Introduction. The loss of inner ear hair cells leads to incurable balance and hearing disorders because these sensory cells do not effectively regenerate in humans. A potential starting point for therapy would be the stimulation of quiescent progenitor cells within the damaged inner ear. Inner ear progenitor/stem cells, which have been described in rodent inner ears, would be primary candidates for such an approach. Despite the identification of progenitor cell populations in the human fetal cochlea and in the adult human spiral ganglion, no proliferative cell populations with the capacity to generate hair cells have been reported in vestibular and cochlear tissues of adult humans. Objectives. The present study aimed at filling this gap by isolating sphere-forming progenitor cells from surgery-derived and autopsy-derived adult human temporal bones in order to generate inner ear cell types in vitro. Abortion-fetus-derived inner ear cochlear tissues served as controls. Results. Sphere-forming and mitogen-responding progenitor cells were isolated from adult vestibular and cochlear tissues. Clonal spheres grown from adult human utricle and cochlear duct were propagated for a limited number of generations. When differentiated in absence of mitogens, the utricle-derived spheres robustly gave rise to hair cell-like cells, as well as to cells expressing supporting cell-, neuron-, and glial markers, indicating that the adult human utricle harbors multipotent progenitor cells. Spheres derived from the adult human cochlear duct did not give rise to hair cell-like or neuronal cell types, which is an indication that human cochlear cells have limited proliferative and differentiation potential. Spheres from the fetal human cochlea, however, gave rise to various inner ear cell types in culture. Conclusion. By combining surgical, autopsy-derived and fetal human source tissues, different human inner ear cell types could be generated in vitro. These cells are now available for further experimentation, drug- and device interaction testing.

Learning Objective: Define features of progenitor cells and stem cells
Email: pascal.senn@insel.ch

Background/PurposeWe have investigated the role of insulin like growth factor-1 (IGF-1) in cochlear hair cell protection. We found that IGF-1 protects mammalian cochlear hair cells from noise exposure or from ischemic stress. Based on these results clinical trial was conducted to treat idiopathic sudden sensorineural hearing loss cases that did not respond to steroid treatment and 56% of patients showed hearing improvement. To establish more effective protocols of IGF-1 therapy for sensorineural hearing loss we tried to elucidate the mechanisms of cochlear hair cell protection by IGF-1.MethodsCochlear explant culture was established from neonatal mice inner ears. We used neomycin as a method of hair cell impairment that was protected by IGF-1 in the explant culture system. To clarify the downstream signal pathways involved in cochlear hair cell protection by IGF-1, we added various inhibitors including PI3K-Akt, MAPK, and PKC inhibitors. We also identified the location of phospho-Akt and phospho-ERK signals that indicated activation of PI3K-Akt and MAPK signals, respectively, to check which cells were affected by which signals. To elucidate the cellular mechanisms involved in IGF-1 action, we checked apoptosis and cell proliferation status after IGF-1 treatment. Results The inhibitors of all three cascades cancelled the action of IGF-1, indicating IGF-1 treatment could activate several kinds of downstream signal pathways to protect cochlear hair cells. With IGF-1 treatment, inner hair cells and Hensens’ and Claudius’ cells were positive for phospho-Akt and phospho-ERK, respectively. Surprisingly both decrease of apoptotic hair cells and proliferation of Hensen’s cells and Claudius’ cells were observed when explant culture with neomycin was treated with IGF-1. Conclusion The results indicated that IGF-1 activated several downstream cascades and, as a result, it promoted proliferation of supporting cells and inhibited apoptosis of cochlea hair cells in neonatal mice.

Learning Objective: Describe which cascades are activated in the cochlea by IGF-1 to protect hair cells.
Email: yamamoto@ent.kuhp.kyoto-u.ac.jp
**Presentation 27**

**Topic:** Basic Science II

**Title:** Pharmacological in vitro and in vivo prevention of cochlear fibrosis in rat: An experimental study

**Author(s):** Frederic Venail, Huan Jia, Florence Francois, Jing Wang, Jean Luc Puel

**Presenter:** Frederic Venail

**Abstract:**

To develop in vitro and in vivo animal models to evaluate the effect and the safety of pharmacological approaches to reduce cochlear fibrosis.

**Study Design:**

We used in vitro models of neonatal rat cochlear slices and cochlear explant to assess the effect on fibrotic proliferation and the toxicity of dexamethasone (DXM) and aracytine (Ara-c). Then we developed in vivo models of KLH immune labyrinthitis and foreign body reaction induced cochlear fibrosis. We evaluated the effect of DXM and Ara-c on cochlear fibrosis development and auditory thresholds changes using osmotic cochlear minipumps.

**Results:**

Both drugs reduced fibrosis in vitro in a dose-dependent manner. However, the efficiency of Ara-c was higher than DXM at a similar level of ototoxicity (16% of cellular loss with DXM vs 9% with Ara-C reaching a 85% reduction of fibrosis tissue proliferation). In vivo, 10 µM Ara-C significantly reduced the fibrotic scar to 39.0 +/- 23.9 % versus 58.6 +/- 8.3% with 100 µM DXM and 77.2 +/- 16.5 in control cochleas (p<0.01). Low frequencies hearing preservation was higher with Ara-C compared to DXM. In deaf animal, electrical stimulation required to elicit electrical ABR was lower than in control animals (p<0.05).

**Conclusion:**

The use of in vitro models can predict the in vivo effect of antifibrotic drugs. This allows a quick screening of candidate drugs. Antimitotic drug Ara-C is more efficient and less toxic than dexamethasone to prevent cochlear fibrosis in rat.

**Learning Objective:**

Identify the inflammatory processes the cochlea

**Email:** frederic.venail@inserm.fr

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**Presentation 28**

**Topic:** Basic Science II

**Title:** Morphological changes of the peripheral processes of spiral ganglion cells after intracochlear application of brain-derived neurotrophic factor in deafened guinea pigs

**Author(s):** Sjaak Klis, Laurien Waaijer, Ties Van Deurzen, Dyan Ramekers, Wilko Grolman

**Presenter:** Sjaak Klis

**Abstract:**

**Objective:** To characterize effects of deafening and subsequent treatment with brain-derived neurotrophic factor (BDNF) on the peripheral processes (PPs) of spiral ganglion cells in guinea pigs. BDNF may prevent degeneration of neural structures after loss of hair cells, with possible relevance for cochlear implant candidates.

**Methods:**

Guinea pigs were deafened with antibiotics. Two weeks after deafening, intracochlear BDNF-treatment was started with osmotic pumps. After cessation of BDNF-treatment the cochleae were prepared for analysis. PPs were counted and morphologically characterized with respect to myelinisation, size and shape.

**Results:**

Deafening dramatically reduced the number of PPs. BDNF-treatment significantly reduced this degenerative effect of deafening. The remaining processes showed an altered morphology; compared to the normal hearing the size in deafened untreated animals was reduced and was increased in BDNF-treated animals. The myelin sheath appeared reduced in size in BDNF-treated animals.

**Conclusion:**

Deafening evokes degeneration of peripheral processes. BDNF-treatment not only reduces this degeneration but also induces morphological alterations in the processes. The physiological consequences of these alterations remain to be determined.

**References:**


**Learning Objective:**

Recognize peripheral processes of spiral ganglion cells degenerate in deafened guinea pigs

**Email:** s.klis@umcutrecht.nl
Recognize the potential role of impedance measures to help guide electrode insertion.

Continuous impedance measurement to guide intracochlear electrode insertion

This study describes the development and evaluation of a software tool that uses continuous impedance measurement during electrode insertion, as a way to assess and optimize electrode position and reduce insertional trauma. Preserving and using residual hearing after cochlear implantation is of increasing interest and may lead to enhanced performance. Thus, minimizing insertion trauma and obtaining precise electrode placement consistently is very important in current candidates for cochlear implantation, whose hearing loss may be in the moderate and severe ranges. Preserving residual hearing is particularly important to enhance outcomes in the case of “hybrid” cochlear implants. However, other than fluoroscopy, real time feedback about the geometry and mechanics of electrode insertion to the surgeon is not available. Fortunately, all CIs incorporate electrode impedance measurements and therefore we propose a new approach that will provide surgeons information about electrode location with respect to the cochlear structures during insertion. The use of this information in the operating theatre may change the way CI surgeries are performed and enhance surgical capabilities. These electrode impedance measures are primarily intended to verify electrode integrity when the patient’s speech processor is programmed by audiologists. We propose to use the electrode impedance measurement functionality for a completely different purpose: to measure and display in real time how close the electrodes are to the cochlear walls during surgery, thereby allowing manipulations and steering in a real time fashion. A prototype program to measure intracochlear electrode impedance and display it graphically in real time has been developed. The software was evaluated in human cadaveric temporal bones and in two live surgeries during intracochlelar electrode insertion. Electrode position was evaluated with real time fluoroscopic analysis. It was found that impedance values were systematically affected by electrode position, with higher values being associated with proximity to the cochlear wall.
Objective: Some limitations of cochlear implants can be attributed to a restricted spectral representation of sound provided by contemporary electrode arrays. Microfabricated high-density un-backed thin film array (TFA) technology enables a greater density of stimulating sites and thus a more complete spectral representation. These TFAs can fit within the limited diameter of the scala tympani but lack the structural rigidity to attain adequate insertion depth. A promising alternative is to integrate such arrays with an insertion platform (IP) mechanically similar to a cochlear array. Method: Commercially fabricated polyimide substrate thin film arrays (21 platinum sites, 180 microns diameter, 250 micron spacing) were integrated with 1 of 2 IPs: 1) a silicon-based insertion electrode (IE) and 2) a previously evaluated, relatively stiffer wire-core insertion test device (ITD). The IP-TFAs were molded together in a pre-curved position using sandwiching layers of silicone adhesive applied with a digitally controlled dispensing system. IP-TFAs were inserted into a 3D plexiglass model of the human cochlea to validate structural integrity, and then into human cadaveric temporal bones. Results: Ten thin film array electrodes (four ITD-TFA, six IE-TFA) were implanted into ten individual temporal bones via the round window. One ITD-TFA and one IE-TFA experienced tip-delamination at the initial stage of insertion. Pre-curving IP-TFAs increased the insertion difficulty, likely contributing to delamination. As an insertion platform, IEs were easier than ITDs to insert as well as integrate with the TFAs. Conclusion: The IE was shown to be a viable IP candidate. Continued development and refinement of the IP-TFA may provide a higher density cochlear implant electrode to improve language perception.

Learning Objective: Identify current electrodes limit spectral representation of sound transmission.

Email: rsharpe2@gmail.com
Evoked Potentials

Title: An Intraoperative Test of Residual Auditory Nerve Function of Cochlear Implant Recipients Using Auditory Stimuli

Author(s): Omar Awan, Baishakhi Choudhury, Oliver F Adunka, Benjamin P Wei, Craig A Buchman, Margaret T Dillon, Shuman He, Douglas C Fitzpatrick

Presenter: Omar Awan

Abstract: Hypothesis: Acoustically evoked cochlear potentials can be measured from the round window (RW) intraoperatively even in profoundly deaf patients undergoing cochlear implantation. Background: Cochlear implant performance outcomes remain quite varied between patients and different factors predicting or affecting outcome have been postulated. One postulated but difficult to measure factor is auditory nerve survival. We hypothesize that neural survival can be estimated by the degree of auditory responsiveness that remains and that this responsiveness can be measured through RW recordings at the time of surgery. Methods: Patients (6 months – adult) undergoing cochlear implantation were included. The Navigator Pro auditory diagnostic system (Biologic Systems Corp.) was used to measure potentials by placing a facial nerve monitor probe at the RW after surgical access to the RW was obtained. The cochlear microphonic (CM), compound action potential (CAP), and neurophonic potential were recorded to tone bursts at frequencies of 0.25-2 kHz at various levels administered through a sound tube. Results: 20 patients were tested and 18 (90%) had measurable potentials to acoustic stimuli, including those who were audiometrically determined to be profoundly deaf at all frequencies. In general a larger magnitude of response was noted for patients with lower audiometric thresholds but this was not true in all cases.

Conclusions: Acoustically evoked cochlear potentials are detectable in candidates for cochlear implantation even if detectable hearing is limited. These findings indicate that a more sensitive measure of cochlear status could be useful in tailoring interventions for hearing loss. Later studies will correlate the degree of neural survival estimated with clinical outcomes. Supported by funding from NIDCD T32-DC005360

Learning Objective: Describe a new method for estimating auditory nerve survival in cochlear implant recipients.

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Evoked Potentials

Title: Do Cochlear Implant Users Rely on Different Acoustic Structure for Phoneme Perception than Normal-Hearing Adults? A Mismatch Negativity Study

Author(s): Aaron C Moberly, Antoine Shahin, Susan Nittrouer, D. Bradley Welling

Presenter: Aaron C Moberly

Abstract: Objectives: The vocal-tract filter shapes the acoustic speech signal, creating structure in the amplitude, spectral, and temporal domains. Structural weighting varies depending on listener age and language, but spectral structure, like formant transitions, is weighted strongly. Paradoxically, current cochlear implant (CI) strategies preferentially preserve amplitude structure, leading to questions about how CI users recognize speech. This study has 3 objectives: 1) examine the extent to which CI users utilize formant and amplitude structure; 2) relate structural use to word recognition; and 3) evaluate an objective electrophysiologic measure, mismatch negativity (MMN), for assessing speech perception in CI users.

Study Design: Cross-sectional study in a university medical center.


Method: Subjects performed 3 tasks: 1) labeling synthetic speech stimuli varying along two continua in either spectral structure (formant transition duration, FTD) or amplitude structure (onset rise time, ORT); 2) MMN testing for both FTD and ORT; and 3) recognizing words in open set. Data on other predictor variables, such as vocabulary size, was also obtained.

Results: Implant users could be categorized into four groups: 1) those who consistently weighted spectral structure heavily, exhibited MMN for FTD, and showed the best word recognition (84-90%); 2) those who inconsistently weighted spectral and amplitude structure, exhibited variable MMN for FTD and ORT, and showed intermediate word recognition (48-60%); 3) those who consistently weighted only amplitude structure, exhibited MMN for ORT, and showed intermediate word recognition (42-54%); and 4) those who were unable to utilize effectively spectral or amplitude structure, exhibited no MMN, and showed poor word recognition (8-32%).

Conclusions: Ability to discriminate and weight spectral structure, specifically formant structure, appears to explain better word recognition in some CI users. Future CI research will focus on targeting delivery of the structure essential for speech perception.

Learning Objective: Identify the difference between amplitude and spectral structures delivered in the acoustic speech signal.

Email: Aaron.Moberly@osumc.edu
**Presentation 35**

**Topic:** Evoked Potentials  
**Title:** Using Cortical Auditory Evoked Potentials to Assess the Impact of Programming Strategy and Stimulation Mode in Hybrid Cochlear Implant Users  
**Author(s):** Carolyn J. Brown, Eun Kyung Jeon, Paul Abbas, Li-Kuei Chiou, Benjamin Kirby  
**Presenter:** Carolyn J. Brown  
**Abstract:** Objective: The Nucleus Hybrid CI was designed for individuals with residual low frequency acoustic hearing. With this device, low frequency information is transmitted acoustically. High frequency information is transmitted electrically. The goal of this study is to determine whether evoked potentials can be used to determine how best to program the speech processor of the CI to achieve optimal performance or to document benefit from a specific stimulation mode. Study Design: Ten postlingually deafened Nucleus Hybrid CI users participated in this study. Study participants were tested in each of three different stimulation modes (acoustic alone, electric alone and acoustic plus electric) using speech stimuli presented in quiet and noise. Three different experimental programming strategies were tested. Electrophysiologic measures (cortical P1-N1-P2 responses at the onset of the acoustic stimulus as well as acoustic change responses) were recorded using synthetic vowel stimuli as well as musical tones presented in the soundfield. The evoked potential data was analyzed off-line using MatLab and a RM-ANOVA was used to compare response amplitudes and latencies with perceptual measures. Results: This presentation will review both group mean trends as well as individual differences. Statistical analysis showed no significant differences in performance using the three different experimental programming strategies. However, differences in the stimulation mode used (acoustic alone, electric alone or combined acoustic and electric) were observed both in the perceptual and evoked potential measures. These differences varied across individuals. Generally, the evoked potential data tended to parallel the perceptual measures. Conclusions: It is possible to record cortical auditory evoked potentials from Hybrid CI users and correlations between perceptual and electrophysiologic data suggest these measures could be used to facilitate programming or to provide objective evidence of lack of benefit from a given stimulation mode. This research was supported by grants RC1 DC010696 and P50 DC00242 from the NIH-NIDCD.  
**Learning Objective:** Recognize how manipulations in programming strategies used with the Hybrid CI impact performance.  
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**Presentation 36**

**Topic:** Evoked Potentials  
**Title:** Audiological Measurements with Wave Field Synthesis  
**Author(s):** Tobias Weißgerber, Uwe Baumann, Katrin Neumann  
**Presenter:** Tobias Weißgerber  
**Abstract:** In standard clinical setups, the localization abilities and speech perception in quiet or noise of hearing aid (HA) or cochlear implant (CI) recipients are typically assessed with only few loudspeakers. This procedure is oftentimes sufficient for the initial fitting of hearing instruments. However, to evaluate the benefit of advanced signal processing algorithms, a more sophisticated measurement setup is necessary. For this purpose, a Wave Field Synthesis (WFS) system with 128 loudspeakers was realized in an anechoic chamber. This WFS setup simulates very realistic auditory scenarios for testing hearing impaired patients. The speech perception in noise is measured with the Oldenburg Sentence Test for different types and directions of noise (focused noise sources inside the room, moving noise sources, simulated traffic noise, plane waves for diffuse noise, etc.). Localization abilities are assessed with the measurement of minimal audible angles. The WFS loudspeaker panels are supplied with LED chains to indicate the location of the auditory event. In a pilot study, the speech reception threshold SRT (signal-to-noise ratio, where 50% of the words were understood correctly) was measured for 3 different conditions. This contribution introduces the concept of Wave Field Synthesis and presents measurement data of CI recipients in different acoustical environments. Furthermore, the opportunities and limits of WFS for optimizing signal processing and the fitting of CIs will be discussed.  
**Learning Objective:** Assess the physical principle of Wave Field Synthesis.  
**Email:** tobias.weissgerber@kgu.de
**Thursday (1:00 PM - 2:30 PM) Marriott Grand 6 - 10**

**Title:** Obligatory Auditory Evoked Potentials in Cochlear Implants Children with Auditory Neuropathy Spectrum Disorder

**Author(s):** Ayca Ciprut, Ferda Akdas

**Abstract:**

Introduction: Auditory neuropathy spectrum disorder is a hearing disorder characterized by poor speech discrimination disproportionate to the degree of hearing loss, abnormal or absent auditory brainstem response in the presence of normal otoacoustic emissions and cochlear microphonics, absent acoustic reflexes, absent efferent suppression of otoacoustic emissions, absent masking level difference. In this study we aim to explore the differences in obligatory auditory evoked potential measures in patients with auditory neuropathy spectrum disorder with either a conventional evoked potential system or an automated cortical potential system. Study Design: Nine children who were diagnosed as having auditory neuropathy spectrum disorder were included in the study. The age range of all the subjects was 3 to 15 years. The age range at the time of implantation was 20 months to 46 months. P1N1 cortical auditory potentials were measured in these children when their speech processor was on and off position with conventional evoked potential system or an automated cortical potential system. P1 latencies obtained with two measurement systems were compared. Results: All children with ANSD who received a cochlear implant had P1 latency when tested with the speech processor on position. No significant differences were obtained in P1 latencies when the automated and conventional measurement systems were compared. Conclusion: P1 latencies have been successfully recorded in children with ANSD who received cochlear implantation. The objective data obtained through cortical potentials also indicates that cochlear implantation can be an option to overcome auditory neuropathy spectrum disorder and to provide a potentially successful method of habilitation.

**Learning Objective:** Identify that P1N1 latency can be recorded in cochlear implanted patients with auditory neuropathy spectrum disorder.

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**Thursday (1:00 PM - 2:30 PM) Four Seasons Grand Ballroom**

**Title:** A Dexamethasone-Eluting Cochlear Implant Electrode Array Protects Against Electrode Insertion Trauma (EIT)-Induced Elevations in Hearing Thresholds, Hair Cell Loss and Damage to Neural Elements: A Dose Response Study

**Author(s):** Thomas R Van De Water, Esperanza Bas, Christine T Dinh, Chhavi Gupta, Isabel Bueno, Enrique Ramon Perez, Adrien A Eshraghi

**Abstract:**

Objective: Test the efficacy of a drug-eluting cochlear implant electrode to protect hearing and hair cells. Design: Experimental animals were pigmented guinea pigs; hearing thresholds were obtained by recording auditory evoked brainstem responses (ABRs) via a dura contacting screw electrode in response to 0.5-16 kHz pure tone stimuli. Thresholds were determined by a deconvolution program. Electrodes of 4 types: silicone; silicone+10%micronized dexamethasone base (DXMb); silicone+1%DXMb; and silicone+0.1%DXMb were inserted purposefully with moderate trauma to a depth of 5mm into the scala tympani via a cochleostomy. At the end of 3mo. of hearing evaluation cochleae were fixed, organ of Corti whole mounts dissected and stained for the presence of hair cells, nerve fibers and synaptic proteins. Results: Cochleae implanted with silicone electrodes experienced >30 dBSPL increase in ABR thresholds for all frequencies and a significant loss (p <.05) of hair cells from all turns at 3mo. post-electrode insertion trauma (EIT), in contrast the ABR threshold increase at 3 mo. post-EIT in the silicone/10%DXMb electrode ears was <5 dBSPL for all frequencies and the was no significant loss (p >.05) of hair cells from any of the cochlear turns. The 1% and 0.1% silicone electrodes also protected hearing against EIT-induced losses but in a dose dependent manner with initial ABR threshold elevations taking a longer period of time post-EIT to return to base line levels. All groups of animals had similar patterns of an initial elevation of ABR thresholds for all frequencies but only the silicone electrode arrays containing dexamethasone regained normal pre-trauma ABR threshold levels. Conclusion: There was a highly significant level of protection of hearing thresholds against permanent EIT-induced losses in the cochleae receiving the DXMb-eluting electrodes containing 10% and 1% DXMb.

**Learning Objective:** Recognize the concept of delivering otoprotective drugs from a cochlear implant electrode array to conserve residual hearing, protect hair cells and neural elements from trauma induced losses.

**Email:** tvandewater@med.miami.edu
OBJECTIVES: Electrode designers and implant surgeons both desire an in-vivo method of examining electrode array position and trajectory with the goal of evaluating and improving electrode design and insertion. We have previously demonstrated that cone-beam computed tomography (CBCT) coupled with custom 3D visualization software for surgical guidance (“X-Eyes Imaging Platform”, GTx-Techna Institute, University Health Network) has sufficient fidelity to evaluate electrode trajectory and intracochlear position. Our aim is to examine the electrode characteristics associated with the Slim Straight Electrode Array (CI422) (Cochlear Corporation) using both CBCT and histopathology, while comparing 3 insertion techniques (round window (RW), extended RW, cochleostomy).

STUDY DESIGN: Fifteen human temporal bones were implanted with the CI422 (5 RW, 5 extended RW, 5 cochleostomy). Post-insertion, temporal bones were imaged with a prototype CBCT imaging system providing low-dose 3D images (~0.35 mSv) with sub-mm spatial resolution (isotropic 0.2 mm3 voxels). The bones were resin impregnated and sectioned for light microscopy. Dimensional electrode characteristics visible in section images were compared with corresponding images using the X-Eyes software.

RESULTS: The CI422 demonstrated the desired electrode characteristics maintaining a lateral wall position within the scala tympani in all cases irrespective of insertion technique. Minor electrode fluctuations (rippling/kinking) were adequately captured by the imaging techniques. Insertion depth was a function of cochlear anatomy rather than insertion site and all techniques allowed adequate insertion of the active array.

CONCLUSION: The CI422 achieved adequate insertion depth and maintained the desired position within the cochlea irrespective of insertion technique. While histopathology remains the gold standard for evaluating intracochlear electrode position, CBCT imaging with the X-Eyes platform proved to be a valuable tool for assessing electrode trajectory across insertion techniques and the independent measurement of the array’s positional characteristics, while holding the additional advantage of assessing the implanted arrays both intra and post-operatively.

Learning Objective:
Identify the use of the Slim Straight Electrode Array (CI422) utility and its positional and trajectory characteristics within the cochlea.

Email: s.cushing@utoronto.ca
Thursday (1:00 PM - 2:30 PM) Four Seasons Grand Ballroom

Presentation 41

**Topic:** Electrode Design/Function  
**Title:** Distribution of cochlear duct length and electrode choice  
**Author(s):** George Alexiades, Claude Jolly, Helge Rask-Anderson  
**Presenter:** George Alexiades  

**Abstract:** Cochlear size is full adult size at birth. Analysis of adult cochlea duct length (CDL) is directly relevant to children. Two histological studies (n=95) report human cochlea duct length at the Organ of Corti to range from 25 to 35 mm. CDL is defined as the distance from the center of the round window membrane to the helicotrema. Deep insertion electrodes should be capable of insertion up to 2 turns (720 degrees) or less, and avoid the small and fragile apical turn. Based on histology, variation of 2 turns of scala tympani length is between 21 and 31 mm. With discrete electrode lengths of 20, 24, 28 and 31 mm, cochlear coverage up to the apical region and with no contacts outside the cochlea is feasible if no cochlear malformations are present. Pre-operative radiological measurement of 2 turns CDL at the Organ of Corti are necessary to choose the electrode adapted for a specific patient cochlea length without penetrating the apical region. A straightforward method exists to evaluate 2 turn CDL using the dimension ‘A’. A is defined as the length from the center of the round window to the opposite bony lateral wall traversing through the center of the modiolus. The correlation between the A value and 2 turn cochlear duct length is .92 (r2). Evaluation of cochlear duct length is imperative to minimize trauma and maximize benefits with good cochlear coverage.

**Learning Objective:** Estimate cochlear duct length by a single radiologic measurement.

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Presentation 42

**Topic:** Electrode Design/Function  
**Title:** Surgical and radiological results after implantation of the CI422-straight electrode array  
**Author(s):** Antje Aschendorff, Susan Arndt, Thomas Wesarg, Rainer L. Beck, Wolfgang Maier, Roland Laszig  
**Presenter:** Antje Aschendorff  

**Abstract:** Insertion of intracochlear electrode arrays can be performed by a classical cochleostomy, a round-window-membrane insertion or by an extended round-window access. Round-window insertions are advantageous as they allow scala tympani insertions in all cases, whereas cochleostomies result in a scala tympani insertion rate of approx. 90%. Drilling at the round window or insertion through the hook-region may not be atraumatic but an atraumatic insertion is necessary to preserve intracochlear structures and ideally residual hearing. The CI422 electrode array (Cochlear Ltd., Sydney) is a straight slim array that can be inserted either via a cochleostomy or a round-window-membrane approach. Insertion depth can be estimated by two markers, designating an insertion depth of 20 and 25mm. Aim of the study is the evaluation of insertion depth, localization of insertion and electrode position and preservation of residual hearing following insertion of the CI422 straight electrode array. A retrospective analysis of intra- and postoperative results of adult CI422 recipients was performed. Electrode position was evaluated by digital volume tomography. Insertion via the round window membrane could be performed in the majority of adult patients. In all cases the bony overhang of the round window niche had to be removed to improve access to the round window membrane. Preservation of residual hearing is possible, but was not successful in all intended cases. Digital volume tomography revealed intracochlear kinking of the array following an insertion depth of >23mm. Localization and depth of insertion may contribute to the ability to preserve residual hearing. An electrode kinking may be a result of an over-insertion and result in substantial intracochlear damage. An insertion depth of approx. 22mm is favourable to provide less intracocheal trauma. The electrode design with a slimmer diameter but some stiffness allows for an insertion either by cochleostomy or round window according to the individual anatomy.

**Learning Objective:** Assess the possibilities of access to intracochlear insertion

**Email:** antje.aschendorff@uniklinik-freiburg.de
Thursday (1:00 PM - 2:30 PM) Four Seasons Grand Ballroom

Presentation 43

**Topic:** Electrode Design/Function

**Title:** Experiences with the new Med El Flex 28 electrode

**Author(s):** Jeremy Lavy

**Presenter:** Jeremy Lavy

**Abstract:**
The MED-EL FLEX 28 ElectrodeSurgical experiences and early outcomes

**Objectives**
To assess the surgical handling of the new MED-EL FLEX 28 electrode in round window insertion in comparison to the other electrodes available on the market. To look at early outcome data from patients who have received this electrode since November 2011.

**Study Design**
Prospective and ongoing with historical comparison.

**Results**
At time of abstract submission we have inserted 20 FLEX 28 electrodes. The earliest implantees are just being switched on. By May 2012 we should have a cohort of more than 40 implants with both surgical and early outcome data.

**Conclusions**
These can not be drawn at time of submission for reasons outlined above but definitive conclusions should be available by May 2012.

**Learning Objective:**
Recognize the handling characteristics of Flex 28 electrode

**Email:** jeremy.lavy1@virgin.net

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Presentation 44

**Topic:** Electrode Design/Function

**Title:** Atypical Electrode Impedance Patterns and Clinical Outcomes

**Author(s):** Teresa A Zwolan, James Heller, Chris McGreevey

**Presenter:** Teresa A Zwolan

**Abstract:**
Objectives
The purpose of this study is to determine the incidence rate of atypical electrode impedance patterns with Freedom implant recipients and the severity of any performance issues associated with these patterns. A second objective is to determine the incidence rate of open and short circuit electrodes in the same subjects.

**Study Design**
This is a retrospective study of all recipients (n=365) who received a Cochlear CI24RE (Freedom) implant at the University of Michigan, excluding those with cochlear malformations or partial insertions. Impedance records will be objectively screened for open circuits, short circuits, reduced impedance on multiple odd or multiple even numbered electrodes and reduced impedance combined with reduced variability on all electrodes. Subjects will be categorized based on clinical records as: Type 1 – significant symptoms or reduced clinical benefit that cannot be resolved by re-programming, Type 2 – symptoms or reduced clinical benefit that has been resolved by re-programming or Type 3 – performance as expected. For any subjects that have undergone explantation and re-implantation, the results of the laboratory analysis of the explanted device will be included.

**Results**
This is an ongoing study. The overall incidence rate of short circuits, open circuits and the two atypical impedance patterns will be presented. The clinical classification for all subjects with atypical impedance patterns will be presented. For explanted devices, the cause of failure will be included and patient management strategies will be reviewed.

**Conclusions**
A portion of the cochlear implant patient population demonstrates atypical impedance patterns. Most of these recipients perform as expected and require no additional monitoring. A small portion has associated symptoms that can be resolved through re-programming. A very small portion has symptoms that can only be resolved by explantation and re-implantation. Accordingly, patient management options should be based on treatment of symptoms, not solely on the existence of particular impedance patterns.

**Learning Objective:**
Identify normal and atypical impedance patterns and short and open circuits when performing impedance telemetry.

**Email:** zwolan@umich.edu
**Thursday (1:00 PM - 2:30 PM) Marriott Waterview Ballroom**

**Presentation 45**

**Topic:** Bone Conduction and Middle Ear Implantable Devices II

**Title:** Fully Implantable Hearing Device in children: An auditory option of rehabilitation

**Author(s):** Jorge Eduardo Almario Chaparro, Leonardo Elías Ordóñez-Ordóñez, Néstor Ricardo González Marín, Isidro Rodríguez Pinzón, Edgardo Alfonso Granados Osorio, Pablo Rodrigo Restrepo Torres, Arturo Morales Rey, Yamile Jaime Claro, Oscar Felipe Rodríguez Hernández

**Presenter:** Jorge Eduardo Almario Chaparro

**Abstract:**

**Title:** Fully Implantable Hearing Device in children: an auditory option of rehabilitation

**Objective:** to assess preoperative and postoperative audiological and safety outcomes in children with fully implantable hearing device Carina-TM.

**Study Design and Methods:** A Before-and-after study was performed. Children with unilateral or bilateral conductive hearing loss with aural atresia or chronic otitis were included in the study. Repeated-measures within-subjects for assess functional gain and detailed monitoring to establish security or adverse effects were performed. T-test for paired samples was used for statistical analysis.

**Results:** Six subjects were included (mean age = 12.5 ± 2.0), 66.7% (n = 4) were male. The patients were flowed-up at six months and no significant differences were found between preoperative and postoperative air conduction and bone conduction pure tone average (PTA). The mean functional gain was 23.5±6.1dB, significant differences between the unaided PTA (59.5 ± 13.7dB) and aided PTA (36 ± 12.9dB) were found (p = 0.001). No major complications were observed.

**Conclusions:** The safety and audiological results are satisfactory and supports the reliable use of the device in children, we need more studies focused on the evaluation of quality of life to know the benefit about it.

**Key words:** fully implantable hearing device, active middle ear implants, microtia, congenital aural atresia, chronic otitis.

**Learning Objective:** Assess the fully implantable hearing device Carina-TM is reliable in children

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**Thursday (1:00 PM - 2:30 PM) Marriott Waterview Ballroom**

**Presentation 46**

**Topic:** Bone Conduction and Middle Ear Implantable Devices II

**Title:** Intraoperative Monitoring System and Results During Middle Ear Surgery with Med-El Vibrand Soundbridge System

**Author(s):** Marco Perotti

**Presenter:** Marco Perotti

**Abstract:**

**Background:** We assessed an intraoperative electrocochleography during the positioning of a “floating mass transducer” (FMT – Vibrant Med-El Innsbruck – Austria) that could be able to indicate the optimal position of the FMT and the best coupling between the transducer, the inner ear structures (oval and round window in these cases) and inner ear fluids. The evoked potential that we have obtained, formerly named as “MECAP” (Mechanically Evoked Compound Action Potential) could indicate the efficacy and safety of the surgical procedure by the evaluation of the evocation threshold and its relationship with preoperative bone conduction hearing threshold.

**OBJECTIVE:** The aim of the study is the assessment of an intraoperative method to establish the best positioning of FMT with a rapid, efficient and safe electrophysiological test.

**METHODS:** We made a retrospective analysis about intraoperative records of MECAP with a promontorial electrode via FMT in 16 patients that underwent a vibroplasty (13 FMT applied to the round window and 3 to the oval window) for mixed or sensorineural hearing loss. We have compared preoperative bone-conduction threshold and intraoperative MECAP threshold.

**RESULTS:** The MECAP was always evoked by an electromechanical stimulus (Blackman-like PIP 2-1-2 and @ 2 kHz). The mean bone-conduction preoperative threshold (PTA at 0.5-1-2-4 kHz) was 31 dB (10-51 dB), while the mean intraoperative MECAP threshold was 53 dB (30-70 dB). The mean gap between bone conduction and “vibrogramm” is constantly no later than 25 dB.

**CONCLUSIONS:** The intraoperative MECAP is a fast and objective method to predict an efficient FMT coupling; furthermore, the MECAP threshold could indicate that the surgical procedure was performed without functional complications for cochlear structures.

**Learning Objective:** Assess Middle Ear Surgery in Patients with Mixed or Sensorineural Hearing Loss

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Thursday (1:00 PM - 2:30 PM) Marriott Waterview Ballroom

Presentation 47

**Topic:** Bone Conduction and Middle Ear Implantable Devices II

**Title:** Impact of FMT Outputs and Positioning on Hearing Outputs in Vibroplasty

**Author(s):** Gunesh P Rajan, Jafri Kuthubutheen, Roberta Marino, Peter Lampacher, Gregor Dittrich

**Presenter:** Roberta Marino

**Abstract:**

Background / Purpose: Vibroplasty has offered a new modality of hearing rehabilitation in patients with mixed hearing loss or total conductive block. The positioning of the floating mass transducer (FMT) in Vibroplasty surgery has a critical effect on hearing outputs. In this study we compare various placement positions of the FMT in the middle ear including its application onto the ossicular chain, round window (RW), and stapes and its impact on hearing outputs and coupling efficiency.

Method: This is an ongoing prospective study of 10 patients. All patients had a standard audiological test battery including routine audiometric testing, Soundfield testing, both aided and unaided, performed pre and post operatively at 1, 3, 6 and 12 months. Direct drive transfer function analysis was performed to assess coupling efficiency. Quality of life measure questionnaires were used to assess quality of life. 8 patients had round window vibroplasty, 1 had stapes and 1 had incus vibroplasty. Patients had chronic suppurative otitis media, failed otosclerosis surgery, external auditory canal atresia or eczema.

Results: Patients with a soft tissue coupler between the FMT and the RW had significantly reduced coupling efficiency. Patients who had direct RW contact had significantly improved coupling efficiency. Patients with a stapes or incus vibroplasty had the greatest coupling efficiency.

Conclusion: It has been previously thought that a soft tissue coupler provides the greatest coupling between the FMT and the RW but we have shown that different vibroplasty modalities have different coupling efficiencies.

**Learning Objective:** Recognize that vibroplasty is a hearing rehabilitation option for patients with mixed or conductive hearing loss

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Thursday (1:00 PM - 2:30 PM) Marriott Waterview Ballroom

Presentation 48

**Topic:** Bone Conduction and Middle Ear Implantable Devices II

**Title:** Prognostic factors of the Vibroplasty in open cavities

**Author(s):** Luis Lassaletta, Elena Muñoz, Peter Grasso, Javier Gavilan

**Presenter:** Luis Lassaletta

**Abstract:**

Objectives: Rehabilitation of hearing following surgery for cholesteatoma usually leads to unstable results. The aim of this study is to present the keys to achieve predictable audiological results with the Vibrant Soundbridge (VSB) in patients with open cavities. Subjects and methods: A homogeneous group of 11 patients affected by cholesteatoma were enrolled. All subjects underwent tympanoplasty surgeries (range 1-3) with limited success. The mean bone conduction (BC) threshold of the implanted ears was 34 dB, while the mean air bone gap was 38 dB. Constant intraoperative monitoring of the compound action potential (CAP) evoked by the mechanical stimulation of the FMT was performed. In order to improve the coupling, cartilage and pericondrium/fascia were placed between the FMT and the round window membrane in 5 and 3 cases respectively. Two patients underwent a subtotal petrosectomy in addition to the VSB placement.

Results: No major surgical complications occurred and all patients are users of the device. No significant change in BC threshold was revealed. The intraoperative measurement of CAP was useful to verify the coupling of the FMT on the RW and to optimize the energy transfer of the FMT into the inner ear. The mean threshold of the CAP at 2 kHz was 48 dB (while the mean BC at 2 kHz was 39 dB). The free field results showed an improvement of speech recognition thresholds SRT50% with the VSB of 32 dB SPL in comparison to the unaided situation. The mean improvement of speech understanding at 65 dB SPL was 80%. Conclusion: In our experience, the VSB represents a predictable treatment option for patients with mixed hearing loss due to chronic ear disease. The CAP measurement is a useful tool to optimize the FMT placement in order to achieve maximum energy transfer to the inner ear.

**Learning Objective:** Assess the mechanisms of active middle ear implants to improve hearing in patients with mixed hearing loss following surgery for cholesteatoma

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Topic: Bone Conduction and Middle Ear Implantable Devices II
Title: Vibrant Soundbridge in sensorineural and mixed hearing loss in 192 pediatric and adult surgeries
Author(s): Wolf-Dieter Baumgartner, Alexandra Jappel, Dominik Riss, Reinhard Ramsebner
Presenter: Wolf-Dieter Baumgartner
Abstract: The Vibrant Soundbridge semiimplantable hearing aid is indicated in sensorineural and mixed hearing loss. In this study different surgical procedures and types of coupling onto the ossicular chain are evaluated. In 52 patients (8 children) the floating mass transducer was coupled via the round window, or oval window, or stapes remnants, or fenestration onto the inner ear structures. Another 140 patients have a classic coupling via the long process of the incus. 6 Patients are implanted bilateral, 7 surgeries were performed in local anesthesia. No complication was observed in 192 implantations. In the postoperative follow up (since 1998 in long process of incus coupling, since 2006 in alternative coupling) the overwhelming majority of patients have an excellent outcome in their hearing performance. The mean amplification is 45 dB (A). In all pediatric surgeries (children in between 4 and 16 years old), severe malformation and atresia pathologies, the aided thresholds are 10 dB (A). The Vibrant Soundbridge is indicated in adults, as well as in children and provides good functional gain and amplification in sensorineural and mixed hearing losses. Especially in children with severe malformations (Treacher-Collins, atresia, craniofacial dysplasia), the alternative coupling, so called Vibroplasty, opens a new field of treatment in otology.

Learning Objective: Assess that Vibrant Soundbridge Surgery in children is safe and successful. The surgical procedure is no problem even in severe pediatric malformations. The youngest implanted child was 4 years old (Treacher-Collins Syndrome)

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Topic: Bone Conduction and Middle Ear Implantable Devices II
Title: Outcome of the clinical trial on Codacs™, a novel transcutaneous Direct Acoustic Cochlear Implant
Author(s): Ad Snik, Thomas Lenarz, Joost Zwartekot, Christof Stieger, Burkard Schwab, Emmanuel Mylanus, Marco Caversaccio, Martin Kompis, Hamidreza Mojallal
Presenter: Ad Snik
Abstract: Introduction: A novel Direct Acoustic Cochlear Implant (DACI) called Codacs™ was developed by Cochlear to offer a treatment option for patients with severe to profound mixed hearing loss. It was evaluated in a European multi-center trial between November 2009 and October 2011. Objective: To confirm the clinical efficacy and safety of the Codacs investigational device Methods: Fifteen patients with severe to profound mixed hearing loss due to otosclerosis or failed stapes surgery have been implanted with the Codacs investigational device. Air and bone conduction thresholds, aided thresholds and speech intelligibility as well as the APHAB questionnaire have been evaluated pre-operatively and up to 5 months post-operatively for all study subjects. Results: The pre- and post-operative bone conduction thresholds improved in some cases and deteriorated in 2 subjects. Speech reception thresholds, word recognition scores and the APHAB questionnaire were more favorable than those obtained with the previous acoustic device of the patients. Using Nijmegen data, speech recognition scores were significantly higher than established norms for the Baha, matched for the degree of sensorineural hearing loss. Conclusions: Implantation with the Codacs investigational device is a safe and effective treatment option for patients with severe to profound mixed hearing loss that results from otosclerosis or failed stapes surgery. Financial disclosure: the Codacs devices were provided for free by the Cochlear company.

Learning Objective: Explain the application range of CoDACS device
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Topic: Bone Conduction and Middle Ear Implantable Devices II

Title: Outcome of Amade vs. AP404 in bilateral Active Middle Ear Implant users

Author(s): Astrid Wolf-Magele, Viktor Koci, Johannes Schnabl, Felix Fischl, Patrick Zorowka, Georg Mathias Sprinzl

Presenter: Astrid Wolf-Magele

Abstract: Background/Aim: The Vibrant Soundbridge is an Active Middle Ear Implant (AMEI), which is used for patients suffering from sensorineural, conductive or mixed hearing loss. Generally the patients are implanted unilaterally and they show good audiological results especially in sound quality without distortion, amplification without feedback or occlusion and speech understanding even in background noise. Recently the bilateral fitting with an AMEI is in common. The benefit of binaural hearing has been shown for conventional hearing aids in various studies. To present the convenience of binaural hearing with an AMEI, summation and squelch effect were investigated and analyzed. We also wanted to find out, if there is a difference in the outcome, using the AP404 or the Amadé audio processor. Materials/Methods: We investigated the binaural hearing abilities of 20 subjects implanted bilaterally with the Med-El Vibrant Soundbridge (VSB) at the Innsbruck Medical University hospital. 10 VSB users wearing AP404 audio processors and 10 subjects wearing Amadé audio processors were tested. Speech tests were performed in a sound attenuated chamber in various settings of the noise direction. Oldenburger (OLSA) sentences were presented always from the front (0° azimuth). Noise was presented from the front (0°), the left (-90°) or the right (+90°) direction. Indifferent hearing conditions (unilateral or bilateral) were performed. For the SONO condition also unaided hearing performance was tested. Results: We observed a benefit in binaural hearing abilities for both the AP404 and the Amadé user group. Detailed data of summation effect and squelch effect depending on noise direction, unilateral or bilateral hearing condition and version of audio processor will be presented. Differences in the audiological outcome of AP404 and Amadé audio processor users are discussed. Conclusions: Bilateral AMEI users have a significant benefit in speech reception in spatial noisy environments. The bilateral implantation of the VSB enhances the quality of

Learning Objective: Describe the outcome of different Audio processors with an Active middle ear implant

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