics.

Results: Test persons with a hearing aid or a cochlear implant have a significantly higher nasalance. The nasalance increases as the hearing loss gets worse. The nasalance of prelingually deaf persons is higher than that of postlingually deaf persons. Vowels and sentences without nasal sounds are pronounced through the nose more significantly. Type and quality of the hearing aid and the cochlear implant, the time the cochlear implant has been used by the patient and the strategy of speech processing all have an effect on the nasalance. Persons with cochlear implant MED EL with CIS-strategy and ESPrit 3 G with ACE-strategy have a higher nasalance of 4–5 %, with cochlear implants ESPrit 22 and ESPrit 24 with SPEAK-strategy a higher nasalance of more than 10 %. The nasalance of persons with a cochlear imlant was 2 % (13 %, 6 %) higher after 1 year (1–5 years, more than 5 years).

Conclusions: The study shows that audition is an important influencing factor. Individuals with a hearing loss use a higher nasalance when speaking for a better perception of their own voices.

G9 – P19

Enhancing Chinese tone recognition in cochlear implantees

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Objectives: Tone recognition is important for speech understanding in tonal languages such as Mandarin Chinese. Cochlear implant patients are able to perceive some tonal information by using temporal cues such as periodicity-related amplitude fluctuations and similarities between the fundamental frequency (*F*0) contour and the amplitude envelope. The present study is to investigate whether modifying the amplitude envelope to better resemble the *F*0 contour can improve tone recognition in cochlear implantees.

Methods: Chinese tone recognition was measured in sixteen Mandarin-speaking cochlear implantees with and without amplitude envelope enhancement. In this study, amplitude envelope enhancement was achieved by adjusting the overall amplitude envelope to increase the similarities between the amplitude envelope and F0 contour before cochlear implant speech processing.

Results: The results showed that the algorithm significantly improved Chinese tone recognition in cochlear implantees.

Conclusions: The results suggested that modifying the amplitude envelope to more closely resemble the *F*0 contour may be a useful approach toward improving Mandarin-speaking cochlear implant patients' tone recognition.

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G9 – P20

Memory and cognition: Critical variables in implant benefit

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Objectives: To assess the role of specialized cognitive abilities and associative memory in the long-term benefit of implantation, and to determine whether long-term implant use and aging affect indices of cognitive function.

Methods: Long-term speech recognition scores (203 consecutively implanted monaural subjects; 25 consecutively implanted binaural subjects) were correlated with tests of the ability to process rapidly changing sequential information, and working memory. A subsample (N = 62) was repeatedly tested (2–11 year intervals) with the cognitive measures to determine whether performance changed as a function of age and implant use.

Results: Cognitive measures predicted long-term speech recognition scores in multichannel cochlear implants in a manner that replicates earlier work (Knutson et al., 1991). No significant change in performance in cognitive function was detected in the implanted sample.

Conclusions: Specialized cognitive abilities and associative memory continue to be important factors in implant benefit. Because these predictors are unaffected by implant use, the methods can be used in ongoing studies of implant users who were not tested prior to implantation, and they might serve a useful function in research on the development of new processor strategies.

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G9 – P21

Bimodal hearing: cochlear implant and hearing aid in opposite ears

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Objectives: This study documented the effects of wearing a cochlear implant in one ear and a well fit digital hearing aid in the opposite (non-implanted) ear (bimodal hearing).

Methods: Nineteen adult (ages 27–79) Cochlear Nucleus 24 implant recipients participated. All subjects were fit with a Widex Vita 38 hearing aid. Soundfield thresholds, aided loudness growth, localized speech recognition, localization of speech stimuli, and subjective questionnaires were obtained. Subjects were tested with the hearing aid monaurally (HA), cochlear implant monaurally (CI), and cochlear implant plus hearing aid binaurally (CI+HA) and then retested approximately one month later.

Results: All measures had a high test-retest reliability. Localization tasks utilized speech stimuli (CNC words) presented from speakers spaced at 10° intervals from +70° to –70°. Speech recognition and localization testing showed a significant effect for listening condition. The bimodal condition was significantly better for both speech recognition and localization than the two monaural conditions. The CI condition was also significantly better than the HA condition. CI+HA soundfield thresholds showed binaural summation in the low to mid frequencies compared to the monaural conditions. CI+HA loudness growth showed binaural summation up to "very loud" judgment. Speech Sound Qualities questionnaire responses correlated with speech recognition and localization testing. Audibility of sound with the hearing aid (i.e., hearing thresholds, aided soundfield thresholds, Speech Intelligibility Index) was a significant predictor of localization and speech recognition abilities.

Conclusions: These findings suggest a well fit digital HA can provide improvement in speech recognition and localization abilities for CI users.

G9 – O22

Benefits of bimodal stimulation for adult cochlear implant users

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Objectives: Patients with residual hearing who undergo cochlear implantation may experience benefit from use of a hearing aid in the non-implanted ear. However, clinical practice guidelines for identifying and fitting adults who may benefit from bimodal stimulation are limited. Consequently, clinical practice appears to vary. The objectives of this study are to: 1) examine patient characteristics associated with hearing aid use after implantation, and 2) examine the benefits of using a hearing aid in the non-implanted ear from patients' perspectives.

Methods: Participants were identified through a retrospective chart review of all patients implanted at one center in Canada. The relationship between various patient characteristics (in particular, pre-implant auditory thresholds and duration of deafness) and the decision to use a hearing aid will be examined. A questionnaire will be administered to evaluate how adult implant patients use bimodal hearing in everyday situations (e. g. frequency, daily activities). The questionnaire will also evaluate perceived communication benefits.

Results: Approximately 15 % of the 200 implanted patients use a hearing aid post-implant. The relationship between patient characteristics and hearing aid use will be presented. Results from the patient questionnaire will be compiled to describe participants' perceptions of benefits from bimodal stimulation.

Conclusions: Expanded candidacy criteria have resulted in the cochlear implantation of more adults with useable residual hearing. Patients may perceive a range of benefits that are not identified with traditional clinical outcome measures. An understanding of the various aspects of contralateral hearing aid use can contribute to clinical practice guidelines and patient counseling.

G9 – P23

Formulation of language structures in a bilingual setting

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In every therapy situation, parents and professionals are always faced with the choice of which language to use in teaching the child with hearing impairment. Most often, the choice is based on either 1) the language most comfortably used by the majority of the household or 2) medium of instruction used in the school system. In a bilingual setting, what influences the development of language structures of cochlear-implanted children undergoing Auditory-Verbal Therapy? This presentation focuses on the probable factors that influence the development of language structures of Filipino cochlear-implanted children undergoing Auditory-Verbal Therapy at CLASP AV Center Manila as it relates to the general stages of early bilingual development. Specifically, the main outcome parameters for determining language structures will focus on the following: Mean Length of Utterance (MLU), sentence structure and complexity. Discussion arising from this presentation may lead both parents and professionals to re-think the methods used in teaching language to children with hearing impairment. Is it time for a paradigm shift?

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G9 – O24

Two years experience with the MED EL Flexsoft® electrode in Vienna

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In january 2004 the worldwide first Flex^{soft} electrode connected with the Med El Combi 40+ cochlear implant system was implanted in Vienna. The Flex^{soft} electrode array is designed for easy and atraumatic deep insertion. Therefore the front end of the Flex^{soft} has been optimized. The aim of this new electrode array is to preserve apical parts of the cochlear structures as well as residual hearing even in the high frequencies despite deep insertion.

Until now 55 patients were implanted with the Flex^{soft} electrode connected with the Med El Combi 40+ / Pulsar CI 100 cochlear implant system. Speech perception outcomes were assessed using Freiburger number and monosyllable tests and sentences in quiet and noise. Preservation of residual hearing was controlled using pure tone audiogram pre- and postoperative. Subjective benefit was assessed using the Nijmegen Cochlear Implant Questionnaire (Hinderink et al, 2000).

The Flex^{soft} electrode is easy to insert into the scala tympani and the softness of the array accommodates minimally invasive surgery such as suprameatal approach. Insertion depth from the edge of cochleostomy ranged from 30 mm up to 33 mm. One month up to one and a half year data will be presented.

The very thin (0.2 × 0.2 at the tip) Flex^{soft} electrode is designed to preserve cochlear structures by requiring low insertion force. Preservation is most important when considering implantation in young children. The paediatric population rely on intact cochlear structures for the rest of their life during electric hearing.

G9 – P25

Results for different groups of cochlear implanted patients

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Objectives: The aim of this study is to demonstrate the audiological and linguistic results of different groups of cochlear implanted people.

Methods: The number of the examined patients is 76 (68 patients with Medel implants and 8 patients with Cochlear implants) and they are divided into several groups – age of implantation: multiple handicap, status and cause of deafness.

Conclusions: 1. These data indicate a significant advantage in language learning, when CI is undertaken bellow the age of three years.

2. The results by deaf born patients between 14 and 18 years, who had a very good rehabilitation before the operation, are very promising in audiological and linguistic aspect. 3. This study suggests that significant benefit can be obtained with the use of hearing aids in the nonoperated ear in combination with CI. 4. The children with multiple handicap achieve progress only in audiological aspect, but there is no linguistic improvement.

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Performance and Outcome (G10)

G10 – P1

Bimodal studies using adaptive dynamic range optimization (ADRO) technology

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Objectives: Adaptive dynamic range optimization (ADRO) is a preprocessing scheme that continuously adjusts the gain in each frequency band to optimize the signal in the output dynamic range. The aim of this study was to demonstrate the clinical benefits available to people with severe-to-profound hearing loss of using an ADRO hearing aid in one ear and an ADRO cochlear implant in the other.

Methods: Subjects were eight who already had been using the SPRINT processor and hearing aid. To control for learning effects, an ABAB design was adopted. In the evaluation session, the subjects assessed in two bimodal conditions: (a) ADRO hearing aid and cochlear implant together, (b) Non-ADRO hearing aid and cochlear implant together. During the acclimatization period, the subjects have been encouraged to use both the ADRO and non-ADRO combinations. The protocol took approximately seven weeks for each subject.

The Hearing in Noise Test sentences in Japanese were used for the speech perception evaluations. And two questionnaires were used to assess listener's preference for the ADRO devices compared the non-ADRO devices.

Results and Conclusions: The result of ADRO and non ADRO were compared. There was a significant difference in the result of a statistical analysis, especially between the result of speech from the front with noise from the HA side and speech from the front with noise from the CI side. The result of questionnaires indicated most of users prefer the combination of ADRO than non-ADRO

G10 – P2

The effect of depth of insertion of cochlear implant electrodes on speech understanding

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Objectives: Electrode arrays in Cochlear implants, depending on the state of the cochlear can be inserted partially (22 to 30 mm) into the cochlea, which results in a frequency mismatch between electrodes and nerve fibres. In 15 patients implanted with a CII Bionic Ear and 28 patients implanted with a Hires90K with a normal cochlea, electrode insertion depths were measured and compared with speech discrimination scores after rehabilitation.

Methods: A Modified Stenvers View of the temporal bone of each patient was taken post operatively on a DSA machine. The number of intracochlear electrodes of the HiFocus I were counted and the length of insertion of the electrodes was determined by adding up the distances between electrodes. All patients were mapped with Hires strategy and consonant, vowel and sentence recognition tests were carried out after 1 week and 4 weeks of rehabilitation.

Results: The speech perception and speech production average scores attained were higher in patients with a insertions of 25 mm or more and lower in patients who had insertion depths of 20 to 24 mm.

Conclusions: Because of the co existing conditions that also affect a patients performance, it was difficult to isolate the effects of insertion depth alone. However after matching as many parameters as possible it would appear from this study that deeper insertion of electrodes produces better hearing.

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G10 – P3

Benefits of deep electrode insertion in postlingually deafened CI users – a prospective long-term study

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The aim of this prospective study was to evaluate long-term benefits of chronic electrical stimulation of apical (low frequency) regions in the cochlea on speech perception, by using different channel arrangements.

Ten newly implanted subjects with a MED-EL cochlear implant and a fully inserted (>30 mm) standard electrode participated in the study. Four different electrode configurations had been defined for the 12-electrode array: A) 8 most apical electrodes only, B) 8 most basal electrodes only, C) 8 electrodes spread across the whole array, D) full 12 electrodes. The study followed an ABCABC+D crossover design with one month familiarization for each condition, after an initial 3–months period. Starting conditions were randomized across patients and conditions. A, B, and C were repeated during the trial in order to compensate for learning effects. D was tested as final condition.

Tests included Freiburger monosyllables, vowels, consonants, and HSM sentences in quiet and noise. Additionally, a pitch ranking test was performed at each visit.

Results indicate that a limitation of the stimulated region within the cochlea has a detrimental effect on subject performance. Performance with condition "apical 8" was significantly worse than with the three other conditions. "Basal 8" and "spread 8" resulted in about equal performance. However, best performance was achieved with the activation of all 12 channels across the whole array.

Outcomes of this chronic study suggest that cochlear implant recipients may benefit from stimulation over the entire length of the cochlea, including the apical region, as achieved by deep electrode insertion.

G10 – P4

Speech perception of children using Combi-40 / Combi-40+ devices implanted at a very young age

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For years children had to be older than two years of age to be a candidate for cochlear implantation, but in the last years there is a wide agreement to lower the age for implantation. The encouragement for this tendency is to provide children with access to auditory stimulation as early as possible, thereby taking advantage of crucial periods for speech and language development.

In our centre 75 children were implanted at an age younger than 4 years, 23 younger than two years. In our poster we present a 4-year follow-up of the further development of the children implanted at an age younger than 2 years. The acceptance of the cochlear implant was without exception very good. The initial device programming took place approximately 4 weeks after surgery. Follow-up visits were held in regular and if necessary individual intervals. All children received extensive postoperative training. Auditory perception and speech development were documented based on observations reported by parents and therapists and standardised tests.

4 years after speech processor activation every single child has reached a different step of development, but they all reduced the gap to normal hearing children.

In our poster we focus on speech tests 4 years after implantation, we demonstrate that profoundly deaf children who receive a cochlear implant at a very young age can develop auditory skills that allow them to interact affectively by verbal communication.

G10 – O5

Speech discrimination with the MED-EL Medium cochlear implant electrode

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Objectives: To evaluate speech perception in subjects implanted with a shortened cochlear implant electrode, which provides less stimulation in the basal turn.

Study Design: Retrospective chart review.

Setting: Tertiary care referral center.

Methods: Medical, surgical, and audiological data were collected from 5 adult subjects who received a MED-EL Combi 40+ cochlear implant with a M-electrode array. This electrode was initially designed for EAS implantations. Thus, it features 12 electrode contacts that are slightly compressed when compared to the standard array. Data on these 5 subjects were compared to a matched cohort of regularly implant patients.

Results: Surgically, all electrodes were completely inserted until the marker ring (31.5 mm in both groups). Average radiological insertion depths for subjects with the C40+ M electrode confirmed full insertions. Speech perception results showed essentially equal performance outcomes for both groups.

Discussion: Electrical stimulation with the compressed electrode array resulted in similar speech discrimination results as compared to regular cochlear implantations with a traditional electrode array. Thus, contact distribution distance, as well as lesser basal stimulation did not show any effect in this study.

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G10 – O6

The Würzburg experience with new cochlear implant technology

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Objectives: Recent technological advances in cochlear implant design have provided the cochlear implant centre with a wider choice for their patients. This paper will provide an overview of the Würzburg clinical experience, with switching from the COMBI 40+ implant to the $PULSAR_{CI}^{100}$.

Methods: A retrospective analysis of subject data will be conducted. Surgical issues will be reviewed, speech audiometry discussed and the use of ART will be evaluated.

Results: Results demonstrate no surgical difficulties with changes from the COMBI 40+ implant to the $PULSAR_{CI}^{100}$ cochlear implant. Speech perception scores show that subjects do benefit from the new implant technology. The Auditory Nerve Response Telemetry (ART) turned out to be a powerful tool for research, biological and medical assessment, intraoperatively as well as post-operatively. Interestingly, the patients who could compare the COMBI 40 + and the $PULSAR_{CI}^{100}$ could hear the difference.

Conclusions: Recent technological developments have enhanced the opportunities for the patient seeking a cochlear implant. Changes in implant, electronics and electrode design can be noticed by the users and, in the case of $PULSAR_{CI}^{100}$ technology, provides users with significant benefits.

G10 – O7

Cochlear implantation in patients with Otosclerosis, clinical and audiometric aspects

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Objectives: The retrospective assessment of patients with otosclerosis provided with a cochlear implant in multicentre study.

Methods: Fifty-three patients with otosclerosis from four cochlear implant centres in the United Kingdom and the Netherlands were reviewed. All data concerning imaging, intra-operative findings and performance outcome were studied. Based on the speech perception scores, the patients were classified as poor or good performers.

Results: The CT scans demonstrated retrofenestral lesions in the majority of the patients. The extent of otosclerotic lesions on the CT scan, categorized in 3 types, tends to be greater in patients with rapidly progressive hearing loss, patients with problematic insertion of the electrode array and patients with FNS. There was a relatively high number of partial insertions and misplacements of the electrode array demanding revision surgery. Thirty-eight percent (20 of 53) of patients experienced FNS at various periods postoperatively. There was wide variability in the speech perception results. The poor and good performers did not differ in age at onset of hearing loss, duration of hearing loss, progression, age at onset of deafness, or duration of deafness.

Conclusions: Cochlear implant surgery in patients with otosclerosis can be challenging. A high proportion of patients experienced FNS mainly caused by the distal electrodes. Better performance was related to less severe otosclerosis on CT scan, full insertion of the electrode array, little or no FNS and little or no need to switch off electrodes. This must be discussed with patients preoperatively.

G10 – O8

Otosclerosis: Which ear to implant?

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Objectives: To determine whether the best speech perception is achieved by implanting the longer, or the shorter, deafened ear in patients with otosclerosis.

Methods: Fifty-nine adult patients with otosclerosis participated in this study. Correlation and multiple regression analyses were used to determine whether the speech perception (CNC phonemes and words, and CUNY sentences, 3, 6 and 12 months after cochlear implantation) was affected by the duration of bilateral deafness, the duration of deafness in the implanted ear or the patient's age.

Results: The duration of bilateral deafness was short (< 10 years for most patients) and did not influence speech perception. The age at implantation had a small but significant negative effect upon speech perception at 3 months post-implantation, but not at longer observation periods. The duration of deafness in the implanted ear had a significant negative effect upon speech perception, for and not beyond the first three months, and even after the effects of age were removed.

Conclusions: Whether the longer- or the shorter- deafened ear is implanted has no long-term effect upon speech perception. Other criteria should guide the surgeon's choice of ear for implantation, such the preservation of the patient's natural hearing, which usually means implanting the longer-deafened ear. However, when the longer-deafened ear is implanted the patient may take more time to reach their hearing potential.

G10 – O9

Cochlear reimplantation

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Objectives: Whilst re-implantation is sometimes necessary it is potentially very distressing. In order to develop a strategy for dealing with such situations we analysed all our cases of re-implantation and ascertained the views of patients and parents.

Methods: Retrospective case note review and patient / parent questionnaire for 32 patients (case load over 330) in whom re-implantation has been necessary.

Results: Device failure accounted for the majority of cases (73 %), with trauma (13 %) and medical complications (9 %) accounting for most of the others. The 'mode of failure' was variable and in some cases gradual making diagnosis potentially difficult. Surgery was carried out successfully in all cases and no patients showed any deterioration in performance following re-implantation. No patients considered not proceeding with the surgery but many felt that they had not been adequately warned of the risk of re-implantation (despite this being a routine part of the pre-operative consultation in all cases).

Conclusions: Re-implantation has significant implications on both a personal and financial level. Patients and parents vary in their reaction to a failure and they appreciate clear information being given from the onset. Detecting failure is not always straightforward and unnecessary delays may occur. It requires early access to the implant team and is greatly facilitated by the manufacturers' support. Our experience has led us to develop guidelines to ensure a consistent and supportive approach to both patients and family. In addition the small but real risk of failure is now emphasised more clearly to both patients/parents and related healthcare workers during the pre-operative discussions.

G10 – O10

Cochlear implantation in the early deafened population

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Objectives: Duke University has an N = 12early deafened (under the age of 6) adults implanted with the Med-El Combi + and Pulsar system that show extraordinary scores on HINT sentences at one month and three month post initial stimulation. This population used to be our poorer performers and now with the Med-El device we are seeing results almost equivalent to post lingual deafened adults. This N = 12 represents 100 % of the early deafened Med-El adult population at this center.

Methods: Every adult patient that receives a Med-El Combi + standard array or a Pulsar standard array is included in the study. HINT sentences are administered pre-operatively and at one month and three month post stimulation. The testing is completed in double-walled sound suite using a compact disc recording of the HINT sentences in sound field.

Results: Based on old data on the earlier study the mean post stimulation score at one or three month was 62 % using sentence material at 50 dB HL.

Conclusions: As the early deafened Med-El population grows at this center then the numbers speak to improved performance using this device for this specific population. The author wants to explore the reason for the small percentage that did not do well and delve more into the amplification history on this population.

Reference

Justus (2004) Turick poster presented at Indianapolis 2004 CI meeting

G10 – O11

Cochlear implantation in the elderly – short and long term experience

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Background: The improvement in performance of the cochlear implantation's technology has opend a wider field of patients – the elderly. Meanwhile cochlear implantation in the elderly has become an accepted method for the treatment of deaf patients. It is a guiding principle to perform cochlear implantation if the patient has a residual speech understanding of 30–40 % or less (german monosyllabic word test @ 70 dB). Anyway it is still difficult to predict how older patients will benefit with a cochlear implant. The indication for implantation has to be proofed individually for each patient. After cochlear implantation in most studies an improvement of the quality of life of the elderly is reported. The social isolation is reduced and the patients are able to take a part in the normal life.

Patients and Methods: 105 patients over 65 years were tested within the regular postoperative fitting sessions using the Freiburger speech test for monosyllabic words and the HSM sentence test with and without background noise. The results were compared to those of a younger reference collective with cochlear implants.

Results: It has been shown that the elderly have a real good benefit after cochlear implantation. Senior patients reached nearly similar speech perception as younger patients. They had no problems handing the high tech cochlear implants.

Conclusions: Senior patients benefited to the same extent as younger patients by cochlear implantation. The elderly gained a similar speech understanding level as younger implanted patients although the elderly reached high levels of speech understanding soon after fitting, but they needed more time to reach similar final test scores. Improvements were seen upto five years post fitting. A special rehabilitation program was not necessary.

G10 – O12

Performance of elderly cochlear implant recipients

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Objective: Our center has extensive experience with cochlear implantation in elderly patients. The objective of the study was to determine in adults with acquired hearing loss, if patient age ≥ 70 years impairs performance after cochlear implantation.

Methods: A retrospective review was performed to identify those cochlear implant recipients ≥ age 70 years. Post-implant open-set speech perception measures were analyzed for this study. The open-set word measures consisted of the Hearing in Noise Test (HINT) administered in quiet and in noise (+10 dB SN) and the CNC word test. An exploratory analysis of the following subgroups was also performed:

1.age ≥ 75 years
2.70 ≤ age < 75 years
3.65 ≤ age < 70 years
4.age < 65 years

Results: Patients 70 years of age or older at the time of implantation do not have clinically inferior audiological performance 6 months after cochlear implantation compared to younger recipients. Six-month and 1 year HINT sentence test and CNC word scores are presented. No post-operative complications occurred.

Conclusions: This study demonstrates that cochlear implantation should be considered in healthy patients 70 years of age or older.

G10 – P13

Cochlear implant supply in respect of the elderly

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The supply of deaf and severe hearing impaired patients with a cochlear implant (CI) allows elderly people to come out of social isolation and participate in everyday life again.

At the University of Kiel, Germany, between 1988 and November 2005 there were 243 patients treated with a CI. Twenty-one deaf or severe hearing impaired patients received a CI at the implantation-age of 60–70. Six were implanted at an age of over 70. The evaluation was carried out with the Kiel CI-Profile for adults. The results have been compared with a control group at the age of 30–40.

All patients scored 100 % in the four-syllable number test at 70 dB with the CI one year after implantation. The patients at the age of 60–70 reached on an average 71 % in the Freiburger monosyllabic word test at 70 dB, whereas the patients aged over 70 got 74 %. The speech comprehension for the Oldenburger sentence test in quiet at 70 dB was on average 86 % at the age of 60–70 and 79 % aged over 70. The control group had a score of 73 % in the Freiburger monosyllabic word test and 86 % for the Oldenburger sentence test in quiet at 70 dB.

In conclusion, this paper shows that rehabilitation with a CI is a clear benefit even in elderly patients suffering from deafness or profound hearing loss. Bearing in mind the increasing life expectancy, the supply with a CI should not be refused for deaf or severe hearing impaired patients of advanced age.

G10 – O14

Management and outcomes of meningitic hearing loss

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Objectives: To evaluate the patient pathway and outcome after cochlear implantation for profound deafness due to meningitis.

Methods: Prospective review of 49 patients with meningitic hearing loss who underwent cochlear implantation. Information regarding causal organism, operative details and audiological assessments was collated from our clinical database. Quality of life for adults & categories of auditory performance (CAP) for children were assessed.

Results: The age range was 18 months to 66 years. Four patients were implanted bilaterally. The most common causal organism was pneumococcus (28.5 %). All acute referrals were fast tracked, however in most cases the assessment process and time to surgery took up to 7 months. At surgery only a minority showed ossification; with the cochlea basal turn being partially patent in 22.4 % and totally obliterated in 14.3 %. Those with full insertion generally did well and those with ossified cochlea had variable outcomes. The auditory performance was related to the number of functioning electrodes confirming the importance of having a variety of electrode arrays available in case of difficult insertion. CAP scores reached 7 in 38.8 % children and more than 4 in 72.2 %. All the adult patients were using the implant for more than 8 hours and 77.8 % were very satisfied with the device.

Conclusions: Cochlear implantation after meningitis can be technically difficult but improves the overall quality of life for the patients. Cochlear ossification effects overall outcome. All meningitic patients should be fast tracked and implanted as early as is possible in view of the problems associated with ossification.

G10 – O15

Cochlear implantation in patients with postmeningitis deafness

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Objective: Deafness after meningitis is caused by two mechanisms: Immediate neurotoxic inner ear damage and late cochlear ossification. Surgical treatment and Postoperative hearing performance depend on these factors.

Methods: Twelve children and 4 adults (among 410 total series) suffering from postmeningitis deafness were evaluated according to age, preoperative imaging (CT, MRI), operative findings and postoperative speech perception results.

Hearing results were compared to those obtained in the whole group of implanted patients.

Results: CT findings demonstrated cochlear ossification in 2 children; Drill out procedure was required in one additional adult patient. Hearing and speech perception results were found to be related to background factors such as age of implantation, mode of communication, developmental and cognitive status, similar to the entire sample of implanted patients. Best results with very good open-set word recognition were achieved in the group of young aged children implanted. Children with severe developmental and cognitive disorders demonstrated detection of sound only. Results in the adult group were inferior to children and inversely correlated with the lag of time between meningitis and surgery. One adult patient required progressively higher stimulation levels and wider pulse width over time.

Conclusions: Postmeningitis deafened patients with or without ossified cochlea may achieve significant benefit from cochlear implantation. Hearing results are similar to the results in the whole group.

G10 – O16

Cochlear implants in post meningitis children

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Objectives: Establish if total ossification of the cochlea due to meningitis can represent an impediment for the development of speech recognition abilities in prelingual children comparing with other children that suffered the illness, but having normal cochleas. To establish the differences of information processing in these children. To establish the necessity of later specific treatments.

Out of a population of 500 children that received a C. I., a sample of 68 children post meningitis was taken.

The development of speech recognition abilities was evaluated at 36 months of C. I. use The neurolinguistic levels eval-

uated were: semantic lexical, grammar, phonologic, memory, perceptive functions and lecto-writing.

Results: The children with ossified cochleas displayed neurolinguistic handicaps that included: difficulty in the resolution of visual operations, inadequate inhibition, labil attention, disruptive conduct, difficulties in understanding instructions, upheavals of memory , echolalia and difficulty for the lecto-writing. The evolution was slower , not acceding to Open Set. They attend special schooling, with support of specific therapy of language together with the auditory one.

Conclusions: The presence of total ossification and partial insertion was always accompanied by different degrees of difficulty in the processing of speech sounds, requiring special schooling and specific treatment of language. The development of abilities of speech perception was slower.

G10 – P17

Long term results of cochlear implantation in postlingually deaf patients with totally ossified cochlea

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The ossified cochlea, although rare, represents a challenge for cochlear implantation. This report is a retrospective study of 5 postlingually deaf patients. (Three women and two men) with total ossification of cochlea. All of them were deafened due to bacterial meningitis. The duration of deafness spanned between 2 and 19 years (Mean: 10.8 years) and the age at implantation ranged from 22 to 39 years (Mean: 29.2 years). We report long-term follow-up results of these patients who have been implanted from 1997 to 2000. Two of the patients received COMBI 40+ GB (split array); one of them received COMBI 40+S (compressed array) and one patient received standard array combi40+.Results indicated that the open-set spondee words recognition score, 4–8 years after CI activation ranged from 0 % to 55 %. Two cases are non-users, two are partially users and one patient uses the device all time.

G10 – P18

Deformities of the inner ear and the internal auditory canal

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Since high resolution computed tomography of the temporal bones and occasionally magnetic resonance imaging are used in the evaluation of cochlear implant candidates with hereditary hearing loss, several inner ear and internal auditory canal malformations have been observed, that cannot be classified as Mondini dysplasias. Thus, a new classification of inner ear deformities is necessary, based on arrested or altered of inner ear embryogenesis. In over 1200 examined children cochlear implant candidates we found 88 cases of various temporal bone malformations not necessarily included in previous classifications but with impact in cochlear implant surgery or outcome. Cochlear implant is contraindicated on some of these deformities, on others electrode insertion might be a challenge and in some cases poorer auditory performance with the cochlear implant may occur.

G10 – O19

Impact of cochlear implantation on voice development of congenitally deaf children

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In this study, the effects of cochlear implantation on voice development in prelingually deaf children is investigated.

60 prelingually deaf children was involved in this study. Children were divided into two groups, those that are younger or older than 48 months. Children were also divided into two groups, those that had been using the cochlear implant for more or less than 18 months. As a control group, 47 children who have a normal speech and language development were selected. In all cases, the F0, F1 and F2 values of the vowel /a/ was studied.

In the patient group, while statistically significant differences between the first and second voice analysis were found in the F0 and F2 values, the change in F1 values were insignificant. In children older than 48 months , a statistically significant difference was found in the F0 and F1 values. Though statistically insignificant, children that had been using the cochlear implant for more than 18 months have the F0, F1 and F2 values that are close to the normal levels.

Our study confirms that the sooner a cochlear implantation is performed, the more effective the development of voice speech and language will be. Furthermore, the length of time using the cochlear implant is important for this development.

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