

SELECTED ABSTRACTS

**ORAL
PRESENTATIONS**

IN ORDER OF PRESENTATION



**152nd Annual Meeting
AMERICAN OTOLOGICAL SOCIETY**

**May 3-5, 2019
JW Marriott Austin
Austin, TX**

Effect of Vitamin D Deficiency and Rickets on Hearing Loss in Children

*Charmee H. Mehta, BSPH; Michaela F. Close, BS; James R. Dornhoffer, MD
Yuan F. Liu, MD; Shaun A. Nguyen, MD
Teddy R. McRackan MD; Ted A. Meyer, MD, PhD*

Objective: To characterize how vitamin D deficiency and rickets influences hearing loss (HL) in children.

Study design: Retrospective review.

Setting: Tertiary referral hospital.

Patients: Children in the Audiological and Genetic Database with a diagnosis of vitamin D deficiency or rickets.

Intervention: none

Main outcome measures: Prevalence, type, severity (4-tone pure-tone average, PTA), and progression of HL.

Results: Of 1197 children with vitamin D deficiency, 751 (62.7%) had HL, with 19.4% having at least moderate HL. 25.4% had conductive, 9.3% sensorineural, and 30.8% had mixed hearing loss. 34.5% had undefined HL with audiograms obtained in a sound-field without bone-conduction thresholds. Children with rickets had a significantly higher rate of HL (79% vs 61%, $p<0.001$) and more HL at baseline (30.0 dB vs 22.5 dB, $p=0.002$) than those with vitamin D deficiency only. Over a median follow-up of 2.0 years (IQR 0.3-4.7), children with rickets continued to display hearing loss (23.8 dB vs 17.5 dB, $p=0.001$). Furthermore, children with femur fractures were more likely to have HL than those without femur fractures (86% vs 62%, $p=0.006$). As these children age, the prevalence of sensorineural hearing loss increases significantly: children 6 years or younger (4%), children 6-12 (9%, $p=0.002$), and children older than 12 (14%, $p<0.001$).

Conclusions: HL is highly prevalent in children with vitamin D deficiency. Children with rickets have a significantly higher prevalence and increased severity compared to children with vitamin D deficiency only. Increased age with deficiency is associated with increased prevalence of sensorineural HL, suggesting age-dependent vulnerability to vitamin D deficiency-related HL.

Define Professional Practice Gap & Educational Need: Lack of contemporary knowledge regarding influence of vitamin D deficiency and rickets on hearing loss in children.

Learning Objective: To characterize how vitamin D deficiency and rickets influences hearing loss (HL) in children.

Desired Result: Consideration of vitamin D deficiency and rickets as an indicator for audiological screening.

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB - Exempt

Factors Influencing Duration of Hearing Loss Prior to Cochlear Implantation

*James R. Dornhoffer, MD; Meredith Holcomb, AuD; Shaun A. Nguyen MD
Ted A. Meyer, MD, PhD; Judy R. Dubno, PhD; Theodore R. McRackan, MD, MSCR*

Objective: Determine the impact of demographic and audiologic factors on duration of hearing loss prior to cochlear implantation.

Study design: Retrospective review of a prospectively maintained cochlear implant database

Setting: University-based tertiary medical center

Patients: 492 patients undergoing cochlear implantation from 2012 to 2018

Interventions/main outcomes measured: Multivariate analysis was performed to establish independent associations between demographic/audiologic factors and duration of hearing loss before cochlear implantation, which is a known predictor of poorer cochlear implant outcomes.

Results: When controlling for other variables, non-white patients had increased duration of hearing loss prior to cochlear implantation when compared to white patients (HR=0.157, p=0.038). Although these patients had higher aided pure-tone averages (46.3 vs. 37.1 dB HL) and lower aided speech recognition scores (CNC quiet 9.4% vs 19.3% and AzBio quiet 11.4% vs. 22.9%), non-whites were less likely to have worn hearing aids prior to cochlear implantation (40.0% vs. 67.5%; all p<0.001). Increased age showed a weak positive association with duration of hearing loss. No independent relationships were noted between duration of hearing loss prior to implantation and sex (p=0.19), insurance type (p=0.26), pre-operative hearing aid use (p=0.17), or other audiologic factors.

Conclusion: These results demonstrate that non-white patients have significant delays in treatment for moderate-to-profound sensorineural hearing loss, which may impact their use and benefit from cochlear implantation. Additional research is needed to determine the factors that contribute to significant treatment delays, which may include reduced access to hearing healthcare.

Define Professional Practice Gap & Educational Need: There is a lack of awareness of the impact of racial and demographic factors on length of time before cochlear implantation.

Learning Objective: Practitioners will be made aware of the impact of the at risk status of non-white patients for delayed presentation for cochlear implant evaluation and increased length of time before cochlear implantation.

Desired Result: Practitioners will be able to focus on at-risk populations in their community, in order to expedite cochlear implant evaluation and encourage routine hearing health care in these populations. Due to the association of length of deafness before implantation and cochlear implant outcomes, this focus will ideally offer non-white patients the best opportunity for success with cochlear implantation.

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB: Approved

Systematic Review and Network Meta-analysis of Cognitive and/or Behavioral Therapies (CBT) for Tinnitus

*Evie C. Landry, DSS, MD, MSc; Calla N. Simeone, BA, MSc
Xochitl Citlalli Romo Sandoval, BSc, MSc; Brian D. Westerberg, MD, MHSc
Jane Lea, BSc, MD; Glynnis Tidball, BA, DipAL, MSc (Aud, SLP)*

Objective: To evaluate the efficacy of cognitive and/or behavioral therapies in improving health-related quality of life (HRQOL), depression and anxiety associated with tinnitus.

Data Sources: EMBASE, MEDLINE, Pubmed, PsycINFO and the Cochrane Registry were used to identify english studies from database inception until February 2018.

Study Selection: Randomized controlled trials(RCTs) comparing cognitive and/or behavioral therapies to one another or to waitlist controls for the treatment of tinnitus were included.

Data extraction: Quality and risk were assessed using GRADE and Cochrane's Risk of Bias tool respectively.

Data synthesis: Pairwise meta-analysis (12 RCTs:1,144 patients) compared psychological interventions to waitlist controls. Outcomes were measured using standardized mean differences(SMDs) and 95% confidence intervals(CI). I2 and subgroup analyses were used to assess heterogeneity. Network meta-analysis(NMA) (19 RCTS:1,543 patients) compared psychological therapies head-to-head. Treatment effects were presented by network diagrams, interval plots and ranking diagrams indicating SMDs with 95%CI. Direct and indirect results were further assessed by inconsistency plots.

Conclusions: Results are consistent with previously published guidelines indicating that CBT is an effective therapy for tinnitus. While guided self-administered forms of CBT had larger effect sizes (SMD:3.44; 95% CI:-.022,7.09; I2:99%) on tinnitus HRQOL, only face-to-face CBT was shown to make statistically significant improvements (SMD:0.75; 95%CI:0.53,0.97; I2:0%). Guided self-administered CBT had the highest likelihood of being ranked first in improving tinnitus HRQOL(75.1%), depression(82.7%) and anxiety(87.2%), though statistically insignificant. This NMA is the first of its kind in this therapeutic area and provides new insights on the effects of different forms of cognitive and/or behavioral therapies for tinnitus.

Define Professional Practice Gap & Educational Need: 1. Tinnitus presents a major burden on health care systems with up to 21% of the general adult population being affected (Kim 2015). Although a wide range of therapies exists for the treatment of subjective tinnitus, none have proven to be curative. 2. Psychological therapies have been widely adopted due to evidence showing that disabling secondary effects depend more on psychological rather than acoustic properties (Cima 2014). 3. Given that health systems have increasing pressures to provide cost-effective services, policy-makers depend on the results of rigorously designed systematic reviews to inform important decisions about service provision.

Learning Objective: The learning objective will be to evaluate the efficacy of cognitive-behavioral therapy (CBT) compared to waitlist or other forms of cognitive or behavioral therapies, for the treatment of tinnitus in adults.

Desired Result: 1. Desired results will be to provide updated evidence that reconfirms the findings of previously published meta-analyses and Cochrane Reviews that CBT is an effective form of therapy for tinnitus. 2. This network meta-analysis, being the first of its kind in this therapeutic area, will provide new insights on the effects of different forms of cognitive and/or behavioral therapies for tinnitus and will explore how the method of delivery influenced results.

Level of Evidence: LEVEL I - Large RCTs with clear cut results

IRB- Exempt

Effect of Malnutrition on Hearing Loss in Children

*Michaela F. Close, BS; Charmee H. Mehta, BSPH; James R. Dornhoffer, MD
Yuan F. Liu, MD; Shaun A. Nguyen MD
Teddy R. McRackan, MD; Ted A. Meyer, MD, PhD*

Objective: To characterize the relation between malnutrition and hearing loss (HL) in children.

Study design: Retrospective review.

Setting: Tertiary referral hospital.

Patients: Children in the Audiological and Genetic Database with a diagnosis of protein-calorie malnutrition, marasmus, and/or kwashiorkor.

Interventions: none

Main outcome measures: Prevalence, type, severity (4-tone pure-tone average, PTA), and progression of HL.

Results: Of 846 children with malnutrition, 597 (70.6%) had HL, with 24.0% having at least moderate HL. Prevalence and severity of hearing loss did not differ by age, but children older than 3 years were more likely to have sensorineural HL (OR=2.36, CI 1.33-4.20). Prevalence of HL did not differ among children with different severities of malnutrition, but severely malnourished children showed significantly worse initial (33.8 dB vs 20 dB, p=0.004) and final PTA (28.8 dB vs 18.8 dB, p=0.002) over a median follow up time of 1.2 years (IQR 0.6-2.9). Severely malnourished children also had significantly higher odds of sensorineural HL (OR=2.51, CI 1.24-5.23) and mixed HL (OR=1.62, CI 1.04-2.52). Among malnourished children, those with short stature had more severe initial HL (25.0 dB vs 21.25, p=0.007). Further analysis of the influence of otolaryngologic and nutritional comorbidities on severity and progression of HL will be discussed.

Conclusions: Prevalence of HL is high in malnourished children. Severe malnutrition was associated with greater severity of HL, less improvement over time, and worse hearing in general than lesser degrees of malnutrition.

Define Professional Practice Gap & Educational Need: Lack of awareness about the relation between malnutrition and hearing loss

Learning Objective: To characterize the relation between malnutrition and hearing loss in children

Desired Result: Malnutrition should be considered as an indicator for audiological screening and earlier intervention

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB - Exempt

Polymorphisms in NLRP3 Inflammasome May Increase Host Susceptibility to Acquired Cholesteatoma

*Neel R. Sangal, BA; Marcus Elias, BS; Biju Joseph, PhD
Luis Ulloa, PhD; Robert Jyung, MD*

Introduction: Recently, inflammation mediated by the nucleotide-binding domain, leucine-rich repeat containing protein 3 (NLRP3) complex has been implicated in the pathogenesis of acquired cholesteatoma. We aim to investigate the incidence and association of polymorphisms in inflammasome associated genes NLRP3 and CARD8 with acquired cholesteatoma formation.

Methods: This is a cross-sectional study assessing rates of mutation in genes of interest in patients with and without cholesteatoma. Based on power analyses on genotype frequency, a total of 132 saliva samples were collected from acquired cholesteatoma patients (n=67) and control patients (n=65) for DNA extraction. Taq-Man SNP genotyping quantitative polymerase chain analysis was utilized to assess the frequency of NLRP3 (QQ- normal, QK- heterozygous, KK- homozygous polymorphism) and CARD8 (CC, CX, XX) polymorphisms. Comparative statistics between the acquired cholesteatoma and control cohort used chi-squared testing with $p < 0.05$ considered significant.

Results: The CARD8 homozygous polymorphism XX held significantly higher rates in the acquired cholesteatoma group (28% vs. 11%, $p=0.036$). The CARD8 CC (31% cholest vs. 42% control, $p=0.421$) and CX (40% cholest vs. 46% control, $p=0.284$) polymorphisms did not demonstrate significant variability between groups. The NLRP3 polymorphisms QQ (88% cholest vs. 94% control, $p=0.74$) and QK (6% cholest vs. 10% control, $p=0.84$) showed no significant differences in rates. Only 1 patient with cholesteatoma presented with homozygous polymorphism of the NLRP3 gene.

Conclusions: The CARD8 homozygous polymorphsim showed significantly increased rates in the acquired cholesteatoma cohort. These findings raise significant questions for future study in understanding the pathogenesis of acquired cholesteatoma.

Define Professional Practice Gap & Educational Need: Lack of basic knowledge about the pathogenesis of bone erosion in cholesteatoma on a biomolecular level.

Learning Objective: We hope to identify a novel causal mechanism for aquired cholesteatoma and introduce ideas for future study.

Desired Result: Researchers will be able to use the knowledge gained from the presentation to develop methods to study the effects of inflammation on bone erosion in cholesteatoma.

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB - Approved

Change in Eustachian Tube Function with Balloon Dilation

*Cuneyt M. Alper, MD; Miriam S. Teixeira, MD, PhD; Tanya J. Rath, MD
Denise Hall-Burton, MD; J. Douglas Swarts, PhD*

Objective: Assess the Eustachian tube (ET) function (ETF) outcomes of balloon dilation of Eustachian tube (BDET)

Study design: Prospective cohort for repeated testing outcomes

Setting: Clinical Research Center

Patients: Ten adults with unilateral or bilateral ventilation tubes (VTs) inserted for otitis media with effusion and verified ET dysfunction (ETD) with advanced test methodology

Intervention: Unilateral balloon dilation of ET

Main outcome measures: Changes in the passive and active muscular properties with BDET, assessed by ETF tests including Forced Response Test (FRT), Inflation Deflation Test (IDT), Pressure Chamber tests and pre- post-operative functional CT scans.

Results: With the FRT, the Opening pressure (OP) at 11 ml/min was 473 ± 167 daPa before the BDET, changing to 341 ± 200 daPa at the 6-month post-BDET visit. Closing pressure (CP) at 11 ml/min was 161 ± 146 daPa before the BDET and changed 93 ± 82 daPa at the 6-month post-BDET visit. Ability to correct positive and negative MEP gradient improved from $28\pm 34\%$ and $20\pm 28\%$ to $76\pm 65\%$ and $29\pm 34\%$ respectively. The images from the pre- and post-BDET functional CT scans did not show apparent changes in the anatomy in most subjects. However, during the limited duration of follow-up most subjects continued to have ETD and need VTs. Passive properties of the ET have changed, the ET was easier to open and it stayed open longer with likely decreased peri-tubal tissue pressures, and there was more effective muscular function.

Conclusions: Adults with VTs may benefit from BDET, however severe ETD may not completely resolve, and patients may continue to need VTs.

Define Professional Practice Gap & Educational Need: Lack of knowledge of indications and testing criteria for, and test results and outcomes of the Eustachian tube balloon dilation

Learning Objective: Learn the indications and testing criteria for, and test results and outcomes of the Eustachian tube balloon dilation

Desired Result: Attendees will seek more information regarding the indications and testing criteria for, and test results and outcomes of the Eustachian tube balloon dilation, and apply this to their practice

Level of evidence does not apply because: This is a prospective longitudinal follow-up and outcomes study of repeat testing on the same cohort with unique set of advanced test methods, before and after an intervention

IRB - Approved

Balloon Dilation for Eustachian Tube Dilatory Dysfunction in Children

Joonas Toivonen, MD; Kosuke Kawai, ScD; Dennis Poe, MD, PhD

Objective: To determine the safety and efficacy of balloon dilation of the Eustachian tube (ET) in pediatric patients

Study design: Retrospective case-controlled series

Setting: Tertiary medical center

Patients: Pediatric patients (<18 years) with persistent (≥ 2 years) recurrent or chronic otitis media with previous tympanostomy tube insertion vs case controls

Intervention(s): Balloon dilation of the cartilaginous ET (BDET) was performed under general anesthesia using concomitant myringotomy with/without tube placement if indicated. Adjunctive adenoidectomy, turbinectomy and/or tympanoplasty were used in selected cases. For suspected disease in the bony ET, an illuminated guidewire was used for probing and clearing the lumen.

Main outcome measure(s): Outcome measures were tympanogram, audiogram, otomicroscopy, ET mucosal inflammation score, Valsalva maneuver.

Results: 48 ETs (27 patients), ages 7 – 17 years (mean 12.5, SD 3.2) underwent BDET. Follow-up ranged from 0.23 to 3.15 years (mean 1.3 years, SD=0.9). Significant improvements were observed for all measures ($p<0.01$). Tympanic membranes were healthy in 8% of cases preoperatively, 39% at 6 months (n=41), 52% at 12 months (n=29) and 75% at 36 months (n=12) postoperatively. Tympanograms improved to type A in 47% of cases at 6 months, 56% at 12 months, and 82% at 36 months. Mean scores of mucosal inflammation declined from preoperative 3.2 (± 0.5) to postoperative 2.5 (± 0.7) at 6 months and 1.7 (± 0.6) at 36 months. Complications included 2 cases of patulous ET that resolved over months.

Conclusions: BDET is a safe and possibly effective procedure in selected pediatric patients with recurrent or chronic otitis media

Define Professional Practice Gap & Educational Need: Balloon dilation of the Eustachian tube (ET) is used in the treatment of dilatory dysfunction of the ET. There are very few publications on the results of balloon dilation of the ET (BDET) in the pediatric population.

Learning Objective: Physicians should be aware that BDET is a safe and possibly effective procedure in selected pediatric patients with recurrent or chronic otitis media.

Desired Result: Attendees will be able to consider BDET as a treatment for pediatric patients with recurrent or chronic otitis media.

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB - Approved

Toll-like Receptor 4 Signaling and Downstream Neutrophilic Inflammation Mediate Endotoxemia-Enhanced Blood-Labyrinth Barrier Trafficking

*Zachary D. Urdang, PhD; Jessica L. Bills, BS; David Y. Cahana, BS
Leslie M. Muldoon, PhD; Edward A. Neuwelt, MD*

Hypothesis: Both toll-like receptor 4 (TLR4) and downstream neutrophil activity are required for endotoxemia-enhanced blood-labyrinth barrier (BLB) trafficking.

Background: Aminoglycoside and cisplatin are valuable clinical therapies; however, these drugs often cause life-long hearing loss. Endotoxemia enhances the ototoxicity of aminoglycosides and cisplatin in a TLR4 dependent mechanism for which downstream pro-inflammatory signaling orchestrates effector immune cells including neutrophils. Neutrophil-mediated vascular injury (NMVI) can enhance molecular trafficking across endothelial barriers and may contribute to endotoxemia-enhanced drug-induced ototoxicity.

Methods: Lipopolysaccharide (LPS) hypo-responsive TLR4-KO mice and congenitally neutropenic granulocyte colony stimulating factor (GCSF) GCSF-KO mice were studied to investigate the relative contributions of TLR4 signaling and downstream neutrophil activity to endotoxemia-enhanced BLB trafficking. C57Bl/6 wild-type mice were used as a positive control. Mice were treated with LPS and 24 hours later cochleae were analyzed for gene transcription of innate inflammatory cytokine/chemokine signaling molecules, neutrophil recruitment, and vascular trafficking of the paracellular tracer biocytin-TMR.

Results: Cochlear transcription of innate pro-inflammatory cytokines/chemokines was increased in endotoxemic C57Bl/6 and GCSF-KO, but not in TLR4-KO mice. More neutrophils were recruited to endotoxemic C57Bl/6 cochleae compared to both TLR4- and GCSF-KO cochleae. Endotoxemia enhanced BLB trafficking of biocytin-TMR in endotoxemic C57Bl/6 cochleae and this was attenuated in both TLR4- and GCSF-KO mice.

Conclusion: Together these results suggest that TLR4-mediated innate immunity cytokine/chemokine signaling alone is not sufficient for endotoxemia-enhanced trafficking of biocytin-TMR and that downstream neutrophil activity is required to enhance BLB trafficking. Clinically, targeting neutrophilic inflammation could protect hearing during aminoglycoside, cisplatin, or other ototoxic drug therapies.

Define Professional Practice Gap & Educational Need: 1. Knowledge about role of the neutrophil in blood-labyrinth barrier permeability .

Learning Objective: 1. Understand how innate neutrophilic inflammation perturbs blood-labyrinth barrier permeability. 2. Understand the role of toll-like receptor 4 in innate immune signaling. 3. Understand how neutrophil mediated vascular injury may influence blood-labyrinth barrier trafficking and permeability.

Desired Result: Understand the hypothetical clinical applications for how endotoxemia, sepsis, and neutrophils interact and can affect blood-labyrinth physiology.

Level of evidence does not apply because: Basic Science Study

IRB - Approved

Quinolone Ear Drops Cause Perforations in Intact Rat Tympanic Membranes

*Carolyn O. Dirain, PhD; David N. Karnani, BS
Patrick J. Antonelli, MD*

Hypothesis: Quinolone ear drops promote the development of perforations (TMPs) in intact tympanic membrane (TMs).

Background: Quinolone ear drops have been associated with TMPs after tympanostomy tubes in children. In the rat, these agents demonstrated cytotoxicity in TM fibroblasts and impairment of TM healing following myringotomy in a drug-specific manner and potentiation by steroids.

Methods: Rats were randomized to 6 groups (10/group), with one ear receiving otic instillation of 30 μ L of dexamethasone, ofloxacin, ciprofloxacin, ofloxacin+dexamethasone, ciprofloxacin+dexamethasone, or neomycin—all at standard clinical concentrations—and the contralateral ear receiving saline, twice daily for 10 days. The TMs were assessed over 28 days.

Results: No TMPs were seen in ears treated with saline, dexamethasone and neomycin. At day 10, TMPs were seen in 1 of 10 ofloxacin- and 3 of 10 ciprofloxacin+dexamethasone-treated ears ($p=0.038$). At day 14, the ofloxacin TMP healed. In contrast, the 3 ciprofloxacin+dexamethasone TMPs remained and one new TMP developed in this group, a ciprofloxacin, and an ofloxacin+dexamethasone-treated ears also have TMPs ($p=0.02$). By day 21, the ofloxacin+dexamethasone TMP and 2 of 4 of the ciprofloxacin+dexamethasone TMPs healed but two new TMPs were seen in ciprofloxacin+dexamethasone ears and one new TMP developed in the ofloxacin+dexamethasone-treated ears ($p=0.02$). At day 28, 1 of 10 ciprofloxacin, 1 of 10 ofloxacin+dexamethasone, and 4 of 10 ciprofloxacin+dexamethasone-treated ears have TMPs ($p=0.02$).

Conclusions: Application of quinolone ear drops can cause TMPs in intact TMs. This effect appears to be drug-specific and potentiated by steroids, as noted in prior studies.

Define Professional Practice Gap & Educational Need: The use of quinolone ear drops, specifically ciprofloxacin and ofloxacin, has risen dramatically over the past 15 years. This is largely because of their perceived absence of undesirable side effects, and concerns over ototoxicity of alternative agents, such as aminoglycoside ear drops (eg, neomycin). Ciprofloxacin and ofloxacin are the only antibiotics approved by the U.S. Food and Drug Administration for instillation into the middle ear. Earlier findings from tissue culture, animal, and epidemiological studies have shown that quinolones impair TM healing and increase the risk of permanent TMPs. These effects appear to be aggravated by steroids. It is unclear whether quinolone ear drops also increases the risk of TMP in intact TMs.

Learning Objective: At the conclusion of this presentation, the attendees will learn that quinolone ear drops can cause TMPs in intact TMs, ciprofloxacin appears to impart a greater risk than ofloxacin, and this effect is potentiated by the addition of dexamethasone.

Desired Result: Attendees may be able to apply this knowledge by considering the potential adverse impact of quinolone ear drops on TMs when prescribing antimicrobial ear drops.

Level of Evidence - Does not apply

IRB - IACUC approved

Results from a Second-Generation Vestibular Implant in Human Subjects: Diagnosis May Impact Electrical Sensitivity of Vestibular Afferents

*Jay T. Rubinstein, MD, PhD, Leo Ling, PhD, Kaibao Nie, PhD
Amy Nowack; James O. Phillips, PhD*

Objective: To report auditory and vestibular outcomes after placement of a combined vestibular and cochlear implant in Meniere's disease (MD) and in sudden hearing and vestibular loss.

Study Design: Retrospective case studies

Setting: Tertiary referral center

Patients: Two human subjects received a second-generation vestibular implant that also includes a Hybrid-L intracochlear array. Subject one had sudden hearing and vestibular loss on the left ten years prior to implantation. She had subsequent symptoms and laboratory findings of bilateral vestibular loss. Subject two had bilateral Meniere's disease for over forty years with resolution of acute attacks but subsequent symptoms and laboratory findings of bilateral vestibular loss. Both subjects had severe-profound deafness in the left ear.

Intervention: Left ear implantation of a combined vestibular and cochlear implant. Electrode positions confirmed by temporal bone CT.

Main Outcome Measures: Electrically-evoked vestibular and cochlear compound action potentials (ECAPs), cochlear implant speech perception, electrically-evoked slow-phase eye velocities, and electrically-evoked vestibular percepts.

Results: Subject one had no intraoperative or postoperative vestibular ECAP measurable, but normal cochlear ECAPs and cochlear implant function in the expected range. She had minimal perceptual or eye-movement response to vestibular stimulation. Subject two had intraoperative ECAPs from two of three canals and normal cochlear ECAPs. Postoperatively, this subject had the largest slow-phase eye velocities to electrical vestibular stimulation that we have seen in humans, exceeding 100 degrees per second in the lateral semicircular canal. Her cochlear implant function is also in the normal range.

Conclusion: In these two subjects, the underlying cause of vestibular loss appears to have a profound impact on electrical sensitivity of vestibular afferents. No such effect was seen with cochlear nerve excitability. If this dichotomy is seen in more subjects, it may limit the potential application of vestibular implants to those diagnoses associated with preserved electrical sensitivity of vestibular afferents. We speculate that the dichotomy is due to anatomical differences between Scarpa's and the spiral ganglion. In one subject, the second-generation device is capable of producing much higher velocity electrically-evoked eye movements than in the four subjects who received the first-generation device.

Define Professional Practice Gap & Educational Need: Lack of knowledge about the clinical feasibility of vestibular implants

Learning Objective: Learn about progress in the development of vestibular implants

Desired Result: Reasonable expectations for the pace of device development

Level of evidence does not apply because: FDA feasibility study

IRB: Approved

Vestibular End Organ Preservation in the Implanted Cochlea

*Brooke M. Su, MD, MPH; Ivan A. Lopez, PhD
Gail Ishiyama, MD Akira Ishiyama, MD*

Hypothesis: Endolymphatic hydrops after cochlear implantation causes vestibular end-organ dysfunction.

Background: Vestibular dysfunction is a known risk after cochlear implantation (CI). CI has been shown to cause endolymphatic hydrops in the cochlea, though its effects on the cyto-architecture of vestibular end-organs are only beginning to be investigated.

Methods: Histopathological analysis of the vestibular end-organs (macula utricule, saccule, and canal cristae) of human temporal bones (HTB), all of which had undergone CI. Group 1 consisted of fifteen patients (CI) found to have endolymphatic hydrops (10 female, 5 male, ages 54 to 98 years). Group 2 consisted of eleven patients without hydrops (6 female, 5 male, ages 59 to 87 years).

Results: The vestibular sensory epithelia of the end-organs in group 1 were well-preserved; in 5 HTBs there was distension of the membranous labyrinth indicating hydrops, 2 HTBs showed ossification of the posterior canal, 3 showed rupture of the membranous labyrinth, 3 showed Scarpa's ganglion atrophy, and 2 had saccule deformation. Group 2 also had well-preserved vestibular end-organs sensory epithelia, though without distension of the membranous labyrinth. 3 HTBs had normal vestibular epithelia, 2 HTBs showed fibrosis in the perilymph, 1 had new bone formation around the otic capsule with normal epithelia, 3 had vestibular nerve atrophy and normal epithelia, and 2 demonstrated saccular degeneration.

Conclusion: In spite of relative morphological and cytologic preservation of the vestibular sensory epithelium, the presence of endolymphatic hydrops is also seen in the vestibular end-organs after CI. Additionally, changes such as vestibular nerve atrophy may also contribute to vestibular dysfunction.

Define Professional Practice Gap & Educational Need: Lack of knowledge on the histopathologic findings associated with vestibular dysfunction after cochlear implantation.

Learning Objective: To describe histopathologic findings of the vestibular end-organs after cochlear implantation that may be related to vestibular dysfunction.

Desired Result: To gain a better understanding of the mechanisms causing vestibular dysfunction after cochlear implantation, and subsequently investigate methods for prevention.

Level of Evidence: LEVEL V - Case series, studies with no controls

IRB - Approved

Neuropsychological Vertigo Inventory for Quantification of Cognitive Dysfunction in Dizzy Patients: Preliminary Results

*Yuan F. Liu, MD; Taylor D. Locklear, MS; Jeffrey D. Sharon, MD
Shaun A. Nguyen, MD; Habib G. Rizk, MD*

Objective: Currently available patient reported outcomes questionnaires for dizzy patients give limited insight into the cognitive dysfunction they often report. Using the newly developed English version of the Neuropsychological Vertigo Inventory (NVI), we aim to quantify the cognitive impairment of dizzy patients.

Study Design: Prospective cohort study.

Setting: Tertiary neurotology clinic.

Patients: Adults with vestibular diagnoses who completed the NVI between June 2018 and October 2018. Patients with neurologic disorders affecting cognition were excluded.

Interventions: none

Main outcome measure: NVI score

Results: Pilot data consisted of 68 enrolled subjects with various causes of dizziness, including 17 vestibular migraine (VM), 13 Ménière's disease (MD), and 14 benign paroxysmal positional vertigo (BPPV) patients with mean ages of 41, 55, and 64, respectively. VM patients were significantly younger than both MD ($p=0.029$) and BPPV ($p=0.001$) patients. Posthoc analysis following ANOVA showed that mean NVI scores of BPPV patients (50 ± 17.4) were significantly lower than those of VM patients (68 ± 16.7 , $p=0.011$) and MD patients (71 ± 18.8 , $p=0.019$). NVI scores were moderately correlated with DHI scores ($r=0.53$, $p<0.001$). A multiple linear regression model for NVI using age, vestibular diagnoses, depression, anxiety, and stroke has an R^2 of 82% ($p<0.001$), with definite VM and definite MD the two variables affecting the score the most.

Conclusions: Cognitive impairment as characterized by the NVI shows that VM patients have higher levels of cognitive dysfunction despite being significantly younger than BPPV patients. Despite being a peripheral disorder, MD elicited levels of cognitive dysfunction similar to VM (a central problem).

Define Professional Practice Gap & Educational Need: Lack of knowledge about cognitive dysfunction caused by vestibular disorders, leading to inadequate awareness of such dysfunction, and inability to address the dysfunction in practice when treating patients.

Learning Objective: To gain knowledge about degree of cognitive dysfunction in different vestibular disorders, including vestibular migraine, Meniere's disease, and benign paroxysmal positional vertigo, and how such dysfunction varies among the disorders.

Desired Result: Physicians may learn to use the Neuropsychological Vertigo Inventory in their own practice to screen for cognitive dysfunction in dizzy patients. They may also gain a tool for evaluating cognitive dysfunction in dizzy patient so that proper treatment or referrals may be made to better treat patients.

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB - Approved

A Cohort Study Comparing Importance of Clinical Factors in Determining Diagnosis and Treatment for Superior Semicircular Canal Dehiscence Syndrome

Lisa Zhang, BS, BA; Francis X. Creighton Jr, MD; John P. Carey, MD

Objective: To determine which clinical factors have the strongest impact on determining diagnosis and decision for surgical repair for superior semicircular canal dehiscence syndrome (SCDS).

Study design: Historical cohort study

Setting: Tertiary care referral center

Patients: A total of 81 patients were evaluated between October 2017 and October 2018 for SCDS. 38 patients were diagnosed with SCDS, and 28 of the individuals ultimately underwent SCDS repair.

Methods: Various clinical factors including presence of subjective reports of autophony, sensitivity to loud sounds, vertigo induced by loud sounds, dizziness, hearing their own heartbeats or other visceral organs, as well as low frequency conductive hearing loss, hyperacusis, and significant increase in affected ear oVEMP (>17) were analyzed with logistic regression both in patients who were diagnosed with SCDS and those who had surgical repair.

Results: From logistic regression analysis two factors emerged as significant predictors of a final diagnosis of SCDS: low frequency conductive hearing loss and oVEMP amplitude ($p = 0.002$, $p = 0.001$, respectively). The same factors were also significant predictors of whether individuals were offered and chose to have surgical repair of the dehiscence ($p = 0.004$, $p = 0.001$, respectively). A logistical regression indicated that these two factors accounted for 56% of the variance for diagnosing SCDS and 59% of the variance for those who had surgical repair.

Conclusions: Low frequency conductive hearing loss and increased oVEMP amplitude are the strongest predictive factors for making a diagnosis of SCDS and for its surgical repair.

Define Professional Practice Gap & Educational Need: Lack of research determining which clinical factors have the strongest impact on determining diagnosis and decision for surgical repair for superior semicircular canal dehiscence syndrome (SCDS).

Learning Objective: Low frequency conductive hearing loss and increased oVEMP amplitude are the strongest predictive factors for making a diagnosis of SCDS and for its surgical repair.

Desired Result: A better understanding of which clinical factors are most important for referral, diagnosis, and management of SCDS.

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB: Approved

The cVEMP as a Prognostic Tool for Development of Bilateral Meniere's Disease

*Kimberley S. Noij, MD; Barbara S. Herrmann, PhD
John J. Guinan Jr., PhD; Steven D. Rauch, MD*

Objective: To investigate if cVEMP is predictive for the development of bilateral Meniere's disease (MD).

Study design: Retrospective cohort study

Setting: Tertiary care center

Patients: Medical charts of 71 patients previously diagnosed with unilateral Meniere's disease and who had cVEMP testing between 2002 and 2011 were screened. Patients with an air-bone gap (ABG) of ≥ 15 dB at one or more frequencies at the time of cVEMP testing were excluded (n=5).

Intervention: The remaining patients (n=66) were contacted by email, phone or mail to answer a questionnaire about their Meniere's disease to identify who developed bilateral disease; i.e. involvement of their second ear. Thirty-five patients answered the questionnaire. Medical charts of the remaining 31 patients were reviewed. Patients with a follow-up time of at least 5 years were included for analyses. In total, 49 patients were included.

Main outcome measure: cVEMP thresholds and tuning measured previously were analyzed with respect to the development of bilateral disease in the interim since that previous testing.

Results: Twelve of the 49 (24.5%) included patients developed bilateral disease. Originally unaffected ears that subsequently developed Meniere's disease had significantly higher cVEMP thresholds than the ears that remained unaffected ($p < 0.001$). A difference in tuning was also observed. cVEMP threshold was lower at 1000 Hz than 500 Hz in 83.3% of the newly affected ears, while this tuning pattern occurred in only 16.2% of ears that remained unaffected.

Conclusion: cVEMP threshold and tuning are predictive of which unilateral MD patients will develop bilateral disease.

Define Professional Practice Gap & Educational Need: Lack of knowledge

Learning Objective: Educate

Desired Result: Clinical applicability

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB: Approved

Imaging is Not Indicated in the Investigation of Isolated Objective Vestibular Weakness

*Deanna Gigliotti, MSc; Brian Blakley, MD
Paige Moore, MD; Jordan Hochman, MD*

Objective: Unilateral vestibular weakness (uVW) has considerable potential etiologies. One source is a vestibular schwannoma. This article evaluates, in the absence of other symptoms and signs, if uVW is an analogue to asymmetric sensorineural hearing loss and serves as an indication for lateral skull base imaging.

Study Design: Retrospective chart review

Setting: Academic tertiary center

Patients: All patients undergoing caloric assessment between January 1 2012 and June 30 2017 were investigated. Patients with uVW (unilateral weakness score >25% on electronystagmography) were included in the study. A Provincial encompassing image library was surveyed for potential adequate imaging (CT IAC infused, MRI brain, MRI IAC) of the target population within the preceding 5 years.

Intervention: diagnostic.

Main Outcome Measure: presence/absence of vestibular schwannoma on imaging.

Results: Of the 3000 ENG reviewed during the period, 737 patients were identified with uVW. Of these, 458 had sufficient imaging, and 10 vestibular schwannomas were identified (cost of \$50,581.94 per tumor). Only one individual had a vestibulopathy in isolation, while the remaining 9 tumor patients also suffered from documented sensorineural hearing loss that would have mandated MRI scanning.

Conclusion: The results of our study suggest that in isolation, vestibular weakness is an insufficient indicator for lateral skull base imaging.

Define Professional Practice Gap & Educational Need: Uncertainty regarding the indication and cost benefit of imaging patients with unilateral vestibular weakness

Learning Objective: At the end of this presentation, attendees will appreciate that in isolation unilateral vestibular weakness does not require imaging

Desired Result: (How will attendees APPLY the knowledge they learned from the presentation): The implementation and employ of patient-centric, cost effective investigations in the dizzy patient.

Level of Evidence: LEVEL V - Case series, studies with no controls

IRB - Exempt

Impact of Underlying Diagnosis on Speech and Quality of Life Outcomes after Cochlear Implantation for Single-Sided Deafness

*Tiffany Peng, MD; Joshua J. Sturm, MD, PhD; Abby Owen
Megan Kuhlmeier, AuD; Ilana P. Cellum, AuD
Lawrence R. Lustig, MD; Ana H. Kim, MD*

Objective: Our objective was to compare outcomes in speech and quality of life in those undergoing cochlear implantation for single-sided deafness (SSD), with the aim to characterize the clinical impact of underlying diagnosis in the affected ear.

Study Design: Prospective case series

Setting: Academic Cochlear Implant Center

Patients: We review the outcome of 38 adult patients implanted with the diagnosis of SSD.

Interventions: All patients were evaluated at 3-, 6, and 12-months post-operatively using AZBio® sentence and speech, consonant-nucleus-consonant (CNC), and Bamford-Kowal-Bench Sentences in Noise(BKB-SIN) tests depending on appropriate testing level. Our previously validated Comprehensive Cochlear Implant Quality of Life (CCIQ) questionnaire was also administered.

Main Outcome Measures: Speech perception, quality of life

Results: Subjects were stratified by the underlying diagnosis: Meniere's (MD; n=9), sudden sensorineural hearing loss (SSNHL; n=12), and Other (eg TBI, acoustic neuroma, progressive, noise-induced; n=17). The mean preoperative PTA of the implanted ear was 76dB±24; that of the non-implanted ear was 33dB±6. SSNHL demonstrated the highest speech perception score at 3 months (98%), and "Other" demonstrated the lowest scores at 85%. All 3 groups demonstrated a nadir in speech scores at 6 months before improving at 12 months. The "other" diagnoses group maintained the lowest speech testing across all time points. All 3 groups reported improved quality of life on CCIQ testing.

Conclusions: Subjects with SSNHL and MD demonstrate excellent speech and quality of life outcomes after cochlear implantation for SSD. Subjects with other diagnoses underlying their SSD demonstrated lower scores on speech testing but nonetheless reported improved quality of life on CCIQ.

Define Professional Practice Gap & Educational Need: 1. Lack of awareness of current outcomes in cochlear implantation for single sided deafness 2. Lack of contemporary knowledge on how underlying diagnosis/etiology of deafness impacts outcomes in cochlear implantation for single-sided deafness 3. Lack of contemporary knowledge in the natural history of speech outcomes and rehabilitation after cochlear implantation for single-sided deafness

Learning Objective: Participants will understand speech outcomes and quality of life outcomes in cochlear implantation for single-sided deafness, as well as strategies for how outcomes may be evaluated in this population. Participants will demonstrate understanding of how outcomes progress and differ among implantees based on the etiology for their single-sided deafness.

Desired Result: Participants will have improved capacity for patient counseling and expectations management for speech and quality of life after cochlear implantation for single-sided deafness. They will also have a data set by which to compare their own patient outcomes in the 12 months following cochlear implantation for these indications.

Level of Evidence: LEVEL V - Case series, studies with no controls

IRB -Approved

Prevalence of Xerostomia Among Cochlear Implant Recipients A Cross-Sectional Survey

*Heather M. Weinreich, MD, MPH; Benjamin Ostrander, MSE
Seth E. Pross, MD; Howard Francis, MD, MBA*

Objective: To determine the prevalence of xerostomia among adult cochlear implant (CI) recipients and if an association exists with unilateral versus bilateral implantation.

Study Design: Cross-sectional survey administered via electronic format.

Setting: Outpatient CI center based in a tertiary care facility.

Patients: Adults greater than or equal to 18 years of age who received an implant or transitioned care to the Johns Hopkins Listening Center in Baltimore, MD.

Intervention: Presence of CI, either unilateral or bilateral

Outcome: Presence or absence of xerostomia, as assessed by an ordinal variable (low risk, at risk, high risk) created from the validated Xerostomia Inventory Score.

Results: A total of 278 subjects completed greater than 50% of the survey, giving a response rate of 21.8%. 59% were female. Average age at completion of the survey was 59 years (SD \pm 16). 27% had bilateral implants. No mean age difference was seen between those with xerostomia versus without. 70% of subjects were on at least one medication with possible xerostomia side effect. There was no significant difference between rate of medication use between unilateral and bilateral CI recipients. When controlling for medication use, mean age between those with xerostomia was similar to those without. Bilateral recipients not on a medication and who developed xerostomia were younger. Prevalence of xerostomia was 20.5% for all recipients, 17.3% for bilateral and 21.6 % for unilateral. After excluding subjects taking a medication, the rate dropped to 12.3%.

Conclusion: The prevalence of xerostomia among CI patients is over 10%, regardless of unilateral vs. bilateral implantation status.

Define Professional Practice Gap & Educational Need: 1. Lack of knowledge regarding rate of xerostomia in cochlear implant population 2. Lack of knowledge regarding rate of xerostomia between bilateral and unilateral cochlear implant recipients 3. Lack of knowledge regarding risk factors for xerostomia in a cochlear implant population

Learning Objective: 1. Calculate the prevalence of xerostomia in a cochlear implant population 2. Determine if prevalence varies between bilateral and unilateral cochlear implant recipients 3. Investigate associations between xerostomia and possible risk factors in a cochlear implant population

Desired Result: Submandibular glands provide basal saliva production which has implication for development of xerostomia and dental health. An awareness of the rate of xerostomia in their cochlear implants recipients and an understanding this may have implications for surgical approaches (e.g. sacrifice of chorda tympani). We also would like attendees to consider the implication this has in bilateral recipients where both chorda tympani nerves may be sacrifice. Moreover, we want to provide knowledge of possible risk factors especially in older patients.

Level of Evidence: Descriptive Cross-sectional study. Some consider Level IV evidence - defer to AOS

IRB - Approved

Identifying Disadvantaged Groups for Cochlear Implantation: Demographics from a Large Cochlear Implant Program

*Natalie Schauwecker, BBA, BS; Anthony M. Tolisano, MD
Bethany Baumgart, AuD; Johanna Whitson, AuD
J. Walter Kutz, MD; Brandon Isaacson, MD; Jacob B. Hunter, MD*

Objective: To characterize the demographics of patients undergoing cochlear implant (CI) evaluations.

Study Design: Retrospective chart review between 2009 and 2018.

Setting: University CI program.

Patients: Adults referred for CI evaluation.

Main Outcome Measures: Demographics, insurance status, and proximity to the CI program.

Results: 784 CI evaluations were performed. The mean age was 64.2 years (range, 18-92 years), 54.7% were male, 87.6% were white, and 89.3% were primary English speakers. Overall, 74.7% qualified for CI, of which 63.8% pursued surgery. The majority (63.9%) had public insurance (e.g. Medicare or Medicaid), followed by private insurance (29.8%) and military insurance (3.3%). Females qualified for CI at a higher rate than males (79.4% vs. 70.9%, $p=0.0064$) but pursued surgery at the same rate (62.4% vs. 65.1%, $p=0.5471$). Minorities qualified for CI at a much higher rate compared to whites (90.1% vs. 75.4%, $p=0.0027$) but were significantly less likely to pursue surgery (57.5% vs. 70.9%, $p=0.0282$). English and non-English speaking patients qualified for surgery at similar rates (75.1% vs. 81.2%, $p=0.3051$) but English speakers pursued surgery at a higher rate (65.3% vs. 48.2%, $p=0.0131$). Although driving distance did not predict patients who qualified for CI, patients who pursued CI lived at a significantly greater distance compared to those who did not pursue CI (34.01 miles vs. 26.78 miles, $p=0.0181$).

Conclusions: Disadvantaged groups, such as minorities, non-English speakers, and women, qualify for CI at a higher rate, suggesting the possibility of delayed CI candidacy referral, and generally pursue surgery at a lower rate.

Define Professional Practice Gap and Educational Need: There has not been a large assessment of the social demographics of patients who undergo cochlear implant evaluations, who qualify for them, and ultimately who pursue cochlear implant surgery. This is especially important for disadvantaged groups who may have increased obstacles to obtaining care.

Learning Objective: To characterize the demographics of patients undergoing cochlear implant evaluations.

Desired Result: To identify demographics such as gender, race, ethnicity, language, and marital status that might impede patients from pursuing cochlear implantation. This can lead to changes in patient referral and even in formal testing to ensure any patient that could benefit from surgery has the opportunity to pursue cochlear implantation.

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB- Approved

Lateral Wall Electrodes Increase the Rate of Post-Activation Non-Auditory Percepts

*Adam C. Kaufman, MD, PhD; James G. Naples, MD; Douglas C. Bigelow, MD
Steven J. Eliades, MD, PhD; Hannah S. Kaufman, AuD; Michael J. Ruckenstein, MD*

Objective: To evaluate factors influencing the development of non-auditory percepts and facial nerve stimulation after cochlear implant (CI) activation.

Study: Retrospective Cohort Study

Setting: Tertiary referral center

Patients: Over the course of five years, 518 consecutive patients who underwent CI were evaluated. Of those, 497 patients had information regarding CI activation.

Interventions: Lateral wall electrodes (LWE) or perimodiolar/mid-scalar electrodes (PME) were used during implantation per patient preference without regard to anatomical factors.

Primary Outcome Measure: Non-auditory percepts and facial nerve stimulation after activation of CI.

Results: Among the 497 patients who had their devices activated at our institution, 357 (72%) patients were implanted with an LWE while 140 (28%) patients were implanted with a PME. Of the patients with LWE, 49 (13.7%) patients experienced some form of non-auditory percept. In comparison, only 11 (9.2%) patients with a PME had some form of non-auditory percept ($P<0.05$). Among the patients who had an LWE, 33 (9.2%) patients had facial nerve stimulation compared to only 6 (4.3%) patients with PME. This difference was statistically significantly ($P<0.05$). Additionally, the 11 (2.2%) patients who had incomplete insertion of the electrode had a significant increase ($P<0.05$) in facial nerve stimulation and the 51 (10.2%) patients who needed a cochleostomy for insertion had a higher rate ($P<0.05$) of both non-auditory percept and facial nerve stimulation. The average patient needed 2.85 electrodes modified or disabled to control symptoms.

Conclusions: The use of LWE, cochleostomies, and incomplete insertions significantly increase the rate of non-auditory percepts after activation of CIs.

Define Professional Practice Gap & Educational Need: Lack of contemporary knowledge about the differing risks for facial nerve stimulation and non-auditory percepts between lateral wall and perimodiolar electrodes. There is a lack of awareness of all the factors that contribute to non-auditory percepts after cochlear implantation.

Learning Objective: To understand that the use of lateral wall electrodes, cochleostomies, and incomplete insertions significantly increase the rate of non-auditory percepts and facial nerve stimulation after activation of cochlear implants.

Desired Result: Physicians will be better able to counsel patients about the risks of different cochlear implant electrodes in relationship to risk of facial nerve stimulation and non-auditory percept. Additionally, this study further validates the practice of exchanging lateral wall electrode to perimodiolar electrodes in the event of uncontrollable facial stimulation.

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB: Approved

Cochlear Implantation with a Slim, Modiolar Array

*Jonathan L. McJunkin, MD; Nedim Durakovic, MD; Jacques Herzog, MD
Cameron C. Wick, MD; Craig A. Buchman, MD*

Objective: Describe the surgical findings associated with successful array insertion in a multi-center trial

Study Design: Prospective, multi-center, within-subject experimental design

Setting: Tertiary referral centers (N=13)

Patients: Adults \geq 18 years old

Intervention: Cochlear Implantation with a slim, modiolar array

Main Outcome measures: Surgeon operative questionnaire, complications and post-operative computer tomography (CT) reconstructions of electrode scalar location

Results: 100 surgeries were completed by 25 surgeons. Surgical questionnaires were completed for all cases. 70 patients had radiographic data available. There were three tip rollovers (3%); one identified intraoperatively through x-ray and corrected via reinsertion and two detected on post-operative CT that underwent successful revision surgery. Cochlear access was described as extended round window in 70% of cases, followed by true round window and separate cochleostomy in 27% and 3%, respectively. 93% of the questionnaires reported an uneventful insertion while 7 cases required an electrode re-load into the sheath without incident.

CT reconstructions revealed most electrodes (91%) were placed fully in the scala tympani (ST), 5 electrodes (7%) translocated from ST to scala vestibuli (SV) and 1 electrode was placed fully in the SV. The average wrap factor was 59.5% and average apical insertion depth was 400 degrees.

Conclusion: The slim, modiolar electrode array has a very consistent perimodiolar position and a low translocation rate. Surgeons used an extended round window approach most frequently to accomplish the sheath-dependent insertion technique. Intraoperative x-ray is needed to detect tip rollovers in the operating room.

Define Professional Practice Gap & Educational Need: 1. Lack of widespread experience with the new slim, modiolar cochlear implant(CI) array. 2. Few reports on scalar location and translocation rates with the new slim, modiolar CI array.

Learning Objective: 1. Describe surgical experiences and insights gained from a multi-institutional study on the new slim, modiolar CI array. 2. Describe slim, modiolar CI array locations based on postoperative CT scan reconstructions.

Desired Result: Attendees will learn the slim, modiolar CI array is best placed with an extended round window cochleostomy and consistently remains within the scala tympani in a perimodiolar position.

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB - Approved

Controlled Microperforation of Human Round Window Membrane *in situ*

Harry Chiang, BA; Michelle Yu, BS; Wenbin Wang, MS
Aykut Aksit, MS; Miguel Arriaga, PhD; Jeffrey W. Kysar, PhD
Anil K. Lalwani, MD

Hypothesis: 3D-printed microneedles can create precise holes on the scale of microns in the *human* round window membrane (hRWM).

Background: An intact RWM is a barrier to delivery of therapeutic material into the inner ear. Microperforation of guinea pig RWM has been shown to overcome this barrier by enhancing diffusion 35-fold. In humans, the challenge is to design a microneedle that can perforate the thicker hRWM.

Methods: Based on the mechanical properties of the hRWM, 100 μm diameter microneedles with 5 μm tip diameter were designed and fabricated using 2-photon polymerization. With a micro-indenter equipped with microneedles, hRWM from fresh frozen temporal bones were perforated *in situ*, simultaneously measuring force and displacement (N=9). Confocal microscopy was used to characterize the RWM perforation. Microneedles were examined for deformity after use.

Results: The microneedles successfully perforated the hRWM without tearing the membrane. The perforations were lens-shaped measuring $131.3 \pm 3.0 \times 15.6 \pm 1.9 \mu\text{m}$ with the length of major axis slightly larger than the microneedle shaft diameter. The mean force required for perforation was $29.0 \pm 6.7 \text{ mN}$, more than an order of magnitude greater than that previously measured in guinea pig ($1.2 \pm 0.6 \text{ mN}$). There was no significant deformation of the microneedles.

Conclusions: 3D-printed microneedles are strong, resist breakage with use, and create small perforations that separate, but do not tear the connective tissue fibers of the human round window membrane. Separation of collagen fibers without tearing is encouraging for clinical use of microneedles, as it should facilitate healing of the hRWM after perforation.

Define Professional Practice Gap & Educational Need: Lack of a tool to overcome inconsistencies with drug delivery across the round window membrane to the inner ear

Learning Objective: 1. To learn how microneedles can create precise holes in human round window membrane 2. To understand the anatomy and mechanics of microneedle perforations in human round window membrane

Desired Result: Microneedles show promise as a technology for improving delivery to the inner ear without compromising round window membrane integrity

Level of evidence does not apply because: Basic sciences study

IRB - Exempt

Regular Wave Patterns on Ambient Pressure Tympanometry in Patients with Pulsatile Tinnitus-associated Pathologies

*Anthony Thai, BA; Zahra N. Sayyid, BS; Davood K. Hosseini, MD
Yifei Ma, MS; Austin Swanson, AuD
Matthew Fitzgerald, PhD; Yona Vaisbuch, MD*

Objective: To introduce the potential use of continuous ambient pressure tympanometry (APT) in the screening of pathologies associated with pulsatile tinnitus

Study design: Retrospective cohort study. APT was performed randomly, and medical records, including imaging, were reviewed. APT findings were objectively characterized using an algorithm based on regularity, frequency and amplitude of the waves. Patients without otologic symptoms or without imaging findings were categorized as controls, and patients with otologic symptoms or imaging findings were categorized as cases.

Setting: Tertiary otology referral center

Patients: Adult patients

Intervention(s): screening with baseline ambient pressure tympanometry

Main outcome measure(s): amplitude and frequency of APT waves; diagnoses based on symptoms and imaging

Results: APT was performed on 589 patients (1035 ears). We identified 465 control patients (827 ears). In this control group, 70% of ears did not display regular APT wave patterns. We identified 124 patients (207 ears) with otologic symptoms or imaging findings. From this group of cases, we identified 9 distinct diagnoses, including superior semicircular canal dehiscence (23 patients, 34 ears), glomus tumors (5 patients, 6 ears), carotid dehiscence (3 patients, 4 ears), myoclonus (3 patients), inner ear hydrops (3 patients), jugular bulb dehiscence (2 patients), sigmoid sinus dehiscence (2 patients), encephalocele (2 patients), and aberrant carotid artery (1 patient).

Conclusion: Characteristic wave patterns on APT over time may be indicative of otherwise unrecognized pathology associated with pulsatile tinnitus. APT is a simple, feasible and widely accessible tool that can help with screening or direct suspicion.

Define Professional Practice Gap & Educational Need: Lack of awareness of usage of an existing screening tool (ambient pressure tympanometry) for identification of pulsatile tinnitus-associated pathologies

Learning Objective: Familiarize participants with ambient pressure tympanometry, wave patterns on this test, and correlations with various pathologies

Desired Result: The attendee will be able to interpret wave patterns on ambient pressure tympanometry and discuss correlations with various otologic pathologies

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB: Approved

Assessment of Hearing-Aid Benefit through Patient-Reported Outcomes

*James R. Dornhoffer, MD; Ted A. Meyer, MD, PhD
Judy R. Dubno, PhD; Theodore R. McRackan, MD, MSCR*

Objective: Determine the association between audiologic and patient-reported outcome measures in hearing-aid users.

Study design: Independent review of audiologic and patient-reported outcomes from a middle-ear implant FDA clinical trial

Setting: Multicenter clinical trial

Patients: 95 hearing-aid users undergoing evaluation for middle-ear implantation

Interventions/main outcomes measured: Pure-tone thresholds (PTA), word recognition scores in quiet (NU-6), scores from low and high predictability Speech Perception in Noise test (low/high SPIN), and patient-reported assessment of communication abilities (Abbreviated Profile of Hearing Aid Benefit, APHAB), all measured unaided and aided. Correlations were examined among audiologic measures and global APHAB and APHAB sub-domain scores. Benefit was defined as the difference in scores between unaided and aided listening.

Results: Significant improvements in all audiologic and patient-reported outcome measures ($p < 0.001$ for all) were observed when comparing unaided and aided listening. No significant correlations were found between aided audiologic measures (PTA, NU-6, and SPIN) and aided APHAB or APHAB sub-domain scores (all $p > 0.05$). Benefit measured by NU-6 and SPIN high showed weak positive correlations with benefit measured by global APHAB ($r = 0.37$, $p < 0.001$; and $r = 0.28$, $p = 0.1005$, respectively) and with benefit measured by ease of communication APHAB sub-domain ($r = 0.37$, $p < 0.001$; and $r = 0.33$, $p = 0.001$, respectively).

Conclusion: Hearing-aid benefit assessed with audiologic outcomes is generally a poor predictor of patient-reported benefit of hearing aids to communication abilities. As such, patient-reported outcomes may provide a unique assessment of patients' perceived benefit from hearing-aid use, which can be used to direct future hearing aid programming, auditory training, or recommendations of alternative hearing services or technologies.

Define Professional Practice Gap & Educational Need: There is a lack of awareness regarding the true association between audiologic and patient-reported outcome measures in hearing-aid users.

Learning Objective: Practitioners will be informed that patient reported hearing-aid benefit and audiologic outcome measures poorly correlate. As such, patient reported outcome measures offer a unique tool for assessment of hearing aid benefit.

Desired Result: Practitioners and researchers will use patient reported outcome measures as a unique assessment tool. Additionally, patient reported measures may be used to direct future hearing-aid research, programming, auditory training, and treatment recommendations.

Level of Evidence: LEVEL IV - Historical cohort or case-control studies

IRB - Exempt

Immune Response of Macrophage Population to Cochlear Implantation

*Kathryn Y. Noonan, MD; Ivan Lopez, PhD
Gail Ishiyama, MD; Akira Ishiyama, MD*

Hypothesis: Macrophages play a role in both preserving cochlear integrity and in the immune response to cochlear implantation (CI).

Background: CI often induces a biologic reaction that may lead to implant failure or reduced hearing. Macrophages are found as resident immune cells in human cochlea and have been recently shown to phagocytize implant material. It has been demonstrated in animal models that macrophage populations increase with surgical stress, however there is limited knowledge of their function and response to CI. This study seeks to investigate the inflammatory response to cochlear implantation by comparing macrophages in implanted and non-implanted temporal bones.

Methods: Nineteen temporal bones from nine implanted ears, seven contralateral controls and three normal control ears were evaluated for the presence and distribution of CD68 and Iba1 positive macrophages.

Results: Two types of macrophages were detected in the cochleas: 1) CD68 or Iba1 positive macrophages only, and 2) CD68 and Iba1 colocalization in macrophages. Macrophage distribution was ubiquitous: They were present in the stria vascularis, Rosenthal canal and mid-modiolus intermingled in the spiral ganglia neurons area. Positive Iba1 and CD68 macrophages were found in the CI and non-CI contralateral and normal cochleas. Iba1 was seen in ramified/amoeboid cells, CD68 was seen in foamy, round macrophages. In CI cochlea, both types of macrophages were detected surrounding the CI path and fibrotic areas (Scala tympani or vestibule).

Conclusion: These results indicate both CD68 and Iba1 macrophages are present in response to CI and reside in the cochlea likely preserving cochlear integrity.

Define Professional Practice Gap & Educational Need: Cochlear implantation causes significant fibrosis and often results in loss of residual hearing. Steroids are often given to protect against the inflammatory response to inner ear insults yet this immune response is poorly understood. Studies have demonstrated that immune cells including macrophages can be found in normal cochlea. The response of these cells to surgical trauma and their contribution to the inflammatory process is yet to be described.

Learning Objective: Describe the distribution and macrophage population in normal human cochlea Compare macrophages in normal cochlea with cochlea that have undergone cochlear implantation Improved understanding of the immune response to surgical stress

Desired Result: Informed decision making with cochlear implant candidates Better management of the inflammatory response to surgical stress

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB - Approved

The Future of Cochlear Implant

Juichi Ito, MD, PhD

The future development of cochlear implant will be shown in the fields of mechanical and biotechnological development. As for biotechnological improvement we have investigated whether SGNs regeneration would improve the cochlear implant performance.

Model animals of guinea pigs and monkeys with degeneration of cochlear hair cells and SGNs were made. Cell transplantation to the SGN area was performed. As for donor cells mesenchymal stem cells (MSCs), embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSCs) were used. Then cochlear implant was performed.

After that electrically stimulated auditory brain stem response (eABR) was investigated. The threshold of eABR measured from cell transplanted animals were lower compared to control animals without cell transplantation.

As for mechanotechnological Improvement a new CI device has been developed. Newly invented device is called artificial auditory epithelium (AAE) or HIBIKI device. The mechanism of AAE is to vibrate the basilar membrane of the cochlea and cause distortions of the vibrating portion of the device. Then electricity produced by the vibrating portion is lead to the SGNs (cochlear nerve) by electrodes and stimulate them. The characteristic of this device is totally-implantable in the inner ear, as well as there is no need of extra battery.

In conclusion both biotechnological way with cell transplantation and mechanotechnological way by AAE are promising way for the future development of CI.

Define Professional Practice Gap & Educational Need: Lack of contemporary knowledge for the development of cochlear implant

Learning Objective: Learn gap between current and future cochlear implant

Desired Result: Attendee will learn the future development of cochlear implant

Level of evidence does not apply because: this presentation is something research level for the near future clinical use

IRB - Approved

Evaluation of Intracochlear Trauma with Manual and Robotic-assisted Cochlear Implant Insertion

*Christopher R. Kaufmann, MD; Allan M. Henslee, PhD
Marlan R. Hansen, MD*

Hypothesis: The objective was to evaluate the effect of cochlear implant (CI) insertion technique on electrode position and intracochlear trauma in cadaveric cochleae. We hypothesize that a robotic assistive insertion device will reduce intracochlear trauma compared to manual insertions.

Background: Variability in CI outcomes exists across patients, implant centers, surgeons, and electrode types. While surgical techniques that reduce electrode insertion trauma are well established, insertion trauma remains one contributing factor to variability in CI outcomes. Prior work has shown that robotic-assisted insertion tools reduce both maximum insertion forces and insertion variability compared to manual insertions.

Methods: Round window CI electrode insertions were performed either by hand (n=12) or utilizing a robotic assistive device (iotaSOFT, n=12) in fresh frozen, human cadaveric cochleae using electrodes from 4 different CI manufacturers. Following insertions, samples were imaged via high resolution X-ray microscopy (Zeiss Xradia) to evaluate electrode position and intracochlear trauma according to the Eshraghi scale.¹

Results: Electrode insertions performed manually had an insertion angle of $358.5 \pm 113.2^\circ$ compared to $325.4 \pm 84.5^\circ$ for device-assisted insertions. Electrode insertions performed manually exhibited a higher Eshraghi score of 3.1 ± 1.2 compared to 1.6 ± 0.5 for device-assisted insertions. Manual insertions had higher rates of scalar translocations and fracture of the osseous spiral lamina.

Conclusions: The robotic-assistive system reduced trauma and scalar translocations associated with electrode insertions in cadaveric cochleae compared to manual insertions. Surgical tools which help to precisely and more consistently insert electrodes may improve CI outcomes, including hearing preservation.

Define Professional Practice Gap & Educational Need: Inconsistencies in insertion techniques of cochlear implant electrodes.

Learning Objective: Attendees should understand differences in intracochlear damage observed between robotically-assisted and manual (by hand) cochlear implant electrode insertions.

Desired Result: Attendees can make more informed decisions regarding cochlear implant electrode insertions.

Level of evidence does not apply because: This is not a clinical study.

IRB - Exempt

Effect of Laser Stapedotomy on Intracochlear Pressure Measurements

*Emily S. Misch, MD; Renee M. Banakis Hartl, MD, AuD
Samuel P. Gubbels, MD; Nathaniel T. Greene, PhD*

Hypothesis: Surgical manipulations during laser stapedotomy can produce intracochlear pressure changes comparable to pressures created by high-intensity acoustic stimuli.

Background: New-onset sensorineural hearing loss is a known risk of stapes surgery and may be related to pressure changes within the cochlea during laser use or other surgical manipulations. Here, we test the hypothesis that high sound pressure levels are generated during laser stapedotomy.

Methods: Human cadaveric heads underwent mastoidectomy. Fiber-optic sensors were placed in scala tympani and vestibuli to measure intracochlear pressures during key steps in stapedotomy surgery, including cutting stapedius tendon, lasering of stapedial crurae, crural downfracture, and lasering of the footplate. The difference in pressure magnitude between key steps was calculated using a one-way ANOVA.

Results: Key steps in laser stapedotomy produced high-intensity pressure spikes in the cochlea. Pressure transients were comparable to intracochlear pressures measured in response to high intensity impulsive acoustic stimuli.

Conclusion: Our results demonstrate that surgical manipulations during laser stapedotomy can create significant pressure changes within the cochlea. Intracochlear pressure magnitudes were comparable to high-intensity acoustic stimulation. Results from this investigation suggest that intracochlear pressure transients from stapedotomy may be of sufficient magnitude to cause damage to the sensory epithelium and affirm the importance of limiting surgical traumatic exposures.

Define Professional Practice Gap & Educational Need: Limited understanding of the intracochlear environment during laser stapedotomy surgery.

Learning Objective: 1. Better appreciate the potential for causing cochlear trauma during laser stapedotomy. 2. Develop an understanding of the relative levels of damaging exposures by examining the equivalent ear canal sound pressure level exposures that correlate with cochlear pressure levels during laser stapedotomy.

Desired Result: 1. Participants will improve understanding of the potential intraoperative causes of new-onset SNHL after laser stapedotomy. 2. Participants will consider iatrogenic cochlear trauma from intracochlear pressure transients created during laser stapedotomy when analyzing their own patient outcomes.

Level of Evidence does not apply because: This is a basic science translational project aimed at examining the potential mechanism of cochlear trauma that cannot be randomized or blinded in a traditional sense.

IRB - Exempt

Utility of Perilymph microRNA Sampling for Identification of Active Gene Expression Pathways in Otosclerosis

Helena Wichova, MD; Matthew Shew, MD; Hinrich Staecker, MD, PhD

Hypothesis: Profiling of microRNA (miRNA) within perilymph samples collected at the time of stapedectomy can be utilized to identify active gene expression pathways in otosclerosis as compared to controls.

Background: MiRNAs are small non-coding RNAs that effect gene expression by post-transcription regulation and silencing. Perilymph sampling allows for a novel way to collect material actively involved in the disease process.

Methods: Perilymph was collected at time of stapedectomy, underwent a microarray analysis, and significantly expressed miRNAs were correlated to known bone morphology pathways using a cochlear transcriptome library. To determine miRNA related specifically to otosclerosis hearing-reservation cochlear implant controls were used for statistical analysis.

Results: A total of 321 significantly expressed miRNAs were identified within the four otosclerosis perilymph samples. MiRNAs associated with 23 genes involved in bone morphology pathways were significantly expressed. A significant difference in the otosclerotic samples as compared to control was noted in miRNA expression regulating HMGA2, ITGB3, SMO, CCND1, TP53, TP63, and RBL2 gene pathways. No significant difference was noted in miRNAs expression associated with ACE, RELN, COL1A1, and COL1A2, genes which were previously correlated with otosclerosis.

Conclusions: Perilymph miRNA profiling obtained at the time of stapedectomy consistently identifies differentially expressed genes compared to controls. Perilymph miRNA sampling with cochlear transcriptome library cross-referencing can be successfully utilized to identify active gene expression pathways in otosclerosis.

Define Professional Practice Gap & Educational Need: Lack of contemporary knowledge regarding pathogenesis of otosclerosis

Learning Objective: To utilize microRNA profiling of perilymph samples collected at the time of stapedectomy to identify active gene expression pathways in otosclerosis

Desired Result: Perilymph miRNA sampling with cochlear transcriptome library cross-referencing can identify active gene expression pathways in otosclerosis and identify potential pharmacologic intervention points

Level of Evidence: LEVEL III - Cohort and case-control studies

IRB: Approved