

SELECTED ABSTRACTS

**ORAL
PRESENTATIONS**

IN ORDER OF PRESENTATION



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AMERICAN OTOLOGICAL SOCIETY**

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**Age-related Patterns of Vestibular Dysfunction in Dizziness and Imbalance:
A Review of Vestibular Testing Results Among 1168 Patients**

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Jason A. Brant, MD Steven J. Eliades, MD, PhD
Douglas C. Bigelow, MD; Michael J. Ruckenstein, MD*

Objective: To identify and characterize differences in vestibular testing results among patients presenting with balance-related complaints; to stratify patterns of vestibular testing abnormalities by age

Study Design: Retrospective chart review

Setting: Academic Balance Center at a Tertiary Referral Center

Patient Population: All patients who underwent vestibular testing from August 2017-August 2018

Main outcome measure: Balance function test results

Results: We reviewed 1168 patients with ages ranging from 11-94 years, including 414 patients 65+ years and 754 patients <65 years. Most patients who underwent testing had at least one abnormal result, with only 22% of patients 65+ years and 40% of patients <65 years yielding no test abnormalities ($p < 0.01$). Among the 781 individuals with abnormal testing results, caloric testing did not result in any significant difference between age groups. Patients 65+ years of age were more likely to demonstrate abnormalities on saccadic and horizontal tracking eye movement ($p < 0.01$), as well as positional and Dix-Hallpike testing with videonystagmography ($p < 0.05$). On computerized dynamic posturography, there were significantly more abnormal composite scores in the older group for both sensory organization testing and motor control testing ($p < 0.01$). On further analysis of patients 65+ years, the highest proportion of abnormal testing was found in patients aged 75-84 years of age ($p < 0.01$).

Conclusion: Among patients presenting with imbalance or dizziness, a majority of patients demonstrate at least one abnormality on balance function assessment. While caloric abnormalities occur across the life span, patients 65+ years of age are more likely to have abnormal results in eye tracking, positional, dix-hallpike testing, and posturography.

Define Professional Practice Gap & Educational Need: To identify and characterize differences in vestibular testing results among patients presenting with balance-related complaints; to stratify patterns of vestibular testing abnormalities by age

Learning Objective: To describe differences in patterns of abnormalities in vestibular testing, To assess differences in the vestibular testing results in an aging population

Desired Result: To characterize and identify differences in identified vestibular abnormalities based on age.

Level of Evidence - IV

Indicate IRB or IACUC : Approved by the University of Pennsylvania Institutional Review Board. IRB Approval # 831279. Date of Approval: 7/27/2018

Relationship between Vestibular Function and Response to Treatment in Vestibular Migraine

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Objective: To examine the impact of peripheral vestibular function on response to treatment in vestibular migraine (VM).

Study Design: Retrospective cohort.

Setting: Vestibular-focused, neurotology clinic.

Patients: Definite VM patients who underwent caloric testing between 12/2015 and 3/2019.

Interventions: Pharmacologic treatment and vestibular rehabilitation.

Main Outcome Measures: Asymmetry on bithermal caloric testing and Dizziness Handicap Inventory (DHI) scores.

Results: 31 patients were included, with mean age of 48.7 ± 20.0 years and mean follow-up of 9.1 ± 8.1 months. Mean caloric asymmetry was $15.1 \pm 15.6\%$ (range 0–52), with 6 (19.4%) patients having asymmetry $>25\%$ (range 35–52). There was significant improvement in DHI total ($p=0.023$), emotional ($p=0.019$), and functional ($p=0.004$) domain scores, but not physical domain ($p=0.391$) scores. Both asymmetry $<25\%$ and asymmetry $>25\%$ groups had significant improvement in DHI functional domain scores ($p=0.017$, $p=0.011$, respectively), and both had no significant improvement in physical domain scores ($p=0.510$, $p=0.308$, respectively). However, those with caloric asymmetry $>25\%$ had significant improvement in total DHI scores ($p=0.012$) and emotional domain scores ($p=0.014$), while those with asymmetry $<25\%$ did not ($p=0.065$ and $p=0.057$, respectively). Greater unilateral weakness correlated significantly with better pre-treatment DHI scores on question 1 ($r=-0.417$, $p=0.020$, physical domain) and 8 ($r=-0.499$, $p=0.004$, physical domain), but less improvement on questions 10 ($r=0.510$, $p=0.015$, “Because of your problem have you been embarrassed in front of others?”, emotional domain).

Conclusions: Compared to VM patients without peripheral vestibular weakness, those with vestibular dysfunction may experience greater improvement in quality of life after treatment, especially in the emotional domain, based on patient-reported outcome measures.

Professional Practice Gap & Educational Need: The role of peripheral vestibular dysfunction in the disease course of VM is unclear. There is also a lack of VM-specific tools to measure treatment outcomes.

Learning Objective: To understand how patients with concurrent VM and peripheral vestibular weakness may present and respond to treatment, and to explore how different domains of quality of life are affected by treatment in the setting of various degrees of vestibular dysfunction.

Desired Result: Physicians should assess for concurrent vestibular dysfunction in patients with VM and advise patients with vestibular weakness that improvement should still be expected with treatment, especially in the emotional domain. Physicians should also be observant of specific areas of quality of life most affected by VM and initiate research in designing more specific outcomes measurement instruments.

Level of Evidence: IV

IRB: Pro00050097 Medical University of South Carolina

Long Term Outcomes from Gamma Knife Treatment for Vestibulocochlear Nerve Schwannomas in a Large, Tertiary Care, Academic Hospital

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Objective: Describe long-term hearing outcomes with audiologic data with modern stereotactic radiosurgery techniques for vestibular schwannoma tumors.

Background: Since the mid 20th century, stereotactic radiosurgery has been an option for central nervous system tumors. Due to the non-invasive manner of treatment, this was extended to treatment for benign vestibular schwannomas without intracranial surgery. Modern advances have localized radiation and reduced dosage, but data is still lacking in the long term hearing outcomes of this method of treatment. As one of the national leaders in this procedure, we present our full database of these outcomes over the full time period of our institutions utility of this modality.

Methods: A retrospective chart review was performed of all patients undergoing stereotactic radiotherapy for vestibular schwannomas within the study period of 1998-2019 and their audiograms analyzed along with patient data. Laterality Gardner-Robertson hearing score changes were the primary outcome analyzed for each patient; and controls were placed to accommodate for patient demographic data

Results: Long term, multi-year audiometric evaluation showed statistically significant loss of serviceable hearing and reduction in hearing ability with the use of stereotactic radiosurgery for treatment of vestibular schwannomas.

Conclusions: Little long term data exists on the audiometric outcomes related to stereotactic radiosurgery treatment for vestibulocochlear schwannomas. Our institution has performed more than 300 stereotactic radiosurgery treatments and present these data. Practitioners should advise patients with vestibulocochlear schwannomas regarding this aspect of treatment.

Define Professional Practice Gap & Educational Need: Long term data on modern stereotactic radiotherapy treatments for vestibular schwannomas in a single-center study are lacking in the literature.

Learning Objective: Participants should describe the long-term serviceable hearing outcomes from stereotactic radiosurgery and accurately consult patients on the otologic implications of different treatment options for benign vestibular schwannomas.

Desired Result: Participants will be able to do the above.

Level of Evidence - Level III

Indicate IRB or IACUC : IRB Approved through Northwestern University IRB STU00208907

Clinical Predictors of Delayed Facial Palsy after Resection of Vestibular Schwannoma

*Kareem O. Tawfik, MD; Michael Coulter, MD; Thomas Alexander, MD, MHSc
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Objectives:

1. Identify clinical predictors of delayed facial palsy (DFP) after microsurgical resection of vestibular schwannoma (VS).
2. Determine whether DFP predicts worse facial nerve (FN) outcomes.

Methods: Adult patients (≥ 18 years) who underwent translabyrinthine or retrosigmoid VS resection between February 2008 and December 2017 were retrospectively reviewed. Postoperative House-Brackmann (HB) FN function was assessed on the day of surgery, daily during patients' inpatient admission, and at postoperative clinic visits. Follow-up exceeded ≥ 12 months for all patients. DFP was defined as any decline in FN function relative to immediate postoperative FN function. DFP was routinely treated with high-dose steroids.

Results: Two hundred ninety-two patients were analyzed. Mean age was 51.5 years (± 12.2) and mean tumor size 20.6mm (± 10.8). DFP occurred in 38.4% of patients ($n=112$). Tumor size (per cm) was not a significant predictor of DFP (OR=0.982, $p=0.8728$). On multivariate analysis including DFP, age, gender, surgical approach, history of radiation, tumor size, HB at discharge, and preoperative FN weakness, DFP was found to independently predict final HB grade (OR 2.364, $p=0.0285$). In the subset of patients with DFP, interval between surgery and onset of paralysis was predictive of final outcome, with a longer time until onset of weakness (per day) indicating better odds of a lower final HB grade (OR 0.784, $p=0.0001$).

Conclusions: In this large series of patients who underwent VS resection, DFP was found to be a significant predictor of long-term FN outcomes. In patients who developed DFP, a longer interval between surgery and onset of weakness predicts better long-term FN function.

Define Professional Practice Gap & Educational Need: Delayed facial palsy after vestibular schwannoma resection can be a source of frustration and worry for patients and clinicians. In order to inform clinical decision-making and patient counseling, it is important to identify clinical predictors of this entity and describe its ramifications for long-term facial nerve outcomes.

Learning Objective: Participants will be able to describe the prevalence of delayed facial palsy among patients undergoing resection of vestibular schwannoma, understand clinical features that portend worse facial nerve outcomes, and describe how the time course of onset of delayed facial palsy affects outcomes.

Desired Result: Participants will have a deeper knowledge of how to counsel patients who develop delayed facial palsy after resection of vestibular schwannoma.

Level of Evidence – Level IV

Indicate IRB or IACUC: Kaiser Permanente Southern California IRB # 028473

Effects of Varying Laser Parameters during Laser Stapedotomy on Intracochlear Pressures

*Elizabeth F. Boscoe, MD; Renee M. Banakis Hartl, AuD, MD
Samuel P. Gubbels, MD; Nathaniel T. Greene, PhD*

Hypothesis: Laser power and pulse duration correlate with intracochlear pressures during laser stapedotomy.

Background: Sensorineural hearing loss is a known complication of stapes surgery. We have previously shown that laser stapedotomy can result in intracochlear pressures that are comparable to high sound pressure levels. In the interest of limiting potential cochlear trauma, optimizing laser settings to those which correspond with the lowest pressure changes may mitigate risk for postoperative sensorineural hearing loss. Here we test the effects of varying laser parameters on intracochlear pressures, in order to more precisely determine which settings present the highest risk for hearing loss with the overarching goal of guiding surgical practice.

Methods: Human cadaveric heads underwent mastoidectomy. The 980nm diode laser was applied to the stapes footplate, and laser power and pulse lengths were varied. Intracochlear pressures were measured via fiber optic pressure probes placed in scala vestibuli and scala tympani.

Results: High intensity pressures were observed in the cochlea during laser stapedotomy at all settings, and the observed pressures increased monotonically with laser power. Likewise, pressures showed relatively constant deviations from baseline during the entire laser pulse durations, with very fast onsets and offsets.

Conclusions: Results confirm significant pressure changes occur during laser stapedotomy. Intracochlear pressures could cause injury via either quasistatic or transient mechanisms, and overall energy delivered will depend on both duration and number of pulses delivered. While the risk to hearing from each component remains unclear, these results affirm the need to optimize laser settings for hearing preservation.

Define Professional Practice Gap & Educational Need: 1. Limited understanding of effects of 980nm diode laser on intracochlear pressures. 2. Undetermined ideal laser parameter settings with variety of parameters used by different surgeons. 3. Unclear effect of laser settings on possible sensorineural hearing loss during laser stapedotomy.

Learning Objective: 1. Better understand the effects of laser stapedotomy on intracochlear pressures. 2. Help guide surgical practice when determining appropriate laser settings during laser stapedotomy.

Desired Result: 1. Appreciate the effects of varying laser parameters during laser stapedotomy on intracochlear pressures. 2. To provide objective data on effects of varying laser parameters and to help guide clinical decision-making during laser stapedotomy.

Level of Evidence – Does not apply

Indicate IRB or IACUC : Exempt

The Transcanal versus the Post-Auricular Approach Is There a Difference in the Patient's Pain?

*Geoffrey C. Casazza, MD; Hilary C. McCrary, MD; Alexander S. Ramirez, MD
Paul R. Krakovitz, MD; Richard K. Gurgel, MD
Clough Shelton, MD; Jeremy D. Meier, MD*

Objective: Understand opioid prescribing patterns in otologic surgery and the difference in opioid use between transcanal and post-auricular surgery

Study Design: Prospective survey

Setting: Multihospital network

Patients: All patients undergoing otologic surgery from March 2017 to August 2018.

Intervention: Patients undergoing otologic surgery were surveyed regarding post-operative opioid use and their level of pain control. Patients were divided by surgical approach (transcanal vs. post-auricular). Those who underwent mastoid drilling were excluded. Narcotic amounts were converted to oral morphine equivalents (OME) for analysis.

Main Outcome Measures: Amount of opioid was calculated and compared between the two groups. Mann Whitney U-test and Chi-square testing were used for analysis.

Results: Fifty-five patients were included in the analysis; of these 18 (33%) had a post-auricular incision. There was no difference in age ($p=0.85$) or gender ($p=0.5$) between the two groups. The mean amount of opioid prescribed (OME) in the post-auricular and transcanal groups was 206.4 and 143 ($p=0.038$) while the mean amount used was 37.7 and 37.5 ($p=0.29$) respectively. There was no difference in percentage of opioid used ($p=0.44$) or in patient reported level of pain control ($p=0.49$) between the two groups.

Conclusion: Patients in both the transcanal and post-auricular groups used only a small portion of their prescribed opioid. There was no difference in the amount of opioid used or the patient's reported level of pain control based on the approach. Otologic surgeons should be aware of these factors to reduce narcotic diversion after ear surgery.

Define Professional Practice Gap & Educational Need: Opioid abuse has become a national crisis. Surgeons should understand their role and their actions can influence the crisis further.

Learning Objective: Understand opioid prescribing and patient use in otologic surgery.

Desired Result: Surgeons will understand patient's perceived pain after otologic surgery to better prescribe opioid pain medications.

Level of Evidence – Level 3

Indicate IRB or IACUC: Exempt

The Value of Diffusion-weighted Imaging for Postoperative Surveillance of Cholesteatoma following Tympanomastoidectomy

*Zachary G. Schwam, MD; Daniel D. Bu, BA; Vivian Z. Kaul, MD
George B. Wanna, MD; Maura K. Cosetti, MD*

Objective: To evaluate DWI MRI as a minimally invasive method of monitoring for recurrent or residual cholesteatoma >6 months after primary surgery.

Study Design: Retrospective case series.

Setting: Tertiary referral center.

Patients: 108 consecutive patients (mean follow-up 2.4 years, range 6 months-3 years) with prior tympanomastoidectomy for cholesteatoma who underwent a DWI MRI >6 months postoperatively.

Interventions: 1.5 Tesla DWI MRI at > 6 months after surgery

Main Outcome Measures: Percentage of positive MRI signal during surveillance, percent surgery avoided, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Results: Of 108 consecutive patients, a positive MRI read was present in 25 patients. All 25 patients in addition to two who had negative MRI findings subsequently underwent second look surgery. Of these, 5 had no cholesteatoma seen intraoperatively. The most common locations of cholesteatoma found on DWI MRI were the epitympanum (n=9), mastoid (n=6), and mesotympanum (n=5). Of the 27 cases, the MRI read and intraoperative findings were discordant in two patients; both cases read as recurrence in the mastoid on imaging, but found to be in the epitympanum intraoperatively. Using this specific protocol, the percentage of surgery prevented was 92%; sensitivity 74%, specificity 50%, NPV 25%, and PPV 90%. The vast majority of patients with negative MRIs did not undergo second-look exploration.

Conclusions: In a consecutive case series for cholesteatoma surveillance, in which positive imaging findings dictated subsequent second look surgery, DWI MRI was found to have high positive predictive value as an initial screen.

Define Professional Practice Gap & Educational Need: Variation in protocol for evaluating the possible diagnosis of residual and recurrent cholesteatomas.

Learning Objective: Comprehension of the utility of DWI-MRI in diagnosing recurrent and residual cholesteatoma.

Desired Result: Optimization of cholesteatoma surveillance protocols.

Level of Evidence – Level IV

Indicate IRB or IACUC : Mount Sinai Hospital IRB-17-02085

Utility of the 'Invert Function' in Delineating Fine Structures in Temporal Bone CT

Tyler R. Schwartz, MD; Gino Mongelluzzo, MD; Arun K. Gadre, MD

Objective: The aim of this paper is to demonstrate the utility of grey-scale inversion (invert function) as a unique image processing technique, in order to improve visualization of subtle pathology in the temporal bone CT scans. This technique has been utilized by the senior author for several years.

Study Design: Idea, Novel Technique

Setting: Tertiary Referral Center

Patients: Patients referred to the neurotology service with temporal bone CT scans demonstrating subtle anatomic and/or pathologic findings.

Interventions: Diagnostic

Background: Grey-scale inversion has been demonstrated in the radiology literature to improve the detection of pulmonary nodules. This is based upon the concept of contrast threshold, which describes the relative luminance increment that is required to detect a signal. It is supported by physiology literature which reports that optimal contrast perception occurs when a dark object is placed against a bright background.

Main Outcome Measures: Provide a series of cases where questionable findings seen on an unprocessed image are revealed using the invert function on the same image.

Results: The improved visualization of subtle findings is demonstrated in a series of images demonstrating pathology and anatomic variants such as semicircular canal dehiscence, facial nerve dehiscence, otic capsule dehiscence, ossicular pathology, otosclerosis and cholesteatoma.

Conclusions: The invert function can improve the ability of the observer to detect subtle anatomic and pathologic changes in temporal bone CT scans for both diagnosis and pre-operative evaluation.

Define Professional Practice Gap & Educational Need: Cases such as superior semicircular canal dehiscence, facial nerve dehiscence, fistulae of the otic capsule and the stapes footplate, or erosion of the ossicles in an opacified middle ear space frequently have very subtle changes on CT scans. This can make it difficult to make a definitive diagnosis. Our paper describes a novel technique for improving CT imaging analysis.

Learning Objective: Demonstrate an adjunctive tool used to evaluate CT of the temporal bones

Desired Result: Improve diagnostic evaluation and pre-operative planning when reviewing a temporal bone CT

Level of Evidence: Level V

Indicate IRB or IACUC: Exempt

Vitamin D Deficiency is Associated with Hearing Loss in the Elderly

Betsy Szeto, MPH; Anil K. Lalwani, MD

Background: Bone mineral density (BMD) has been putatively linked to hearing loss. However, the roles of serum calcium levels and vitamin D status have yet to be elucidated. The purpose of this study is to examine the relationship between BMD, calcium levels, vitamin D status, and hearing loss in a nationally representative sample.

Methods: Using the National Health and Nutrition Examination Survey (2005-2006 and 2009-2010), audiometry and BMD data of participants ages 70 and over were analyzed. Femoral neck and total spine BMD were measured using dual-energy x-ray absorptiometry. Hearing loss was defined as pure tone averages at 500, 1000, 2000, and 4000 Hz greater than 25 db HL in either ear. Multivariable logistic regression was used to examine the relationship between hearing loss and BMD, vitamin D status, and calcium levels, adjusting for covariates.

Results: 1278, 738, 1542, and 1542 participants were included in multivariable analyses for femoral neck BMD, total spine BMD, calcium levels, and vitamin D status, respectively. Femoral neck BMD (odds ratio [OR], 0.81; 95% confidence interval [CI], 0.27-2.45), total spine BMD (OR, 0.53; 95% CI, 0.12-2.24), and calcium levels (OR, 1.01; 95% CI, 0.64-1.57) were not found to be associated with hearing loss. Vitamin D deficiency was found to be associated with increased odds of hearing loss (OR, 1.67; 95% CI, 1.11-2.52).

Conclusions: In the elderly, vitamin D deficiency, but not BMD or calcium levels, was associated with hearing loss. These findings, if replicated, suggest that vitamin D supplementation may be an important intervention to prevent hearing loss.

Define Professional Practice Gap & Educational Need: A possible link may exist between bone mineral density (BMD) and hearing loss, but research on the topic continues to be limited.

Learning Objective: To determine the relationship between BMD, calcium levels, vitamin D status, calcium levels, and hearing loss.

Desired Result: A quantification of the relationship between hearing loss and BMD, calcium levels, and vitamin D status, respectively.

Level of Evidence: Cross-sectional data analysis

IRB: Exempt

Central Auditory Processing and the Relationship to Perceived Hearing Difficulty

*Brandon A. Shepherd, MD; Charles E. Bishop, AuD, PhD
Christopher Spankovich, AuD, PhD, MPH Dan Su, MPH
Karen Valle, MS; John M. Schweinfurth, MD*

Objective: There are limited population-based studies on auditory processing. We aimed to assess the relationship between central auditory processing (CAP) measures and perceived hearing loss (PHL) despite normal pure-tone audiometry.

Study Design: Cross-sectional.

Setting: Tertiary academic center

Patients: Participants of an African-American cohort (26% male; Age 54.2, SD 9.2) with normal hearing as evidenced by Pure Tone Audiometry defined as PTA4 (Average of 500, 1000, 2000, and 4000 Hz) <25dBHL (n=911) or across all tested frequencies (AF: 500, 1000, 2000, 4000, 8000 Hz) < 25dBHL (n=516).

Interventions/Main outcomes: The Quick Speech-in-Noise (QSIN) and Dichotic Digits, Double Pairs (DDT) tests were used to assess CAP. Logistic regression models adjusted for age, sex, education, and hearing level were used to examine various measures of CAP on the primary outcome of PHL.

Results: PHL was present in 251 (28%) and 137 (27%) participants using the PTA4 and AF models, respectively. Fully adjusted regression models revealed that each 1-point increase in QSIN increases the odds of reporting PHL by 13.7% (OR 1.137, p<0.001, (95% CI: 1.084,1.192)) using the PTA4 model and 15.0% (OR 1.150, p<0.001, (95% CI: 1.079,1.226)) using the AF model. For DDT testing, each 1% reduction in score increased the odds of reporting PHL by 7.7% (OR 0.923, p=0.002, (95% CI: 0.877,0.971)) in a fully adjusted PTA4 model and 6.6% (OR 0.934, p=0.041, (95% CI: 0.874,0.997)) when adjusting for all but PTA in the AF model.

Conclusion: We identified a high prevalence of CAP deficits in normal hearing patients with PHL within the study.

Define Professional Practice Gap & Educational Need: Patient's perception of hearing loss and audiometry do not always align. Measures of central auditory processing are useful, yet underutilized in patients with functional limitations yet audiometrically normal hearing.

Learning Objective: Learners should be able to understand the relationship of central auditory processing measures to patient's perception of hearing loss.

Desired Result: Education on CAP may raise the learner's awareness of factors related to perceived hearing loss and adjust practice patterns regarding further work-up of patients with normal audiometry yet hearing complaints.

Level of Evidence – LEVEL IV – Historical cohort or case control studies

Indicate IRB or IACUC : Approved - IRB 2006-0243

**Does “Unserviceable” Mean Unaidable?
Assessing Hearing Aid Outcomes in Patients with Word Recognition < 50%**

*Emma D. Tran, BSc; Austin Swanson, AuD; Matthew B. Fitzgerald, AuD
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Objective: To assess hearing aid (HA) outcomes of patients with word-recognition-in-quiet (WRQ) <50% in at least one ear—often classified as Class D or “unserviceable” hearing.

Study Design: Cross-sectional study

Setting: Tertiary referral center

Patients: Adult patients who have conducted audiometric testing at our clinic, tested at WRQ <50% in at least one ear, and did not go on to receive cochlear implantation (n=3,253).

Interventions: N/A

Main Outcome Measures: Hearing aid fitting and return rates, HA compliance measured with follow-up visits, and HA usage hours for individual ears and with respect to the contralateral ear performance.

Results: Chi-squared analysis of hearing aid fitting demonstrates that our clinic is fitting ears with WRQ <50% at a significantly lower rate than those with AAO-HNS Class B/C (“serviceable”) hearing (21.5% vs 36.7%, $p < 0.0001$). Of those actually fitted with HAs, return rates for ears with WRQ <50% mirror those with Class B/C hearing (13.7% vs 13.4% $p=0.95$). A significantly lower percentage of patients come for initial HA follow-up visits compared to those with Class B/C hearing (54.5% vs 61.7%, $p=0.03$), but this rate equalizes after 2 years from fitting (22.7% vs 24.4%, $p=0.59$).

Conclusions: Our results demonstrate that 21% of ears with WRQ <50% are being fitted with conventional HAs. Of those, over 80% of patients are keeping their HAs (and not going on to cochlear implantation), and at least a third of those are coming back for HA follow-up on a long-term (>1 year) basis. This suggests those with Class D hearing, generally considered “unserviceable,” can still be aidable.

Define Professional Practice Gap & Educational Need:

Various hearing classification guidelines including those for vestibular schwannoma and for cochlear implant candidacy have classified ears with WRQ <50% as “unserviceable.” However, hearing aid (HA) outcomes for conventional HA fitted to these ears have not yet been established.

Learning Objective:

- 1) There are some patients with WRQ <50% in at least one ear who are being fitted with HAs, keeping their HAs (without going on to be implanted) and are maintaining their HA through long-term follow-up greater than 1 year after fitting.
- 2) These HA outcomes suggest that some patients with WRQ <50% derive benefit from conventional HA in that ear.

Desired Result:

- 1) Legacy hearing classification schemes that describe absolute cut-offs may not be the best way to guide hearing device selection and what was previously described as Class D or “unserviceable” hearing may actually be aidable.
- 2) In light of expanding criteria for cochlear implantation—and especially after the FDA approval of CI for single-sided deafness and asymmetrical hearing loss—it is becoming more important to assess HA outcomes for various degrees of hearing loss to ensure those who can benefit from hearing aids are still being directed to try them.

Level of Evidence - IV

Indicate IRB or IACUC: IRB 50573, Stanford Health Care.

Marijuana and Tinnitus - Does it Help or Harm? Results from a Nationally Representative Sample

*Janet S. Choi, MD, MPH; Bhavishya Clark, MD; Joni K. Doherty, MD, PhD
John S. Ogahlai, MD, Courtney C.J. Voelker, MD, PhD*

Objective: Assess the association between marijuana and tinnitus in a nationally representative sample of US adults.

Study design: Cross-Sectional analysis

Setting: National Health and Nutritional Examination Survey

Patients: We analyzed data from the 2011-12 NHANES during which 2,844 participants aged 20-69 years who had complete data on tinnitus, audiometry, and substance use.

Main outcome measure: Tinnitus was defined as reporting any tinnitus in the past 1 year. Frequent marijuana use was defined as reporting use at least once a month for ≥ 1 year. Logistic regression was used to examine the associations. Depression was determined based on a validated assessment, PHQ-9. Sampling weights were incorporated to yield results that are generalizable to the US population.

Results: The prevalence of tinnitus was 16.9% [95%CI:14.5-19.3%] in US adults. The rates of ever marijuana and frequent marijuana use were 60.7% [95%CI:56.3-65.0%] and 27.7% [95%CI:24.1-31.3%], respectively. In a multivariate model adjusting for demographics, high-frequency hearing loss, and depression, the rates of tinnitus was significantly higher among ever marijuana users (OR: 1.33 [95%CI: 1.04-1.69]) and frequent marijuana users (OR: 1.36 [95%CI:1.02-1.81]) vs never marijuana users. The rates of tinnitus were higher among the frequent marijuana users (19.7% [95%CI:16.0-23.4%]) in comparison to the non-frequent marijuana users (14.9% [95%CI:11.9-17.9]) and never marijuana users (12.3% [95%CI:9.9-14.6%]). Severity or frequency of tinnitus was not associated with marijuana use. There was no association of tinnitus with cocaine, heroin or methamphetamine use.

Conclusions: Marijuana use was significantly associated with tinnitus in US adults. Observed dose-response relationships suggest that the marijuana use may worsen tinnitus. Future research is warranted to understand the causality of the association and its underlying mechanism.

Define Professional Practice Gap & Educational Need: The prevalence of marijuana use has significantly increased over the last decade. There have been contradicting anecdotal views on whether marijuana use worsens or improves tinnitus. However, studies on the effects of marijuana use on tinnitus have been mostly limited to animal models with inconsistent results. Current study is the first large nationally representative epidemiological study to assess the relationship between marijuana use and tinnitus.

Learning Objective: To examine the association between marijuana use and tinnitus in a population level. To explore various characteristics of tinnitus and marijuana use that can potentially elucidate the causal relationship.

Desired Result: Better understanding of the relationship between marijuana use and tinnitus after adjusting for relevant demographic and medical factors including high-frequency hearing loss and depression that are highly associated with tinnitus.

Level of Evidence: 2b

Indicate IRB or IACUC: Exempt

Non-Opioid Anesthesia in Otologic Surgery

Michael W. Randall, MD; Christopher Danner, MD; David Samuels, MD

Objective: To decrease the risk of opioid exposure in patients undergoing otologic surgery by utilizing non-opioid anesthesia and post-operative pain control methods.

Background: Opioid use disorder can often start with a prescription for post-surgical pain. The perioperative period represents an important opportunity to prevent introduction of opioids to all patients but especially those that are opioid naïve. In light of the opioid epidemic in the United States, there has recently been a shift toward non-opioid anesthesia in select cases to help prevent early exposure to opioids and drastically decrease the risk of opioid use disorder.

Study Design: Retrospective Chart Review

Setting: Outpatient surgery in a private practice otologic group at tertiary care center hospital

Patients: 504 adult patients undergoing otologic surgery

Interventions: Comparison of patients undergoing non-opioid anesthesia vs. patients that had anesthesia utilizing opioid medications. Non-opioid anesthesia medications include gabapentinoids, acetaminophen, non-steroidal anti-inflammatory drugs, ketamine, intravenous lidocaine, dexmedetomidine, and glucocorticoids.

Main Outcome Measures: Time from procedure end to extubation and wake up, post-operative pain ratings in the post-anesthesia care unit, the number of post-operative calls regarding pain control

Results: From our limited data collection so far, non-opioid patient pain control as measured by the pain scale in the post anesthesia care unit has been nearly equivalent to patients who underwent anesthesia utilizing opioids. The number of post-operative calls related to pain has been less in the non-opioid anesthesia group. The time from procedure end to extubation and wake up is less in the non-opioid group.

Conclusions: Non-opioid anesthesia is a safe practice for otologic surgery that decreases exposure to addictive opioids while having equivalent post-operative pain control. Utilizing non-opioid anesthesia also decreases time spent in the operating room waking up the patient.

Define Professional Practice Gap & Educational Need: There is an opioid epidemic in the United States with a major contribution from post-operative prescribing of opioids for pain control. Many patients have their first exposure to opioids from anesthesia which can potentially start a cascade leading to opioid use disorders.

Learning Objective: Demonstrate understanding of the opioid epidemic and the contribution from opioid utilizing anesthesia practices as well as post-operative prescription of opioids for pain control

Desired Result: While utilizing non-opioid anesthesia patients will still have adequate pain control without being exposed to potentially addictive opioid pain medications. It will also decrease non-surgical time spent in the operating room with a faster time to extubation, as well as decrease the number of post-operative calls regarding pain

Level of Evidence - Level III

Indicate IRB or IACUC: Exempt

Characterization of Ciprofloxacin Resistant Bacterial Response to High Dose Ciprofloxacin *in vitro* Assay

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Aravind S. Ponukumati, BS; Isabella W. Martin, MD
George A. O'Toole Jr., PhD; James E. Saunders, MD

Hypothesis: Ciprofloxacin-resistant bacterial isolates are able to withstand the high concentrations of ciprofloxacin present in commercially available ototopical solutions.

Background: Ciprofloxacin-resistant ear pathogens are commonly treated with topical solutions containing high concentrations of ciprofloxacin (3000 mcg/ml ciprofloxacin) assuming that the high concentration of topical ciprofloxacin will overcome the resistance. However, recent evidence has demonstrated poorer clinical outcomes for ciprofloxacin resistant bacteria treated solely with topical ciprofloxacin.

Methods: We evaluated 36 ciprofloxacin-resistant and 4 control isolates including *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Corynebacterium spp.* with ciprofloxacin minimum inhibitory concentration (MIC) assays and Ciprodex minimum bactericidal concentration (MBC) assays.

Results: Ciprofloxacin MICs ranged from 1–256mcg/mL with a mean of 88.5mcg/mL. Ciprodex MBCs ranged from 0.7–1500mcg/mL with a mean of 239.6mcg/mL. Ciprofloxacin MIC's between species were compared with Mann-Whitney U tests. There was no significant difference between MIC levels for *P. aeruginosa* and *Corynebacterium spp.* ($p=0.24$). Despite the higher MIC levels seen for *S. aureus*, no statistical difference was found when compared to *P. aeruginosa* ($p=0.17$) or *Corynebacterium spp.* ($p=0.10$). All MIC levels for all species were below the concentration of topical ciprofloxacin used.

Conclusions: *In vitro* levels of topical ciprofloxacin lower than the concentration of common ototopical solutions were able to inhibit growth in all clinical isolates tested. Ciprofloxacin-resistant *S. aureus* may be more tolerant of elevated ciprofloxacin concentrations. Other factors such as limited topical drug delivery to the middle ear, biofilms, or duration of drug delivery may work in concert with elevated *in vitro* resistance to influence patient outcomes.

Define Professional Practice Gap & Educational Need: Topical ciprofloxacin-containing solutions are regularly utilized in the setting of otitis media, even against organisms that demonstrate phenotypic ciprofloxacin resistance in laboratory testing. This study shows that *in vitro* concentrations of ciprofloxacin are able to inhibit growth in resistant isolates, however with studies showing limited fluoroquinolone penetration into the middle ear and rapid declines in concentration within hours, the efficacy of topical fluoroquinolones on ciprofloxacin resistant pathogens *in vivo* is still unknown.

Learning Objective: To describe the extent of ciprofloxacin resistance amongst a collection of resistant bacterial isolates and better understand the efficacy of the current standard treatment for ciprofloxacin-resistant pathogens in otitis media.

Desired Result: This *in vitro* study contributes to the literature by quantifying ciprofloxacin resistance amongst a collection of resistant isolates, and challenging the assumption that topical ciprofloxacin solutions are sufficiently concentrated to overcome high-level resistance. With the primary concern being penetration into the middle ear *in vivo*, we hope that this study increases awareness and healthy skepticism of the use of Ciprodex in cases of ciprofloxacin-resistant pathogens in otitis media. Even with our limited sample size, one isolate was able to survive up to a 1:1 dilution of Ciprodex.

Level of Evidence does not apply because: Basic Science Research

Indicate IRB or IACUC: Exempt.

Evaluating the Impact of Cochlear Implantation on Cognition in Older Adults

*Alvin deTorres, MD; Kaitlyn N. Urano, AuD; Kevin Duff,
PhD Norman L. Foster, MD; Richard K. Gurgel, MD*

Objective: To examine the effects of cochlear implantation on cognition in older adults with severe-profound sensorineural hearing loss.

Study Design: Prospective cohort study.

Setting: Tertiary referral center.

Patients: Cochlear implant (CI) candidates age 65 years and older (n=28).

Interventions: Single side cochlear implantation in the worse hearing ear.

Main Outcome Measures: Performance on audiometric tests (consonant-nucleus-consonant [CNC] word, AzBio sentence, pure tone average) and a battery of neuropsychologic tests (Mini-Mental Status Exam, d2 Test of Attention, Hopkins Verbal Learning Test, Digit span, Spatial span, Hayling Sentence Completion Test, Stroop test, Brief Visuospatial Memory Test, Trails A and B, Geriatric Depression Scale) were recorded before, six-months after, and twelve-months after CI surgery.

Results: Linear regression models show a correlation in tests of executive function with hearing improvement after cochlear implantation. Specifically, performance in digit span ($R^2=0.347$, $p=0.01$) and trails B ($R^2=0.285$, $p=0.02$) correlated with improved hearing. Performance in verbal learning and memory (Hopkins Verbal learning test) improved at both time intervals after cochlear implantation ($X^2(2)=5.99$, $p=0.018$).

Conclusions: CI in older adults can positively affect cognitive domains of learning, memory, and executive function. After one year of follow-up, similar changes were not observed in the cognitive domains of complex attention, perceptual motor function, and social cognition.

Define Professional Practice Gap & Educational Need: Lack of knowledge on the impact of cochlear implant on specific cognitive domains in older adults.

Learning Objective: 1) Understand the impact of cochlear implantation on cognition in older adults based on performance in neurocognitive testing. 2) Correlate hearing outcomes with performance on these tests.

Desired Result: Attendees will obtain a deeper understanding of the important relation of hearing to the multiple domains of cognition. Attendees will appreciate the potential impact cochlear implantation may have in older patients with severe-profound sensorineural hearing loss at risk for cognitive impairment. Our findings may inform future clinical trials as to which cognitive measures are most affected by cochlear implantation.

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

Indicate IRB or IACUC : Approved, University of Utah, IRB#83983, 9/15/2015

Cochlear Implant Benefit for Individual Patients: Dependence on Pre-Implant Aided Speech Recognition

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

Objective: Improvement after cochlear implantation is rarely reported for individual patients while considering statistical limitations inherent to dichotomous outcomes and percentage scores. We examined pre-operative aided vs. post-cochlear implant (CI) changes in speech recognition for individual patients relative to established 95% confidence intervals.

Study Design: Retrospective review of a prospectively maintained cochlear implant (CI) database.

Setting: Tertiary academic center

Patients: 407 adults undergoing cochlear implantation

Interventions/Main Outcome Measures: Pre-operative aided and ≥ 6 -month post-CI CNC word and AzBio sentence scores in quiet and noise (+10dB SNR).

Results: Mean improvement in aided to CI speech recognition was 33.4% (SD=21.7), 44.8% (SD=29.4), and 32.0% (SD=23.3) for CNC, AzBio quiet, and AzBio+10 respectively. For individuals, 14.5% (CNC), 10.9% (AzBio quiet), and 21.4% (AzBio+10dB SNR) had CI scores within 95% confidence intervals of their aided speech recognition scores (i.e., no significant improvement). These patients were more likely to have better pre-CI aided speech recognition in quiet ($d=0.90-0.94$) than patients who showed significant improvement; no patients with pre-CI aided CNC or AzBio quiet scores $>50\%$ showed significant improvement with CIs.

Conclusions: Cochlear implantation resulted in equivalent or improved speech recognition ability in the vast majority of patients. For patients with better pre-CI aided speech recognition, proper counseling should be provided, as these patients are less likely to significantly improve with CIs. Additional research is needed to assess other aspects of functional improvement for CI candidates with relatively good aided performance, in addition to those who become CI candidates based on relatively poor aided speech recognition in noise.

Define Professional Practice Gap & Educational Need: For patients with some degree of residual hearing or hearing aid-serviceable hearing, the decision to pursue a CI is complex. Patients must weigh the possible benefits of cochlear implantation against their current hearing aid benefit. However, analyses comparing pre-operative aided and post-CI speech recognition for individual patients in a large sample is lacking.

Learning Objective: To explore changes in CI outcomes for individual patients relative to 95% confidence intervals for common word and sentence recognition tests.

Desired Result: Practitioners and researchers will recognize that cochlear implantation is an effective treatment for patients with moderate to profound hearing loss as almost all patients (99.2%) had statistically equivalent or better speech recognition ability with their implant. However, significant improvements with cochlear implants may be less likely in patients with better aided speech recognition in quiet.

Level of Evidence – Level IV: Historical cohort or case-controlled studies.

Indicate IRB or IACUC : Approved on 12/20/17 by the Medical University of South Carolina IRB - Pro00073019

Can a Self-Report Measure Be Used to Assess Cognitive Skills in Adult Cochlear Implant Candidates?

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Aaron C. Moberly, MD*

Objective: To assess self-rated testing of cognition using the Behavior Rating Inventory of Executive Function – Adult (BRIEF-A) as a proxy for laboratory-based neurocognitive testing in addition to its relation to quality of life in adult cochlear implant (CI) candidates.

Background: Executive Functioning (EF) refers to neurocognitive abilities involved in behavioral regulation in the setting of goal-directed activity. EF has been evaluated in pediatric and adult cochlear implant (CI) users with deficits noted when compared to matched normal-hearing controls. Laboratory-based neurocognitive skills assessed in CI users have included measures of working memory, processing speed, inhibition-concentration, and nonverbal reasoning.

Methods: Twenty postlingually deaf adult CI candidates were enrolled. Participants completed self-reports of EF using the validated BRIEF-A survey. Participants additionally underwent formal laboratory-based neurocognitive testing, as well as assessment of quality of life using the Nijmegen Cochlear Implant Questionnaire (NCIQ). Pearson correlations were examined between both BRIEF-A and lab-based neurocognitive measures as well as BRIEF-A and quality of life scores.

Results: Self-report EF on the BRIEF-A demonstrated significant correlations with visual neurocognitive measures of working memory ($r = 0.8$) as well as with quality of life ($r = 0.6$).

Conclusions: Executive functioning as measured by BRIEF-A demonstrates correlations with laboratory-based metrics of neurocognitive ability as well as pre-operative quality of life. Our findings suggest that the BRIEF-A can be utilized in the pre-operative evaluation of adult CI candidates, perhaps as a surrogate for neurocognitive testing, at least for working memory skills, and self-report EF appears to relate to hearing-related quality of life.

Study Design: Retrospective Cohort

Define Professional Practice Gap & Educational Need: Facilitate evaluation of cognition in adult cochlear implant candidates in order to further our ability to accurately predict post-operative speech processing outcomes.

Learning Objective: To understand the potential value of including a self-report clinical measure of cognitive functioning in adult cochlear implant candidates.

Desired Result: Evaluate for correlation between BRIEF-A measurement of preoperative executive functioning with laboratory-based neurocognitive testing and a pre-operative quality of life metric

Level of Evidence - IV

Indicate IRB or IACUC : IRB #2015H0173

Cochlear Implantation Hearing Preservation Surgery: A Meta-Analysis

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Michael B. Gluth, MD; Marcus D. Atlas, MBBS
Nikolas H. Blevins, MD; Peter L. Santa Maria, MBBS, PhD*

Objective: To assess the effect of surgical techniques, electrode array design, and perioperative interventions on low frequency hearing preservation outcomes in cochlear implantation surgery.

Data sources: In accordance to the PRISMA guidelines, a thorough literature search was performed from January 1, 1995 to July 1, 2019 and included Ovid Medline, Embase, and PubMed. The search terms included were [(electric and acoustic hearing) OR (hybrid cochlear implant) OR (EAS cochlear implant*) or (partial deafness cochlear implant*) or (hearing preservation cochlear implant*)].

Study selection: Inclusion criteria were peer-reviewed publications evaluating hearing preservation as the primary goal of intervention. The search was restricted to human studies published in English. Studies were excluded if they were descriptive in nature or lacked hearing outcomes in accordance to pre-determined hearing preservation definitions.

Data extraction: Data such as surgical technique, electrode array characteristics, and the use peri- and operative steroids were extracted. Raw audiometric data were utilized when possible. Data were excluded if ambiguity of any variables existed.

Data synthesis: Multivariable ordinal logistic regression models were used for surgical technique, electrode array characteristics, and steroids. Statistical significance was defined as $p < 0.05$.

Conclusions: There continues to be a clear lack of consistency in hearing preservation definitions in literature. In this updated meta-analysis, the following are associated with superior hearing preservation outcomes: posterior tympanotomy, lubrication with electrode insertion, electrode fixation with soft tissue or fibrin glue, and straight electrode arrays. Conflicting results exist for intra- and post-operative steroid administration depending on the definition of hearing preservation.

Define Professional Practice Gap & Educational Need: From electrode array to the use of post-operative steroids, extreme variability exists in hearing preservation cochlear implantation surgery. The very definitions and criterion employed to assess hearing preservation outcomes are significantly varied. As a result, standardization across cochlear implant surgeons is lacking.

Learning Objective: 1. Assess the immense variability of hearing preservation definitions in cochlear implantation surgery.
2. Compare the influences of surgical techniques, electrode arrays, and steroid use on hearing preservation outcomes.

Desired Result: Heighten cochlear implant surgeons' awareness of the possibilities for improving outcomes in hearing preservation surgery.

Level of Evidence: N/A

Indicate IRB or IACUC: Exempt

Speech Recognition Outcomes in Adult Cochlear Implant Recipients using Slim Straight (CI522) or Slim Perimodiolar (CI532) Arrays

*Margaret E. MacPhail, MS; Nathan T. Connell, MD
David B. Pisoni, PhD; Charles W. Yates, MD; Rick F. Nelson, MD, PhD*

Objective: To compare patient outcomes between perimodiolar CI532 electrode and lateral wall CI522 electrode cochlear implants.

Study Design: Retrospective cohort study

Setting: Tertiary care unit – university-based medical center.

Patients: 64 patients with cochlear implantation of CI522 or CI532 (≥ 12 at age of implantation) and complete preoperative and postoperative audiologic function testing.

Interventions: Cochlear implantation with CI522 or CI532 electrodes. Measurement of preoperative aided pure tone average (PTA) and pre- and postoperative sentence recognition testing.

Main Outcome Measures: Audiologic function testing, accuracy of electrode placement, surgical complications

Results: Patients with lateral wall 522 electrode insertion (n=39) and perimodiolar 532 electrodes (n=25) were matched for mean (SD) age (59.1 [19.2] vs. 62.9 [12.9] years). Preoperative hearing capability, measured as a function of aided preoperative PTA (56.1 [17.7] vs. 54.1 [10.3] dB) and AzBio scores (11 [15.6] vs. 10 [16.4] % correct), demonstrated no significant difference. Postoperative audiologic tests (AzBio scores obtained at 6, 9, or 12 months follow-up) were similar between patients with 522 vs. 532 electrode arrays (72.9 [19.3] vs 66.0 [22.0] % correct, $P = 0.19$). In subgroup analysis of patients with more severe hearing deficits (preoperative AzBio scores $< 10\%$ correct), more patients with 522 electrodes achieved AzBio $> 70\%$ correct (66.7% vs 41.1%), but the average scores were not statistically different between 522 and 532 arrays (72.9 [20.7] vs. 65.8 [23.8] % correct, $P = 0.24$). No patients experienced tip rollover, facial nerve injury, or postoperative infection.

Conclusions: CI522 and CI532 provide comparable improvement in audiologic functioning. Lateral wall and perimodiolar electrode implants show similar progress in speech recognition outcomes.

Define Professional Practice Gap & Educational Need: Limited available information on comparable efficaciousness and reliability of electrode placement in CI522 and CI532 electrodes.

Learning Objective: A more complete understanding of how lateral wall electrode and perimodiolar electrode cochlear implants affect postoperative audiologic function.

Desired Result: Improve understanding of individual differences and variability in expected hearing outcomes between cochlear implant patients with 522 or 532 electrodes by utilizing pre- and postoperative speech recognition tests.

Level of Evidence: Level IV

IRB: #1807298113; Approved.

The Audiometric Profile of Today's Cochlear Implant Recipient Highlights Limitations of Traditional Candidacy Paradigms that Prioritize Binaural Performance

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Sara L. Hollander; Matthew L. Carlson, MD*

Objective: To characterize the pre-implant audiometric profile of today's conventional adult cochlear implant (CI) recipient in order to identify potential barriers to CI access.

Study Design: Retrospective case series

Setting: Tertiary referral center, October 2015 - December 2018

Patients: Adult cochlear implant recipients

Main Outcome Measures: Preoperative speech perception scores in the ipsilateral and contralateral ear, and the most recent ipsilateral postoperative speech perception scores.

Results: A total of 245 adults were identified. Mean age at time of CI candidacy testing was 71.2 years (IQR 65.4-81.2). Mean pre-implantation speech perception performance in the ear to be implanted was 15.4% (IQR 0-28) for CNC word scores, and 18.8% (IQR 0-35) for AzBio sentence scores in quiet. Mean speech perception performance in the contralateral ear was 40.9% (IQR 22-60) on CNC word scores, and 53.6% (IQR: 30.7-80.2) on AzBio sentence tests. On average, adult CI recipients improved 38.1% on CNC word tests and 51.9% on AzBio sentence tests in the ipsilateral ear following implantation ($P<0.001$).

Conclusions: Today, the majority of implant recipients present with asymmetrical hearing loss, where the poorer hearing ear scores significantly lower than the ipsilateral 50% sentence score cutoff, but the better hearing ear spans the binaural cutoff of 60%. These results suggest that a large number of candidates are disqualified by good speech perception in the better hearing ear. The current candidacy paradigm that prioritizes binaural best aided scores over ear-specific performance restricts access to cochlear implantation for a large population of patients who may otherwise benefit from this technology.

Define Professional Practice Gap & Educational Need: Since November 2000, the FDA candidacy criteria for cochlear implantation have been up to 50% sentence recognition in the ear to be implanted and up to 60% in the binaural best-aided condition. However, hearing loss remains a significant public health concern, and cochlear implants remain underutilized. The referral patterns for cochlear implant candidates warrant scrutiny.

Learning Objective: To characterize the pre-implant audiometric profile of today's conventional adult cochlear implant recipient in order to identify potential barriers to cochlear implant access.

Desired Result: To recognize the disparity between audiometric profiles in the modern cochlear implant recipient and the audiometric profiles described in current FDA candidacy guidelines, and improve referral and utilization rates for cochlear implants.

Level of Evidence: Level IV

Indicate IRB or IACUC: Approved 16-006130

Cochlear Implantation in Children 12 Months of Age and Younger: Evidence for Expansion of Pediatric Cochlear Implant Candidacy Criteria

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Colin L.W. Driscoll, MD; Brian A. Neff, MD; Matthew L. Carlson, MD*

Objective: To investigate surgical, anesthetic, and device-related complications as well as auditory and speech-language development outcomes associated with cochlear implantation (CI) in children ≤ 12 months of age.

Study Design: Retrospective study

Setting: Tertiary center

Patients: All children who underwent CI at ≤ 12 months of age and an audiometric control group implanted between 13-41 months of age.

Interventions: Cochlear implantation.

Main Outcome Measures: Surgical, anesthetic and device-related complications; postoperative audiometric and speech-language development outcomes.

Results: From the years 2002-2018, 81 ears in 46 patients met study criteria. The mean age at time of implantation was 8.8 months (range 4-12) and the mean duration of follow up was 60.6 months (0-188). The mean anesthetic time for bilateral cases was 193 minutes (range 101-282) and 98% of operations had <30 cc estimated blood loss. There were no major perioperative surgical or anesthetic complications. There were 4 device failures (5%) requiring re-implantation ranging from 4 months to 28 months following surgery. 96% of patients implanted ≤ 12 months of age are meeting or exceeding communication expectations compared to age-matched normal hearing peers. The cohort implanted ≤ 12 months of age had a higher proportion of subjects who acquired age-appropriate benchmarks for receptive and expressive language development and a higher proportion that achieved $>80\%$ on age-appropriate speech perception tests at last follow-up compared to children implanted at a later age.

Conclusions: Cochlear implantation in otherwise healthy children ≤ 12 months of age is safe when performed by an experienced team. Early access to sound through CI, when neuroplasticity is greatest, confers better long-term audiometric and speech-language development outcomes.

Define Professional Practice Gap & Educational Need: Pediatric cochlear implant labeling has not significantly changed in the last 20 years. Early access to sound in this group is critical in order to optimize audiometric and speech-language development outcomes.

Learning Objective: Cochlear implantation of pediatric patients less than 12 months of age is a safe procedure with the benefit of better long-term audiological outcomes.

Desired Result: Strong consideration of expanding FDA labeling for pediatric cochlear implant less than 12 months of age.

Level of Evidence – Level III- retrospective cohort study

Indicate IRB or IACUC: Approved IRB 16-006130

Comparative Analysis of Robotics-Assisted and Manual Insertions of Cochlear Implant Electrode Arrays

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

Hypothesis: We hypothesize that robotics-assisted cochlear implant (CI) insertion system will decrease the number of scala translocations with no significant difference in insertion depths compared to manual insertions across multiple surgeons and electrode types.

Background: Prior work has shown that our prototype robotic-assisted CI insertion system reduces insertion forces, variability, and traumatic events compared to manual insertions in benchtop setting by single system user. Here we assess a next-generation system use across multiple surgeons during simulated cadaveric surgery. The study compares the intracochlear electrode array position after both robotics-assisted and manual insertions using multiple electrode array types.

Methods: After brief system training period, 10 neurotologists performed bilateral electrode insertions into cochleae of full cadaveric heads (n=10) via facial recess approach using both the robotics-assisted system and manual insertion by hand. Lateral wall electrodes from 3 different manufacturers (n=20) were randomized between surgeons. Intracochlear position of the electrode was evaluated using high resolution 3D X-ray microscopy and trauma events were scored (0-5 scale) and compared between robotics-assisted and manual insertions.

Results: The robotics-assisted insertions decreased the incidence of scala translocations compared to manual insertions (30% robotic vs 60% manual, $p=0.17$, Chi-Square Likelihood Ratio Test). The robotics-assisted system also reduced the average trauma score from 2 ± 1.76 to 0.5 ± 0.7 ($p=0.07$).

Conclusions: Robotics-assisted insertion systems provide a means to standardize electrode insertions across individual surgeons and experience levels. Insertion techniques which reduce insertional variability and the likelihood of translocations have the potential to improve CI outcomes.

Define Professional Practice Gap & Educational Need: CI insertion techniques affect intracochlear electrode array position.

Learning Objective: Demonstrate benefits of robotics-assisted CI insertions on intracochlear electrode position.

Desired Result: Gain knowledge of how CI electrode array insertion technologies may improve CI outcomes.

Level of Evidence – Level II

Indicate IRB or IACUC: Exempt

Histopathological Findings Associated with Cochlear Implant Electrode Translocation

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Danielle R. Trakimas, MD, MSE David H. Jung, MD, PhD
Aaron K. Remenschneider, MD, MPH; Elliott D. Kozin, MD*

Objective: We aim to assess the histopathology of human temporal bones (TBs) with evidence of cochlear implantation (CI) electrode scalar translocation.

Study Design: Otopathology study.

Setting: Otopathology laboratory.

Patients: Temporal bones from patients who had a history of CI and histopathological evidence of interscalar translocation.

Intervention: Histopathological assessment of human TBs.

Main Outcome Measures: TBs from each patient were harvested postmortem and histologically analyzed for intracochlear changes in the context of CI electrode translocation. Clinical histories and CI performance were also reviewed.

Results: Nineteen human TBs from patients who underwent a CI during life and had histopathological evidence of electrode translocation were identified. The mean age at implantation was 64 years (± 11 years), and the mean age at death 75 years (± 11 years). All CI were multi-channel, 68% and 32% were straight and precurved electrodes, respectively. The most common site of translocation was the ascending limb of the basal turn (n=13 TBs), with injury of the lateral wall, disruption of the basilar membrane, fracture of the spiral osseous lamina occurring in 47%, 58% and 47%, respectively. The number of total spiral ganglion neurons (SGN) was lower, with an average of 60% less (range: 27%-84%) compared to age-matched controls. Fibroosseous changes were more commonly found in cases that the translocation injured the spiral osseous lamina (n=8 TBs).

Conclusions: Cochlear implant electrode translocation was associated with fibroosseous formation and lower population of SGN. Techniques to decrease the risk of electrode translocation are likely to result in lesser amount of fibroosseous changes, improved residual hearing and CI performance.

Define Professional Practice Gap & Educational Need: Atraumatic cochlear implant electrode insertion is essential for preserving residual hearing and successful auditory rehabilitation. Insertion trauma can result in scalar translocation, and be associated to a wide spectrum of injury to the cochlea including trauma to the lateral wall and modiolus, disruption of the basilar membrane and fracture of the osseous spiral lamina. An intracochlear injury caused by electrode translocation may lead to acute and long-term irreversible histological changes and limit electric acoustic stimulation.

Learning Objective: Understand how cochlear implant electrode translocation and associated intracochlear injury may cause permanent cochlear damage and prevent successful audiometric performance.

Desired Result: Cochlear electrode translocation can have an immediate impact on residual hearing and should be evaluated in cochlear implant studies and hearing outcomes.

Level of Evidence - IV

Indicate IRB or IACUC: Exempt

Predictors of Fibrotic and Bone Tissue Formation with 3-D Reconstructions of Post-Implantation Human Temporal Bones

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Ivan A Lopez, PhD; Akira Ishiyama MD*

Hypothesis: The number of years of cochlear implant use, surgical approach round window vs. cochleostomy, length of electrode and angular insertion may impact the degree of tissue fibrosis and bone formation

Background: Tissue fibrosis and bone formation after cochlear implantation (CI) are known phenomenon, and their presence has been implicated in poorer speech performance and loss of residual hearing of CI patients.

Methods: 3-D reconstructions were developed using histopathological slides evaluated under light microscopy from archival human temporal bones (HTBs) from patients with a history of CI. Fifteen HTB reconstructions were generated to evaluate the degree of tissue fibrosis and of bone formation.

Results: Longer years of implantation was a significant predictor of increased bone formation ($r=0.638$, p -value=0.011) and total new tissue formation ($r=0.588$, p -value=0.021), however there was not a correlation with fibrosis ($r=0.235$, p -value=0.399). Median total tissue formations was significantly higher in patients with a history of cochleostomy compared with round window insertions, 25.98% and 10.34%, respectively (Mann-Whitney $U=7$, $p=0.018$ two-tailed).

No correlation was found between electrode length and total new tissue ($p=0.192$), total bone ($p=0.193$), total fibrosis ($p=0.498$). No correlation was found between the degree of angular insertion and total new tissue ($p=0.35$), total bone ($p=0.27$), or total fibrosis ($p=0.83$).

Conclusions: An understanding of the factors which increase tissue fibrosis and bone formation is critical to improve speech performance and preserve residual hearing. While tissue formation did not extend apically beyond the electrode tip, no associations between electrode length or degree of angular insertion on increased tissue formation was noted. Increased years with the CI are associated with increased bone formation and increased total new tissue formation. Cochleostomy was associated with increased total tissue formation compared with round window. The round window insertion approach is preferred.

Define Professional Practice Gap & Educational Need: Lack of knowledge of the factors associated with increased degree of tissue formation.

Learning Objective: Increased years with CI are associated with increased fibrosis and bone formation. The round window approach is preferred due to the significant decrease in tissue formation compared with the cochleostomy approach.

Desired Result: Participants will gain a better understanding of factors leading to tissue formation following cochlear implantation

Level of Evidence - LEVEL V- Case series, studies

IRB: Approved, IRB 10-001449; Grant 1U24DC051910-01

Prematurity as a Risk Factor for Otologic Pathology
Zaroug Jaleel, B.S; Rita Y. Wang, B.S; Michelle C. Hsu, M.S
Jessica R. Levi, MD

Objective: Prematurity, defined by gestational age (GA) <37 weeks, is a risk factor for poor neonatal and early childhood outcomes. An understudied sequela of prematurity is its possible association with otologic pathology. This study explores the relationship between prematurity and otologic diagnoses, particularly characterizing hearing loss in prematurely-born children.

Study Design: Retrospective Case-control study

Setting: Tertiary referral center

Patients: Pediatric patients aged 0-18 presenting to an otolaryngology clinic with a primary otologic diagnosis. (i.e Sensorineural hearing loss (SNHL), Conductive Hearing Loss (CHL), Otitis Media, Eustachian tube dysfunction (ETD))

Interventions: Patients were retrospectively divided into four GA categories (<28 weeks, 28-32 weeks, 32-37 weeks, ≥37 weeks)

Main Outcome Measures: Adjusted odds ratio (aOR) of GA and associated otologic conditions.

Results: Adjusting for covariates, patients with low GA (<37 weeks) were significantly more likely to be diagnosed with CHL when compared to full-term children (≥37 weeks) ($p < 0.05$). This result held across all GA categories with <28 weeks (aOR [95% CI]) (4.26 [1.55-11.719]), 28-32 weeks (4.31 [2.12-8.79]), and 32-37 weeks (1.50 [1.02-2.19]). Prematurity was overall also associated with ETD compared to full-term children ($p < 0.05$) with ≥28 to <32 weeks (2.53 [1.48-4.32]) and ≥32 to <37 weeks (1.55 [1.18-2.03]). Prematurity was not significantly associated with SNHL, Otitis Media or a failed hearing screen.

Conclusions: Prematurity was associated with a higher rate of CHL and ETD diagnosis with no significant difference in SNHL diagnosis when compared to presenting full-term children. The results support an association between prematurity and otologic pathology.

REQUIRED:

Define Professional Practice Gap & Educational Need: Currently there is little research into the role prematurity plays in otologic pathology in pediatric patients. This is one of the first comprehensive studies looking at the association between low gestational age and common otologic diagnosis in pediatric patients.

Learning Objective: Understand prematurity as an independent risk factor for otologic pathology in pediatric patients with an increased rate of conductive hearing loss.

Desired Result: By the end of this lecture attendees should be able to discuss the otologic complications of prematurity

Level of Evidence – Level 3

Indicate IRB or IACUC : Exempt by Boston Medical Center IRB (H-37753).

An In Vivo Model as an Approach to Deliver Potential Therapies for Noise-Induced Hair Cell Loss

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Hypothesis: Our aim was to develop a minimally invasive approach for continuous delivery of therapeutics to the mouse cochlea.

Background: Techniques for cochlear drug delivery include systemic injection, trans-tympanic injection, endolymphatic sac injection, cochleostomy with perilymphatic perfusion and most recently round-window application.

Methods: Using a retrosigmoid approach, a hole was drilled into the posterior semi-circular canal of FVB mice (n = 36 mice) and a catheter attached to a micro-osmotic pump (1 ul/ hour, 3 days), was inserted. Fibrant sealant and fascia closed the opening. The pump, containing either an antioxidant plus DMSO or DMSO alone, was placed subcutaneously on the back. 100 dB SPL noise was presented for 30 minutes. Preoperative, post-noise and 14 days postoperative ABR testing at 8, 12, 16 and 24 kHz was performed for both ears.

Results: ABR thresholds pre- and post-noise exposure were compared between mice which were treated with one of six antioxidants plus DMSO, versus mice treated with DMSO alone. Pump insertion did not affect thresholds. Significantly threshold recovery was observed post-noise for mice treated with one of the antioxidants.

Conclusions: The semi-circular canal delivery model, used previously for acute, one-time delivery, presents a reliable approach for continuous drug delivery to the cochlea. Further advantages of this technique include avoidance of systemic toxicity, control of inner ear drug dosage, rapid onset of effect, and allowance of an intra-animal control ear. Disadvantages include disruption of the inner ear microarchitecture by puncturing the semi-circular canal wall.

Professional Practice Gap & Educational Need: Drug treatment for hearing loss is an emerging field, and research to identify optimal therapeutics is needed. Drug delivery to the cochlea is difficult and potentially damaging. A semi-circular canal approach avoids breaching the cochlea itself, providing a less invasive route to cochlear perilymph. Identifying novel therapeutics will improve the management of inner ear disorders.

Learning Objective: Techniques for drug delivery to the cochlea, ABR thresholds, Physiology of perilymph drainage, Noise-induced hair cell loss, Rodent anatomy of the inner ear

Desired Result: Establishing an *in vivo* model to test potential therapies for noise-induced hair cell loss and other inner ear disorders.

Level of Evidence: Level II

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