PROGRAM and ABSTRACTS

of the

One Hundred Fifty Fifth Annual Meeting

AMERICAN OTOLOGICAL SOCIETY

April 29-30, 2022
Hyatt Regency Dallas
Dallas, TX

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(2022 AOS Program Book)

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American Otological Society Mission Statement

Purpose

The American Otological Society, created in 1868, is dedicated to fostering a dialogue on and dissemination of, information pertaining to advances in evidence based diagnosis and management of otologic and neurotologic disorders. The focus on otologic and neurotologic disorders and scientific advances are translated to the provision of quality care that is consistent with the ACGME general competency areas and the Institute of Medicine competencies.

Target Audience

The primary target audience for the educational efforts of the American Otological Society is the current and potential members of the society. These members are physicians, physicians-in-training, audiologists and researchers in the fields of otology and neurotology. Educational activities are also open to other healthcare professionals who are involved in the care of patients with otologic and neurotologic conditions.

Activities

The primary activity of the American Otological Society is the Annual Meeting that focuses on the advancement of the scientific and clinical evidence that supports advances in otologic and neurotologic care to patients. Additionally, non certified educational support and resources include the publication and dissemination of peer reviewed and evidence-based content through *Otology & Neurotology* Journal and support for research in otology/neurotology and lateral skull base surgery and related disciplines.

Content

The content for the Annual Meeting and other related educational efforts are focused on otologic and neurotologic evidence based science, clinical standards of care, effects on communication, and other topics to the specialty.

Expected Results

The expected results are focused on enhancing knowledge translation and promoting competence for the membership and other identified target audiences. The Annual Meeting, the CME certified annual activity of the society, and the other scholarly activities such as the publication of the Journal and support for research provide a rich and robust environment for self assessment and reflection, access to resources for lifelong learning and opportunities for discussion and re-evaluation.

Resolution on Diversity of Meeting Presenters and Participation for the American Otological Society and the American Neurotology Society

- Whereas, the councils of the American Neurotology Society and American Otological Society desire to promote inclusivity within the membership of both organizations.

- Whereas it is recognized that diverse leadership and diversity of presenters allows for cross pollination of knowledge, perspective and experiences enabling a stronger and more robust educational experience for our members.

- Whereas the Councils of the organizations recognize the importance of acknowledging diversity among our patients, our trainees and our colleagues.

- Whereas, the purpose of the education programs of both organizations is to disseminate information designed to improve physician knowledge, patient care and outcomes, and advance the respective specialties.

- Whereas, valuable scientific contributions to Otology and Neurotology by colleagues (regardless of gender, race, or other attributes) should be presented at the society's respective meetings.

- Be it resolved that the Scientific Program Committees of the American Neurotology Society and American Otological Society will select speakers and panel members endeavoring to balance educational goals while promoting the diversity of our respective Societies' memberships and educational offerings.

- Be it resolved the Executive Councils of the ANS and AOS will select participation at all levels of the organizations endeavoring to reflect diversity of our respective Societies' memberships.

Continuing Medical Education Credit Information

CONTINUING MEDICAL EDUCATION CREDIT INFORMATION

Accreditation

This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of American College of Surgeons and American Otological Society. The American College of Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this live activity for a maximum of **7.25** *AMA PRA Category 1 Credits™*. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

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ABOHNS MOC Recognition Statement

Successful completion of this CME activity, which includes participation in the evaluation component, enables the participant to meet the expectations of the American Board of Otolaryngology's Maintenance of Certification (MOC) program. It is the American College of Surgeon's (the CME provider) responsibility to submit participant completion information to ACCME for the purpose of recognizing participation.

ABOHNS MOC Participant Data Privacy Information

If you are a Diplomate of the American Board of Otolaryngology-Head and Neck Surgery (ABOHNS) and would like to claim CME for MOC points for this educational activity (optional), you will be asked to provide personal information (Diplomate ID, first and last name, and month and day of birth) as part of the registration and/or evaluation process. The American College of Surgeons will only use this information to transmit your CME for MOC points to the ACCME on your behalf, upon successful completion of the activity.

IMPORTANT: **Completion of the AOS CME certificate must be done by June 5, 2022.** Registered attendees will receive an email from the AOS website with instructions for completing the evaluation and downloading a certificate of completion after the COSM meeting takes place. You must be registered for AOS to earn CME/MOC credit.

Program Objectives Educational Activity Details

What are the practice or patient care problems being addressed by this activity?

- Dementia related or exacerbated by hearing loss
- Management of hearing loss by cochlear implantation for patients with vestibular schwannoma
- Sensorineural hearing loss: causality and treatment

How will this activity improve the learners' competence (knowledge in action), performance (skill set) and/or patient outcomes (impact of care)?

Competence:

- Increased provider recognition of the relationship between hearing loss and cognitive decline and need for timely management.
- Increase knowledge of potential effective use of cochlear implantation for vestibular schwannoma.
- Increase recognition of inflammatory disease in sensorineural hearing loss and approaches to evaluation.

Performance:

- Knowledge will increase ability of providers to educate patients about the benefit of treating sensorineural hearing loss, thereby improving compliance with recommended interventions.
- Increase provider use of appropriate genetic testing and other evaluations for sensorineural hearing loss etiology.

Patient Outcomes:

- Reduce severity of dementia exacerbated by hearing loss through education of providers and the public about need for timely intervention when hearing loss occurs.
- Improve patient understanding of etiology of hearing loss and potential treatments, both current and emergent.
- Improved hearing though cochlear implantation for some patients with vestibular schwannoma.

State the learning objectives for this activity:

- Recognize when patients with vestibular schwannoma may benefit from cochlear implantation.
- Describe the mechanisms by which hearing loss may predispose to dementia and possible approaches to prevent or lessen its impact.
- Discuss the role of genetics in development of individualized precision medicine approach to treatment of hearing loss.
- Explain the role of inflammatory pathways and disease in causality of sensorineural hearing loss.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons must ensure that anyone in a position to control the content of the educational activity (planners and speakers/authors/discussants/moderators) has disclosed all financial relationships with any commercial interest (termed by the ACCME as "ineligible companies", defined below) held in the last 24 months (see below for definitions). Please note that first authors were required to collect and submit disclosure information on behalf all other authors/contributors, if applicable.

Ineligible Company: The ACCME defines an "ineligible company" as any entity producing, marketing, re-selling, or distributing health care goods or services used on or consumed by patients. Providers of clinical services directly to patients are NOT included in this definition.
Financial Relationships: Relationships in which the individual benefits by receiving a salary, royalty, intellectual property rights, consulting fee, honoraria, ownership interest (e.g., stocks, stock options or other ownership interest, excluding diversified mutual funds), or other financial benefit. Financial benefits are usually associated with roles such as employment, management position, independent contractor (including contracted research), consulting, speaking and teaching, membership on advisory committees or review panels, board membership, and other activities from which remuneration is received, or expected. ACCME considers relationships of the person involved in the CME activity to include financial relationships of a spouse or partner.
Conflict of Interest: Circumstances create a conflict of interest when an individual has an opportunity to affect CME content about products or services of a ineligible company with which he/she has a financial relationship.

The ACCME also requires that ACS manage any reported conflict and eliminate the potential for bias during the educational activity. Any conflicts noted below have been managed to our satisfaction. The disclosure information is intended to identify any commercial relationships and allow learners to form their own judgments. However, if you perceive a bias during the educational activity, please report it on the evaluation.

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You may view the AOS Speaker COI/Disclosure list on the **AOS website** or COSM program.

THE AMERICAN OTOLOGICAL SOCIETY WOULD LIKE TO THANK THE FOLLOWING MEMBERS FOR THEIR CONTRIBUTION TO THE 2022 AOS SCIENTIFIC PROGRAM

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All primary and contributing authors are required to complete a disclosure/conflict of interest statement and abide by the publication/copyright statements at time of abstract submission in order for the abstract to be considered by the Program Advisory Committee.

PUBLICATION STATEMENT: The material in these abstracts must not have been published or presented previously at another national or international meeting and may not be under consideration for presentation at another national or international meeting including another COSM society. The study detailed in these abstracts may be submitted for consideration for publication to Otology & Neurotology at any time after this call for papers begins. However, should the abstract be selected as a poster or an oral presentation, publication of the manuscript will be delayed until after the 2022 COSM meeting takes place. If this policy is violated, the ANS will prohibit presentation at the COSM meeting and the manuscript will be withdrawn from publication in print or online. The penalty for any duplicate presentation/publication is prohibition of the author from presenting at a COSM society meeting for up to three years. Duplicate submission to ANS or another participating COSM Society will disqualify your abstract immediately.

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Journal Requirements/Instructions to Primary Authors
Manuscripts are required of ALL ORAL AND POSTER presentations. Manuscripts must be submitted online a minimum of four weeks prior to the annual meeting, via the journal's Editorial Manager site:
https://www.editorialmanager.com/on/

Failure to comply with the guidelines & requirements of the American Otological Society and the O&N Journal will result in the disqualification of your presentation.

MARK YOUR CALENDAR!
The Abstract deadline for the 156th Annual AOS meeting in Boston, MA on May 5-7 is Thursday, October 15, 2022.
Abstract Instructions and submission form will be available on website in August.

The 57th Annual ANS Fall Meeting
"SUPER SATURDAY"
September 10, 2022
Philadelphia, PA

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AMERICAN OTOLOGICAL SOCIETY
155th Annual Meeting
PRELIMINARY PROGRAM
April 29-30, 2022
Dallas, TX

FRIDAY, APRIL 29, 2022

1:00 BUSINESS MEETING *(New member introduction)*
(Members Only)

1:30 SCIENTIFIC PROGRAM
(*Open to registered Members and Non-members – Badge required for admittance*)

1:30 WELCOME & OPENING REMARKS BY THE PRESIDENT
Marlan R. Hansen, MD

1:35 PRESIDENTIAL CITATIONS
Bruce J. Gantz, MD
Ronna Hertzano, MD, PhD
Matthew A. Howard, III, MD
Jay T. Rubinstein, MD, PhD
D. Bradley Welling, MD, PhD

1:45 INTRODUCTION OF GUEST OF HONOR
Marlan R. Hansen, MD

1:48 GUEST OF HONOR LECTURE
"How Does Hearing Loss Cause Dementia?"
Timothy D. Griffiths, FMedSci
Professor of Cognitive Neurology
Newcastle University Medical School
United Kingdom

2:18 INTRODUCTION OF ABSTRACTS
Meredith E. Adams, MD, Moderator
Oliver F. Adunka, MD, Moderator

2:20 Microneedles Facilitate Intracochlear Delivery Without Anatomic or Physiologic Injury
Stephen Leong, BA
Aykut Aksit, MS
Elizabeth S. Olson, PhD
Jeffrey W. Kysar, PhD
Anil K. Lalwani, MD

2:27 Risks of Noise-Induced Hearing Loss during Cochlear Implant Insertion Errors
Carolyn A. Chabuz, MD
Joseph Gonzalez, MD
Kenny Rodriguez, MD
John Peacock, PhD
Renee M. Banakis Hartl, MD
Stephen P. Cass, MD

Nathaniel T. Greene, PhD

2:34 Predictive Value of Trans-Impedance Matrix Measurements to Detect Electrode Tip Foldovers
Emily Kay-Rivest MD, MSc
Sean O. McMenomey, MD
Daniel Jethanamest, MD, MSc
William H. Shapiro, AuD
David R. Friedmann MD, MSc
Susan B. Waltzman PhD
J. Thomas Roland Jr. MD

2:41 Dynamic Behavior and Insertional Forces of a Pre-Curved Electrode Using the Pull-Back Technique in a Fresh Micro-Dissected Cochlea
Miriam R. Smetak, MD, MS
Katherine E. Riojas, PhD
Jack H. Noble, PhD
Robert F. Labadie, MD, PhD

2:48 AOS RESIDENT RESEARCH TRAVEL AWARD
Comparative Analysis of Robotics-Assisted and Manual Insertions of Cochlear Implant Electrode Arrays
Alexander D. Claussen, MD
Seiji B. Shibata, MD, PhD
Christopher R. Kaufmann, MD
Allan Henslee, PhD
Marlan R. Hansen, MD

2:55 DISCUSSION

3:00 BREAK WITH EXHIBITORS

3:30 INTRODUCTION OF ABSTRACTS
Paul W. Gidley, MD, Moderator
Ravi Samy, MD, Moderator

3:32 Prevalence of Subclinical Hearing Loss in the United States
Jacqueline M. Dragon, BA
Alexandria L. Irace, BA
Maeher R. Grewal, BS
Justin S. Golub, MD, MS

3:39 Diabetes Mellitus and Sensorineural Hearing Loss: A TriNetX Network Study
Saima Wase, BS
Divya Balachander, BS
Claudia Cabrera, MD, MS
Sarah Mowry, MD

3:46 Video Analysis of Otologic Instrument Movement During Resident Mastoidectomies
Royal M. Pipaliya, BS
Mallory J. Raymond, MD
M. Andrew Rowley Jr., BS
Polly Jasper, BS
Ted A. Meyer, MD PhD

3:53 **Immediate Improvement in Subjective Visual Vertical (SVV) and Disequilibrium Predicts Resolution of Benign Paroxysmal Positional Vertigo following Single Canalith Repositioning Maneuver**
Christine C. Little, BA
Zachary G. Schwam, MD
Marc Campo PT, PhD
James Gurley, PT, DPT
Bryan Hujsak PT, DPT, MBA
Maura K. Cosetti, MD
Jennifer Kelly, PT, DPT

4:00 **DISCUSSION**

4:05 **PANEL**
Cochlear Implants and Vestibular Schwannoma: Who to Implant and When?
Mia E. Miller, MD - Moderator
J. Thomas Roland Jr., MD
Jay T. Rubinstein, MD
Cameron C. Wick, MD
Erika A. Woodson, MD

5:05 **ANNOUNCEMENT OF AOS/ANS POSTER AWARDS**
Nancy M. Young, MD - AOS Education Director
Howard W. Francis, MD, MBA - ANS Education Director

5:10 **CLOSING REMARKS/ADJOURNMENT**

SATURDAY, APRIL 30, 2022

7:00 **BUSINESS MEETING** *(Treasurer & Committee Reports)*
(Members Only)

7:30 **SCIENTIFIC PROGRAM**
(Open to registered Members and Non-members – Badge required for admittance)

7:30 **WELCOME & OPENING REMARKS BY THE PRESIDENT**
Marlan R. Hansen, MD

7:33 **INTRODUCTION OF ABSTRACTS**
Samuel P. Gubbels, MD - Moderator
Adrien A. Eshraghi, MD - Moderator

7:35 **Cochlear Implants: When Hardware Fails. Using Impedance as an Initial Indicator of Decline**
Walleed H. Almutairi, MD
Justyn F.D. Pisa, AuD
Jordan B. Hochman. MD

7:42 **Electrode Positioning after Cochlear Reimplantation with Same Device**
Miriam R. Smetak, MD, MS
Shanik J. Fernando, MD
Robert T. Dwyer, AuD
Benoit M. Dawant, PhD
Jack H. Noble, PhD
Robert F. Labadie, MD, PhD

7:49 Differential Speech Perception in Quiet and Noise for Adults and Children Before and After Cochlear implantation for Unilateral Sensory Hearing Loss
Kevin D. Brown, MD, PhD
Lisa R. Park, AUD
Anne M. Selleck, MD
Matthew M. Dedmon, MD, PhD
Harold C. Pillsbury, MD
Margaret T. Dillon, AUD

7:56 Speech Recognition Performance Differences Between Precurved and Straight Electrode Arrays
Rahul K. Sharma, MD
Miriam R. Smetak, MD
Ankita Patro, MD
Nathan R. Lindquist, MD
Elizabeth L. Perkins, MD
Jourdan T. Holder, AuD, PhD
Kareem Tawfik, MD

8:03 Are Cochlear Implant Recipient Speech Performance Scores Consistent Across Different Tests?
Nicholas S. Andresen, MD
Varun Vohra, BA
Stephen P. Bowditch, AuD
Nae-Yuh Wang, PhD MS
Charles C. Della Santina, MD PhD
Daniel Q. Sun, MD

8:10 Initial Experience with Two Active Transcutaneous Bone Anchored Implants
Zachary G. Schwam, MD
Samuel Oh, BA
Kevin Wong, MD
Caleb Fan, MD
Enrique Perez MD, MBA
Maura K. Cosetti, MD
George B. Wanna, MD

8:17 DISCUSSION

8:22 INTRODUCTION OF SAUMIL N. MERCHANT MEMORIAL LECTURE
Marlan R. Hansen, MD

8:25 SAUMIL N. MERCHANT MEMORIAL LECTURE
"Precision Medicine for Hearing Loss"
Richard JH Smith, MD
Sterba Hearing Research Professor and Vice Chair - Department of Otolaryngology
Director – The Molecular Otolaryngology and Renal Research Laboratories
Director – Iowa Institute of Human Genetics
Professor of Otolaryngology, Molecular Physiology & Biophysics, Pediatrics and Internal Medicine (Division of Nephrology)

9:05 INTRODUCTION OF ABSTRACTS
Brian A. Neff, MD - Moderator
Alejandro Rivas, MD - Moderator

9:07 AOS RESIDENT RESEARCH TRAVEL AWARD

Dynamic Molecular Markers of Otosclerosis in the Human Cochlea
Sarah Hodge, MD
Ivan A Lopez, PhD
Hirooki Matsui, MD
Gail Ishiyama MD
Alex Cronkite MD
Akira Ishiyama, MD

9:14 Impact of Modern Surgical Techniques on Rates of Sensorineural Hearing Loss and Revision Surgery after Stapedotomy
Nabil F. Darwich, MD, PhD
Alexandra E. Quimby, MD, MPH
Tiffany P. Hwa, MD
Stephen J. Eliades, MD, PhD
Jason A. Brant, MD
Douglas C. Bigelow, MD
Michael J. Ruckenstein, MD, MSc

9:21 National and International Rates of Stapedectomy Performed at Academic and Non-Academic Centers across the Department of Defense
Jason K. Adams, MD
John P. Marinelli, MD
Ronit E. Malka, MD
Carlos R. Esquivel, MD
Travis R. Newberry, MD
Samuel A. Spear, MD
Isaac D. Erbele, MD

9:28 Cochlear and Vestibular Dysfunction in the COVID-19 Era: A Population Based Study
Claudia I. Cabrera, MD, MS
Benjamin Johnson, MD
Maroun Semaan, MD
Alejandro Rivas, MD
Sarah Mowry, MD
Nauman Manzoor, MD

9:35 Standardization of Outcome Measures for Intratympanic Steroid Treatment for Idiopathic Sudden Sensorineural Hearing Loss
Neil K. Osafo, BS
David R. Friedland, MD, PhD
Michael S. Harris, MD
Jazzmyne Adams, MPH
Chasity Davis
Ling Tong, MA
Jake Luo, PhD

9:42 DISCUSSION

9:47 BREAK WITH EXHIBITORS

10:15 INTRODUCTION OF ABSTRACTS
Richard K. Gurgel, MD - Moderator
Kevin D. Brown, MD - Moderator

10:17 Changes and Trends in the Cochlear Implant Literature over a 40-year period: A Comprehensive Historical Literature Review
Jacob Kahane, MD
Anne Maxwell, MD
Moises Arriaga MD, MBA

10:24 Association of Baseline Frailty Status and Age with Postoperative Complications following Cochlear Implantation: A National Inpatient Sample Study
Kyril L. Cole, MPH
Alis J. Dicpinigaitis, BA
Eric Babajanian, MD
Steven A. Gordon MD MPH
Neil S. Patel, MD
Christian A. Bowers, MD
Richard K. Gurgel, MD, MSCI

10:31 Influence of Fractalkine Receptor CX3CR1 Deletion on Cochlear Hair Cell Survival and Macrophage Expression in Chronic Suppurative Otitis Media
Viktoria Schiel, MD, PhD
Anping Xia, MD, PhD
Jing Chen, MPH, DABT
Brian Bacacao, BS
Laurent A. Bekale, MD, PhD
Peter L. Santa Maria, MD, PhD

10:38 Evaluation of Safety and Efficacy of Povidone-Iodine Solution as an Ototopical Treatment in a Murine Model of Chronic Suppurative Otitis Media
Adam C. Kaufman, MD, PhD
Brian Bacacao, BS
Laurent Bekale, PhD
Peter L. Santa Maria, MD, PhD

10:45 Improvement of Eosinophilic Otitis Media with Targeted Biologic Therapy
C. Yoonhee Ryder, BS
Mark A. Zacharek, MD
Christopher M. Welch, MD, PhD

10:52 DISCUSSION

10:57 PANEL
"New Developments in Inner Ear Inflammation"
Soha N. Ghossaini, MD, Moderator
Keiko Hirose, MD
Michael Hoa, MD
Alicia M. Quesnel, MD
Andrea Vambutas, MD

11:57 INTRODUCTION OF INCOMING PRESIDENT
Lawrence R. Lustig, MD

12:00 CLOSING REMARKS/ADJOURNMENT

SELECTED ABSTRACTS

ORAL PRESENTATIONS

IN ORDER OF PRESENTATION

155th Annual Meeting
AMERICAN OTOLOGICAL SOCIETY

April 29-30, 2022
Hyatt Regency
Dallas, TX

Microneedles Facilitate Intracochlear Delivery without Anatomic or Physiologic Injury

Stephen Leong, BA; Aykut Aksit, MS; Elizabeth S. Olson, PhD
Jeffrey W. Kysar, PhD; Anil K. Lalwani, MD

Hypothesis: Microneedle-mediated intracochlear injection through the round window membrane (RWM) will facilitate intracochlear delivery, not affect hearing, and allow for full reconstitution of the RWM within 48 hours.

Background: Previously, hollow microneedles developed in our laboratory were shown to be capable of perforating the RWM and aspirating perilymph for diagnostic proteomic analysis without cochlear damage. There is similar need for tools to facilitate atraumatic intracochlear delivery to implement inner ear therapies. In this study, we assess the feasibility and consequences of direct intracochlear injection of material via hollow microneedles.

Methods: Two-photon polymerization lithography was used to 3D-print 100μm-diameter hollow microneedles. Tympanic bullae of guinea pigs were extracted, RWMs were perforated *ex vivo*, and 1μL of 10mM rhodamine was injected into the cochlea over 1 minute. Similarly, 1μL of artificial perilymph was injected over 1 minute *in vivo* in guinea pigs. Distortion product otoacoustic emissions (DPOAE) and compound action potential (CAP) were recorded prior to *in vivo* perforation and 48 hours following injection. After euthanasia, the RWM was harvested for confocal microscopy.

Results: *Ex vivo* assessment of the cochlea under light microscopy revealed distribution of rhodamine throughout the basal turn of the cochlea immediately following injection, followed by slow diffusion through the middle and apical turns. Following *in vivo* injection, there were no significant changes in DPOAE and CAP. Confocal microscopy demonstrated full reconstitution of the RWM without inflammation or residual perforation.

Conclusions: Hollow microneedles are safe and effective for intracochlear injection of agents, thus making inner ear therapy possible without concomitant damage or hearing loss.

***Professional Practice Gap & Educational Need:** Currently, no clinical technology exists for diagnostic aspiration of perilymph and direct intracochlear injection of therapeutics. Our 3D-printed hollow microneedles have the potential to fill this practice gap. By demonstrating the safety and efficacy of direct intracochlear injection via hollow microneedles, we create new avenues for inner ear intervention, including inner ear gene therapy.

***Learning Objective:** To understand the current landscape of direct intracochlear delivery. To understand the contribution that our technology makes to the field.

***Desired Result:** Increased interest and investment in 3D-printed hollow microneedles for intracochlear delivery of therapeutics.

***Level of Evidence:** n/a

***Indicate IRB or IACUC:** Columbia University Irving Medical Center – IACUC No. AABA5450 (approved 3/8/2021)

Risks of Noise-Induced Hearing Loss during Cochlear Implant Insertion Errors

Carolyn A Chabuz, MD; Joseph Gonzalez, MD; Kenny Rodriguez, MD; John Peacock, PhD
Renee M. Banakis Hartl, MD; Stephen P. Cass, MD; Nathaniel T. Greene, PhD

Hypothesis: We have previously shown that during cochlear implantation (CI), the electrode contacts cochlear structures and generates high pressure transients that may cause injury; we hypothesize that pressure transients may coincide with and be used to identify insertion errors.

Background: CIs have been an effective treatment for severe to profound hearing impairment, and are increasingly offered to patients with residual acoustic hearing; however, a large subset of patients lose this residual hearing after CI implantation. Several mechanisms have been investigated as sources of this hearing loss, and we have identified generation of high amplitude pressure transients in the cochlea during CI insertion that may be sufficiently loud to cause noise induced hearing loss. Insertion errors may represent an additional cause of residual hearing loss, but are often difficult to identify during surgery

Methods: To determine whether intracochlear pressures predict errors, cadaveric human heads were surgically prepared with a mastoidectomy and extended facial recess. Fiber-optic pressure sensors were inserted into the scala vestibuli and scala tympani near the oval and round windows to measure intracochlear pressures. CI electrodes were inserted via a round window approach under fluoroscopy.

Results: CI electrode mis-insertions produced pressure transients in the cochlea up to 160-170 dB SPL equivalent. The electrode position within the cochlea, design-related electrode dynamics, and poor surgical technique were associated with increased rates of insertion errors and pressure transients.

Conclusions: These results provide insertion pressure profiles for CI mis-insertions and suggest that appropriate 'soft' surgical techniques can minimize acoustic exposure during CI surgery.

Professional Practice Gap & Educational Need: There are a variety of speeds/depths for electrode insertion along with different techniques and surgical skill levels that can affect residual hearing outcomes. We hope to create insertion pressure profiles for the major CIs on the market along with profiles for purposeful mis-insertions to better understand the generation of these intracochlear pressure transients and how to further preserve residual hearing.

Learning Objective: Understand the dynamics of CI insertion, including the extant and patterns of cochlear damage associated with surgical approaches, electrode types, and speed and depth of insertion. Determine whether similar pressure transients are generated with CI mis-insertions and if intracochlear pressure monitoring may be used to identify such deleterious outcomes.

Desired Result: Create insertion pressure profiles for specific CI electrodes along with profiles for mis-insertions.

Level of Evidence - Level III

Indicate IRB or IACUC : Exempt.

Predictive Value of Trans-Impedance Matrix Measurements to Detect Electrode Tip Foldovers

Emily Kay-Rivest MD, MSc; Sean O. McMenomey MD; Daniel Jethanamest MD, MSc
William H. Shapiro AuD; David R. Friedmann MD, MSc
Susan B. Waltzman PhD; J. Thomas Roland Jr., MD

Objective: To evaluate the ability of the trans-impedance matrix (TIM) measurement to detect cochlear implant electrode tip foldover by comparing results to a gold standard, the intraoperative plain film radiograph.

Study design: Retrospective case series.

Setting: Tertiary referral hospital.

Patients: 103 patients who underwent cochlear implantation between June 2020 and August 2021.

Interventions: Intraoperative electrophysiologic monitoring (electrode impedances, Neural Response Telemetry, and TIM measurement) and modified Stenver's view plain film radiographs.

Main outcome measures: Identification of tip foldover on both TIM and plain films.

Results: In total, 103 patients (117 ears) had both a TIM measurement and intraoperative -ray available for review, including 68 adults and 35 children. 100 (85%) received the *Cochlear Slim Modiolar* electrode. Tip foldovers were noted in three of 117 implants (2.5%). In all cases, TIM was able to detect the foldover, and the electrode arrays were reinserted with repeat X-ray demonstrating a normal configuration. Two other abnormal TIM patterns were identified. One was in a patient with an obstructed cochlea in whom only 10 electrodes could be inserted, the other was in a patient with a common cavity abnormality. One additional patient required electrode revision intraoperatively, due to overinsertion. In this patient, the TIM appeared to be within normal limits but the overinsertion was apparent only on X-ray. Overall, the sensitivity of TIM measurements in detecting tip foldover was 100%.

Conclusions: TIM measurements were able to accurately identify tip foldovers but were not sensitive to overinsertion of the array. More research is needed to define the adjunctive role of TIM as an intraoperative measure.

***Professional Practice Gap & Educational Need:** In certain cochlear implant centres, routine intraoperative X-ray may not always be readily available. We explore the TIM and its ability to detect tip foldovers, which may represent a feasible alternative for position placement check in the context of normal cochleovestibular anatomy.

***Learning Objective:** TIM measurements were able to detect tip foldovers in all cases.

***Desired Result:** To provide the attendee with the knowledge of an additional tool for intraoperative monitoring and explore other possible benefits of the transimpedance matrix.

***Level of Evidence -** Level III

***Indicate IRB or IACUC:** NYU School of Medicine Institutional Review Board i21-01186.

Dynamic Behavior and Insertional Forces of a Pre-Curved Electrode Using the Pull-Back Technique in a Fresh Micro-Dissected Cochlea

Miriam R. Smetak, MD, MS; Katherine E. Riojas, PhD
Jack H. Noble, PhD; Robert F. Labadie, MD, PhD

Hypothesis: This study evaluated the utility of the pull-back technique in improving perimodiolar positioning of a pre-curved cochlear implant electrode with simultaneous insertion force profile measurement and direct observation of dynamic electrode behavior in a cadaveric cochlea through an intact, semi-transparent basilar membrane.

Background: Pre-curved electrodes with closer proximity to the modiolus have improved outcomes compared to straight electrodes. The effectiveness of the pull-back technique in further improving perimodiolar positioning and the insertion force profile have not been adequately studied.

Methods: The bone overlying the scala vestibuli was removed in 15 fresh cadaveric temporal bones, leaving the scala tympani unviolated. Each specimen was then mounted to a force sensor and robotic insertions of Cochlear 532/632 electrodes were performed. Force profiles were obtained during standard insertion, over-insertion, and pull-back with simultaneous video recording of the electrode through the semi-transparent basilar membrane.

Results: Standard insertion resulted in a mean peak force of 0.14 N (95% CI 0.10-0.18) and occurred at either sheath insertion (n=11, 73.3%) or complete electrode insertion (n=4, 26.7%). Over-insertion was associated with a peak force of 0.18 N (95% CI 0.14-0.21) which was not significantly higher than standard insertion (P = 0.18). Pull-back had a mean peak force of 0.10 N (95% CI 0.06-0.14), which was significantly lower than standard insertion (P = 0.02). Six temporal bones (40%) demonstrated visibly improved perimodiolar positioning.

Conclusions: Pull-back technique was not associated with significantly higher insertional forces compared to standard insertion. This study demonstrated improved perimodiolar positioning compared to standard insertion in 40% of temporal bones studied.

***Professional Practice Gap & Educational Need:** Various electrode insertion techniques have been proposed in order to position the electrode closer to the modiolus, thereby improving postoperative hearing outcomes. Here, we investigate the utility of the pull-back technique in a micro-dissected cadaveric cochlea with simultaneous measurement of force profile and video recording of electrode behavior, allowing for direct observation of the effects of the technique on electrode positioning.

***Learning Objective:** For the pre-curved electrode, the pull-back technique may improve perimodiolar positioning. Gentle over-insertion followed by electrode pull-back does not lead to significantly increased forces compared to standard insertion.

***Desired Result:** Cochlear implant surgeons should consider using the pull-back technique when inserting pre-curved electrodes. The technique involves a gentle over-insertion followed by pulling the electrode back to the standard insertion depth to achieve close contact of the electrode with the modiolus.

***Level of Evidence –** Level I

***Indicate IRB or IACUC :** N/A

RESIDENT RESEARCH TRAVEL AWARD

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

Alexander D. Claussen, MD; Seiji B. Shibata, MD, PhD; Christopher R. Kaufmann, MD
Allan Henslee, PhD; Marlan R. Hansen, MD

Hypothesis: Robotics-assisted cochlear implant (CI) electrode array insertions will result in improved trauma scoring when compared to manual.

Background: Although techniques to reduce intracochlear trauma and translocations are well established, significant variability in CI outcomes remains. To address this issue, we have developed a robotics-assisted insertion system designed to aid the surgeon in inserting electrode arrays with consistent speeds and reduced variability. This study evaluated the effect of robotics-assisted insertions on the intracochlear trauma as compared to manual insertions in cadaveric cochleae in a simulated operative environment.

Methods: Using a round window approach, 12 neurotologists performed bilateral electrode insertions into cochlea of full cadaveric heads using both the robotics-assisted system and manual insertion by hand. Lateral wall electrodes from 3 different manufacturers (n=24) were utilized and randomized between surgeons. Insertion angle of the electrode and trauma scoring were evaluated using high resolution 3D X-ray microscopy and compared between robotics-assisted and manual insertions.

Results: 3D X-ray microscopy provided sufficient resolution to characterize the *in situ* trauma and insertion angle. Robotics-assisted insertions significantly decreased the trauma score compared to manual insertions (average 1.3 vs 2.2, device vs manual respectively, $p<0.05$ Wilcoxon signed-rank test). There was no significant difference between insertion angles observed for both manual and robotics-assisted techniques (328±87° vs 335±109°, device vs manual respectively).

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 intracochlear trauma have the potential to improve CI outcomes.

***Professional Practice Gap & Educational Need:** The need for atraumatic techniques during CI electrode insertion is well established, but the effects of insertion speed and variability on intracochlear trauma-related events are not well defined or characterized.

***Learning Objective:** To evaluate the difference in electrode translocation incidence during robotics-assisted CI electrode insertions vs. manual (by-hand) insertions in cadaveric cochleae.

***Desired Result:** Understand quantified difference in intracochlear trauma score of electrodes inserted with robotics-assisted device vs. manual insertions; and be aware of human related limitations of manual electrode insertions.

***Level of Evidence:** N/A

***Indicate IRB or IACUC:** Exempt

Prevalence of Subclinical Hearing Loss in the United States

Jacqueline M. Dragon, BA; Alexandria L. Irace, BA
Maeher R. Grewal, BS; Justin S. Golub, MD, MS

Objective: Worse hearing has recently been associated with worse cognition and depressive symptoms. This holds true even among adults considered to have normal hearing (4-frequency pure tone average [PTA4] $\leq$ 25 dB), thus supporting the term subclinical hearing loss (SCHL). A detailed study of the prevalence of SCHL in the U.S. has not been performed.

Study Design: Analysis of biennial cross-sectional epidemiological survey (NHANES; 1999-2012, 2015-2016).

Setting: Community

Subjects: Non-institutionalized U.S. citizens age ≥12 years

Main Outcome Measures: 4-frequency (500, 1000, 2000, 4000 Hz) PTA (PTA4) and high frequency (6000, 8000 Hz) PTA (PTAhf).

Results: 81% percent (95% CI=80.1-82.1%) of participants (~227.3 million Americans) had SCHL defined by 1≤PTA4≤25 dB. 65% (63.1-66.1%) had SCHL defined by 1≤PTAhf≤25 dB (~181 million Americans). The average age of hearing loss (HL) onset at PTA4 thresholds of 25, 20, and 15 dB was 75.4, 67.4, and 58.4 years, respectively. The average age of HL onset at PTAhf thresholds of 25, 20, and 15 dB was 52.4, 46.9, and 40.6 years, respectively. Across the lifespan, the PTA4 showed constant acceleration of 0.0044 dB/year^2 (95% CI=0.00429-0.00443). PTAhf showed constant acceleration of 0.0091 dB/year^2 (95% CI=0.00900-0.00924).

Conclusions: This study informs national discussions on the definition of HL onset. Recent data has suggested that the threshold to define adult HL may be too high, particularly because even so-called subclinical levels of HL may be associated with deleterious conditions of aging. We present the prevalence of SCHL as well as of HL defined by various stricter cutpoints.

***Professional Practice Gap & Educational Need:** Recent evidence has suggested that the association between HL and neurocognitive conditions of aging may begin at earlier levels of HL than previously expected. A granular characterization of the prevalence of so-called SCHL has not been reported.

***Learning Objective:** Determine the prevalence of SCHL in Americans. Understand the prevalence of HL based on stricter cutpoints.

***Desired Result:** Providers will understand that the current definition of HL has been challenged as well as the prevalence of HL based on stricter definitions.

***Level of Evidence -** III

***Indicate IRB or IACUC :** Exempt

Diabetes Mellitus and Sensorineural Hearing Loss:
A TriNetX Network Study

Saima Wase, BS; Divya Balachander, BS
Claudia Cabrera, MD, MS; Sarah Mowry, MD

Objective: The literature reports a high prevalence of sensorineural hearing loss ranging from 54-67.5% among patients with diabetes mellitus. The inconsistency in literature reveals the need for further study. Our objective is to evaluate the relationship between diabetes and hearing loss.

Study Design: We utilize the TriNetX global health research network, a database with real-time access to millions of electronic medical records.

Setting: Database

Patients: Adult patients from 2015 to 2020 in the United States, aged ≥18 presenting with and without diabetes

Interventions: N/A

Main Outcome Measures: Likelihood of hearing loss

Results: 939,238 were included in the analysis. After matching sensorineural hearing loss was found in 1,438 diabetic patients (.307%) and 657 in our control group (.14%). The odds of having hearing loss were found to be 2.2 [95% CI (1.99, 2.40)] times higher in patients with diabetes compared to their non-diabetic counterparts. DM patients had significantly higher proportion of minorities, including Asians (3.789% vs 2.563%, P<.001), American Indians (0.545% vs 0.347%, P<.001), Native Hawaiians (0.225% vs 0.11%, P<.001), Hispanics (10.582% vs 5.847%, P<.001), and non-Hispanics (64.27% vs 58.80%, P<.001).

Conclusions: Our study of the TriNetX database in the last five years suggests a relationship between diabetes and sensorineural hearing loss. We believe this study is among the first to corroborate this finding in a large sample size. Further research is needed to investigate the mechanism of these complications and the vulnerability of population groups.
***Professional Practice Gap & Educational Need:** Understand the risk factors of hearing loss.

***Learning Objective:** Understand the association between diabetes and hearing loss.

***Desired Result:** Heightened awareness of the association between diabetes and hearing loss.

***Level of Evidence –** N/A

***Indicate IRB or IACUC:** Exempt

Video Analysis of Otologic Instrument Movement during Resident Mastoidectomies

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Objective: To measure surgical instrument movement during resident mastoidectomies and identify metrics that correlate with experience.

Study Design: Retrospective case series

Setting: Tertiary care center

Subjects: Ten PGY2, six PGY3, seven PGY4, and nineteen PGY5 otolaryngology residents

Interventions: One-minute intraoperative recordings of mastoidectomies performed during cochlear implantation were collected. Drill and suction-irrigator motion were analyzed with sports motion tracking software.

Main Outcome Measures: Instrument speed, acceleration, distance travelled, angle, and angular velocity were calculated. Mann-Whitney U tests were used to compare mean instrument metrics between PGY levels. Change in drill distance, speed, and acceleration over time for seven residents were individually analyzed.

Results: The mean drill distance, speed and acceleration increased from 11.0 cm, 1.8 cm/s, and 13.8 cm/s^2 for PGY2s to 18.4 cm, 2.9 cm/s and 29.1 cm/s^2 for PGY5s ($p = 0.0007$, $p = 0.001$, $p = 0.0008$, respectively). The mean suction-irrigator distance travelled increased from 5.8 cm for PGY2s to 9.0 cm for PGY4s ($p = 0.04$), but decreased to 7.9 cm for PGY5s ($p=0.2$). Mean suction-irrigator speed increased from 1.0 cm/s for PGY2s to 1.5 cm/s for PGY4s ($p = 0.04$), then decreased to 1.2 cm/s for PGY5s ($p=0.2$). Of the seven residents individually analyzed, drill distance, speed, and acceleration increased for five, six and seven residents, respectively. Group mean drill distance, speed, and acceleration improved by 3.3 cm, 0.2 cm/s, and 5.7 cm/s^2 yearly.

Conclusions: Drill movement metrics increase with resident experience level and can differentiate novices from more experienced surgeons. These and other objective metrics could be used to evaluate and monitor surgical skills progress.

***Professional Practice Gap & Educational Need:** Objective measures of surgical performance are lacking. Resident education continues to rely on subjective forms of feedback to monitor progress and influence promotion and certification.

***Learning Objective:** To understand the application of objective video analysis for measuring surgical instrument movement; to compare objective measures of resident surgical instrument movement across experience levels; to understand the variation in progress of surgical instrument movement amongst resident experience level.

***Desired Result:** Attendees should appreciate the application of objective video analysis for measuring surgical instrument movement, be able to compare objective measures of resident surgical instrument movement across experience levels, and understand the variation in progress of surgical instrument movement amongst resident experience level.

***Level of Evidence -** Level V

***Indicate IRB or IACUC:** Approved - IRB Pro00068069 on 10/02/2017 at the Medical University of South Carolina.

Immediate Improvement in Subjective Visual Vertical (SVV) and Disequilibrium Predicts Resolution of Benign Paroxysmal Positional Vertigo following Single Canalith Repositioning Maneuver

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Conrad Nytko, PT; James Gurley, PT, DPT; Jennifer Kelly, PT, DPT
Maura K. Cosetti, MD; Jennifer Kelly, PT, DPT

Objective: To evaluate whether immediate post-canalith repositioning maneuver (CRM) balance changes are predictive of Benign Paroxysmal Positional Vertigo (BPPV) resolution.

Study Design: Retrospective cohort study

Setting: Tertiary referral center.

Patients: Adults (n=33, average age 59, range 56-64) with confirmed unilateral BPPV.

Interventions: single CRM with frenzel goggles

Main Outcome Measures: Visual Analog Scale (VAS) for disequilibrium, the Subjective Visual Vertical (SVV), the Subjective Visual Horizontal (SVH), and the Modified Clinical Test of Sensory Interaction on Balance (mCTSIB) were administered pre- and immediately following single CRM. Dix-Hallpike was performed 2-3 weeks after CRM to assess for BPPV resolution. Pre- and post-treatment balance assessments were compared between groups to determine if post CRM balance changes could predict BPPV resolution.

Results: Change in VAS and SVV score following CRM treatment was statistically different between BPPV patients who responded to CRM therapy (n=18) and those who did not (n=15), (p =.02 and p =.02 respectively). Change in SVH and mCTSIB score did not predict improvement. Patients who responded to CRM treatment were statistically younger (p=.03) and more likely to present with idiopathic BPPV compared to secondary causes (p=.02).

Conclusions: Immediate improvement in VAS and SVV following CRM can be used to predict which patients are likely to experience resolution of BPPV and may assist in directing timing and need for future interventions. BPPV etiology and younger age may have a favorable predictive value for improvement following single CRM .

***Professional Practice Gap & Educational Need:** Although canalith repositioning maneuvers (CRMs) are highly effective in treating BPPV, an estimated 8-50% of patients treated with a single session of CRM will experience persistent BPPV. BPPV can lead to significant medical costs when managed incorrectly, with >65% of the BPPV population undergoing unnecessary imaging, diagnostic testing, or therapeutic interventions. The burdensome financial cost to individuals, difficulty in complying with follow-up care and impact on quality of life warrant better predictive outcomes of BPPV resolution. Outcome measures that could predict the efficacy of CRM treatment can help reduce these costs, promote efficient care and improve allocation of healthcare resources.

***Learning Objective:** demonstrate the utility of VAS and SVV balance changes as a predictive tool for evaluating which patients are likely to experience persist BPPV following CRM treatment.

***Desired Result:** empower clinicians to make informed decision regarding which patients may benefit from closer follow up care for signs of persistent BPPV.

***Level of Evidence:** III

***Indicate IRB or IACUC:** IRB 15.07, Mercy College

Cochlear Implants: When Hardware Fails, Using Impedance as an Initial Indicator of Decline

Walleed H. Almutairi, MD; Justyn F.D. Pisa, AuD; Jordan B. Hochman, MD

Objective: In February of 2020, a cochlear implant manufacturer initiated a field action notice to remove an electrode array from circulation. In this study, we quantify device failure and specifically examine the relationship of impedance change as a precursor to declining speech perception.

Study Design: Retrospective/Cohort Study.

Setting: Tertiary Referral Center

Patients: 48 patients (51 devices) were implanted between October 2017 to December 2019. Post-operative speech perception (AzBio) scores at 12 months were used as a reference, with further testing at 3-6 month intervals. Degree of change in impedances from 1-month post-activation were analysed at similar intervals. Exclusion Criteria included: <18 years of age, medical/surgical/soft failures and English as an additional language.

Interventions: Diagnostic.

Main Outcome Measures: Device failures were confirmed by the following: impedance levels $\leq$ 3.0μΩ and/or declines of 50% from their original (baseline) value, and speech perception decline >15% on the AzBio test.

Results: To date, 11 (22%) electrodes have failed. The number of devices currently being monitored for suspected failure is 12 (24%). There are statistically significant differences ($p<0.001$), in speech perception scores and impedance levels between normative and suspect/failed devices. The entire electrode array (Channels 1-16) may be impacted. There was no relationship between degree of impedance change and speech scores. The average length of time for a change to become apparent was 22 months (+/- 5) post implantation.

Conclusions: Impedance values can be used as a reliable indicator of future decline facilitating patient counselling and possible early intervention. No relationship was identified that corelated changes in impedance with speech perception.

Define Professional Practice Gap & Educational Need: Cochlear implant recalls are rare unfortunate events. It is imperative that a patient have access to recalled device performance and be provided the requisite information for best possible counselling. Impedance values can be used to inform patient decision making.

Learning Objective: The use of impedance values to monitor implant function and possible decline. Changes in impedance of >50% or a drop of 3.0 uO provide a strong suggestion of future change in device function.

Desired Result: If impedance decline can be used as a predictor for a decline in speech performance.

Level of Evidence - III

Indicate IRB or IACUC: HS18623 (H2015:209)

Electrode Positioning after Cochlear Reimplantation with Same Device

Miriam R. Smetak, MD, MS; Shanik J. Fernando, MD; Robert T. Dwyer, AuD; Benoit M. Dawant, PhD
Jack H. Noble, PhD; Robert F. Labadie, MD, PhD

Objective: To investigate whether revision surgery with the same device results in a change in three key indicators of electrode positioning: scalar location, mean perimodiolar distance ($\bar{M}$), and angular insertion depth (AID).

Study Design: Retrospective analysis of a cochlear implant database from 2017 to 2021.

Setting: University-based tertiary medical center.

Patients: Sixteen patients underwent revision cochlear implantation with same device.

Interventions: Intra-operative CT scans were obtained after initial and revision implantation. Electrode position was calculated using auto-segmentation techniques.

Main Outcome Measures: Initial and revision scalar location, $\bar{M}$, and AID were compared. Changes in electrode positioning were calculated for all combinations of initial and revision electrodes.

Results: Mean change in $\bar{M}$ for all ears was -0.07 (95% CI [-0.18, 0.03]) (P = 0.16). The mean change in AID for all ears was -5º (95% CI [-35º, 25º]) (P = 0.72). Overall, there was no significant difference in $\bar{M}$ or AID for any of the initial and revision electrode combinations studied. Three initial implantations with pre-curved electrodes resulted in a translocation from Scala Tympani (ST) to Scala Vestibuli (SV). Two remained translocated after revision, while one was corrected when revised with a straight electrode. An additional 5 translocations occurred only after revision.

Conclusions: In this study examining revision cochlear implantation with a single device, we demonstrated no significant change in key indicators of cochlear positioning, even when revising with a different style of electrode. However, the revision electrode is not necessarily confined by the initial trajectory and additional translocations can occur.

***Professional Practice Gap & Educational Need:** With increasing prevalence and longer duration of device use, rates of revision cochlear implantation can only be expected to continue to rise. In this study we sought to understand the effect of revision surgery on electrode positioning.

***Learning Objective:** We demonstrate that there is no significant difference in key indicators of electrode positioning after revision cochlear implantation, even when revising with a different type of electrode. There may be an increased risk of translocation during revision cochlear implantation, although this requires further study.

***Desired Result:** To demonstrate that overall revision cochlear implantation does not result in significant change in electrode positioning but that the revision electrode is not necessarily confined to the tract of the initially implanted electrode.

***Level of Evidence –** LEVEL V – Case series, studies with no controls

***Indicate IRB or IACUC:** Vanderbilt University Medical Center, IRB #101743, #090155, #202094

Differential Speech Perception in Quiet and Noise for Adults and Children Before and After Cochlear implantation for Unilateral Sensory Hearing Loss

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Matthew M. Dedmon, MD, PhD; Harold C. Pillsbury MD
Margaret T. Dillon AUD

Objective: Determine the patterns of speech perception growth in quiet and noise with cochlear implant (CI) use for adults and children with unilateral hearing loss (UHL).

Study Design: Repeated measures of speech perception in quiet for the affected ear and speech perception in noise with both ears.

Setting: Tertiary academic healthcare center

Patients: Two FDA-approved prospective clinical trials evaluated the benefits of cochlear implantation for adults and children with UHL. Criteria for inclusion were moderate to profound UHL and poor CNC word recognition in the affected ear (adults: <60%, children: <30%).

Interventions: Cochlear implantation

Main Outcome Measures: Speech perception was assessed preoperatively and 6, 12, and 24 months post-activation by 40 adults and children with UHL. Performance was quantified for CNC words in quiet with the CI alone and sentence recognition in noise (BKB-SIN) with the CI plus normal-hearing ear in three target-to-masker configurations to assess summation, squelch, and head shadow effects.

Results: Both adults and children experienced a significant improvement in CNC scores post-activation (24-month: 59±13% and 59±15%, respectively), with adults reaching asymptote earlier. Children had poorer performance in noise than adults without the CI. With the CI, children had significant improvements for the summation, squelch, and head shadow conditions; adults showed benefits in the head shadow condition only.

Conclusions: Children with UHL perform more poorly than adults in noise without a CI, yet experience significant improvement in binaural hearing (summation, squelch and shadow) with a CI. Adults show benefits primarily in head shadow.

***Professional Practice Gap & Educational Need:** There is incomplete knowledge of the differences in benefits experienced by adults and children for speech perception in noise following cochlear implantation for UHL.

***Learning Objective:** The learner will understand that children with UHL require a higher signal to noise ratio to understand speech in noise. They also gain benefits in all noise configurations, including summation, squelch and head shadow, while only adults experience benefits in head shadow.

***Desired Result:** The learner will be able to inform patients of the benefits of cochlear implantation for UHL in adults and children.

***Level of Evidence –** Level 3

***Indicate IRB or IACUC:** IRB 14-1544 and 15-3350, University of North Carolina, Chapel Hill

Speech Recognition Performance Differences Between Precurved and Straight Electrode Arrays

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Nathan R. Lindquist, MD; Elizabeth L. Perkins, MD
Jourdan T. Holder, AuD, PhD; Kareem O. Tawfik, MD

Objective: Precurved cochlear implant (CI) electrode arrays have shown superior audiometric outcomes compared to straight electrodes. Previously reported results are confounded by other influential variables such as pre-operative hearing and age. This study compares hearing outcomes for precurved and straight electrodes while controlling for other factors.

Study Design: Retrospective Cohort Study

Setting: Tertiary Academic Medical Center

Patients: 171 adult CI recipients between 2015-2020 with Cochlear brand 522/622 (straight) or 532/632 (precurved) electrode arrays.

Interventions: None

Main Outcome Measures: Speech recognition testing (CNC and AzBio) was collected at 6 and 12 months post-activation. Analyses included Fisher's exact test, chi-square test of independence, and multivariable linear regression models.

Results: 171 patients (189 ears) with either 6-month and/or 12-month CNC or AzBio testing were included. 112 (59%) and 77 (41%) ears were implanted with straight and precurved electrode arrays respectively. Average age at implantation was 69 years (IQR 58-77). CNC scores were significantly different (p=0.008) between straight (52% Correct, IQR 36-68) and precurved arrays (66% Correct, IQR 48-74). AzBio scores were not significantly different (p=0.130) between straight (74% Corrected, IQR 56-86) and precurved arrays (82% correct, IQR 58-90). Controlling for age, race, sex, pre-operative hearing, and follow-up time, precurved electrodes performed significantly better on CNC (b=9.42, 95% CI 2.75-16.1, p=0.006) but not AzBio (b=6.48, 95% CI -1.21-14.2, p=0.10) testing.

Conclusions: Precurved electrodes exhibit superior speech recognition scores at 6 and 12 months postoperatively. Strong consideration should be given to implanting precurved electrode arrays due to benefits associated with perimodiolar positioning.

***Professional Practice Gap & Educational Need:** Understanding the difference in audiometric outcomes between precurved and straight electrodes will help to guide electrode selection.

***Learning Objective:** To understand differences in speech recognition scores post-operatively by electrode type (precurved vs. straight)

***Desired Result:** To demonstrate a difference in hearing performance post-operatively by electrode type.

***Level of Evidence -** III

***Indicate IRB or IACUC :** Approved by the Vanderbilt University IRB (# 090155)

Are Cochlear Implant Recipient Speech Performance Scores Consistent Across Different Tests?

Nicholas S. Andresen, MD; Varun Vohra, BA; Stephen P. Bowditch, AuD
Nae-Yuh Wang, PhD MS; Charles C. Della Santina, MD PhD; Daniel Q. Sun, MD

Objective: Cochlear implant (CI) candidacy and post-operative outcomes are assessed through multiple different speech discrimination tests, limiting comparisons across time periods or institutions. The objective of this study was to investigate the extent of agreement among commonly used speech understanding scores in assessment of CI candidacy or performance in individual patients.

Study Design: Pre- and post-operative AzBio Sentence Test, Consonant-nucleus-consonant Word (CNCw), and Hearing in Noise Test (HINT) scores in quiet, collected during the same testing session, for individuals who received a CI between 1985-2018 were analyzed to derive transformation functions between test instruments. Simple linear regression with logit-transformation was used to determine mean scores and variances. Bland-Altman plots were used to assess agreement between testing methods.

Setting: Single academic medical center.

Patients: 1,710 individuals with a mean age of 57.9 years (range 18-95 years) and 46% (784/1,710) male.

Interventions: N.A.

Main Outcome Measures: Mean, variance, correlation coefficients, and agreement as a function of test score.

Results: Same-session AzBio/CNCw (n=2,052), AzBio/HINT (n=525), and CNCw/HINT (n=7,187) scores were available in 1710 unique patients. Pair-wise test comparisons demonstrated score correlation between different speech tests, but also revealed large variance and limited agreement between different tests performed in the same session.

Conclusions: Transformation functions between test batteries were predictive of mean but not variance in scores, or extent of agreement between test batteries. Point-wise comparisons of scores across CI test batteries should be used with caution in clinical and research settings.

***Professional Practice Gap & Educational Need:** There is a need to understand how different speech performance scores can be compared.

***Learning Objective:** Understand the variability of different speech performance scores (AzBio, CNCw, HINT) recorded during the same testing session in a large cohort of cochlear implant recipients at a large academic medical center.

***Desired Result:** Individuals will be able to describe the large amount of variability between different speech performance scores and that speech performance scores cannot be reliably converted.

***Level of Evidence -** Level IV.

***Indicate IRB or IACUC :** IRB00188251.

Initial Experience with Two Active Transcutaneous Bone Anchored Implants

Zachary G. Schwam MD; Samuel Oh BA; Kevin Wong MD; Caleb Fan MD
Enrique Perez, MD, MBA; Maura K. Cosetti MD; George B. Wanna MD

Objective: Evaluate our initial experience with two active transcutaneous bone anchored implant (BAI) systems.

Study Design: Retrospective cohort study.

Setting: Tertiary otology-neurotology practice.

Patients: Those with conductive hearing loss meeting criteria to undergo BAI.

Interventions: Implantation with Med El Bonebridge BCI602 and Cochlear™ OSIA® among other indicated procedures.

Main Outcome Measures: ease of procedure, procedure time, patient satisfaction.

Results: Five Bonebridges and ten OSIA® were implanted 2020-2021. Average patient age was 34.8 years, BCPTA 18.0dB, ABG 47.3dB. Etiology of hearing loss was microtia/atresia (n=6), radical mastoidectomy (n=4), tympanosclerosis, ossicular discontinuity, and inability to wear conventional hearing aids in the remainder. Operative times were similar between the implants (Bonebridge mean 78.0 mins, OSIA® 80.8 mins). Difficult implantation was encountered in one case with Bonebridge compared to 5/10 OSIA® due to circumferential clearance and skull shape. One Bonebridge patient had a prominent device profile postoperatively, while 5/10 OSIA® patients had significant edema, inflammation, and issues with the magnet. While all patients were pleased with the audio quality and derived benefit with a mean follow-up of 2.4 months, two OSIA® patients reported static noise with usage. Two OSIA® were explanted due to infection; one was performed one year prior and referred by an outside provider; the other occurred 4 months later with wound breakdown. There were no statistically significant differences in any of the outcomes measured.

Conclusions: Active transcutaneous implants are effective in indicated cases with similar operative times. Additional data are needed to compare postoperative infections and device prominence.

***Professional Practice Gap & Educational Need:** Educate otolaryngologists and otologists/neurotologists on newer bone anchored implants.

***Learning Objective:** To describe the various important factors that go into decision making when choosing between these two implants, describe the learning curve associated, and to use the above information to inform one's own practice.

***Desired Result:** Attendees will be able to report on the differences between the two manufacturers for ease of implant placement and soft tissue effects in each group.

***Level of Evidence –** V.

***Indicate IRB or IACUC:** Exempt.

RESIDENT RESEARCH TRAVEL AWARD

Dynamic Molecular Markers of Otosclerosis in the Human Cochlea

Sarah Hodge, MD; Ivan A Lopez, PhD; Hirooki Matsui, MD
Gail Ishiyama MD; Alex Cronkite MD; Akira Ishiyama, MD

Objective: To investigate the role of key proteins in the complex pathogenesis of otosclerosis in human temporal bones

Background: Molecular biological proteomic studies have suggested key proteins involved in bony remodeling in otosclerosis. The present study investigates the expression of some of these key proteins: transforming growth factor beta-1 (TGF beta-1), ubiquitin, nidogen-1, collagen-X, and bone sialoprotein (BSP) using immunohistochemistry techniques on celloidin embedded sections of the inner ear from patients with otosclerosis.

Methods: Archival celloidin formalin-fixed 20-micron thick sections from 7 patients diagnosed with otosclerosis were studied. Sections in the mid-modiolar region were immunoreacted with rabbit polyclonal antibodies against nidogen-1, collagen X, BSP, and monoclonal antibodies against TGF beta-1 and ubiquitin. Digital images were acquired using a high-resolution light and laser confocal microscope.

Results: TGF beta-1, ubiquitin, nidogen-1, and collagen-X were expressed in the otospongiotic region, and to lesser extent, in the otosclerotic region, the latter previously believed to be inactive. BSP, meanwhile, was present in the extracellular bone matrix. TGF beta-1 was specifically localized to the perivascular bone within the otospongiotic region. Ubiquitin distribution localized to both the otosclerotic and otospongiotic foci, and within the membranous labyrinth. There was a basal level of expression of these markers in the normal hearing specimens with increasingly more expression as hearing loss progressed.

Conclusions: These proteins identified and described using immunohistochemistry may play an important role in the pathogenesis of otosclerosis. Results support an active bone remodeling process, particularly in the otospongiotic foci suggesting these proteins may be targets for future therapeutic interventions.

Professional Practice Gap & Educational Need: The definitive biochemical changes involved in otosclerosis are widely unknown. Identifying and characterizing molecular markers is a crucial component to better understanding this disease process.

Learning Objective: To describe the role of key biochemical markers in the complex pathogenesis of otosclerosis

Desired Result: Identifying the presence and distribution of key proteins can help elucidate molecular processes and identify possible targets for future therapeutics.

Level of Evidence – Level IV

Indicate IRB or IACUC : #10-001449, UCLA

Impact of Modern Surgical Techniques on Rates of Sensorineural Hearing Loss and Revision Surgery after Stapedotomy

Nabil F. Darwich, MD, PhD; Alexandra E. Quimby, MD, MPH
Tiffany P. Hwa, MD; Stephen J. Eliades, MD, PhD; Jason A. Brant, MD
Douglas C. Bigelow MD; Michael J. Ruckenstein, MD MSc

Objective: Historically, stapedectomy complication rates are quoted at 1% for profound postoperative sensorineural hearing loss (SNHL), 5-6% for non-profound SNHL, and 5% for revision surgery. We sought to reassess the rates of these and other common post-operative complications in our experience using modern surgical technique.

Study Design: Retrospective case series.

Setting: Single academic tertiary referral center.

Patients: Adults ($\geq$ 18 years) who have undergone stapedotomy from 2013-2020.

Interventions: Stapedotomy.

Main Outcome Measures: Rates of post-operative profound SNHL, dizziness, tinnitus, and dysgeusia; successful air-bone-gap closure; and revision rates.

Results: 468 stapedotomies performed in 402 patients by 4 surgeons were reviewed. Mean age was 49.85 years. The average preoperative air-bone gap was 31.60 dB. In 366 operations (78.20%), the patient experienced closure of the air-bone gap within 10 dB, and in a further 74 (15.81%) there was closure to between 10-20 dB. Air pure tone audiometry scores improved by an average of 25.63 dB after surgery. Rates of postoperative dizziness, tinnitus, and dysgeusia were 6.20%, 3.63%, and 7.26%, respectively. There were 2 cases (0.43%) of postoperative profound SHNL and no non-profound SNHL. There were 54 (11.72%) revision stapedotomies; however, in 20 of these (37.03%), the original stapedotomy was performed over 20 years ago. The revision rate for stapedotomies performed at our institution within the past 20 years was 3.63% (17 revision surgeries), completed within an average of 14.35 months from initial surgery.

Conclusions: Rates of post-operative SNHL and revision surgery following stapedotomy performed using modern technique are substantially lower than those commonly cited to patients based on classic techniques and historical data.

***Professional Practice Gap & Educational Need:** Complication and success rates of stapedotomy cited to patients in pre-operative counselling are in many instances based on historical data that does not take into account modern surgical technique.

***Learning Objective:** Gain an updated understanding of the risks of stapedotomy in the modern era in order to better inform discussions with patients surrounding surgery.

***Desired Result:** At the conclusion of this presentation, the participants should be able to recognize the rates of hearing loss and revision surgery after stapedotomy using modern surgical techniques compared to historical techniques. Participants will also be able to discuss surgical outcomes of modern stapedotomy.

***Level of Evidence –** V

***Indicate IRB or IACUC :** University of Pennsylvania, IRB exempt.

National and International Rates of Stapedectomy Performed at Academic and Non-Academic Centers across the Department of Defense

Jason K. Adams, MD; John P. Marinelli, MD; Ronit E. Malka, MD
Carlos R. Esquivel, MD; Travis R. Newberry, MD
Samuel A. Spear, MD; Isaac D. Erbele, MD

Objective: Stapedectomy remains a key indicator case reportable to the ACGME despite the decline in the incidence of otosclerosis over the last half-century. This study compared the rates of stapedectomy performed by otolaryngologists at academic and non-academic centers.

Study Design: Retrospective review.

Setting: Tertiary referral academic centers, non-academic centers, civilian purchased care across the Department of Defense between 2015 and 2020.

Patients: Tricare beneficiaries with otosclerosis near a military treatment facility with an otolaryngologist.

Interventions: Stapedectomy (CPT codes 69660, 69661, and 69662).

Main Outcome Measures: Number of stapedectomies performed by setting.

Results: From 2015 to 2020, 426 stapedectomies were performed at or near a military treatment facility with an otolaryngologist (274 directly by military otolaryngologists, 152 by community providers). At tertiary care centers (n=7), 214 were performed by military otolaryngologists and 14 were performed in the surrounding area (direct care rate = 94%). At non-academic centers (n=65), 60 stapedectomies were performed by military otolaryngologists and 138 were performed in the community (direct care rate = 30%). Among the 60 stapedectomies performed at non-academic centers, 43 were performed by fellowship trained neurotologists and 17 were performed by general otolaryngologists (4% of stapedectomies). The difference in the rate of direct care was statistically significant between stapedectomies performed at academic and non-academic centers ($p<0.0001$).

Conclusions: Low surgical volume by general otolaryngologists reinforces recent epidemiologic trends and suggests that stapes surgery should most appropriately be considered a key indicator case for fellows pursuing otology subspecialty training, rather than a key indicator for otolaryngology r esidents.

Professional Practice Gap & Educational Need: Recent population-based data suggest the incidence of otosclerosis is likely too low to support the development of meaningful proficiency in stapes surgery at most otolaryngology training programs. Despite the strongly suggestive epidemiologic trends, limited data characterizes the surgical implications of modern incidence rates and the resultant stapes surgery rates after graduation from residency.

Learning Objective: Describe the differences in rates of stapedectomy performed at comprehensive general otolaryngology centers and academic specialty otolaryngology centers within a single healthcare system.

Desired Result: Given the declining incidence of otosclerosis, in combination with the infrequency of stapes surgery performed by general comprehensive otolaryngologists, stapedectomy should be removed as a key indicator case for otolaryngology trainees and instead emphasized as a fellowship-l evel case.

Level of Evidence – Level III

Indicate IRB or IACUC : Approved IRB **number** C.2022.002n.

Cochlear and Vestibular Dysfunction in the COVID-19 Era:
A Population Based Study

Claudia I. Cabrera, MD, MS; Benjamin Johnson, MD; Maroun Semaan, MD
Alejandro Rivas, MD; Sarah Mowry, MD; Nauman Manzoor, MD

Objective: During the recent pandemic sudden hearing loss, vertigo and tinnitus have been reported as clinical manifestations of COVID-19 infection or a side effect of the COVID-19 vaccination. The aim of our study was to investigate the likelihood of the aforementioned otological symptoms between COVID-19 + unvaccinated, and COVID-19 negative (–) vaccinated patients, within the first 8 weeks after diagnosis of COVID-19 or after the vaccine.

Study Design: Retrospective Longitudinal study using 1:1 greedy nearest-neighbor propensity score matching based on age, gender, race, and ethnicity.

Setting: TriNetX Research Network.

Patients: January 1, 2020 through September 2, 2021 (date of data access).

Interventions: N/A

Main Outcome Measures: Sudden hearing loss, acute vestibular disorders and tinnitus.

Results: A total of 1,078,487 patients met our criteria for the COVID-19 (–) vaccinated cohort, and 383,907 for the COVID-19 + unvaccinated one. After matching we found a higher likelihood of vertigo OR 3.8 ($p< 0.001$), tinnitus OR 1.2 ($p<0.01$) among those COVID-19 + unvaccinated patients when compared to those COVID-19 (–) vaccinated. There was no difference in the likelihood of sudden hearing loss between groups.

Conclusions: Our study suggests there is a higher likelihood of developing vertigo and tinnitus related to a COVID-19 infection when compared to being vaccinated against the disease. This study is the first to study this by utilizing data from approximately 50 large healthcare organizations using a large sample size and a matched design. Further research is needed to investigate the mechanism and long-term effects in the quality of life of patients who develop these conditions.

***Professional Practice Gap & Educational Need:** Understand the likelihood of a patient experiencing sudden hearing loss, vertigo and tinnitus after diagnosis of COVID-19 or after being vaccinated.

***Learning Objective:** Understand the association of those symptoms and COVID-19.

***Desired Result:** Increase awareness of ontological symptoms and COVID-19 and future practices.

***Level of Evidence –** N/A

***Indicate IRB or IACUC :** Exempt.

Standardization of Outcome Measures for Intratympanic Steroid Treatment for Idiopathic Sudden Sensorineural Hearing Loss

Neil K. Osafo, BS; David R. Friedland, MD, PhD; Michael S. Harris, MD
Jazzmyne Adams, MPH; Chasity Davis; Ling Tong, MA; Jake Luo, PhD

Objective: To compare patient response to intratympanic steroid (IT) treatment using the American Academy of Otolaryngology Head and Neck Surgery (AAO-HNSF) guideline vs other reported criteria.

Study Design: Retrospective chart review

Setting: Academic otology practice

Patients: 74 patients with a diagnosis of idiopathic sudden sensorineural hearing loss (ISSNHL) between April 2003 and December 2020 were included. All patients had at least 1 treatment with IT steroids and both pretreatment and follow-up audiograms.

Interventions: IT steroid injection

Main Outcome Measures: 1) Determination of the efficacy of IT steroids for ISSNHL using the AAO-HNSF guideline vs other reported criteria; 2) Correlation of clinical and treatment variables with response to IT steroid

Results: PTA-4 using AAO-HNSF reporting criteria demonstrated full recovery in 24.32% of patients. Applying the 8 other reported outcomes criteria to our patients showed full recovery ranging from 14.87% to 40.54% of patients. Similarly, AAO-HNSF criteria showed no recovery in 51.35% of patients, while applying the other reported criteria showed no recovery in 51.45% to 82.43% of patients. Low frequencies exhibited full recovery in 33.78% of patients while high frequencies recovered in 27.03%. Younger age ($p=0.003$, effect size 0.924) and IT injection within a week of onset ($p<0.001$, effect size 1.099) positively correlated with full recovery. There was no impact of prior or concurrent oral steroids nor number of steroid injections on outcome.

Conclusions: Great variability exists in the literature for assessment of IT steroid outcomes in ISSNHL. AAO-HNSF standardization of outcome measures is necessary to accurately characterize IT steroid efficacy.

***Professional Practice Gap & Educational Need:** Lack of accurate information regarding the efficacy of IT steroid treatment for ISSNHL

***Learning Objective:** 1) To promote standardization of reporting outcomes for ISSNHL; 2) To recognize variables associated with recovery from ISSNHL

***Desired Result:** Utilization of AAO-HNSF guideline as standard for reporting outcomes

***Level of Evidence -** IV

***Indicate IRB or IACUC :** IRB#: 1538127

Changes and Trends in the Cochlear Implant Literature over a 40-year period: A Comprehensive Historical Literature Review

Jacob Kahane, MD; Anne Maxwell, MD; Moises Arriaga, MD, MBA

Objective: The objective of this study is to historically evaluate changes and trends within the cochlear implant literature over time.

Study Design: Comprehensive Literature Review

Setting: Tertiary care academic medical center

Patients: A historical review of the cochlear implant literature was conducted in 10-year intervals from 1980 to 2020. The 5 journals with the highest volume of cochlear implant literature in 1980 and still in publication today were queried using PubMed.

Interventions: Address the trends and changes within the cochlear implant literature from 1980 to 2020.

Main Outcome Measures: The main outcome of this literature review is the change in the quality and quantity of cochlear implant studies over time. .

Results: 182 articles met inclusion criteria. A statistically significant increase in publications occurred every decade from 1980 to 2020. The mean level of evidence of all articles significantly improved every decade after 1990. The mean level of evidence for articles primarily concerning pediatric populations (3.8) was not significantly different than from those investigating adult patients (3.7). Articles from the United States (3.8) had a significantly lower level of evidence than those from other regions (3.0) across all time frames. The percentage of prospective studies increased every decade until 2020. The percentage of articles from non-university practices decreased significantly from 1990 to 2000. The percentage of articles mentioning the single channel electrode in a historical context significantly decreased from 1980 to 2000. The percentage of articles citing either William House or Graeme Clark as the inventor of the cochlear implant decreased from 1980 to 1990. Across all time frames, William House is mentioned significantly more often than Graeme Clark as the inventor of the cochlear implant.

Conclusions: The evaluation of the historical trends within the cochlear implant literature sheds light on significant developments and events within the field over time. Overall, the quality of evidence has become stronger within the last 20 years, with a trend toward more prospective studies. This review shows how developments in the field of neurotology and world events, such as the development of the ACGME accredited fellowship program in the mid to late 1990s and the COVID pandemic of 2020, have influenced the cochlear implant literature.

Define Professional Practice Gap & Educational Need: This study addresses a knowledge gap in the historical cochlear implant literature. We have found no other studies that use historical literature to evaluate the trends and changes in quality of cochlear implant research over time.

Learning Objective: Review cochlear implant literature over the past 40 years in order to critically evaluate future directions of study and gain historical perspective.

Desired Result: Improve future directions of study within the field of cochlear implantation by evaluating the historical literature

Level of Evidence - I

Indicate IRB or IACUC: Exempt

Association of Baseline Frailty Status and Age with Postoperative Complications Following Cochlear Implantation: A National Inpatient Sample Study

Kyril L. Cole, MPH; Alis J. Dicpinigaitis, BA; Eric Babajanian, MD
Steven A. Gordon, MD, MPH; Neil S. Patel, MD
Christian A. Bowers, MD; Richard K. Gurgel, MD, MSCI

Objective: To determine the independent associations of chronological age and frailty, as measured by a validated, 5-factor modified frailty index (mFI-5 respectively), on postoperative outcomes of patients undergoing cochlear implantation (CI).

Study Design: Cross-sectional national database study

Setting: National Inpatient Sample Database

Patients: Adult patients undergoing CI surgery from 2001-2018.

Interventions: Cochlear implantation. In addition to demographics and postoperative complications, the mFI-5 (comprising a pre-operative history of chronic obstructive pulmonary disease, congestive heart failure, hypertension, diabetes mellitus, and partial or total-dependent functional status) was calculated for all patients included in the analysis.

Main Outcome Measures: Any postoperative complications, including major complications (pneumonia, sepsis, etc.), minor complications (urinary tract infections, blood transfusions, etc.), and implant-specific complications (otitis media, implant failure, etc.). Predictors of complications were examined using multivariate logistic regression with an odds ratio (OR) and a 95% confidence interval (95% CI) reported.

Results: There were 5,130 patients included with a median age of 60 (interquartile range 44-73) and a female predominance (53.5%). There were 2,979 (58.1%) robust patients (non-frail, mFI-5=0), 1,710 (33.3%) pre-frail (mF-5=1), 362 (7.1%) frail (mFI-5=2), and 78 (1.5%) severely-frail (mFI-5$\geq$3). There were 328 (6.5%) patients who experienced postoperative complications. Multivariate analysis showed no statistically significant correlation between patient age and complications, however, increasing frailty did show an independent correlation with non-home discharge (severely frail, OR 16.99, 95% CI 10.36-27.90, $p < 0.001$).

Conclusions: Increasing frailty and age do not predispose to postoperative complications in this patient cohort. However, frail patients are at increased risk for non-home discharge.

***Professional Practice Gap & Educational Need:** Patients and clinicians may believe that older patients should not be considered for CI due to risks of surgery. Many studies have been devoted to the safety of CI in older adults, though few report on an accurate metric to account for medical comorbidities, i.e., frailty, and how frailty may impact the postoperative course of CI patients. This study suggests that CI is low risk at the ages studied, but patients with increasing frailty may require more intensive postoperative monitoring for discharge to home.

***Learning Objective:** Understanding frailty's predictive ability on postoperative complications following CI.

***Desired Result:** To provide a metric that can risk stratify adult CI patients for postoperative complications or non-home discharge.

Level of Evidence - Level III

Indicate IRB or IACUC: University of Utah IRB_00147585

Influence of Fractalkine Receptor CX3CR1 Deletion on Cochlear Hair Cell Survival and Macrophage Expression in Chronic Suppurative Otitis Media

Viktoria Schiel, MD, PhD; Anping Xia, MD, PhD; Jing Chen, MPH, DABT
Brian Bacacao, BS; Laurent A. Bekale, MD, PhD; Peter L. Santa Maria, MD, PhD

Background: Chronic Suppurative Otitis Media (CSOM) is a neglected disease that afflicts 330 million people worldwide and is the most common cause of permanent hearing loss among children in the developing world.

Hypothesis: We have demonstrated that CSOM causes macrophage associated sensory hearing loss. In this report, we examined the influence of fractalkine receptor (CX3CR1) deletion ($CX3CR1^{GFP/GFP}$) in CSOM.

Methods: We investigated in our novel pseudomonas aeruginosa PA CSOM animal model, previously validated to mimic the human disease.

Results: We observed partial outer hair cell (OHC) loss in the cochlear basal turn, no OHC loss in the middle and apical turns in both $CX3CR1^{GFP/GFP}$ and wild type (WT) mice at 14 days after bacterial inoculation. The number of OHCs in the base remained as 26.6/100 μm of the basilar membrane in $CX3CR1^{GFP/GFP}$ mouse and 27.0/100 μm of the basilar membrane in WT mouse. There was no significant difference ($p = 0.95$). In contrast to OHC loss, no IHC loss was found in all cochlear turns. We also counted F4/80 macrophages in hair cells area and outer sulcus region with Z-stack images in whole mount samples. Macrophages have 6.0/100 μm of the basilar membrane in $CX3CR1^{GFP/GFP}$ mice and 5.6/100 μm of the basilar membrane in WT mouse. There was also no significant difference ($p = 0.68$).

Conclusions: Together, the data did not support the correlation in HC loss and macrophage numbers between fractalkine receptor deletion and WT CSOM. We will further investigate the immune responses in the whole cochlea in $CX3CR1^{GFP/GFP}$ comparing with WT mouse.

***Professional Practice Gap & Educational Need:** We propose to investigate how sensory hearing loss (SHL) is caused by chronic suppurative otitis media (CSOM): severe chronic middle ear infections. CSOM is a neglected disease that afflicts 330 million people worldwide and is the most common cause of permanent hearing loss among children in the developing world. It is characterized by a chronically discharging infected middle ear, and there is currently no effective cure.

***Learning Objective:** To investigate the interaction between the CX3CR1 receptor function on macrophages and hair cells loss in chronic suppurative otitis media.

***Desired Result:** To show a correlation between the CX3CR1 receptor function on macrophages and hair cells loss in CSOM to further investigate the immune response in sensory hearing loss.

***Level of Evidence -** Level III

***Indicate IRB or IACUC :** APLAC (Administrative Panel on Laboratory Animal Care, Stanford University) protocol number 32855

Evaluation of Safety and Efficacy of Povidone-Iodine Solution as an Ototopical Treatment in a Murine Model of Chronic Suppurative Otitis Media

Adam C. Kaufman, MD, PhD; Brian Bacacao, BS
Laurent Bekale, PhD; Peter L. Santa Maria, MD, PhD

Hypothesis: Povidone-Iodine solution can eliminate biofilms and persister cells rapidly in *in vivo* achievable concentrations without inducing ototoxicity.

Background: Chronic suppurative otitis media (CSOM) is a substantial global problem. Current treatment options often induce a temporary remission without leading to a permanent cessation of symptoms secondary to the inability treatments inability to eliminate biofilm and persister cells. Povidone-Iodine has been shown to be able to clear biofilm and planktonic cells in *in vitro* assays, but there are reports of ototoxic effects limiting its utility.

Methods: Bacterial and biofilm growth with quantification by spectrophotomer, murine auditory brainstem response (ABR) and distortion product otoacoustic emissions (DPOAE), immunohistochemistry, *in vivo* povidone-iodine treatment of murine CSOM, persister cell assay

Results: Commercially available 10% povidone-iodine solution is able to completely eradicate multiple clinical strains of *pseudomonas aeruginosa* (PA) and *staphylococcus aureas* (SA) is as little as 5 minutes of exposure. 1% povidone-iodine solutions are able to reduce bioburden of PA and SA to levels that are not clinically relevant (10^4 CFU/mL). Mice that have received a transtympanic injection of 1% povidone-iodine solution did not have significantly different ABR or DPOAE results compared to mice that received a saline injection. The DPOAE of mice that received a povidone-iodine scrub worsened by almost 30 decibels which is a significant change ($p<0.05$). Immunohistochemistry was performed to confirm loss of outer hair cells. A murine model of CSOM was inoculated with PA and a persister cell assay was completed to determine clearance of infection.

Conclusions: Povidone-iodine solution is effective at eliminating biofilm and persister cells at *in vivo* achievable concentrations. The diluted solution does not have ototoxic potential while the scrub variant, which contains detergents, significantly worsened hearing thresholds after a single treatment.

***Define Professional Practice Gap & Educational Need:** CSOM is a recalcitrant disease requiring frequent courses of ototopical treatments often eventually needing surgical intervention. There is a desperate need for more effective medical options. Povidone-iodine is often overlooked as treatment option due to prior reports of ototoxicity. Diluted solutions of povidone-iodine without detergent do not appear to raise the hearing thresholds in mice. Povidone-iodine solutions are able to clear biofilm and persister cells of PA and SA.

***Learning Objective:** Povidone-iodine is able to rapidly sterilize PA and SA in all bacterial states
Povidone-iodine scrub is ototoxic while the solution variant does not appear to impact ABR and DPOAE in murine models

***Desired Result:** Diluted povidone-iodine solutions should be considered earlier in the treatment algorithm for CSOM.

Level of Evidence – Laboratory Science

Indicate IRB or IACUC : IACUC Protocol 33535 Stanford University

Improvement of Eosinophilic Otitis Media with Targeted Biologic Therapy

C. Yoonhee Ryder, BS; Mark A. Zacharek, MD; Christopher M. Welch, MD, PhD

Objective: To compare the responses of eosinophilic otitis media to treatment with or without a targeted biologic therapy against IL-4, IL-5, or IL-13 signaling

Study Design: Retrospective review

Setting: Tertiary referral center

Patients: Subjects with Type 2 chronic rhinosinusitis with nasal polyposis (CRSwNP) and eosinophilic otitis media who underwent treatment between 2005 and 2021

Intervention: Treatment with targeted biologic therapy

Main Outcome Measures: Pre- and post-treatment nasal endoscopy, ear examination, and audiologic evaluation

Results: Four hundred seventy-seven subjects were identified with Type 2 CRSwNP treated between 2005 and 2021. Sixty-two had symptomatic otitis media with pre- and post-treatment evaluation. Retrospective chart review assessed pre- and post-treatment exam findings, nasal endoscopy findings, and audiologic measures (hearing loss, tympanometry). During treatment nineteen subjects received a targeted biologic therapy, while forty-three did not. Exam, endoscopy, and audiometric findings were graded on a 3-point scale and compared pre- and post-treatment to generate a differential score (a larger value indicates improvement). Nasal endoscopy scores improved with biologic therapy relative to the control group, though not statistically significant (control 1.04, biologic 1.36, p 0.22). Subjective ear exam and audiometric findings were significantly improved with biologic therapy (control 0.05, biologic 0.84, p 9.3×10^{-5}; control -0.1, biologic 0.62, p 0.0002).

Conclusions: Biological therapies targeting IL-4, IL-5, and IL-13 signaling have changed treatment strategies for eosinophilic conditions such as Type 2 CRSwNP. This is the largest study to date demonstrating improvement in ear symptoms in subjects with eosinophilic otitis media in response to targeted biologic therapy, and immune modulation represents a novel treatment strategy for this challenging condition.

Professional Practice Gap & Educational Need: Current treatment strategies for otologic symptoms in eosinophilic disease are not tremendously effective or durable, resulting in a need for improved treatment options

Learning Objective: To determine if targeted biologic therapy, often used for eosinophilic asthma and Type 2 chronic rhinosinusitis with nasal polyposis, improves coexistent eosinophilic otitis media

Desired Result: Treatment of eosinophilic otitis media with targeted biologic therapy will result in improvement of otologic symptoms with a durable response compared to current treatment options

Level of Evidence – Level IV

Indicate IRB or IACUC: Exempt.

SELECTED ABSTRACTS

POSTER PRESENTATIONS

155th Annual Meeting
AMERICAN OTOLOGICAL SOCIETY

April 29-30, 2022
Hyatt Regency
Dallas, TX

Genetic Mutations in Middle Ear Cholesteatoma

Chisei Satoh, MD, PhD; Koh-ichro Yoshiura, MD, PhD; Hiroyuki Mishima, DDS, PhD
Haruo Yoshida, MD, PhD; Haruo Takahashi, MD, PhD; Yoshihiko Kumai, MD, PhD

Hypothesis: Mutation of a proto-oncogene may increase the pathology of a middle ear cholesteatoma.

Background: Many studies have suggested that chronic inflammation contributes greatly to the development of cholesteatoma. However, it remains unknown whether neoplastic-like features play any role.

Objective: To analyze genetic variants of middle ear cholesteatoma and address the question: Do the pathologies exhibit features of neoplasms?

Methods: DNA was extracted from cholesteatomas and blood samples of five patients, followed by exome sequencing. MuTect2 software was used to extract somatic variants present in cholesteatomas but not blood. All exons of the variant genes were analyzed using an additional 17 cholesteatoma/blood pairs. Capture baits for these genes were designed using the Sure Design system (Agilent Technology), and the genes were sequenced.

Results: Exome sequencing of five patients revealed 24 genes with somatic mutations. Sequencing of all exons of these genes in 17 additional cholesteatoma/blood pairs revealed variants in Myc in two samples and variants in Notch1 in five; both genes are known proto-oncogenes.

Conclusion: Five of the 22 cholesteatoma samples exhibited variants in Notch1 (a proto-oncogene), suggesting that Notch1 signaling may be associated with the pathology of cholesteatoma. Further studies are necessary to explore the clinical significance of this observation.

Professional Practice Gap & Educational Need: There is limited knowledge about genetic mutations in cholesteatoma.

Learning Objective: To find out if cholesteatoma is close to a neoplasm in terms of genetic mutation.

Desired Result: There is a gene that is commonly mutated in cholesteatoma samples.

Level of Evidence - Does not apply

Indicate IRB or IACUC: This study protocol has been approved by the committee for Ethical Issues on Human Genome and Gene Analysis at Nagasaki University: 20150501-2

Bilateral Sensorineural Hearing Loss in a Patient Treated with Nivolumab and Ipilimumab for Metastatic Melanoma

Nader Berry, BS; Karl W. Doerfer, MD; Jonathan Choi, MD
Dennis I. Bojrab Sr., MD

Objective: To report a case and discuss existing literature related to diagnosis and management of sudden, bilateral, sensorineural hearing loss (SNHL) and uveitis following treatment for metastatic melanoma with immune checkpoint inhibitors Nivolumab and Ipilimumab.

Study Design: Case Report

Setting: Tertiary Neurotology Referral Center

Patients: A 77 year-old male who developed sudden, bilateral, SNHL and uveitis after starting immune checkpoint inhibitor therapy (ICIT) for metastatic melanoma.

Interventions: Treatment of SNHL using intratympanic steroid injections and systemic steroids. Treatment of uveitis with steroid eye drops.

Main Outcome Measures: Audiogram, ophthalmologic evaluation**.**

Results: During ICIT for metastatic melanoma, the patient developed acute, bilateral, hearing loss, auditory distortion, and vision changes. Leptomeningeal disease was ruled out. Audiogram demonstrated moderate sloping to severe high-frequency hearing loss, and poor word recognition. Ophthalmic evaluation confirmed uveitis. ICIT was held for two weeks during which he was treated with multiple intratympanic steroid injections, a high-dose, systemic steroid taper, and steroid eye drops. Following treatment, the patient's hearing and vision recovered, and ICIT was resumed.

Conclusions: This case report describes otologic side effects of ICIT with Nivolumab and Ipilimumab for metastatic melanoma. It highlights the potential efficacy of both topical and systemic steroids for SNHL and uveitis likely related to ICIT. It also shows the need for further investigation of potential otologic side effects of ICIT.

Define Professional Practice Gap & Educational Need: Sudden SNHL associated with ICIT is not well described in current otolaryngology literature. This possible adverse outcome will likely become more common as use of ICIT increases. Otolaryngologists should be aware of this disease entity, associated complications, prognosis, and management options.

Learning Objective: Increase awareness of ICIT related sudden SNHL, associated complications, prognosis, and management options.

Desired Result: To improve physicians' ability to understand, diagnose, and manage otologic complications related to ICIT.

Level of Evidence - Level V

Indicate IRB or IACUC : Exempt

The Incremental Economic Burden of Concurrent Depression in Hearing Loss Patients: A MEPS Study

Humzah A. Quereshy, MD, MBA; Noah Yaffe, BS; Brooke A. Quinton, BS
Sarah E. Mowry, MD

Objective: To analyze the incremental economic burden of depression on adults with concurrent hearing loss in the United States

Study Design: Retrospective cross-sectional study

Methods: Using the Medical Expenditure Panel Survey (MEPS) from 2007 to 2015, patients with hearing loss with at least one outpatient visit were identified by ICD-10-CM codes and stratified based on the presence of concurrent depression. A multivariate two-part regression model was used to determine incremental economic burden, healthcare utilization, and expenditures. This form of analysis has been well-founded in other specialties and has not been replicated in otology.

Results: Of 3360 patients with hearing loss, 720 (21.43%) were diagnosed with depression (mean expenditures: $14147.54±2101.17) and 2640 patients (78.57%) without depression (mean expenditures: $10071.18±805.49). The prevalence of depression was higher in patients with hearing loss (21.4%) than in patients without hearing loss (13.4%) ($p<0.001$). Patients with hearing loss and concurrent depression were more likely to be female ($p<0.001$), white ($p<0.001$), poor ($p=0.016$), and have comorbidities ($p<0.001$). These patients faced an increased expenditure ratio compared to those without depression (expenditure ratio: 1.47 [1.22,1.77], $p<0.001$). These patients had higher utilization for emergency room visits and medication visits ($p<0.001$) and higher expenditures for emergency room visits ($p=0.004$) and prescription medications ($p<0.001$) when adjusted for sociodemographic factors and comorbidities.

Conclusions: Patients with hearing loss and concurrent depression face a significant incremental economic burden due to their diagnosis of depression, compared to those without hearing loss. Otolaryngologists need to be more cognizant of the burden of depression among this patient population.

***Professional Practice Gap & Educational Need:** Lack of awareness and treatment of multidisciplinary effects of hearing loss

***Learning Objective:** Increase awareness of the compounding effect of hearing loss and psychiatric illness on financial toxicity.

***Desired Result:** Improve comprehensive care provided by otologists and neurotologists to holistically support their hearing loss patient population.

***Level of Evidence -** III

***Indicate IRB or IACUC:** Exempt

Hearing Test History and Discordance between Audiometry-Measured and Self-Reported Hearing

Janet S. Choi, MD MPH; Tyler J. Gathman, BS; Tina C. Huang, MD
Meredith E. Adams, MD MS

Objective: Discordance between objective and subjective measures of hearing is prevalent. However, the role of an audiogram on one's assessment of hearing has not been explored on a population-level. This study aims to investigate the association between hearing test history and discordance in audiometry-measured and self-reported hearing.

Study Design: National cross-sectional study.

Setting: 2005-2016 National Health and Nutrition Examination Survey

Patients: 13,832 participants (12-85+ years)

Intervention: Survey (self-reported hearing condition; time of last hearing test) and pure-tone audiometry.

Main outcome measure: Discordance between audiometry-measured hearing loss (defined as speech frequency pure-tone average ≥25dB HL in better hearing ear) and self-reported hearing loss.

Results: Rates of discordance between audiometry-measured and self-reported hearing were 15.4% [95% CI: 14.4-16.6%] overall and significantly higher among older adults (≥60 years) at 25.7% [95% CI: 24.1-27.5%]. Discordance was most prevalent among older adults who have never had their hearing tested (27.9% [95% CI: 24.5-31.6%]) and those who had hearing tested within 5 years (22.8% [95% CI: 19.3-26.7%]). In multivariate analyses adjusting for demographics, audiometric hearing loss severity, and tinnitus, underreporting of hearing loss was significantly less likely among individuals who had hearing tested previously (OR: 0.52 [95% CI: 0.40-0.67]), especially if they were tested less than 1 year ago (OR: 0.17 [95% CI: 0.10-0.26]).

Conclusions: Rates of discordance between audiometry-measured and self-reported hearing were higher for older adults who experience greater health consequences of hearing loss and would benefit most from amplification. Routine audiometric testing accompanied by proper counseling and education may improve awareness of hearing loss and understanding of one's own hearing, particularly among older adults.

***Professional Practice Gap & Educational Need:** This study will improve the current gap in our knowledge on the impact of hearing test on one's assessment of hearing on a population level.

***Learning Objective:** At the conclusion of this presentation, the participants should be able to recognize the difference in rates and patterns of discordance between audiometry-measured and self-reported hearing by history of previous hearing test.

***Desired Result:** Findings from the study will inform physicians about the potential role of audiogram for improving the discordance in subjective and objective measures of hearing in the US population, especially in older adults who commonly underreport their hearing loss.

***Level of Evidence –** level III

***Indicate IRB or IACUC: E**xempt

Understanding the Impact of a Global Pandemic on Cochlear Implantation in the United States

John P. Marinelli, MD; Ashley M. Nassiri, MD, MBA; Christine M. Lohse, MS
Colin L. W. Driscoll, MD; Brian A. Neff, MD; Matthew L. Carlson, MD

Objective: Cochlear Americas and Advanced Bionics together supply approximately 85% of cochlear implants (CIs) in the United States. The objective of the current study was to characterize the impact of the COVID-19 pandemic on national cochlear implantation rates using Cochlear Americas and Advanced Bionics cochlear implantation data between 2015 and 2020 across all ages.

Study Design: Analysis of prospectively registered patient data from two major CI manufacturers in the United States.

Patients: Children or adults who received unilateral or bilateral CIs.

Interventions: Cochlear implantation.

Main Outcome Measures: Annual implantation rates by age.

Results: A total of 46,346 patients received CIs between 2015 and 2020. The annual number of implant recipients increased significantly during the first five years of the study period for both children and adults, from a total of 6,179 in 2015 to 9,226 in 2019 ($p<0.001$). During 2020, national cochlear implantation rates witnessed a –13.1% drop across all ages compared to 2019, including a drop of –1.6% for those aged ≤3 years, –4.7% for those aged 4-17, –9.8% for those aged 18-64, –16.7% for those aged 65-79, and –22.6% for those aged ≥80. In a multivariable linear regression model, the percent drop in CIs differed significantly by age group ($p=0.004$) but not by miles traveled by the patient from home to the CI center ($p=0.45$).

Conclusions: Children ≤3 years old were prioritized nationally with minimal interruption witnessed during 2020. Increasing age was associated with experiencing significantly greater decreases in cochlear implantation rates, with those aged ≥80 years old experiencing more than a 3-year setback in total annual CIs.

Professional Practice Gap & Educational Need: The COVID-19 pandemic introduced multiple barriers to cochlear implantation, and thus far the magnitude of the pandemic's impact on cochlear implant hearing healthcare in the United States is unknown. The current study reports national cochlear implantation rates directly from two of the major cochlear implant manufacturers in the United States inclusive of the year 2020. Identifying uniquely disadvantaged subgroups of the population affected by the pandemic may facilitate development of widespread efforts to correct the backlog in cochlear implant hearing healthcare.

Learning Objectives:

(1) Describe the rising annual rates of cochlear implantation for two of the major cochlear implant manufacturers in the United States between 2015 and 2019.
(2) Understand the unique impact of the COVID-19 pandemic on national trends in cochlear implantation, particularly surrounding the differences between children with congenital deafness and adults of advanced age.
(3) Describe the month-to-month variation in cochlear implantation rates across the United States as it relates to national COVID-19 numbers during the year 2020.
(4) Understand the influence of patients' location of geographic residence on likelihood of receiving a cochlear implant during the COVID-19 pandemic.

Desired Result: Physicians and researchers would be able to better understand the impact of the COVID-19 pandemic on patient access to cochlear implants across the United States.

Level of Evidence: III

Indicate IRB or IACUC: Exempt.

Migraine Features in Patients with Fluctuating Hearing Loss

Mehdi Abouzari, MD, PhD; Shahrnaz Jamshidi, MD; Alizah S. Gomez, BS
Negaar Aryan, MD; Ariel Lee, BS; Hamid R. Djalilian, MD

Objective: To evaluate the presence of migraine features in patients with fluctuating hearing loss.

Study Design: Retrospective cohort.

Setting: Tertiary-care neurotology clinic.

Patients: Fifty-nine patients diagnosed with fluctuating hearing loss (other etiologies ruled out with exam, audiometry, CT scan, and MRI) between 2013-2021, with a mean age of 56 ± 16 years.

Interventions: Patients were evaluated for meeting the International Classification of Headache Disorders (ICHD) 3rd edition criteria for migraine headache without aura.

Main Outcome Measures: We compared the prevalence of migraine features in patients who met the majority of ICHD 3rd edition criteria (3 or more out of 5) for migraine headache to those who did not (less than 3 out of 5).

Results: There were 32 females (54%) and 27 male (46%) patients. Forty-two patients (71%) fulfilled 3 or more ICHD criteria for migraine headache without aura (migraine group). Of the patients who met less than 3 criteria (non-migraine group), 1 (2%) met 2/5 criteria, and 16 (27%) met 1/5 criteria, for a total of 17 (29%) patients. Migraine features were not significantly different between the migraine and non-migraine groups.

Conclusions: A large proportion of fluctuating hearing loss patients with migrainous features do not meet the ICHD criteria for migraine headache. The lack of meaningful differences in migraine features between patients in our cohort who fulfilled the majority of ICHD migraine criteria and those who do not represent selection bias rather than meaningful features unique to the cohorts. The diagnostic criteria for migraine may be too strict and unnecessarily exclude many patients from receiving migraine treatment.

Define Professional Practice Gap & Educational Need: Many patients with migraine-related fluctuating hearing loss do not meet the ICHD criteria for migraine and thus may not be treated as migraine patients by clinicians. In order to account for these patients, it will be important to re-examine the ICHD migraine criteria and to determine whether there exist meaningful differences in the prevalence of migraine features and symptomatology in these patients compared to those who meet the ICHD migraine criteria. Our study further supports the need to evaluate patients presenting with fluctuating hearing loss for possible migraine disorder when other causes have been ruled out.

Learning Objective: To educate ANS members on a series of patients with fluctuating hearing loss and identify limitations in the diagnostic criteria for migraine that may prevent patients from receiving appropriate treatment.

Desired Result: Increased awareness and consideration of migraine-related fluctuating hearing loss in the differential diagnosis by clinicians and expansion of the ICHD criteria for migraine headache may help expand the pool of patients who benefit from migraine therapy.

Level of Evidence - IV

Indicate IRB or IACUC: The study has IRB approval from the UC Irvine review board under the PI name of Hamid R. Djalilian.

Hearing Aids Enhance Active Music Enjoyment among Individuals with Hearing Loss

Alexander Chern, MD; Michael W. Denham, BA, BS, MPhil; Alexis S. Leiderman, BS
Rahul K. Sharma, MD; Anil K. Lalwani, MD

Objective: The impact of hearing aids (HAs) on music enjoyment is poorly studied. We examine the effect of HAs on active music enjoyment in individuals with varying levels of hearing loss (HL).

Study Design: Cross-sectional, within-subjects design

Setting: Tertiary medical center, community

Patients: Adult (≥18 years) bilateral HA users

Interventions: HA usage

Main Outcome Measures: The main outcome was music enjoyment. Subjects actively listened to musical stimuli and rated their enjoyment across three validated measures (pleasantness, musicality, and naturalness) with and without their HAs (order of conditions randomly assigned) using a visual analog scale. The main exposures were HA usage and HL (measured by pure tone average [PTA] and word recognition score [WRS] of the better ear).

Results:
One hundred bilateral HA users (mean age 66.0 years, 52% female, 44% with music experience, better ear mean PTA 50.2 dB, mean WRS 84.5) completed the study. Multivariable linear regression demonstrated increasing severity of HL was associated with decreased music enjoyment (pleasantness, musicality, naturalness) with and without HAs ($p<0.05$), adjusting for age, sex, education, race, HA type, age HL diagnosis, duration HL, duration HA use, musical preference, musical experience, and music discrimination. The use of hearing aids increased music enjoyment (musicality) across all subjects and subjects with moderate to moderately-severe HL (paired t-test).

Conclusions: Increased severity of HL is associated with decreased music enjoyment that can be enhanced with the use of HAs. Thus, the use of hearing aids can positively enhance both speech and music appreciation.

Define Professional Practice Gap & Educational Need: Hearing aids were designed for speech, not music listening. The impact of hearing aids on music enjoyment is poorly studied. Understanding this association will help inform healthcare personnel of the effect of hearing aids on music enjoyment across a range of hearing loss.

Learning Objective: After this presentation, the learner will be able to describe the relationship between hearing loss and music enjoyment, as well as the potential effect of hearing aids on music enjoyment.

Desired Result: Otolaryngologists will better understand the relationship between hearing loss and music enjoyment.

Level of Evidence – Level III

Indicate IRB or IACUC: Columbia Irving University Medical Center IRB-AAAR3559

Cochlear Implantation Outcomes in the Older Adult: A Scoping Review

Emily Kay-Rivest, MD, MSc; Jamie Schlacter, BSc; Susan Waltzman, PhD

Objective: To summarize available literature on cochlear implantation outcomes in older adults.

Data sources: MEDLINE, Embase and Web of Science were searched through July 2021.

Study selection: A scoping review was performed in accordance with the Preferred Reporting Items of Systematic Reviews and Meta-analysis extension for scoping review (PRISMA-ScR) guidelines. Studies reporting outcomes of CI recipients over age 60 were reviewed.

Data extraction: Extracted data was divided into five categories: open-set speech perception scores, perioperative complications and type of anesthesia, neurocognitive outcomes, quality of life assessments and vestibular outcomes/falls.

Data synthesis: Over 3000 abstracts were screened, and 107 studies were included from 21 countries, encompassing 5704 patients. 79 studies reported speech perception outcomes. Elderly patients achieved scores similar to younger patients, which were stable over time (over 10 years). Perioperative complications were discussed in 38 studies, with minor complications occurring in 0 to 23.5% of patient. 105 patients underwent CI under local anesthetic. Neurocognitive outcomes were assessed in 13 studies (10 prospective). Over a 7-year period, patients with mild cognitive impairment who underwent CI had lower rates of progression to dementia. Quality of life was assessed in 44, demonstrating improvements on various depression, anxiety and loneliness scales. Eight studies reported vestibular outcomes, and although changes in vestibular function were noted objectively, there was no increased incidence of postoperative falls.

Conclusions: Age should not be a limiting factor in cochlear implant candidacy, as older patients can achieve comparable performance with low rates of adverse events. Longitudinal studies will help assess long-term changes in cognition, and whether CI truly prevents cognitive decline.

***Professional Practice Gap & Educational Need:** 1) There is no comprehensive review of current literature which encompasses multiple important outcomes in older adults undergoing CI. 2) Research gaps are identified and can guide future studies towards areas that are less well described, such as neurocognitive outcomes, vestibular function changes, and the role of frailty.

***Learning Objective:** To review open-set speech perception scores, perioperative complications and type of anesthesia, neurocognitive outcomes, quality of life assessments and vestibular outcomes/falls in older adults undergoing CI.

***Desired Result:** Our goal is to provide attendees with a concise roadmap when faced with an older adult undergoing a CI, allowing them to better counsel patients and their families using the available outcomes literature.

***Level of Evidence -** NA

***Indicate IRB or IACUC:** Exempt.

Defining the Learning Curve for Endoscopic Ear Surgery: A Multi-Institutional Study

Kevin Wong, MD; Scott Gorthey, MD; Annie E. Arrighi-Allisan, BA; Caleb J. Fan, MD
Zachary G. Schwam, MD; George B. Wanna, MD; Maura K. Cosetti, MD

Objectives: 1) Quantify the learning curve for transcanal endoscopic ear surgery (TEES) and 2) determine if demographic factors or previous experiences influence skill development.

Study Design: Prospective, multi-center study.

Setting: Two academic teaching hospitals.

Subjects: 38 otolaryngology residents from two residency programs in the United States, 26 from program A and 12 from program B.

Interventions: Each participant completed a demographics survey and questions regarding previous otoendoscopy, sinus endoscopy, and video game experience. Residents then completed 10 amassed trials of a "precision stacking" task using a validated endoscopic ear simulator.

Main Outcome Measures: Trial completion times; rate of improvement over time; inverse regression learning curves.

Results: Mean age was 30 years old (range 26-34 years). Fifteen participants were female and 23 were male. Combined task completion times were analyzed over 10 trials to create inverse learning curves using non-linear regressions. The greatest improvements occurred over the first 3 trials and plateau reached before the 10^{th} trial. Prior experience with otoendoscopy (B=-16.7, p=0.005) and sinus endoscopy (B=-23.4, p=0.001) independently correlated with lower overall trial times. However, on multivariate logistic regression, residents *without* prior endoscopic experience improved at a faster rate than those with experience ($p<0.001$). Age, gender, postgraduate year, handedness, interest in otology, and video game experience did not correlate with trial times.

Conclusions: Novice surgeons can acquire endoscopic ear experience with simulation training. Specific task competencies can be achieved within 10 trials, suggesting that prior experiences, or lack thereof, may not dictate the ability to acquire new skills. There may be a translational value to previous endoscopic sinus experience on learning TEES.

Define Professional Practice Gap & Educational Need: As the prevalence of endoscopic ear surgery grows, uncertainties remain in regards to many aspects of its teaching and training. Defining the learning curve is one crucial step with implications for both patient safety and residency education.

Learning Objective: 1) Understand the learning curve for novice surgeons learning endoscopic ear surgery; 2) recognize the benefit of previous endoscopic experience –ear and sinus alike – for skills development.

Desired Result: 1) Increased incorporation of simulation into otology training; 2) recognition of learning curves as an important metric to optimize teaching, improve surgical outcomes, and minimize patient risk.

Level of Evidence: III - Cohort

Indicate IRB or IACUC: Mount Sinai Institutional Review Board (IRB- 20-01637)

Severe Hearing Loss is Associated with Poor Dynamic Balance Regardless of Vestibular Status and Age

Maria A. Mavrommatis, MD; Anat Lubetzky, PT, PhD, CSCS; Jennifer Kelly, DPT, NCS
Brittani Morris, DPT; Sarah Mischianti, SPT; Andrew Medlin, SPT; Maura Cosetti, MD

Objective: To identify the relationship between Hearing Class and dynamic balance

Study design: Cross-sectional

Setting: Tertiary academic practice

Patients: 86 patients (mean age 56.5 ± 17.7 years) who underwent behavioral audiometry and assessments of dynamic balance; 46 (53.5%) had hearing loss alone, 17 (19.8%) had vestibular dysfunction alone, and 23 (26.7%) had both

Intervention(s): Timed Up-and-Go (TUG) and Four-Square Step Test (FSST)

Main outcome measure(s): TUG and FSST are timed tests of dynamic balance where slower performance is associated with an increased risk for falls; Hearing Class as defined by the AAO-HNS guidelines, increasing in severity from Class A to D.

Results: 60 patients were classified as Hearing Class A (including all 17 patients with vestibular dysfunction alone and 15/23 (65.2%) patients with both vestibular dysfunction and hearing loss.) 12 were Hearing Class B, 9 were Class C, and 5 Class D. Overall, progressively slower TUG and FSST scores were noted with increasing Hearing Class. Class D was significantly slower than Class A in the FSST and TUG tests ($p = 0.025$ and 0.002, respectively) and Class B in FSST alone ($p = 0.018$). Age could not exclusively explain poorer TUG and FSST scores in patients with a higher Hearing Class, as Class D was not significantly older than Class B despite significant differences in FSST scores between the two groups ($p = 0.013$).

Conclusions: Severe hearing loss may independently contribute to balance dysfunction and risk of falls. Given the small number of patients in Class D, these results should be interpreted with caution and suggest further investigation into hearing loss and dynamic balance is warranted.

Define Professional Practice Gap & Educational Need: While it is widely accepted that vestibular dysfunction contributes to difficulties with dynamic balance, it appears that hearing loss may also have a significant impact.

Learning Objective: Severe hearing loss may contribute to balance dysfunction and risk of falls, independent from vestibular dysfunction and age.

Desired Result: Improved understanding of the relationship between hearing loss and dynamic balance may guide fall-risk intervention and therapy for patients with advanced hearing loss.

Level of Evidence – Level IV

Indicate IRB or IACUC: Mount Sinai 18-00431

Comparison of CT Incidence of SSWA and SCD in a Cohort of Patients with Idiopathic Pulsatile Tinnitus Compared with Control

Nathan D. Cass, MD; Nathan R. Lindquist, MD; Miriam R. Smetak, MD
Ankita Patro, MD; Kareem O. Tawfik, MD

Objective: Determine incidence of SSWA and SCD in pulsatile tinnitus patients compared with a control group.

Background: Patients with idiopathic pulsatile tinnitus (PT) who undergo workup with high resolution CT scan are occasionally found to have sigmoid sinus wall abnormalities (SSWA) or superior semicircular canal dehiscence (SCD), and may be offered surgery. We sought to confirm the incidence of these radiographic diagnoses in a representative group of patients with otherwise idiopathic PT, and compare it with a control group without idiopathic PT.

Study Design: Retrospective.

Setting: Tertiary care center.

Subjects: Patients with pulsatile tinnitus (n=46) or cochlear implant candidates (n=29) serving as controls who underwent high resolution CT scan (slice thickness 0.5 to 0.67mm) at our institution.

Main Outcome Measures: Incidence of SSWA and SCD, compared via unpaired T-test.

Results: Incidence of SCD is similar (p=0.81) between controls (13.8%) and PT subjects (13.0%), whereas SSWA is more common (p=0.0015) in PT subjects (17.4%) than controls (6.9%).

Conclusions: SSWA is likely causing PT in patients who exhibit this radiographic finding, without another obvious cause for PT. SCD is found at similar rates in our control group, leading us to believe SCD is less likely to be the causative agent in idiopathic PT. Further investigation is necessary to explain the high incidence of SCD in cochlear implant candidates.

Define Professional Practice Gap & Educational Need: We aim to compare incidence of SSWA in patients with PT, using a control group comparator, to give a better understanding of the incidence in the population to ensure neurotologists are treating the true underlying pathology in those who suffer from this condition.

Learning Objective: Understand the incidence of SSWA in a control group, compared to those with pulsatile tinnitus.

Desired Result: Apply the incidence of these conditions to practice, to offer surgical therapy to those with the best chance of experiencing symptom resolution.

Level of Evidence: III

Indicate IRB or IACUC: Vanderbilt University Medical Center IRB #210996

Automated Whole Cochlear T2 Signal Changes Do Not Correlate with Hearing Loss in Observed Acoustic Neuroma

Nathan D. Cass MD; Yubo Fan, MS; Nathan R. Lindquist, MD
Benoit M Dawant, PhD; Kareem O. Tawfik. MD

Objective: To evaluate the correlation between whole cochlear T2 signal changes obtained with a novel automated segmentation method and hearing levels, both at diagnosis and over time, in patients with observed acoustic neuroma.

Study Design: Retrospective evaluation at a tertiary neurotology practice.

Setting: Academic medical center neurotology practice and associated collaborative engineering program.

Patients: 127 patients with acoustic neuroma observed over time, each with ≥2 MRI scans (367 total) and ≥2 audiograms (472 total) over that time period.

Main Outcome Measures: Correlation of the ipsilateral-to-contralateral ratio of whole cochlea T2 signal with hearing outcomes as measured by pure tone average (PTA) and word recognition score (WRS).

Results: The ratio of cochlear T2 signal, as determined by a novel automated method, did not show a correlation with hearing levels at diagnosis. Change in signal ratio over time did also not correlate with changes in hearing over time. Cochlear signal ratio change did not precede, nor follow, changes in hearing.

Conclusions: Whole cochlear T2 signal ratio does not correlate with hearing levels in patients with observed acoustic neuroma. Nevertheless, the technology of automated segmentation and signal processing holds great promise for future evaluation of other clinical entities that may be associated with cochlear signal changes.

Define Professional Practice Gap & Educational Need: When counseling patients with small to medium sized acoustic neuroma, surgeons desire better markers for identifying the rates at which hearing will be lost in different patients, as it may clarify treatment recommendations. This study sought to evaluate one such marker via an innovative machine learning algorithm measuring cochlear T2 signal.

Learning Objective: To understand the correlation, or lack thereof, between T2 cochlear signal and hearing levels in patients with observed acoustic neuroma.

Desired Result: We hope that neurotologists will continue to search for better markers of impending hearing loss in observed acoustic neuroma.

Level of Evidence: V

Indicate IRB or IACUC: IRB Approved (#210996, Vanderbilt University Medical Center)

Stapedotomy Outcomes of Retrofenestral Otosclerosis: Association of the Halo Sign with Surgical Outcomes

Robert M. Conway, DO; Pedrom C. Sioshansi, MD; Amy Schettino, MD; Dennis I. Bojrab, MD
Christopher A. Schutt, MD; Seilesh C. Babu, MD

Objective: To examine the association of the "halo sign" on computed tomography (CT) with pre- and postoperative audiologic outcomes

Study Design: Retrospective chart review

Setting: Single tertiary care center

Patients: Adult patients undergoing primary stapedotomy with perioperative CT scan

Interventions: Stapedotomy

Main Outcome Measures: Patients were grouped based on the presence or absence of a halo sign on perioperative CT. Audiologic outcomes compared were pre- and postoperative word recognition score (WRS) and pure tone averages (PTA), bone conduction thresholds, and air-bone gap (ABG) in decibels (dB). Complications examined included postoperative profound hearing loss, facial paralysis, BPPV, or third window symptoms.

Results: Two hundred twenty-nine consecutive patients undergoing stapedotomy with perioperative CTs were included, 30 in the halo sign group and 199 in the non-halo sign group. Both preoperative PTA and ABG were significantly worse in the halo group. Preoperative ABG was 29.3 dB and 24.8 dB for the halo and non-halo groups, respectively (p=0.01). Similarly, preoperative PTA was 61.9 and 53.4 dB for halo and non-halo groups, respectively (p<0.05). There was no difference in preoperative mean bone conduction thresholds or WRS. Postoperative PTA, ABG, mean bone conduction thresholds did not differ significantly between the two groups. There was no difference in the complication profile between the two groups.

Conclusions: Patients with a halo sign on CT had significantly worse preoperative PTA and ABG compared to those without a halo sign. Both groups improved significantly following stapedotomy with similar postoperative audiologic outcomes.

***Professional Practice Gap & Educational Need:** There is limited evidence available on how halo sign on CT affects audiologic outcomes of patients undergoing stapedotomy.

***Learning Objective:** To increase the evidence of how CT image findings may affect stapedotomy outcomes.

***Desired Result:** To demonstrate that patients with halo sign on CT scan have similar outcomes after stapedotomy.

***Level of Evidence -** IV

***Indicate IRB or IACUC :** 1130957-4

Evaluation of Psoriatic Disease on the Audio-Vestibular System: Systematic Review & Meta-Analysis

Seth S. Jeong, BA; Michael C. Shih, BS; Paul R. Lambert, MD

Objective: To explore the association between psoriasis and the audio-vestibular system.

Data sources: Following PRISMA guidelines, the English-language literature from Pubmed, Scopus, CINAHL, and Cochrane databases were searched from inception to October 7, 2021.

Study selection: Included studies described audiometric or vestibular findings for subjects with psoriasis.

Data extraction: Risk of bias was assessed using Cochrane Handbook for Systematic Reviews of Interventions. Primary outcomes were audiometric and vestibular assessments.

Data synthesis: Continuous variables were summarized as pooled means (standard deviation). Meta-analysis was represented as odds ratios (OR) or mean difference (MD) with 95% confidence intervals.

Results: A total of 11 studies with 528 psoriasis and 558 controls were included. Age did not significantly differ between psoriasis (46.0[11.7]) and controls (46.7[13.0]) (MD 0.42[-1.33, 2.18], p=0.64). PASI score was 7.8 (7.8). Psoriatic manifestations included 94 plaque psoriasis, 21 guttate, 20 palmoplantar, 6 inverse, and 2 erythromatic. Audiometry analysis showed that speech reception threshold was worse with psoriasis (MD 3.48[1.88, 5.08] dB, p<0.0001). Greater hearing loss was present in psoriasis patients compared to healthy controls (MD 4.06[2.89, 5.22] dB, p<0.00001). Abnormal stapedial reflex was more common in psoriasis (OR 5.24[1.70,16.13], p=0.004). Abnormal vestibular testing was more common in psoriasis for caloric testing (OR 17.66[4.25, 73.29], p<0.0001) and saccade test (OR 5.07[1.64,15.65], p=0.005). Two additional studies of 41681 psoriasis and 80273 controls found that psoriasis patients were at higher risk for sudden sensorineural hearing loss (OR 1.50[1.25,1.80], p<0.0001)

Conclusions: Psoriasis is associated with hearing loss and vestibular dysfunction. The mechanisms of otologic manifestations remain unclear, and more basic science and translational research is needed.

***Professional Practice Gap & Educational Need:** Need for increased understanding regarding interplay of psoriasis with the audio-vestibular system.

***Learning Objective:** To understand the extent psoriasis can impact a patient's audio-vestibular system

***Desired Result:** Considerations for improvement of patients' quality of life, and call for basic science and translational research.

***Level of Evidence -** III

***Indicate IRB or IACUC :** N/A

Video Education Before Cochlear Implantation Enhances Patient Knowledge and Confidence: A Randomized-Controlled Study

Ankita Patro, MD, MS; David S. Haynes, MD; Kareem O. Tawfik, MD
Matthew R. O'Malley, MD; Marc L. Bennett, MD
Robert F. Labadie, MD, PhD; Elizabeth Perkins, MD

Objective: Evaluate video education's effects on patient knowledge and attitudes related to cochlear implantation (CI).

Study Design: Prospective, provider-blinded, randomized-controlled trial.

Setting: Tertiary referral center.

Patients: 56 adult CI candidates (28 video, 28 control) between 2020 and 2021.

Interventions: Following initial consultation with the surgeon and audiologist, patients were randomized into either the video or control group. Both groups completed five surveys: (1) prior to arrival; (2) after initial consultation; (3) on the day of surgery; (4) at the 1-month postoperative visit; and (5) at the 3-month postoperative visit. Video group participants viewed a 15-minute video on the CI process prior to completing the second survey.

Main Outcome Measures: Demographics, 17-question knowledge quiz, patient attitudes.

Results: There were no differences in age ($p=0.83$), gender ($p=0.79$), race ($p=0.33$), education level ($p=0.58$), income ($p=0.17$), time to surgery ($p=0.88$), or baseline knowledge ($p=0.08$) between the video and control groups. Video group participants had significantly higher knowledge scores after initial consultation (83% vs. 67%, $p<0.001$) and at 1 month post-op (80% vs. 70%, $p=0.02$). On the day of surgery, a higher percentage of the video group (87%) felt fully confident in pursuing implantation compared to the control group (58%) ($p=0.02$). Nearly half of the video group reported that the videos directly influenced their decision to proceed with CI surgery. Average rating for the videos was 9.2 out of 10.

Conclusions: Video supplementation to the traditional CI process improved patient understanding at multiple timepoints and significantly increased confidence in pursuing surgery.

Define Professional Practice Gap & Educational Need: While video education has been used in other specialties to decrease patient anxiety and increase knowledge, the role of videos for CI patients, who already struggle with social deprivation and communication during traditional office visits, has yet to be explored.

Learning Objective: To highlight the utility of video education in the CI process and demonstrate its benefits in patient understanding and confidence.

Desired Result: To report patient knowledge and attitude gains with educational videos and, in turn, encourage their adoption as a standard part of the CI process.

Level of Evidence: Level II.

Indicate IRB or IACUC: IRB Exempt (201932, Vanderbilt University).

Extensive Cervicofacial Emphysema Post Eustachian Tube Balloon Tuboplasty

Isabelle JH Jang, MD, MMed; Heng Wai Yuen, MMed

Objectives:

1. To report the rare complication of cervicofacial subcutaneous emphysema post eustachian tube balloon dilation.
2. To discuss factors that could predispose patients to this complication, and preventive measures.

Study Design: Retrospective case review.

Setting: Tertiary hospital.

Case summary: 50-year-old male presented with recurrent right eustachian tube dysfunction causing ear blockage and intermittent middle ear effusion. He underwent two previous right Eustachian tube balloon tuboplasty under general anesthesia. Both procedures were uneventful, done at one-year intervals, with resolution of symptoms between procedures. One year after the last procedure, he presented with similar signs and symptoms. Clinical examination showed right tympanic membrane retraction, with poor mobility on Valsalva maneuver. Audiometry showed right mixed hearing loss with type C tympanogram. He underwent right Eustachian tube balloon tuboplasty again under general anesthesia. On the first post-operative day, patient developed palpable subcutaneous emphysema over bilateral parotid, neck, and suprasternal region. The postoperative computed tomography (CT) images with contrast showed extensive emphysema in subcutaneous and deep spaces of bilateral face and neck, extending to the mediastinum. Complete resolution was seen with conservative treatment.

Conclusions: This case highlights the rare complication of subcutaneous emphysema and pneumomediastinum post eustachian tube balloon tuboplasty. Clinicians must employ meticulous techniques to ensure minimal trauma, and be watchful for such complications post-procedure, even if the procedure was uneventful. Post-procedure advice to avoid Valsalva maneuvers, effortful coughing, sneezing, blowing of nose and heavy weightlifting should be advised. Furthermore, clinicians should take care to choose appropriate patients for this procedure and consider pre-operative imaging if deemed necessary.

***Professional Practice Gap & Educational Need:** To report the rare complication of cervicofacial subcutaneous emphysema post eustachian tube balloon dilation, including images showing the extent of extensive subcutaneous emphysema. This case also allows discussion of factors that could predispose patients to this complication, and how it can be avoided.

***Learning Objective:** For clinicians to learn about the possible complication of subcutaneous emphysema and pneumomediastinum post eustachian tube balloon tuboplasty; and to discuss predisposing factors, preventive measures, and management of the complication.

***Desired Result:** For clinicians to be aware of the rare complication of subcutaneous emphysema and pneumomediastinum post eustachian tube balloon tuboplasty, and to adapt measures for prevention when performing the procedure.

***Level of Evidence –** Level V.

***Indicate IRB or IACUC:** Exempt.

Cochlear Implant Hearing Outcomes vary by Implant Type in the Presence of Congenital Inner Ear Malformations

Jake Langlie, BS; Ariel Finberg, BS; Chrisanda Sanchez, AuD; Molly R. Smeal, AuD
Meredith Holcomb, AuD; Rahul Mittal, PhD; Adrien A. Eshraghi, MD, MSc

Objective: Cochlear implant (CI) indications have expanded to include patients with severe to profound sensorineural hearing loss due to inner ear malformations (IEM). In this study, we determined CI outcomes and surgical complications in children with IEM.

Study Design: Retrospective chart review.

Setting: Tertiary care hospital.

Patients: Children under 18 years old with congenital IEM (n=32), implanted between 2011-2021.

Intervention: CI surgery in patients with IEM.

Main Outcome Measures: Electrode design type (perimodiolar vs lateral wall), complication rate, speech recognition threshold (SRT), and speech awareness threshold (SAT) were compared pre-operatively and post-operatively.

Results: For children receiving CI for IEM, the mean age was 4 years old (SD: 2.3), 69% were male, and 57% reported English as their primary language. SRT and SAT scores were compared with mean improvements of 58 dB and 54 dB following surgery. The most common IEM was enlarged vestibular aqueducts (EVA). In implanted patients with EVA, rate of complication (gusher, electrode extrusion, reimplantation) varied by implant type with 63% of perimodiolar implants and 33% of lateral wall implants having surgical complications. Among these patients, those receiving a perimodiolar implant had less average improvement of hearing 8-12 months postoperatively (SRT = 42 dB; SAT = 47 dB) compared to those receiving a lateral wall implant (SRT = 70 dB; SAT = 80 dB)

Conclusions: Individuals with IEM can benefit from CI as indicated by improvement in SRT and SAT post-operative scores. Perimodiolar electrodes, designed to accommodate normal inner ear anatomy, appear to have higher rates of complications and less gain of function post-implantation compared to lateral wall electrodes in patients with EVA.

***Professional Practice Gap & Educational Need:** Limited cohort studies have been performed regarding outcomes of CI implantation in patients with congenital inner ear malformations, especially in the US population. Previous case studies have shown greater complication rates during cochlear implantation of patients with inner ear malformations.

***Learning Objective:** Recognize that cochlear implant patients with inner ear malformations suffer from greater surgical complications, and therefore, should have better consultation about alternative options and greater surgical planning prior to implantation.

***Desired Result:** Physicians will gain knowledge about the benefits and risks of cochlear implant surgery in patients with specific congenital inner ear malformations. This study will aid in electrode selection, gusher management, prevention of electrode extrusion, and guide the need for immediate post-operative radiology exams.

***Level of Evidence –** Level IV

***Indicate IRB or IACUC:** University of Miami IRB #20141009, approved 1/19/2021

Surgical Outcomes of Hearing Rehabilitation After Transcutaneous Bone-Conduction Implantation in a Large Adult and Pediatric Case Series

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Objective: To assess surgical outcomes following implantation of the active transcutaneous bone conduction implant Bonebridge®.

Study Design: Retrospective review of all Bonebridge® implants.

Setting: Tertiary referral center.

Patients: Bonebridge® recipients from January 2017 to August 2021.

Interventions: Active transcutaneous bone conduction implantation.

Main Outcome Measures: Age, sex, surgical indication, prior hearing aid use, operative time, post-operative complications, follow-up time and further treatments.

Results: There were 42 adults (mean age 45 years; 67% female; average follow-up 21 months ± 20.6 months) and 20 children (mean age 13.1 years; 60% female; average follow-up 41 months ± 20.4 months) who received a Bonebridge® implant. Indications for implantation included conductive hearing loss (adults 40%, children 75%), mixed hearing loss (adults 27%, children 5%) and single-sided deafness (adults 33%, children 20%). Most common etiologies of hearing loss included cholesteatoma (adults 24%, children 20%), aural atresia (adults 14%, children 20%), chronic otitis media (adults 14%, children 20%), sudden sensorineural hearing loss (adults 17%), tympanic membrane perforation (adults 12%) and sensorineural hearing loss status-post vestibular schwannoma resection (adults 7%). Average operative time was 100 ± 41 minutes. Bilateral implantation was performed in one adult and one child. Six adults (14%) experienced complications requiring explantation, with two electing to not undergo reimplantation. Two children experienced overlying skin infection and one developed wound dehiscence, with none requiring explantation.

Conclusions: In the largest North American series to date consisting of both adult and pediatric patients, Bonebridge® implantation was a safe aural rehabilitation option for a variety of etiologies.

***Professional Practice Gap & Educational Need:** There is a lack of data regarding large dataset outcomes in both adult and pediatric patients in North America following implantation of the active transcutaneous bone conduction implant Bonebridge®.

***Learning Objective:** To discuss and elucidate long-term surgical outcomes following Bonebridge® implantation in adult and pediatric patients.

***Desired Result:** To provide evidence regarding the safety of the Bonebridge® bone conduction implant for adults and children in North America.

***Level of Evidence –** Level V

***Indicate IRB or IACUC :** Approved Adult IRB Number: 2019H0366 and Pediatric IRB Number: STUDY00001609

Intraoperative Electrocochleography with Active Insertion Monitoring to Assist in Preserving Residual Hearing during Cochlear Implantation: A Single Center's Experience

Michael J. Eliason, MD; Kanthaiah Koka, PhD; Luke Edelmayer, MD
Michael D. Seidman, MD

Objective: To provide the initial data and lessons learned on sixteen patients at a single center by a single surgeon whose cochlear implant (CI) was performed using real-time Electrocochleography (ECochG) assessment during array insertion.

Study Design: retrospective case series

Setting: Tertiary Care Otology/Neurotology Practice

Patients: Sixteen patients was performed on consecutive patients who underwent CI by the senior author using real-time ECochG monitoring with AIM system from January, 2019 to November, 2020.

Interventions: Patients were prospectively identified and ultimately underwent implantation at a single tertiary care institution using Advanced Bionics cochlear implants. There were 6 Ultra HiRes implants and 10 Ultra HiRes 3D implants. There were 3 patients with HFMS (HiFocus MidScala) electrode vs 13 SlimJ (HiFocus SlimJ) electrode types. ECochG recordings were made from the apical electrode of the CI array as it was advanced into the cochlea.

Main Outcome Measures: Active insertion monitoring of the ECochG responses during insertion of the CI electrode to assess for changes in residual acoustic hearing intraoperatively. Pre- and post-operative audiometric assessments.

Results: There are three distinctive patterns observed in this group regarding ECochG responses during insertion that are characterized to describe concomitant changes in residual hearing during CI insertion.

Conclusions: Active insertion monitoring of acoustic hearing using ECochG in real time is a tool the CI surgeon can use to calibrate insertion techniques and may serve as a prognostic indicator of post-operative acoustic hearing.

***Professional Practice Gap & Educational Need:** Active insertion monitoring during CI electrode insertion is a tool for the surgeon to optimize post-operative acoustic hearing preservation.

***Learning Objective:** To provide initial data and lessons learned from a robust CI practice utilizing active monitoring during electrode insertion for purposes of maximizing post-operative hearing outcomes.

***Desired Result:** Successful monitoring of electrocochleographic signal regarding the patient's native acoustic hearing.

***Level of Evidence –** Level IV

***Indicate IRB or IACUC :** IRB approved research study.

A Novel Anterior Transcanal Surgical Approach for Treating Patulous Eustachian Tube Dysfunction

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Michael D. Seidman, MD

Objective: To describe a unique modification of a traditional tympanoplasty to facilitate better access to the anterior mesotympanum and tubotympanic region of the middle ear to treat troublesome patulous eustachian tube dysfunction.

Study Design: Retrospective Review with Surgical Technique Description

Setting: Tertiary Care Otology/Neurotology Practice

Patients: A total of five ears underwent the anterior transcanal tympanoplasty technique

Interventions: Treatment of bothersome patulous eustachian tube dysfunction with a novel surgical approach/technique

Main Outcome Measures: Clinical resolution of symptomatic patulous dysfunction and audiometric assessment before and after surgical intervention.

Results: All patients reported resolution of patulous dysfunction. Audiologic assessment before and after surgery showed no changes in speech reception threshold as measured in decibels.

Conclusions: This presentation describes a novel and simple technique to surgically correct the very bothersome symptoms resulting from patulous eustachian tube dysfunction. The anterior transcanal tympanoplasty approach maximizes visualization and instrumentation of the middle ear orifice to the Eustachian tube to safely provide occlusion that effectively resolves these symptoms.

***Professional Practice Gap & Educational Need:** While the incidence of patulous eustachian tube dysfunction is low, the increased use of eustachian tube dilation has resulted in an increase in these patients seen in our Otology clinics. Patulous eustachian tube dysfunction remains a bothersome condition for afflicted patients and one that is difficult for the Otologist to adequately treat. The novel approach using an anterior transcanal tympanoplasty provides the ear surgeon a unique means of correcting the dysfunction.

***Learning Objective:** To describe a novel surgical approach to treat bothersome patulous eustachian tube dysfunction.

***Desired Result:** Successful novel approach to treat a rare, but bothersome Otologic condition.

***Level of Evidence –** Level IV (Case Series)

***Indicate IRB or IACUC :** Exempt.

Socioeconomic Disparities in Adult Cochlear Implantation

Rachel Greiner, BS; Jay T. Rubinstein, MD, PhD
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Objective: To explore socioeconomic disparities in adult cochlear implant evaluation (CIE) referrals and cochlear implantation.

Study Design: Retrospective chart review.

Setting: Tertiary referral academic center.

Patients: Adults (n=271) with an audiogram performed between 2015-2019 with a pure-tone average (PTA) ≥ 60 dB and word recognition score (WRS) ≤ 60% in the better hearing ear or no WRS performed.

Intervention: Cochlear Implantation

Main Outcome Measures: Rate of referral to CIE and cochlear implantation.

Results: There were 122 insured patients referred to CIE of which 84 were considered cochlear implant (CI) candidates and 73 were implanted. In multivariate regression analysis, non-English-speaking patients were referred to CIE at lower rates (P =.011) than English-speaking patients. In addition, when patients were evaluated by otolaryngology nurse practitioners (P<.001) or solely audiologists (P <.001) they were referred at lower rates to CIE compared to when they were evaluated by otolaryngologist physicians. Patients who met CI candidacy criteria with private insurance (P=.03) or Medicare with private insurance supplement (P=.03) had higher rates of cochlear implantation than those with Medicare or Medicaid. Of the uninsured patients (n=22) 3 were referred to CIE and 2 were considered CI candidates. No uninsured patients received a CI.

Conclusions: Language and the type of provider patients were evaluated by were associated with a disparity in rates of CIE referral. Insurance type did influence rate of cochlear implantation once patients completed CIE and were considered CI candidates. Additional research is needed to implement strategies for more inclusive treatment.

***Professional Practice Gap & Educational Need:** Most patients who would qualify for CI are not implanted. Receiving a CIE referral is a critical step in obtaining a CI. Providers would benefit from a greater understanding of the impact socioeconomic disparities have on rate of implantation to ensure appropriate referral to CIE.

***Learning Objective:** Identify socioeconomic disparities within cochlear implantation and explain barriers to CIE referral.

***Desired Result:** 1. Gain knowledge to provide more equitable access to cochlear implantation. 2. Considerations for CIE referral in non-English-speaking patients.

***Level of Evidence -** V

***Indicate IRB or IACUC :** University of Washington IRB No. 00012875.

Azimuthal Sound Source Localization in Patients with Congenital Aural Atresia: Performance with Bone Conduction Implants vs. Cartilage Conduction Hearing Aids

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Tadashi Nishimura, MD, PhD; Emily Z. Stucken, MD

Objective: Compare localization performance who use both osseointegrated bone conduction implants (BCI) and cartilage conduction hearing aids (CCHA) to the unaided condition in patients with conductive hearing loss due to congenital aural atresia.

Study Design: Prospective cohort study.

Setting: Academic tertiary care referral center.

Patients: Adults with congenital aural atresia previously implanted with an osseointegrated BCI participating in a separate clinical study testing the efficacy of CCHA.

Main Outcome Measures:

1. Localization accuracy (quantified in degrees of error) for presentation of sounds from an azimuthal array of 24 loudspeakers spaced at 15^{o} intervals in an anechoic chamber with BCI, CCHA, and in the unaided condition.
2. Subjective measure of perceived localization benefit quantified with responses to the Speech, Spatial and Qualities of Hearing Scale (SSQ).

Results: Localization performance was compared between devices for individuals, across individuals, and with performance from listeners with normal hearing. No large differences in performance were noted between devices for individual subjects. Subjective results were mixed, without significant differences in SSQ scores between devices.

Conclusions: Patients with conductive hearing loss due to congenital aural atresia demonstrate comparable objective localization performance and subjective spatial benefit with BCI and CCHA. Continued investigation in additional patients is needed to quantify potential significant benefits in this unique population.

***Professional Practice Gap & Educational Need:** Studies of localization performance and subjective spatial hearing benefit for patients with congenital aural atresia have shown promise for both BCI and CCHA, suggesting the potential for improvements to patient quality of life with these interventions; however, large studies with carefully designed psychoacoustic stimulation paradigms may illustrate some benefits that clinical studies are unable to capture with standard audiometry alone.

***Learning Objectives:**

1. Characterize differences in objective localization performance between BCI and CCHA devices for patients with conductive hearing loss due to atresia.
2. Characterize differences in subjective spatial hearing benefit between BCI and CCHA devices for patients with conductive hearing loss due to atresia.

***Desired Result:** Attendees will demonstrate an improved understanding of the limitations of localization performance from unilateral rehabilitation devices in patients with bilateral conductive hearing loss.

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

***Indicate IRB or IACUC:** Approved 1/28/21, University of Michigan IRBMED Protocol #HUM00190678

Access to Ear and Hearing Care Globally: Findings from the Lancet Commission on Global Hearing Loss

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Catherine M. McMahon, MAud, PhD; Susan D. Emmett, MD, MPH

Objective: Characterize global access to ear and hearing care (EHC) to inform future policy recommendations

Study Design: Cross-sectional survey

Setting: Subjects were surveyed via contact lists of the World Health Organization, Global Otolaryngology-Head and Neck Surgery Initiative, and Global HEAR Collaborative.

Subjects: Otolaryngologists, audiologists, and other health professionals

Interventions: None

Main Outcome Measures: Workforce, training programs, affordability, government funding, and incorporation of EHC into national health strategy by World Bank income group

Results: There were 124 survey responses representing 58 countries: 76% from low- and middle-income countries (LMICs) and 24% from high-income countries (HICs). Regarding workforce, 38% of respondents (31% in LMICs, 60% in HICs) agreed there is an adequate supply of ENT surgeons, 23% (12% in LMICs, 57% in HICs) for audiologists, 21% (10% in LMICs, 57% in HICs) for speech-language pathologists, and 14% (12% in LICs, 20% in HICs) for EHC community health workers. Only 13% (7% in LMICs, 30% in HICs) agreed there are adequate training programs for EHC workforce. On affordability of care, 28% respondents (21% in LMICs, 50% in HICs) agreed that hearing aids are affordable and 23% that cochlear implants are affordable (14% in LMICs, 53% in HICs). Finally, 20% of participants agreed that government funding or investment is sufficient (13% in LMICs, 43% in HICs) and 44% that EHC care is included in national health strategy (37% in LMICs, 67% in HICs).

Conclusions: Globally, EHC may be limited by systems-level barriers that disproportionately affect LMICs. Future policy recommendations should advance EHC in national health strategies and funding priorities to address workforce and cost barriers.

Professional Practice Gap & Educational Need: Despite global efforts to strengthen EHC, barriers to EHC remain ill-defined.

Learning Objective: Learners will gain an understanding of barriers to EHC across countries by World Bank income group.

Desired Result: Learners will use this knowledge to improve understanding of EHC barriers and develop appropriate policy- and program-level interventions.

Level of Evidence – Level V

Indicate IRB or IACUC: Exempt

Prospective, Single-Blinded Study on the Use of Medical Grade Honey in the Prevention of Bone Anchored Hearing Aid Associated Skin Breakdown

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Objective: To demonstrate that postoperative use of medicinal grade honey compared to current post-operative care decreases bone anchored hearing aid (BAHA) associated skin reactions and breakdown and promotes faster healing.

Study Design: Prospective, single blinded, randomized study

Setting: Tertiary referral center

Patients: Adults >18 years old undergoing bone-anchored hearing aid implantation (BAHA) surgery. Patients undergoing revision surgery or with history of radiation to the site were excluded.

Interventions: Participants were randomized to postoperative medical honey (MediHoney) or standard care. The experimental group applied MediHoney to the abutment site daily for 2 weeks post-op. The control group applied bacitracin ointment. Photos were taken of the site for the first 7 days post-operatively, then at 2 weeks, 1 month, 3 months and 6 months. The de-identified photos were sent to 4 blinded otolaryngologists, who graded the abutment site using the Holgers skin classification. Patient's subjective level of pain and discomfort were assessed.

Main Outcome Measures: The key outcome variables were the differences in the Holgers values, levels of pain at abutment site and infection rates between the 2 groups, which were analyzed using t-test, ANOVA and Post-Hoc tests. A p-value < 0.05 is considered significant.

Results: With $n = 17$, there were no statistically significant differences in the Holgers scale ratings detected between the two groups at any of the time points. The average level of pain (scale 0-10, 0 no pain) at 6 months was significantly lower in the MediHoney group (0.583 ± 1.021) compared to the control (5.833 ± 4.119, $p = 0.013$). The overall infection rate was 16.7% ($n = 1$) and this patient was in the control group.

Conclusions: Skin reactions are the most common complication after BAHA Connect implant surgery. Post-operative use of MediHoney may decrease long term discomfort associated with BAHAs.

***Professional Practice Gap & Educational Need:** None

***Learning Objective:** To learn about a unique preventative therapy for BAHA associated cutaneous reactions and infections.

***Desired Result:** Consider use of MediHoney in addition to standard care post-operatively in patient's undergoing BAHA implantation.

***Level of Evidence -** II

***Indicate IRB or IACUC :** IRB# 1325595-3

Variability of Cholesteatoma Operative Notes: Need for Standardization?

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Adrian L. James, DM; Elliott D. Kozin, MD

Objective: Characterize the variability and "completeness" (i.e. presence of essential items) of dictated cholesteatoma operative notes (ON).

Study design: Retrospective chart review.

Setting: Tertiary referral center.

Patients: Dictated ON by three otologists/neurotologists of primary cholesteatoma surgery were included. ON of revision cholesteatoma surgery or created with templates were excluded.

Intervention(s): European Academy of Otology and Neurotology and Japanese Otological Society Middle Ear (ME) Cholesteatoma Joint Consensus Statement used to create list of 32 assessable ON items including peri-operative findings (e.g. ossicle mobility) and surgical steps (e.g. ossicular chain reconstruction [OCR]).

Main outcome measure(s): ON completeness scores (%) were calculated by dividing the sum of present items by the maximum possible score.

Results: A total of 50 ON were assessed. The overall completeness score was 68.7±9.8%. Perioperative findings were documented less than surgical procedure items (53.3% vs 75.6%; p<.001). Peri-operatively, the etiology of cholesteatomas in 52.0%, status of ME mucosa in 29.2%, chorda tympani in 52.1%, tensor tympani in 4.2%, and presence of ME effusion was documented in 8.3% of ON. Ossicular erosion was documented more than ossicular mobility (70.2% vs 38.9%; p <.001). Erosion of the malleus was documented less than the incus (46.0% vs 84.0%; p<.001) and stapes (46.0% vs 82.0%; p<.001). Mobility of the malleus was documented less than the stapes (19.5% vs 64.0%; p<.001), but similar to the incus (19.5% vs 22.7%; p=.755). The extent of OCR (97.9%) and ossiculoplasty material (100%) were frequently described.

Conclusions: In this quality initiative study, our findings show variability in cholesteatoma ON documentation. Perioperative findings such as ossicular mobility are underreported.

***Professional Practice Gap & Educational Need:** Operative notes (ON) are utilized to document procedural details and used in medical quality assurance and outcomes research, but few studies have examined the variability in documentation, especially in the otolaryngology literature.

***Learning Objective:** Understand and identify commonly missed areas in cholesteatoma ON documentation.

***Desired Result:** The development of a standardized OR may improve the "completeness" of documentation and potentially improve patient care.

***Level of Evidence:** IV

***Indicate IRB or IACUC:** Exempt

Three-dimensional Printing for Preoperative Planning of Complex Otologic Procedures

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Objective: Surgery in complex otologic cases is often challenging since the temporal bone anatomy can be considerably distorted. Preoperative planning in these cases is currently based on physical examination and CT/MRI findings. Our objective was to evaluate whether tailored 3D printed models of the involved temporal bone have any advantage over standard imaging studies for preoperative planning.

Methods: Life-sized 3D printed models of the temporal bone were created based on CT and MRI images in three patients. One patient had recurrent cholesteatoma involving the TMJ and the temporal fossa, another patient had a huge congenital cholesteatoma, and the third had an extensive glomus tympanicum. The added value of the 3D printed models was assessed for each of 11 domains by 7 otologic surgeons who were asked to rate to what extent the 3D model was advantageous over the imaging studies according to a validated Likert scale for importance.

Results: The mean rating for all domains was 3.6 ± 0.63, ("moderately important" to "very important", tending towards "very important") and the median was 4 ("very important'). There was complete agreement between raters for domains 3 and 4, while it was 0.608 (good) for domain 1, 0.585 (moderate) for domain 2 and 0.429 (moderate) for domain 5.

Conclusions: Patient-specific 3D printed models of the temporal bone were rated by 7 otologic surgeons to range from moderately important to very important for preoperative planning of complex otologic procedures. Outcome studies are warranted to establish their usefulness in reducing recurrence rates.

***Professional Practice Gap & Educational Need:** Temporal bone 3D models are currently not considered standard of care nor are they mentioned in any of the guidelines. However, as technology improves and data on their usefulness accumulate, 3D models may become a valuable part of the preoperative evaluation and preoperative surgical planning.

***Learning Objectives:** To raise awareness among otologic surgeons of the advantages in using 3D models for preoperative planning in complex cases.

***Desired Result:** Tailored temporal bone 3D models will find widespread use among otologic surgeons.

***Level of Evidence –** Level V.

***Indicate IRB or IACUC:** Institutional Review Board approval was acquired before the data was collected. Approval N. 0174-18 TLV.

Accessibility to University Tinnitus Program during COVID-19 Pandemic

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Emily Bellile, MS; Emily Stucken, MD

Objective: To evaluate the accessibility of the University of Michigan Tinnitus program as it transitioned from in-person to virtual format in response to the global pandemic.

Study Design: Retrospective review

Setting: Tertiary academic center

Patients: 324 subjects who participated in the Michigan Tinnitus group information class from 4/5/2019 to 3/5/2021.

Interventions: Attendance of group tinnitus class, tinnitus and social/emotional questionnaires

Main Outcome Measures: Demographics and ADI (Deprivation index from University of Wisconsin resource), Tinnitus surveys (THI/TRQ), Social/emotional surveys

Results: Of the 324 patients analyzed, 168 participated in the in-person tinnitus class, while 156 participated in the virtual course over Zoom. A one-way ANOVA revealed that the mean age of the virtual participants (μ=56 years) was significantly younger than in-person (μ= 61 years) participants (p=0.02). There was no statistical difference between gender and smoking history. Of the total subjects, 222 subjects were able to have their home addresses linked with ADI rankings. In these rankings, a subject is given a score from 1-100, which is used to describe the level of neighborhood disadvantage they might experience based on their address. Higher scores indicate more disadvantage. Current data suggests a trend of larger percentage of participants with higher ADI rankings participating in the virtual format compared to in-person participants. In questionnaire scores, there is no significant difference between two participation groups for Tinnitus Handicap Inventory (THI) (p=0.09) and Tinnitus Reaction Questionnaire (TRQ) scores (p=0.09).

Conclusions: Preliminary data suggests expanding tinnitus management and educational appointments to a virtual format increases accessibility for lower SES populations in the state of Michigan.

***Professional Practice Gap & Educational Need:** Few studies have identified the accessibility of services during the pandemic, especially in audiological management. There is a lack of understanding potential benefits to offering virtual audiological appointments, though virtual care is explored in other medical professions.

***Learning Objective:** To identify group differences in tinnitus education participants between in-person and virtual settings.

***Desired Result:** Patients from lower SES populations had a greater participation in a virtual format for tinnitus education, following a clinical reorganization in response to COVID-19 pandemic. This knowledge allows audiologists and medical professionals to consider offering more virtual services to address accessibility gaps.

***Level of Evidence -** Level V

***Indicate IRB or IACUC :** HUM00203064

Electrode-to-Modiolus Distance in Round Window versus Cochleostomy Surgical Approaches: A Meta-Analysis

Sanjay Jinka, BS; Vardhan Avasarala, BS
Anita Jeyakumar, MD, MS

Objective: Contrast electrode-to-modiolus distances achieved from round window (RW) and cochleostomy (C) approaches.

Data Sources: Peer-reviewed articles were identified from PubMed and Google Scholar utilizing the search methodology of a MeSH searching for studies comparing RW and C surgical approaches. Only articles with an English version were considered, and date of publication was not considered.

Study Selection: Studies included for detailed review had to meet the search criteria of including human subjects, including data about straight 12-electrode contact arrays specifically, and determining electrode-to-modiolus distance for all 12 electrode positions with combined flat-panel computed tomography and curved multiplanar reconstruction. Only studies published after 2000 were considered.

Data Extraction: Quality and validity was determined by PRISMA guidelines. Extracted data was made comparable by analyzing RW and C electrode-to-modiolus distances for only the 12 electrode positions common to all studies.

Data Synthesis: Two-sample independent t-testing was used to compare the two surgical approaches at each electrode site.

Conclusions: 37 papers were reviewed. 48 electrode arrays were analyzed with a mean patient age of 26. The RW approach allows for electrode insertion to be significantly ($p<0.05$) closer to the cochlear modiolus than the C approach across pediatric and adult populations. Decreased distance correlates with increased probability of perimodiolar placement and minimized electrical impedance.

***Professional Practice Gap & Educational Need:** Understanding the differences between the RW and C surgical approaches in peri-modiolar cochlear electrode array placement.

***Learning Objective:** Understand differences between RW and C surgical approaches. Understand benefits of decreased electrode-to-modiolus distances. Learn how to use surgical approach as an avenue to improve electrode-to-modiolus distances.

***Desired Result:** Consideration of electrode-to-modiolus distance when selecting between RW and C approaches. Additionally, inspiring further study looking at trauma and hearing preservation is necessary to delineate potential adverse effects with decreased electrode-to-modiolus distance.

***Level of Evidence -** IV

***Indicate IRB or IACUC:** Exempt

Transcanal Endoscopic Versus Microscopic Tympanoplasty: Is There a Difference in Perforation Closure Rates?

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Brandon Isaacson, MD; J. Walter Kutz Jr., MD

Objective: To compare closure rates of endoscopic and microscopic tympanoplasty as influenced by perforation size, perforation location, and graft position.

Study Design: Retrospective chart review.

Setting: Tertiary university medical center.

Patients: Adult patients who underwent tympanoplasty by a fellowship-trained neurotologist from January 2010 to December 2019, had at least two months of follow-up, and had a tympanic perforation with no cholesteatoma prior to surgery.

Interventions: Transcanal endoscopic tympanoplasty or microscopic tympanoplasty.

Main Outcome Measures: The primary outcome is post-operative closure of the tympanic membrane perforation as assessed using otomicroscopy at the last follow-up appointment.

Results: Two-hundred and eleven patients - 98 in the transcanal endoscopic tympanoplasty (ET) group and 113 in the microscopic tympanoplasty (MT) group - were identified. Tympanic membrane closure rates were not significantly different between the ET and MT groups (79.6% and 84.1% respectively; $p = 0.473$), and further multivariable analysis revealed that closure rates for ET relative to MT had an insignificant odds ratio (0.56; $p = 0.144$). Similar analyses found no significant difference between the two methods in subsets of perforation size (small, large, subtotal/total), perforation location (anterior, posterior, inferior), and graft position (underlay, overlay). The MT group was more likely to have a postauricular incision (94.7% vs 0.0%; $p < 0.001$). Men were more likely to see their perforations closed than women on multivariable analysis (OR 2.46; $p = 0.035$).

Conclusions: Endoscopic tympanoplasty resulted in similar rates of post-operative closure rates compared to the microscopic technique with less need for postauricular incision.

***Professional Practice Gap & Educational Need:** Although microscopic and transcanal endoscopic tympanoplasties have similar outcomes generally, it is not clear if certain characteristics of the tympanic membrane perforation, such as size and location, cause one technique to be more successful than the other. A better understanding of how perforation characteristics may affect the efficacy of the two techniques differently is needed.

***Learning Objective:** Recognize that the endoscopic and microscopic tympanoplasty techniques result in similar perforation healing outcomes, regardless of perforation size, perforation location, or overlay or underlay graft placement.

***Desired Result:** Attendees will be able to apply this knowledge when evaluating which technique to use for tympanic membrane perforation repair, based on the characteristics of each patient's perforation.

***Level of Evidence:** Level IV—Historical cohort or case-control study

***Indicate IRB or IACUC:** UT Southwestern Medical Center (STU 012013-017, approved 9/17/19)

Assessing the Differences in Hearing and Healing in Pediatric Microscopic and Transcanal Endoscopic Tympanoplasty Procedures

Tanner J. Mitton, BS; Daniel E. Killeen, MD; Zoha K. Momin, BS; J. Walter Kutz Jr., MD

Objective: To compare closure rates and hearing outcomes of microscopic and endoscopic tympanoplasty in pediatric patients.

Study Design: Retrospective chart review.

Setting: Tertiary university medical center.

Patients: Pediatric patients who underwent tympanoplasty surgery by a fellowship-trained neurotologist between 2010-2019 with at least two months of follow-up, a tympanic membrane perforation, and no preoperative cholesteatoma.

Interventions: Transcanal endoscopic tympanoplasty surgery or microscopic tympanoplasty surgery.

Main Outcome Measures: The primary outcome is postoperative closure of the tympanic membrane perforation, assessed using otomicroscopy at the last follow-up appointment. Secondary outcomes include operative time and changes in the air-bone gap (ABG) and pure tone average (PTA).

Results: Two hundred and eleven tympanoplasty surgeries were analyzed—121 in the transcanal endoscopic tympanoplasty (TEES) group and 90 in the microscopic tympanoplasty (MT) group. Tympanic membrane closure rates were no different between the two groups (TEES = 82.6%, MT = 88.9%; $p = 0.24$), and no significant association was found on multivariable analysis (TEES OR = 0.8; $p = 0.61$). Both groups showed improvements in the 4-month PTA and ABG and the 12-month PTA, but the 12-month ABG only improved in the TEES group ($p < 0.01$). The TEES group had a shorter average operative time (109.8 vs 123.5 minutes; $p = 0.03$) and less need for post-auricular incision (0% vs 93.3%; $p < 0.01$).

Conclusions: In pediatric tympanoplasty, TEES gives similar membrane closure and hearing outcomes as the microscopic technique, with less operative time and need for post-auricular incision.

***Professional Practice Gap & Educational Need:** Current analyses of pediatric TEES and microscopic tympanoplasty healing and hearing outcomes are often limited by small sample size, absence of hearing outcome analysis, or the inclusion of patients with significant confounding factors, like cholesteatoma. Robust analysis of a large sample controlling for confounding variables and examining hearing outcomes is needed to confirm that the outcomes of the two tympanoplasty techniques are comparable in children, and that either technique can be used effectively.

***Learning Objective:** Recognize that pediatric patients have similar healing and hearing outcomes following either TEES or microscopic tympanoplasty surgery, but the operative time and post-auricular incision rates for the TEES approach are lower than those of the microscopic approach.

***Desired Result:** Physicians will gain understanding of the comparability of the TEES and microscopic approaches in pediatric tympanoplasty and effectively apply this knowledge to pediatric otologic care.

***Level of Evidence:** Level IV

***Indicate IRB or IACUC:** UT Southwestern Medical Center (STU 012013-017, approved 9/17/19)

Hearing Preservation in Round Window versus Cochleostomy Surgical Approaches: A Meta-Analysis

Vardhan Avasarala, BS; Sanjay Jinka, BS
Anita Jeyakumar, MD, MS

Objective: Contrast the Hearing Preservation achieved from round window (RW) and cochleostomy (C) surgical approaches.

Data Sources: Peer-reviewed articles were selected from PubMed and Google Scholar using the MeSH search terms Round window AND Cochleostomy. Only English and non-animal studies were selected, and date of publication was not considered.

Study Selection: Studies included for detailed review collected data analyzing hearing preservation under 3 categories: complete hearing loss, partial hearing preservation (>10 dB), and complete hearing preservation (<10dB loss) following either a cochleostomy or round window surgical method.

Data Extraction: Quality and validity was determined by PRISMA guidelines. Extracted data was made comparable by analyzing RW and C hearing preservation data that was homogenous across included studies.

Data Synthesis: A chi-squared test was used to compare the distribution between hearing preservation categories between the two surgical approaches.

Conclusions: 18 papers were reviewed. The distribution between the round window and cochleostomy groups were found to be significant ($p<0.05$) with the percentages indicating that the round window surgical approach is better at preserving hearing than the standard cochleostomy method. RW procedures yielded complete hearing preservation in 42.6% of cases compared to only 31.3% in C.

***Professional Practice Gap & Educational Need:** Understanding the differences between the RW and C surgical approaches maintaining residual hearing preservation following the procedure.

***Learning Objective:** Understand differences between RW and C surgical approaches. Learn how to use surgical approach as an avenue to improve residual hearing preservation.

***Desired Result:** Consideration of hearing preservation when selecting between RW and C approaches. Additionally, inspiring further research with a greater sample size collecting homogenous data to increase strength of the results.

***Level of Evidence -** IV

***Indicate IRB or IACUC:** Exempt

The Efficacy of Intratympanic Injections in Sudden Sensorineural Hearing Loss

A. Celeste Gibson, MD; Jennifer R. Silva-Nash, MSc; Andrew R, Mangan, BS
Deanne King, MD, PhD; John L. Dornhoffer, MD

Objective: To evaluate the efficacy of intratympanic (IT) dexamethasone injections for sudden sensorineural hearing loss (SSNHL) with regard to subjective and objective audiometric data.

Study Design: Retrospective chart review.

Setting: Tertiary referral center.

Patients: 56 patients (27-85 years of age) who received an IT dexamethasone injection for SSNHL from 2014-2020.

Main Outcome Measures: Patient demographics, indication and medication used for IT perfusion, complication rate, and patient's sense of subjective improvement were collected. Pre- and post-injection audiometric data were compared.

Results: Fifty-six patients received a total of 79 injections, with 18 patients receiving more than one injection. Dexamethasone 10mg/ml was the most common medication utilized (84%), followed by dexamethasone 12mg/ml. Nineteen injections resulted in a complication, 13 of which were tympanic membrane perforation and 3 were acute otitis media. Subjective relief was reported by 38% of patients.
There was not a significant difference between pre- and post-injection air conduction pure tone average (AC PTA) (62.5 vs 60.1, p=0.213). However, the difference was larger among patients who received oral and injected steroids (57.8 vs 51.7, p=0.059).

Conclusions: Our data suggest that in our clinic, intratympanic injections did not result in a significant improvement in subjective or objective hearing recovery in patients suffering from SSNHL. In addition, complications followed 24% of injections.

Professional Practice Gap & Educational Need: Although the use of IT injections for SSNHL have increased, research regarding efficacy remains inconclusive. Our review adds to the literature by providing subjective and objective data, and complication rates to help guide current clinical practice.

Learning Objective: Our data suggest that in our clinic, intratympanic injections did not result in a significant improvement in subjective or objective hearing recovery in patients suffering from SSNHL. In addition, complications followed 24% of injections.

Desired Result: To analyze the efficacy of intratympanic injections for SSNHL from our institution's database.

Level of Evidence: Level IV

Indicate IRB or IACUC: Exempt

Treatment Options in Mal de Debarquement Syndrome: A Scoping Review

Corin M. Kinkhabwala, MD; Angel Cadena, MD; Habib G. Rizk, MD

Objective: The purpose of this study was to present a scoping review of mal de debarquement syndrome, a cause of chronic rocking dizziness of unclear etiology and unpredictable prognosis (MDDS), with the following question: "What are the current treatment options available for MDDS?"

Data sources: Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Review (PRISMA-ScR) guidelines, we performed systematic search queries in PubMed (NLM, NIH), Scopus (Elsevier), CINAHL (EBSCOhost), and PsycINFO (EBSCOhost) for MDDS-related texts. Documents must have been in the English language, and the time frame was all documents up until March 2021.

Study selection: Studies were selected for detailed review if they were published in a journal, if one of the primary objectives was the assessment of at least one treatment option for MDDS, or if the study was a systematic or scoping review with information on management of MDDS. 169 unique references were identified and underwent review. 40 were selected for full-text review and 37 for data extraction.

Data extraction: In determining which studies were ultimately extracted, the quality and validity of all documents were assessed by two independent reviewers. Conflicts resolved by a third reviewer.

Data synthesis: Data were stratified by treatment methodology for MDDS. The categories used were pharmacologic, vestibulo-ocular reflex (VOR) rehabilitation, and neuromodulating stimulation.

Conclusions: Improvement in patient-reported outcomes is reported with several treatment modalities including specific protocols of vestibular rehabilitaiton, repetitive transcranial magnetic stimulation (rTMS) protocols, and pharmacologic management with several types of neurotropic drugs.

Define Professional Practice Gap & Educational Need: MDDS is a challenging diagnostic and therapeutic problem. Practicing otolaryngologists who evaluate patients with dizziness will be exposed to this condition. Diagnostic criteria were established in 2020 by the Barany Society. There have been recent advances in treatment options available but not set gold standard for treatment yet

Learning Objective: To educate otolaryngologists on the current treatment options available to them for MDDS patients

Desired Result: More widespread awareness of the management for MDDS

Level of Evidence - Level V

Indicate IRB or IACUC : Medical University of South Carolina Pro00050097

Multimodality and Multidisciplinary Treatment of Chronic Rocking Dizziness/Non-Otologic Vertigo: Single Institution Case Series

Corin M. Kinkhabwala, MD; Angel Cadena, MD; Seth Jeong, MD
Shaun A. Nguyen, MD; Habib G. Rizk, MD

Objective: To review the characteristics of patients with symptoms of chronic rocking dizziness (CRD) and assess the efficacy of medical treatment involving SNRI and benzodiazepines with or without vestibular rehabilitation in this population

Study Design: Retrospective case review

Setting: The study was performed at a university-based tertiary medical center

Patients: Adult patients with CRD seen in vestibular clinic between 10/2015 and 7/2021. Subsets were created for Mal de debarquement (MDDS) fulfilling the Barany Society criteria, persistent postural-perceptual dizziness (PPPD), CRD with associated vestibular migraine, unclassified CRD and spontaneous MDDS.

Interventions: Vestibular rehabilitation (VR) and/or pharmacologic treatment with the goal of treating symptoms of CRD

Main Outcome Measures: Quantitative assessment of dizziness handicap inventory (DHI) with change of score before and after intervention.

Results: Preliminary results thus far demonstrate 106 CRD patients, 23 MDDS, 23 spontaneous MDDS, 86 PPPD, 16 CRD with vestibular migraine, and 26 unclassified CRD. For pure MDDS patients, mean total change in DHI for pharmacologic-only therapy was -15.0 (SD 4.24), and change in DHI for combined therapy was -10.89 (SD 20.98). Venlafaxine had a DHI change of -17 (SD 20) and benzodiazepines had a DHI change of -22 (SD 13).

Conclusions: There is no significant statistical difference in the different treatment methodologies for MDDS, however, there is a significant clinical difference in reduction of DHI for each modality and pharmacologic therapy.

Define Professional Practice Gap & Educational Need: Pharmacologic advances in the management of MDDS have been limited, and assessment of migraine prophylaxis in its treatment is yet to be validated.

Learning Objective: To provide otolaryngologists with additional information in the management of MDDS to assist with pharmacologic and VR management strategies.

Desired Result: Improved MDDS patient outcomes

Level of Evidence - Level IV

Indicate IRB or IACUC : Medical University of South Carolina Pro00050097

Subjective and Objective Taste Change Following Stapes Surgery: Meta-Analysis and Systematic Review of the Literature

Daniel H. Coelho, MD; Seong M. Lee, BA (presenter); Edward Yang, BA

Introduction: Iatrogenic injury to the chorda tympani (CT) is a well-recognized, though potential underestimated consequence of stapes surgery. This study aims to review the currently available literature to determine the incidence and prognosis of taste disturbances in these patients.

Data Sources: PubMed, Embase, and Cochrane Library databases

Methods: Databases were searched according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Search terms included (chorda tympani OR gustatory OR taste OR chemosensory OR dysgeusia OR nervus intermedius) AND (ear surgery OR middle ear OR stapes OR stapedectomy OR stapedotomy). Papers were further divided by methodology into "objective" and "subjective" assessments of taste dysfunction. Rates of taste disturbance between the two groups were compared using a chi-squared test.

Results: Initial search yielded 7217 papers. Once inclusion/exclusion criteria were applied and duplicates were removed, 7 papers were identified, representing 293 patients (119 with objective testing, 174 subjective testing). For all patients, an incidence of taste change was noted in 165 (56%). Post-operative objective taste change was noted in 82/119 (69%) of patients, whereas subjective taste change was noted in 83/174 (48%). The difference between the two groups was significant ($p = .0003$). The overall rate of recovery was 79/121 (65%). 32/82 (39%) and 10/39 (26%) patients demonstrated long-term objective and subjective taste loss respectively ($p = .148$).

Conclusion: Changes in taste occur relatively frequently following stapedectomy. Surgeons should continue to counsel prospective patients as to the risks of both short- and long-term taste disturbance.

***Professional Practice Gap & Educational Need:** Improved understanding of stapedectomy complications through the power of systematic review, pooled data, and meta-analysis.

***Learning Objective:** To review currently available literature to determine the incidence and prognosis of taste disturbances in these patients.

***Desired Result:** Surgeons must highlight the relatively common occurrence of post-stapes surgery taste disturbance when counseling prospective patients.

***Level of Evidence –** N/A (though some rubrics would say Level IV)

***Indicate IRB or IACUC :** Exempt

Lateral Graft Tympanoplasty Outcomes in Patients with Comorbidities

Zoha K. Momin, BS; Kristen L. Yancey, MD; Tanner J. Mitton, BS
J. Walter Kutz Jr., MD

Objective: To compare the effects of preoperative comorbidities, such as smoking, diabetes mellitus, and age, on the success of lateral graft tympanoplasty.

Study Design: Retrospective chart review

Setting: Tertiary medical center

Patients: Ninety-six patients undergoing lateral graft tympanoplasty from December 2008 to November 2020 with at least two months follow-up. Patient demographics, diabetes mellitus and smoking status, perforation closure rates, healing complications and hearing outcomes were recorded. Simultaneous ossiculoplasty was not excluded from the hearing analysis.

Interventions: Lateral graft tympanoplasty.

Main Outcome Measures: The primary outcome was perforation closure. Secondary outcomes were need for revision surgery, postoperative complications, and change in air-bone gap.

Results: Ninety-nine ears (mean age 40.94 ± 18.44 years) were included. Tympanic membrane perforation closure was achieved in 86 (87%) ears. Tympanic membrane closure rate was not associated with diabetes ($p = 0.42$), smoking (OR = 1.58, $p = 0.68$), or increasing age (OR = 1.00, $p = 0.85$). The presence of cholesteatoma (OR = 1.44, $p = 0.60$) and prior tympanoplasty (OR = 0.47, $p = 0.22$) were not associated with tympanic membrane closure rates. The air-bone gap (ABG) improved from a mean of 27.55 ± 11.88 dB to a mean of 23.54 ± 11.73 dB postoperatively ($p < 0.01$). History of prior tympanoplasty was associated with smaller ABG improvement following surgery ($ß = 5.403$, $R^2 = 0.215$, $p = 0.03$).

Conclusions: Diabetes, active smoking and advanced age were not associated with adverse healing in patients undergoing lateral graft tympanoplasty. Further investigation with a larger, prospectively enrolled sample is warranted.

***Professional Practice Gap & Educational Need:** Patients with a history of diabetes, active smoking or advanced age may constitute a high-risk patient population with respect to wound healing. Evaluation of these patient-specific factors on healing following lateral graft tympanoplasty have yet to be fully explored in the literature.

***Learning Objective:** To understand patient-specific factors (diabetes, active smoking, advanced age) do not affect lateral graft tympanoplasty outcomes.

***Desired Result:** To demonstrate diabetes, smoking, and advanced age did not compromise healing or hearing outcomes following lateral graft tympanoplasty.

***Level of Evidence:** IV

***Indicate IRB or IACUC:** IRB UT Southwestern Medical Center (STU 012013-017)

Expanding Understanding of Electrocochleography in Cochlear Implantation: Auditory Neuropathy Spectrum Disorder with Normal Pure Tone Average

Hilary C. McCrary, MD, MPH; Steve Gordon, MD; Eric Babajanian, MD
Kathryn M. Johnson, AuD; Neil S. Patel, MD

Objective: Describe the preoperative decision making, intraoperative electrocochleographic (ECoG) findings, and outcome of cochlear implantation (CI) in a patient with auditory neuropathy spectrum disorder (ANSD) and normal pure tone thresholds.

Study Design: Case report.

Setting: Tertiary care academic center.

Patients: A 19-year-old with a history of hypoxic ischemic encephalopathy and seizures was referred for hearing rehabilitation in the setting of typical hearing by pure tone audiometry, but poor speech understanding. A diagnosis of ANSD was made based on ABR, DPOAE, and acoustic reflex testing. Imaging revealed no central cause of hearing impairment.

Interventions: Right-sided cochlear implantation.

Main Outcome Measures: Pre- and postoperative audiometric data. Intraoperative electrocochleography (ECoG).

Results: Preoperative audiologic and cochlear implant assessment for the right and left ear, respectively: PTA 15 dB, 8dB; Word Recognition Score (WRS) 36%, 56%; CNC Words: 8%, 28%; and AzBio Quiet: 0%, 36%. Intraoperative ECoG amplitudes and audiometry showed responses in the 100 uV range and estimated PTA of 42 dB HL. Postoperative testing at 1 month post-initial activation revealed PTA of 45 dB HL and unchanged word and sentence scores. However, the patient cites an improved ability to communicate, increased confidence, and averages over 14 hours of device use daily. Further follow up data will be available at the time of presentation.

Conclusions: To our knowledge this is the first reported case of CI in an ear with normal PTA. Intraoperative and postoperative audiometric findings add to the understanding of ECoG and CI in ANSD.

***Professional Practice Gap & Educational Need:** To discuss the decision-making and workup, operative technique and intraoperative testing, and postoperative results with CI for ANSD.

***Learning Objective:** To describe the application of cochlear implantation in ANSD patients with normal PTA.

***Desired Result:** Improved knowledge about the applications of cochlear implantation in ANSD patients and the role of ECoG.

***Level of Evidence –** Level V

***Indicate IRB or IACUC:** Exempt

Tympanoplasty with and without Mastoidectomy for Chronic Otitis Media without Cholesteatoma: A Systematic Review and Meta-analysis

Nicolas S. Poupore, BS; Tamar M. Gordis, BA; Shaun A. Nguyen, MD, MA
Ted A. Meyer, MD, PhD; William W. Carroll, MD; Paul R. Lambert, MD

Objective: To compare surgical and audiometric outcomes of tympanoplasty alone to tympanoplasty with mastoidectomy.

Data sources: According to PRISMA guidelines, English articles in PubMed, Scopus, CINAHL, and Cochrane Library databases from inception to 7/29/2021 were searched.

Study selection: Studies including a comparison of patients who underwent tympanoplasty (T) to patients who underwent tympanoplasty with mastoidectomy (T&M) were included. Patients with cholesteatoma were excluded.

Data extraction: Patient demographics, complications, and postoperative audiological findings were collected.

Data synthesis: Mean differences (MD) and Risk difference (RD) were calculated using RevMan 5.4. Heterogeneity was assessed using Q test and I^2 statistic. Risk of bias was assessed using ROBINS-I tool.

Results: A total of 27 studies fulfilled eligibility with tympanoplasty (n = 1711) and tympanoplasty with mastoidectomy (n = 1186). When pooling the data, comparing mean differences between T vs. T&M for ABG (-0.3 dB: 95%CI -1.9 to 1.3, p = 0.73) and PTA (1.9 dB: 95%CI -0.3 to 4.2, p=0.09) were not statistically significant. Graft failure was higher with T only (16.4% vs. 14.2%) than T&M [RD: -0.04 (95% CI: -0.07 to -0.00), p=0.03; I^2: 35%].

Conclusions: This study endorses clinically similar audiological outcomes and a reduced risk difference of graft failure with mastoidectomy. While these data suggest that adding a mastoidectomy could decrease the risk of graft failure, the risk reduction is minimal. More research on the cost-effectiveness of adding a mastoidectomy to gain a small, reduced risk difference of graft failure is warranted.

***Professional Practice Gap & Educational Need:** Tympanoplasty alone and with mastoidectomy have been extensively debated in terms of safety, efficacy, and cost-effectiveness.

***Learning Objective:** To compare surgical and audiometric outcomes of tympanoplasty alone to tympanoplasty with mastoidectomy.

***Desired Result:** Graft failure rates and postoperative PTA and ABG changes

***Level of Evidence:** Level III

***Indicate IRB or IACUC:** Exempt.

Epitympanum and Mastoid Obliteration Reduces Recidivism in Acquired Cholesteatoma Surgery: Technique and Results

Stefania Goncalves, MD; Brandon Kamrava, MD; Torin Thielhelm, MS; Courtney Dable, MS
Jorge L Hernandez-Rojas MD; Simon I. Angeli, MD

Background: Cholesteatomas are a locally aggressive and leads to a significant impact on the patients' quality of life. Rate of recidivistic disease after traditional tympanomastoidectomy techniques have ranged 10%-60%. A recent meta-analysis reported that adding mastoid obliteration resulted in less than 3% risk of recidivistic disease in canal wall up and canal wall down mastoidectomy by eliminating the possibility of tympanum retractions into air containing spaces creating an environment that prevents the growth of potential residual keratin tissue.

Objective: To determine the rate of recurrent and/or residual cholesteatoma in acquired retraction cholesteatoma (AC) cases undergoing tympanomastoidectomy plus a refined technique of epitympanum and mastoid obliteration using a combination of autografts between 2015-2020.

Study Design: Retrospective case-control series of patients who underwent canal-wall-up and canal-wall-down tympanomastoidectomy with epitympanum and mastoid obliteration for AC with a minimum of one year follow up.

Main Outcome Measures: Rate of recidivism (i.e., residual and recurrent cholesteatoma) in cases of AC after tympanomastoidectomy with epitympanum and mastoid obliteration compared to historical control cases of tympanomastoidectomy without obliteration. Recidivism identified by otoscopy, imaging, or intraoperative findings during a second-look procedure.

Results: Thirty-five patients with a diagnosis of AC underwent primary and/or revision surgery with epitympanum and mastoid obliteration. Two of them were lost to follow-up and ten underwent a second look procedure. None of the cases developed recidivistic disease after at least 1 year of follow up, while recidivism was noted in 9% of 157 cases of tympanomastoidectomy without obliteration.

Conclusions: Epitympanum and mastoid obliteration with tympanomastoidectomy shows promise in reducing the rate of recurrence of AC. Refinements of the surgical technique have led to improve survival of the autografts used for obliteration.

Define Professional Practice Gap & Educational Need: Addressing cholesteatoma recurrence.

Learning Objective: Mastoid obliteration can decrease the rate of recurrence of cholesteatoma surgery.

Desired Result: Reduction of the rate of recurrence of cholesteatoma. Learn tips and pitfalls in mastoid obliteration surgery

Level of Evidence – Level III

Indicate IRB or IACUC: IRB # 20200699 (Approved 10/6/22020).

Factors Associated with Prognosis of Idiopathic Sudden Sensorineural Hearing Loss

Victoria J. Cress, BA; Chloe E. Dominguez, BS; Kari D. Roberts, BS
Hector A. Perez, MD; Yuan F. Liu, MD

Hypothesis: To characterize the disease progression of patients presenting with idiopathic sudden sensorineural hearing loss and identify potential positive and negative prognostic factors.

Background: Many potential risk factors for idiopathic sudden sensorineural hearing loss (ISSNHL) have been described. However, the impact of these risk factors on ISSNHL prognosis remains unclear.

Methods: We retrospectively assessed outcomes in 66 patients having idiopathic sudden sensorineural hearing loss from January 2012 to January 2021. Medical histories, audiometric data, and treatment modalities were collected and compared.

Results: Patients with higher initial word recognition scores (WRS) on the affected side were less likely to have positive change in pure tone average (PTA) (p-value 0.043). Patients with more severe PTA changes on the affected side had a greater likelihood for improvement in PTA with time and treatment (p-value 0.017). No significance in improvement of PTA or WRS on the affected side was noted in patients treated with oral (p-value 0.93) or intratympanic steroids (p-value 0.82) nor in correlation with patient age (p-value 0.93), sex (p-value 0.69), or BMI (p-value 0.15). Comorbidities analysis is ongoing.

Conclusions: Prognosis for ISSNHL may be independent from treatment with steroids, regardless of route of administration. Our study suggests that the most predictive prognostic factors for ISSNHL can be found on an initial audiogram. Patients with high WRS scores may have a less favorable outcome in PTA recovery, while those with significant losses in PTA may have a higher likelihood for hearing improvement.

***Professional Practice Gap & Educational Need:** Expand understanding of prognostic factors in patients treated for idiopathic sudden sensorineural hearing loss.

***Learning Objective:** Identification of positive and negative prognostic factors in patients treated for idiopathic sudden sensorineural hearing loss; Encourage discussion of observed trends at other institutions.

***Desired Result:** Increased provider awareness of prognostic factors involved in the treatment of idiopathic sudden sensorineural hearing loss.

***Level of Evidence -** IV

***Indicate IRB or IACUC :** Loma Linda University Institutional Review Board - #5210056

AMERICAN OTOLOGICAL SOCIETY RESEARCH FOUNDATION
RESEARCH GRANT AWARDS

The American Otological Society is committed to the non-promotional advancement of knowledge and science and to a free exchange of medical education in otology and neurotology. The American Otological Society, through its Research Foundation, is offering Research Grant Awards, an Award for a Clinical Trial, full-time Research Training Fellowships, exclusive medical student grants, and a Clinician-Scientist Award. All of the AOS grant awards may involve research on any topic related to ear disorders. The research need not be directly on an otological disease but may explore normal functions of the cochlea, labyrinth or central auditory or vestibular systems. However, the applicant must describe how the proposed research will benefit our understanding, diagnosis or treatment of otological disorders. Research supported by all of the grant mechanisms can relate to any aspects of the ear, hearing and balance disorders. We welcome applications that address quality and safety of care as well as to improve education and training in otology.

These grant awards and fellowships are for work conducted in *United States or Canadian institutions only*. Additional details may be found on the AOS website. https://www.americanotologicalsociety.org/aos-grant-submission-instructions

SAVE THE DATE 2022

NOVEMBER 1, 2022. If you would like to submit a grant for consideration of funding in the next cycle, 2023-2024, in ONE PDF, include a LETTER OF INTENT and BIOSKETCH (NIH template), including details regarding other existing support, and any potential overlap with your mentor(s) must be submitted by November 1st of the year prior to funding. The next funding cycle begins July 1, 2023. The letter of intent must state the desired grant mechanism for the proposal (CSA, Fellowship grant, Clinical Investigation, Research grant or Medical Student grant), the Principal Investigator, and Institution(s), a working title, with an abstract and Specific Aims (2-page limit on abstract and aims).The biosketch is not included in the page limit.

Complete applications will be invited from selected applicants based on the Research Advisory Board's review of the letters of intent. Applicants will be notified whether they are invited to submit a full application the first week of December. Completed applications must be received by January 31st.

Applications are reviewed by members of the Board of Trustees of the AOS Research Fund. The Board makes recommendations regarding funding to the AOS Council. Final funding decisions are made by the AOS Council, which typically meets during the Combined Otolaryngology Spring Meetings, yielding decisions in May. Applicants are notified regarding a funding decision after the AOS Council has met.

Information may be obtained from:
Andrea Vambutas, MD, Executive Secretary, Research Fund of the American Otological Society
Email: avambuta@northwell.edu

AND **Kristen Bordignon**, AOS Research Fund Administrative Assistant

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AOS PROGRESS REPORTS
Grant recipients 2021-2022

PI NAME (IN ALPHABETICAL ORDER)	DESIGNATION	INSTITUTION	GRANT MECHANISM	GRANT TITLE	FUNDS AWARDED
Dougherty, Mark C.	MD	University of Iowa	Fellowship Grant	Metabolomic Profiling of Human Vestibular Schwannoma and Meningioma Before and After Radiation Therapy	$44,000.00
Kohlberg, Gavriel	MD	University of Washington	CSA RENEWAL (year 2)	Use of Multisensory Input and Deep Learning Techniques to Develop a Next Generation Listening Device to Improve Speech Perception in Noise for Individuals with Hearing Loss	$80,000.00
Krishnan, Pavan	BA	Johns Hopkins University	Fellowship Grant	Identification of Biomarkers in Human Plasma for Diagnosis of Vestibular Migraine	$30,000.00
Leong, Stephen	BA	Columbia University	Fellowship Grant	Microneedle Mediated Aspiration of Perilymph for Sequential Proteomic Characterization after Corticosteroid Administration	$30,000.00
McDermott Jr., Brian	PhD	Case Western Reserve University	Research Grant	Genetic Regulation of Tmc Proteins in Hair Cells	$55,000.00
Pan, Dorothy	MD, PhD	University of Southern California	Fellowship Grant	Characterizing Nanoparticle Transport from the Middle to Inner Ear through the Round Window Membrane	$44,000.00
Shibata, Seiji B.	MD, PhD	University of Southern California	Clinician Scientist Award	Cellular Reprogramming of Peripheral Glial Cells to Regenerate Primary Auditory Neurons	$80,000.00

TOTAL DISTRIBUTION FY 2022 - $363,000

American Otological Society Research Grant
Progress report: 2/1/2021 – 1/31/2021
PI: Gavriel D. Kohlberg, MD
Title: Use of multisensory input and deep learning techniques to develop a next generation listening device to improve speech perception in noise for individuals with hearing loss

Progress report:

A potential avenue to improve noise reduction algorithms, and thereby speech understanding in background noise, involves using both auditory information and visual information of the speaker's face via video camera (from a smartphone camera or camera embedded in glasses).[1,2] However, there may be situations where the background noise is so intense, or the listener's ability to hear in background noise is so poor, that even an improved noise reduction algorithm may not sufficiently help the listener comprehend speech. A potential solution to this situation is the use of real time captioning of the speech that can be read by the listener. Unfortunately, automated speech recognition programs that translate speech into text perform poorly in background noise. Here too, there may be a benefit to combining both visual information of the speaker's face and the speaker's auditory information into an automated speech recognition program in order to generate more accurate speech text translation in background noise. While real time captioning that works well in background noise may be of benefit to listeners, it is relatively unknown how listeners combine auditory information with speech text generated from an automated speech recognition program in background noise. Maximum likelihood estimation (MLE), a Bayesian model, has been used to study how individuals integrate redundant cues from different senses and can be applied to study how speech text and auditory information are integrated. It is worth noting that advances in noise reduction and real time captioning of speech has the potential to benefit communication applications beyond the specific applications denoted below.

We propose to evaluate whether automated speech recognition programs and noise reduction algorithms designed to function on both auditory and visual information are more efficacious in background noise compared to similar programs based on auditory information alone. Furthermore, we propose to evaluate how listeners combine real time captioning output from automated speech recognition programs with auditory information through the following aims:

Aim 1: To develop an automated speech recognition (ASR) program, which improves on existing preliminary technology, that integrates visual cues (via video camera) and auditory cues (via microphone) and supplies a real-time estimation of the current phonetic message. *We will test the hypothesis that the ASR with both auditory and visual input will achieve a higher word recognition rate compared to the same ASR based on auditory input alone.*

Progress:
We had previously implemented an audiovisual based Automated Speech Recognition program that outperformed Google Speech-to-Text and found that our implementation outperformed the commercially available program starting at SNR of +10 dB. In the last year we have created a video repository of recordings of all 300 AzBio sentences of a single speaker. We have also started recording AzBio sentences both on a smartphone and augmented reality glasses. We have updated the ASR to work with smartphone video. We have also updated our program to work in two modes – one with both auditory and video information as input and another version with just auditory information as input. We are currently evaluating the programs to see if the audiovisual based ASR outperforms the auditory alone version.

Aim 2: To develop an algorithm that combines the auditory information and visual information of a target speaker to perform novel audiovisual noise reduction for the speaker's auditory information in background noise. *We will test the hypothesis that individuals with normal hearing will achieve improved speech perception in noise with this novel form of noise reduction.*

Progress:
In the last year we implemented an audiovisual Kalman Filter based (KF_{AV}) noised reduction algorithm. We then compared this novel KF_{AV} algorithm to a KF algorithm that uses auditory information only (KF_A) as well as to the original speech without any noise reduction changes. We found that in the presence of multi-talker babble, our

KF_{AV} algorithm had lower mean square error compared to the clean speech signal vs the KF_A algorithm and the speech signal in multi-talker babble at an SNR of +5, 0 and -5 dB. These results offer preliminary evidence that our novel KF_{AV} algorithm outperforms KF_A at noise reduction.

Aim 3: To evaluate how listeners combine real time visual speech text generated from an Automated Speech Recognition Program (ASR) with auditory speech information where both the output of the ASR and the auditory information have been corrupted by background noise. *We will test the hypothesis that normal hearing listeners integrate auditory and text information in a statistically optimal fashion.* We will use MLE to predict optimal performance for how noise corrupted auditory and visual text information can be combined by a listener. We will then compare the MLE model prediction to performance of normal hearing listeners on combined auditory and text speech perception tasks in a variety of noise conditions.

Progress:
In the last year I have studied the Bayesian model of cue combination and the simplified maximum likelihood (MLE) model of cue combination. I learned how to perform psychoacoustic experiments using adaptive testing with the updated maximum likelihood method in order to estimate the psychometric function. We then designed an experiment to evaluate the above hypothesis in aim 3 that normal hearing listeners integrate auditory and text information in a statistically optimal fashion and we found that listeners integrate auditory and text information in a statistically sub optimal (but beneficial) fashion when both information sources are presented at threshold. However, when the text has a high error rate, it can actually act as a distractor and lead to worse performance by the listener on the combined auditory and text information compared to the auditory information alone. These results were presented as a poster at the Acoustical Society of America meeting this past year.

1. Kohlberg GD, Gal YK, Lalwani AK. Development of a Low-Cost, Noninvasive, Portable Visual Speech Recognition Program. *Ann Otol Rhinol Laryngol.* 2016;125(9):752-757.
2. Raghavan AM, Lipschitz N, Breen JT, Samy RN, Kohlberg GD. Visual Speech Recognition: Improving Speech Perception in Noise through Artificial Intelligence. *Otolaryngol Head Neck Surg.* 2020;163(4):771-777.

American Otological Society Clinician Scientist Award – 6 Month Progress Report
Fellowship Grant Funding Period: 7/1/2021 – 6/30/2022
Progress Report Date: 1/31/2022
Principal Investigator: Seiji B. Shibata MD PhD
Mentors: Justin Ichida, PhD; Neil Segil, PhD
Project Title: *Cellular reprogramming of peripheral glial cells to generate auditory neurons*

Background:
Sensorineural hearing loss (SNHL) is the most common neurological impairment, affecting an estimated 466 million people worldwide. SNHL is a major public health issue as by 2050, over 900 million people are predicted to have some degree of hearing loss. The auditory nerve plays a crucial role in hearing by transmitting acoustic signals generated from the inner ear to the brain. In auditory neuropathy (AN) or neural deafness, where the health of the spiral ganglion cell or auditory nerve is affected, there are currently no effective therapeutics. In mammals, spontaneous regeneration of the nerve or soma does not occur. Thus regenerative medicine holds enormous potential in AN. Our research aims to explore direct cell reprogramming of the glial cells in the inner ear to induce spiral ganglion neurons (SGN). Given the plasticity of certain somatic cells, in- vivo direct reprogramming is an emerging field in regenerative medicine. One potential source in the inner ear is the peripheral glial cells, primarily composed of Schwann cells and mesenchymal cells. Earlier work has shown that cochlear glial cells can be reprogrammed into neuron-like cells by overexpression of bHLH transcription factors Ascl1, Neurog1, and NeuroD1 in vitro. However, similar attempts of “additive” overexpression of lineage-specific transcription factors in the CNS have been challenged by low conversion rates and failure to generate the desired neuronal phenotypes in vivo. Recently, down-regulation of the single RNA binding protein, Polypyrimidine tract-binding protein 1 (Ptbp1), has been shown to be sufficient to convert mouse astrocytes in the brain and muller cells in the retina to functional neurons, thereby alleviating motor defects in Parkinson’s disease model and restoring vision. This strategy of regulatory gene “subtraction” has yet to be explored in the inner ear and may offer an option to restore auditory nerve loss in AN.

Aim 1: Explore *in vitro* and *in vivo* direct reprogramming using cochlear glial cells.
Specific goals of Aim1:

1) Determine optimal vector and promoter to transduce the cochlear glial cells *in vivo*.
2) Explore *in vitro* direct reprogramming of cochlear glial cells.

Progress: For Aim 1.1, we are determining which adeno-associated viral vectors are most efficient at delivering transgenes into the glial cells in the cochlea. We have injected AAV2/1-CMV-GFP into the RWM and found that GFP expression is localized in the glial cells in the osseous spiral lamina (Fig1A). We are currently ordering AAV serotypes 1, 9, and synthetic vectors PHP.9 or DJ harboring reporter genes driven by GFAP promoter or MBP promoter. In addition, we will clone Schwann cell specific myelin protein zero (mpz/P0) into the best performing AAV serotype and perform and screening analysis in neonatal mice ears.

For Aim 1.2, we demonstrate that mouse embryo fibroblasts can be induced into sensory neuron like cells, with morphological and molecular features consistent with sensory neurons (Fig1B). This demonstrates the feasibility of the additive approach to overexpress lineage specific transcription factor to convert fibroblasts into neurons. We propose using RNA interference (RNAi) to down regulate Ptbp1 gene *in vitro* and *in vivo*. We hypothesize that we can specifically deliver transgenes to cochlear glial cells and suppress Ptbp1 with RNAi to induce cochlear glial cells to neuron conversion. We will also explore neurogenic molecules miRNAs, miR-9/9, and miR-124, that are highly abundant in neuronal tissue and are essential for neural differentiation. Data collection on this specific aim has been delayed due to COVID-related restrictions and personnel limitations in campus research facilities.

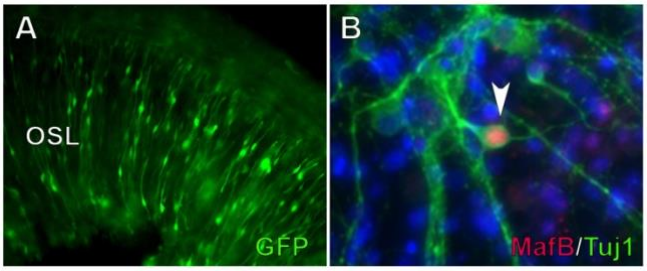

Fig1. Neonatal cochlea following injection of AAV2/1-CMV-GFP and induced spiral ganglion cells following cocktail of transcription factors. GFP positive glial cells are shown in the osseous spiral lamina (OSL) (A). Induced spiral ganglion neurons (arrowhead) express MafB and Tuj1 (B).

Aim 2: Determine the effects of Na+/K+ ATPase inhibitor Ouabain on the SGN and Schwann cells and *in vivo.*
Progress: We sought to develop a mouse model with primary SGN degeneration at an early developmental stage to assess reactive gliosis and regenerative competence in the neonatal cochlea. We hypothesized that Ouabain will selectively lesion SGNs when administered in the neonatal mice, and the remaining Schwann cells

will retain regenerative capacity. We injected P1-2 CBA/CaJ mice with 1 µl of Ouabain at concentration of 50-1000 µM into the perilymphatic space through the posterior semicircular canal. The cochlear whole mounts were assessed between 48 hours and 1 week. However, we did not identify hair cell or neurite destruction as previously described in the literature. The concentration was increased to 2 mM, nonetheless there was no destruction of the hair cells or SGN at 1 week (Figure1A and B). The higher concentration of Ouabain above 2 mM proved to be toxic to the neonatal mice leading to poor postoperative survival. Subsequently, we changed the administration route of Ouabain to RWM, however this also did not lead to degeneration of SGN. The Ouabain was then injected via a cochleostomy into the endolymphatic space but again did not lead to SGN or hair cell death. We tested Ouabain in older mice beyond P10 and identified SGN loss and hair cell damage as previously described. From our preliminary results, we hypothesize that the ototoxicity of Ouabain through Na+/K+ ATPase inhibition is limited during the earlier stage of cochlear development in mice. We speculate that the paucity of Na+/K+ ATPase α/β subunit distribution during neonatal development in mouse cochlea may contribute to reduced damage. We plan to confirm these results in subsequent experiments, testing expression of Na+/K+ ATPase α/β subunits with immunohistochemistry in the neonatal cochlea at various timepoints. In summary, in addition to the species variability that has been described with Ouabain deafening, there is likely a age dependency of the ototoxic effect of Ouabain in mice. It is conceivable that there may also be a strain dependency, but previous reports that have utilized adult CBA/CaJ mice have shown SGN loss. We will continue to explore novel means of inducing primary SGN death.

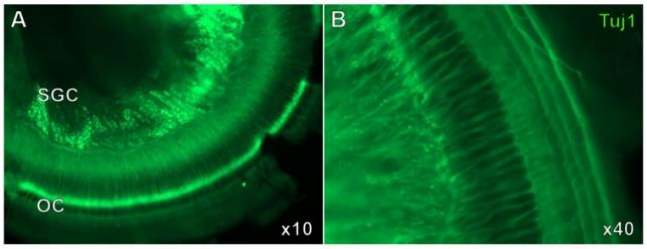

Fig2. Ouabain ears following 2 mM injection into the perilymph. Whole mount images stained with TUJ1 obtained by immunofluorescence microscope. In the apex, spiral ganglion cells (SGC) and neurites morphology are intact (A). Neural organization and number of HC were also grossly intact in the basal turn (B).

Currently, we are investigating secondary SGN loss in the neonatal mice. Similar to Ouabain, we aim to induce neonatal deafness with injection of aminoglycoside Neomycin. We hypothesized that rapid damage of hair cells during this critical period may lead to rapid degeneration of the SGN. The CBA/CaJ mice were used in this study. Neomycin 400 nL (50 and 100 mg/ml) was administered into the endolymphatic space at postnatal day 2 (P2). Cochlear histology was assessed at P5 and P9. Immunohistochemistry of the cochlear whole mount tissue and cryosections were evaluated using confocal microscopy. Injection of neomycin into the endolymphatic space led to significant hair cell degeneration, demonstrating a base-to-apex gradient pattern of hair cells damage as early as P5 (Fig 3B, C, E and F). Rapid secondary degeneration and disorganization of the peripheral neurites along with SGC loss were noted at P9 (Fig 3B, C, and D). Furthermore, there was a dose and time-dependent response of hair cell and SGC loss (Fig 3E and F). These results demonstrate that direct injection of neomycin into the cochlea induces robust degeneration of hair cells and rapid denervation in neonatal mice in a time and dose-dependent manner. This chemically-induced deafening model in neonatal mice allows us to investigate the processes of neural degeneration and regeneration during early cochlear development. We will further assess the survival rate of SGC and developing neurons in the cochlear nucleus.

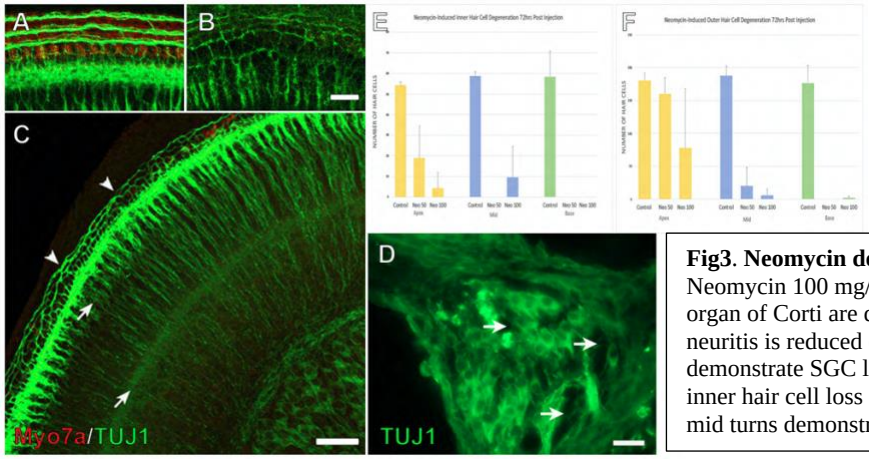

Fig3. Neomycin deafened ears. Control ear mid-turn (A). P5 Neomycin 100 mg/ml injected mid-turn (B-D). The neurites in organ of Corti are disorganization (arrowhead) and density of neuritis is reduced (arrow) (B and C). At P9 cryosections demonstrate SGC loss (arrow) (D). There is significant outer and inner hair cell loss following Neomycin injection, the base and mid turns demonstrate close to complete elimination at P5 (E and

Training Progress: I have published one paper and two book chapters in the past 6 months. In my lab, I have been able to set up equipment and perform viral and small molecule nano-injections into the inner ear, I have received animal husbandry and confocal microscopy training. During this award period, I have also had the opportunity to train two students in my lab.

American Otological Society Fellowship Grant
Progress Report: 7/1/2021 – 2/7/2022
PI: Mark C. Dougherty, MD
Title: Metabolomic Profiling of Human Vestibular Schwannoma and Meningioma Before and After Radiation Therapy

Introduction: Vestibular schwannomas (VS) and meningiomas account for approximately 10% and 37% of all primary intracranial neoplasms, respectively, with meningiomas being the single most common primary intracranial tumor.[1] They are the most common tumor in the cerebellopontine angle and share multiple key genetic and anatomic features, which makes studying them in parallel advantageous. The most important shared feature is frequent mutations in the *NF2* tumor suppressor gene. In most cases, these tumors can be treated with surgical resection and/or radiation with good outcomes. However, when those treatments fail no further options exist.[2] Metabolomics is the study of metabolic networks, which are critical for tissue phenotype and function and represent a common downstream pathway from genes, RNA, and proteins. Few efforts have been made to characterize the metabolomics of most central nervous system (CNS) neoplasms, including meningiomas and schwannomas.[3–6] Doing so can provide insight into novel therapeutic targets. The objective of the proposed work is to leverage our access to many primary human tumor specimens to characterize their metabolomic profiles before and after radiation. Results from these studies will facilitate *our long-term goal to identify key metabolic pathways in meningiomas and schwannomas that can be therapeutically targeted to limit tumor growth and increase the efficacy of radiotherapy*. Doing so could dramatically improve both the duration and quality of life in some of our most difficult patients.

Aim 1: Characterize the metabolomic profile of human VS and meningioma. *Hypothesis: metabolomic profiling techniques used in surgically resected human VS and meningiomas will display identifiable metabolite profiles.* We will perform gas chromatography-mass spectroscopy (GC-MS) analysis on tissue samples flash-frozen at the time of surgical resection and on mouse xenograft specimens. Sample analysis will be performed on the Thermo Q Exactive GC-MS to describe the metabolome of these tumors (>100 metabolites).

Progress: Our first step was to perform metabolomic profiling of primarily resected human schwannoma and meningioma tissue. As of February 2022, this has been done for 40 meningiomas and 13 schwannomas. Initial metabolomics data from primary meningioma and schwannoma tumor specimens have confirmed that, unlike in typical malignant tumors, the lactate:pyruvate and lactate:citrate ratios are low (Table 1). This suggests a lack of the Warburg effect, which is the phenomenon wherein malignant tumors heavily favor aerobic glycolysis over oxidative phosphorylation as a means of energy production.[7] Metabolomic analysis of an additional 17 meningiomas and 16 schwannomas is in progress as of the time of this writing. A critical limitation to our current analysis of primary tumor samples is a lack of true control samples. Because normal arachnoid cells and Schwann cells cannot be harvested in sufficient quantities for metabolomic analysis, a true control tissue does not exist. However, we plan to use normal dura (for meningioma) and culture human arachnoid and Schwann cells as control tissues; harvesting these additional tissues will commence following approval by the Institutional Review Board.

Meningioma		**Lactate:Pyruvate**	**Lactate:Citrate**
Primary Tumors (n=40)	Mean	1.48 (±1.08)	1.72 (±2.24)
Cultures (n=6)	6h 20gy/control	1.75 (p = 0.14)	0.89 (p = 0.41)
	72h 20gy/control	1.30 (p = 0.34)	0.88 (p = 0.69)
Schwannoma		**Lactate:Pyruvate**	**Lactate:Citrate**
Primary Tumors (n=13)	Mean	0.48 (±0.19)	0.72 (±0.31)
Cultures (n=5)	6h 20gy/control	0.83 (p = 0.77)	0.75 (p = 0.82)
	72h 20gy/control	0.93 (p = 0.86)	0.94 (p = 0.93)

Table 1. Low lactate:pyruvate and lactate:citrate ratios suggest lack of aerobic glycolysis (Warburg Effect) typical of malignant tumors.

Aim 2: Characterize the effect of radiation therapy on metabolomic profile of VS and meningioma in a dose-response fashion. *Hypothesis: human VS and meningiomas will display distinct metabolomic profiles following doses of therapeutic radiation, with metabolic changes increasing in a dose-response fashion beyond a minimum threshold dose*. No prior metabolomic analysis has been performed pre- and post-radiation for these tumors. We will therefore measure response patterns of increasing doses of radiation (0-20 Gy) on primary human schwannoma and meningioma cultures and xenograft tissues. These changes may provide insights into potential targets to enhance radiosensitivity.

Progress: Thus far, we have established primary cell cultures from 11 human meningioma and 9 human schwannoma samples and treated these with a single fraction of gamma radiation (0, 3, 10, or 20 Gy; typical clinical stereotactic radiation doses range from 10-15 Gy). We have obtained untargeted metabolomic data at one (24 hours, 2 meningiomas) or two (6 & 72 hours, 6 meningiomas & 5 schwannomas) time points after radiation for a subset of those. Network analyses have not yet demonstrated findings reaching statistical significance, which we attribute to heterogeneity between tumors, variations in cell culture growth due to the benign nature of these tumors, and small sample number. Nevertheless, meningioma culture metabolomic heatmaps have already demonstrated unsupervised clustering of metabolites consistent with known biological functions—including fatty acids, amino acids, and the tricarboxylic acid (TCA) cycle (Figure 1). Thus, we anticipate significant pathway and network findings following completion of more cell cultures and xenografts. Analysis of additional tissue cultures is currently in progress.

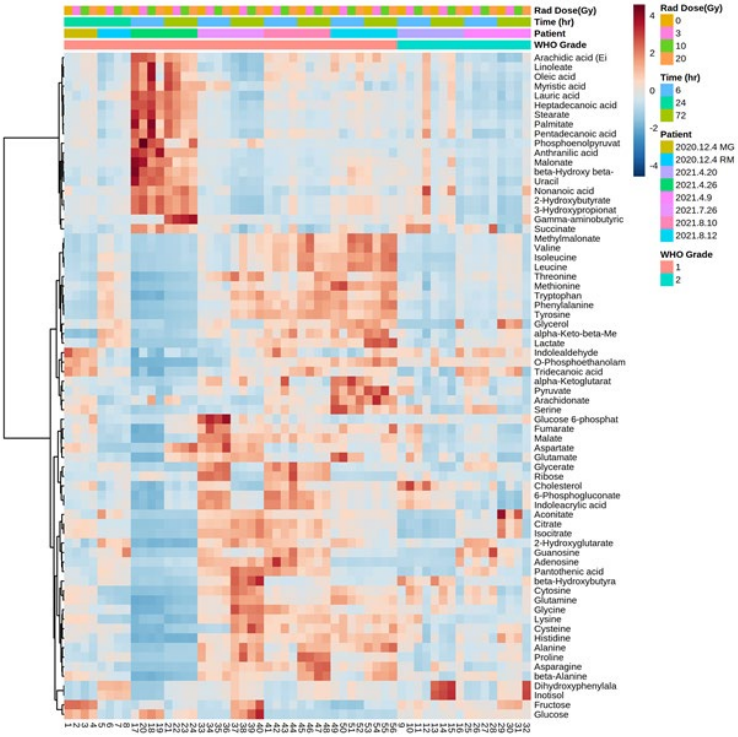

Figure 1. Meningioma culture metabolite heatmap indicating higher (red) & lower (blue) relative concentrations. Unsupervised hierarchical clustering by the Ward method.

We have also established an *in vivo* mouse xenograft model; 83 mice have been implanted with human tumors as of this writing (Figure 2) and 44 xenograft tumors have been harvested at the experimental endpoint. We expect that inter-tumoral heterogeneity will be of lesser impact in xenograft tumors than in cell cultures since they are in an environment more akin to the natural tumor microenvironment and can survive longer in the model system (1-2 weeks in culture vs. 1-3 months *in vivo*). Metabolomic data from the first batch of mouse xenograft tumors is forthcoming.

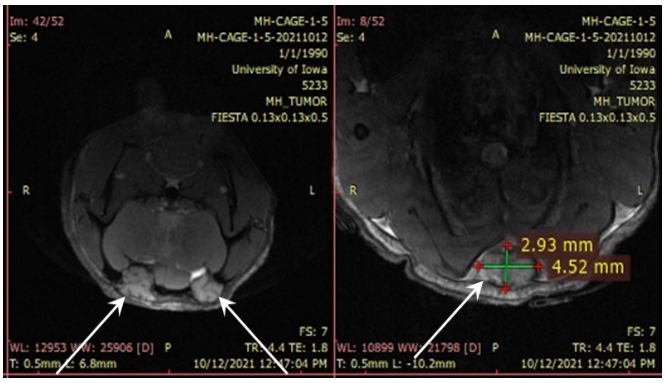

Figure 2. Xenograft model of human schwannoma. Acutely resected tumor fragment is placed intradurally in the bilateral parietal regions (left) and subcutaneously in the interscapular region (right). White arrows indicate implanted tumor. MRI obtained one month after implantation.

Future Directions: Following the completion of these aims, we hope to perform pathway analysis via stable isotope tracing of Carbon-13 (^{13}C) labeled metabolites. Cell cultures and mouse xenografts will be established and radiated as described in Aim 2. Stable isotope tracing can then identify key steps in pathways (e.g. glycolysis, citric acid cycle) that are altered following radiation of cell cultures or xenograft tumors.

References

1. Ostrom QT, Cioffi G, Gittleman H, et al. CBTRUS Statistical Report: Primary Brain and Other Central Nervous System Tumors Diagnosed in the United States in 2012-2016. *Neuro Oncol*. 2019;21(Suppl 5):v1-v100. doi:10.1093/neuonc/noz150
2. Hadjipanayis CG, Carlson ML, Link MJ, et al. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on Surgical Resection for the Treatment of Patients With Vestibular Schwannomas. *Neurosurgery*. 2018;82(2):E40-E43. doi:10.1093/neuros/nyx512
3. Bender L, Somme F, Ruhland E, Cicek AE, Bund C, Namer IJ. Metabolomic Profile of Aggressive Meningiomas by Using High-Resolution Magic Angle Spinning Nuclear Magnetic Resonance. *J Proteome Res*. 2020;19(1):292-299. doi:10.1021/acs.jproteome.9b00521
4. Pfisterer WK, Nieman RA, Scheck AC, Coons SW, Spetzler RF, Preul MC. Using ex vivo proton magnetic resonance spectroscopy to reveal associations between biochemical and biological features of meningiomas. *Neurosurg Focus*. 2010;28(1):E12. doi:10.3171/2009.11.FOCUS09216
5. Tompkins SC, Sheldon RD, Rauckhorst AJ, et al. Disrupting Mitochondrial Pyruvate Uptake Directs Glutamine into the TCA Cycle away from Glutathione Synthesis and Impairs Hepatocellular Tumorigenesis. *Cell Reports*. 2019;28(10):2608-2619.e6. doi:10.1016/j.celrep.2019.07.098
6. Chae EY, Shin HJ, Kim S, et al. The Role of High-Resolution Magic Angle Spinning 1H Nuclear Magnetic Resonance Spectroscopy for Predicting the Invasive Component in Patients with Ductal Carcinoma In Situ Diagnosed on Preoperative Biopsy. *PLoS One*. 2016;11(8):e0161038. doi:10.1371/journal.pone.0161038
7. Liberti MV, Locasale JW. The Warburg Effect: How Does it Benefit Cancer Cells? *Trends Biochem Sci*. 2016;41(3):211-218. doi:10.1016/j.tibs.2015.12.001

American Otological Society Research Grant
Progress report: 7/1/2021 – 1/31/2022
PI: Brian M. McDermott, Jr., Ph.D.
Title: **Genetic regulation of Tmc proteins in hair cells**

Progress Report:

Introduction:

Hearing and balance disorders impact nearly 600 million people worldwide, with perturbations of the sensory hair cells being a major cause of these disorders. The auditory, vestibular, and lateral line system—which detects water motion in fish—all depend on the hair cell to transduce mechanical stimuli into electrical signals in a process termed mechanotransduction. To accomplish effective mechanotransduction, hair bundles are organized with strict orientations, termed planar cell polarity (PCP), in all sensory systems.

The transmembrane channel-like (TMC) protein family is required for human hearing, and mutation of associated genes results in deafness forms DFNB7/11 and DFNA36 in humans as well as hearing and lateral line defects in zebrafish. Mouse and human genomes each contain the paralogs *TMC1* and *TMC2*. The zebrafish genome contains three *TMC1* and *TMC2* orthologs—*tmc1*, *tmc2a*, and *tmc2b*, and each of the cognate mRNAs are present in the larval ear. We recently demonstrated that *tmc1*, *tmc2a*, and *tmc2b* are required for zebrafish hearing (Chen *et al. Human Molecular Genetics* (2020)). Moreover, we have demonstrated that Tmc2a and Tmc2b are obligatory for lateral line function (Chou *et al. Nature Communications* (2017)). Genetic, biochemical, and biophysical studies support the hypothesis that Tmc proteins are pore-forming components of mechanotransduction channels in hair cells. Importantly, in mice, TMCs are not equivalent in their role in mechanotransduction, and TMC2 cannot perfectly substitute for TMC1, indicating that regulation of expression of TMC members in specific hair cells within the ear is vital to proper hearing. Recently, we have noted that there is a stereotyped relationship between Tmc use by hair cells and the orientation that the hair bundle faces within each sensory epithelium in both the lateral line and the ear. Specifically, in lateral line neuromasts that have hair cells that face posterior and anterior, 100% of hair cells express Tmc2b; however, only 38% of neuromast hair cells express Tmc2a, and these all face posterior. Moreover, in the saccule, the hearing organ of the zebrafish ear, we have demonstrated that Tmc1 is only expressed in a small subset of hair cells that face exclusively dorsally and ventrally and are limited to two stripes at each pole of the organ, a finding we published in *Frontiers in Cell and Developmental Biology* Zhu et al (2021). In all, these observations lead to the fascinating **hypothesis that factors that govern PCP also may govern the expression of Tmc subunits of the mechanotransduction channel in hair cells.**

To test this hypothesis, we propose the following aims for this American Otological Society (AOS) Research Grant application. Specifically, we will test if PCP-related proteins Emx2 (Empty Spiracles Homeobox 2) and Vangl2 (VANGL Planar Cell Polarity Protein 2) regulate Tmc protein expression in hair cells using genetics and imaging experiments in the optically clear zebrafish animal model system. Emx2 and Vangl2 have been selected because they have been shown to regulate PCP in hair cells in both mammals and fish.

In **Specific Aim 1 (SA1),** we will determine the impact of Emx2 removal and overexpression on Tmc-mediated mechanotransduction and *tmc2a* expression in neuromasts. Emx2 is expressed in hair cells that face anterior in the neuromast organ. Considering our previous data that the ~38% of neuromast hair cells that express Tmc2a all face posterior, we hypothesize that Emx2 downregulates *tmc2a* expression. To test this hypothesis, we will examine neuromasts in a genetic background (*tmc2b*$^{-/-}$) that only express Tmc2a in 38% of hair cells all of which face posterior. We will determine if removal of Emx2 (*emx2*$^{-/-}$), which causes all hair cells to face posterior, triggers an increase in the percentage of hair cells that express Tmc2a and can mechanotransduce. We will also determine if an Emx2 gain of function transgenic (*emx2*^{GOF}), which expresses Emx2 in all hair cells and causes all hair cells to face anterior, prompts a decrease in the percentage of hair cells that express *tmc2a* and can mechanotransduce. In a second assay, we will directly test expression of *tmc2a* mRNA, in neuromast hair cells in the *emx2*$^{-/-}$ *and emx2*^{GOF} to determine the role of this factor in *tmc2a* expression. An increase or a decrease in Tmc2a-mediated mechanotransduction in these experiments would support the hypothesis that Emx2 downregulates Tmc2a expression.

Hypothesis: Emx2 downregulates Tmc2a.

Progress:

We have begun to carried out experiments on how Emx2 impacts *tmc2a* mRNA expression in hair cells and mechanotransduction by studying the following experimental groups. **Group 1**, *tmc2b*$^{-/-}$*; emx2*$^{-/-}$ double knockouts. In this animal, all mechanotransduction in the anterior-posterior (A-P) facing neuromasts depend on Tmc2a (if they do transduce), and all hair cells face posterior. Control animals are *tmc2b*$^{-/-}$ *emx2*$^{+/+}$ and wild types. Assay 1 was carried out on these animals. **Assay 1:** Larval zebrafish were labeled with FM1-43FX and fluorophore-coupled phalloidin (co-labeling the actin bundles) to relate mechanotransduction channel function to hair bundle orientation. FM1-43FX is a fluorescent molecule that traverses through mechanotransduction channels, serving as an indicator of channel function. We then use confocal imaging to visualize the A-P facing neuromasts (L1-3) and determine which of their hair cells are functional, and observe their orientations. All method details, including statistical tests, have been described in our publications [1-3]. Ten embryos of each genotype at 7 dpf were used and 3 neuromasts were used from each animal's posterior lateral line. **Results:** In the *tmc2b*$^{-/-}$*; emx2*$^{-/-}$ double knockouts, 100% of hair cells faced posteriorly and 100% of hair cells took up FM1-43FX (N = 10 zebrafish). In both the control groups, the *tmc2b*$^{-/-}$ *emx2*$^{+/+}$ and the wild type, ~38% of hair cells took up the FM1-43X (N = 10 zebrafish). These promising results indicate that Emx2 downregulates Tmc2a. Our next step is to repeat the experiment with **Group 2**, *tmc2b*$^{-/-}$; *emx2*^{GOF} *animals*. In the *emx2*^{GOF} animal, all hair cells express Emx2 and will face the opposite direction as those in Group 1, anterior. Any transduction in the neuromasts will depend on Tmc2a. We will continue with the other sub-aims.

In **SA2,** we will determine if Vangl2 influences Tmc expression in neuromasts and in the ear. Vangl2 is a PCP factor that is expressed in all hair cells. Mutation of *vangl2* (*vangl2*$^{-/-}$) causes hair cells to face random directions, losing their stereotyped hair bundle patterning. We will determine if mutation of *vangl2* and the associated loss of PCP organization of hair bundles impact the expression of *tmc* genes and mechanotransduction. In the neuromast, we will determine if mutation of *vangl2* increases or decreases the percentage of hair cells that express *tmc2a* mRNA or decreases the percentage of hair cells that express *tmc2b* mRNA. In the saccule, Tmc1-positive hair cells of *vangl2*$^{+/+}$ fish have a dorsal-ventral pattern of hair bundle orientations; we will determine if mutation of *vangl2* and the randomization of hair bundle directions alters the pattern of hair cells that express *tmc1* mRNA and can mechanotransduce.

Progress:

We have tested if Vangl2 may impact *tmc2a* mRNA expression in hair cells of neuromasts by removal of Vangl2. In this experiment, we performed RNAscope to detect *tmc2a* mRNA. We probed *vangl2*$^{-/-}$ mutant and *vangl2*$^{-/+}$ (or wildtype) control animals with *tmc2a* RNAscope probes and determined the mean percentages of hair cells that express this transcript. **Results:** In the *vangl2*$^{-/-}$ mutant and *vangl2*$^{-/+}$ and wildtype control animals, ~38% of hair cells of neuromast expressed *tmc2a* mRNA (N = 10 zebrafish). These results indicate that Vangl2 does not control Tmc2a expression. Next, we will test if Vangl2 controls Tmc2b expression. In addition, we will test if Vangl2 influences Tmc1 expression in the ear.

References:

1. Zhu, S., et al., *Tmc Reliance Is Biased by the Hair Cell Subtype and Position Within the Ear.* Front Cell Dev Biol, 2020. **8**: p. 570486.
2. Chen, Z., et al., *Tmc proteins are essential for zebrafish hearing where Tmc1 is not obligatory.* Hum Mol Genet, 2020. **29**(12): p. 2004-2021.
3. Chou, S.W., et al., *A molecular basis for water motion detection by the mechanosensory lateral line of zebrafish.* Nat Commun, 2017. **8**(1): p. 2234.

American Otological Society Fellowship Grant: Progress Report

Fellowship Grant Funding Period: 07/01/2021 – 06/30/2022
Progress Report Date: 02/07/2022
Principal Investigator: Dorothy W. Pan
Mentor: John S. Oghalai
Project Title: Characterizing Nanoparticle Transport from the Middle to Inner Ear through the Round Window Membrane

Background

Despite sensorineural hearing loss having debilitating social, educational, and medical consequences, no approved treatments exist to restore hearing other than auditory prosthetic devices, such as hearing aids and cochlear implants. New directions in therapeutics to treat inner ear disorders are being investigated using nanoparticles (NPs), which could carry small molecule, protein, and gene therapies to treat sensorineural hearing loss. Therapeutic delivery to the inner ear is difficult due to its location within the temporal bone, the blood labyrinth barrier restricting systemic therapies, and the tympanic membrane acting as a barrier between the external and middle ear along with the round window membrane (RWM) acting as a barrier between the middle and inner ear. A method to locally deliver NPs to the inner ear is an intratympanic injection to reach the middle ear. Once in the middle ear, NPs still must cross the RWM into the cochlea and then distribute from the cochlear base to apex.

In our lab, we can noninvasively image the RWM and cochlear scalae using optical coherence tomography *in vivo* while mice are anesthetized. We sought to characterize the optimal NP properties, based on a gold nanoparticle core, for delivery into the cochlea. We synthesize fluorescent gold NPs which can be seen with our imaging techniques. Mice are anesthetized and the middle ear bulla is surgically opened to reveal the otic capsule and RWM.

Specific Aim 1: To determine the efficiency of fluorescently tagged gold NP transit from the middle ear through the RWM to the inner ear *in vivo*.

Approach: We use an optical coherence tomography system coupled with 2-photon fluorescence microscopy which can image above and below the plane of the RWM *in vivo* while the mouse is anesthetized.
Progress: We have discovered that our gold nanoparticle solution must be extremely concentrated to be seen in our optical coherence tomography system. The sensitivity of our OCT coupled with 2-photon fluorescence microscopy system is not optimized to detect the gold nanoparticles or fluorescence signal necessary for a quantitative measurement of nanoparticle transport across the RWM, as well as for other experiments and goals for our lab. The engineers in the lab are in the process of rebuilding this system with a faster MEMS mirror for OCT and updated PMT for fluorescence detection. This should be completed in the spring, and we hope to make progress in determining gold nanoparticle transport across the RWM towards the end of the grant period.

Specific Aim 2: To determine the distribution of NPs in the perilymph from the cochlear base to apex *in vivo*.

Approach: Optical coherence tomography can image gold NPs as small as 20nm and can scan the entire cochlea from the base to the apex noninvasively while the mouse is anesthetized *in vivo*.
Progress: Our optical coherence tomography system requires a highly concentrated solution of gold nanoparticles to be visualized. Due to the difficulties of visualizing a dilute solution of nanoparticles, we opted to directly inject the gold nanoparticles, based on a 50 nm gold core, suspended in artificial perilymph into the posterior semicircular canal. This posterior semicircular canal injection method has been used to deliver viral vectors into the mouse cochlea particularly for gene therapy, however, has never been used in conjunction with optical coherence tomography or vibrometry measurements in the literature. During the gold nanoparticle injection, we record continuous images of the cochlea. We have found as shown in Figure 1 that 1) posterior semicircular canal injection of solutions enters the perilymphatic space, as the gold nanoparticles are clearly visualized in the scala vestibuli but not the scala media after injection; 2) injection of 1 uL of nanoparticles at 0.5 uL/min allows the gold nanoparticles to fully perfuse the perilymphatic space up to the apex; and 3) the gold nanoparticles settle out of solution likely depositing onto membranes by an hour after injection.

Furthermore, given the success of posterior semicircular canal perfusion of the gold nanoparticles, we recorded vibrometry measurements at the basilar membrane and tectorial membrane in wild type normal

hearing CBA/CaJ mice 4-8 weeks of age. These tuning and sensitivity curves provide real time minute to minute measurements of cochlear mechanics. We showed that performing the canalostomy for the posterior semicircular canal injection and perfusing artificial perilymph alone, as shown in Figure 2, did not change tuning curves and gain curves significantly. However, perfusion of the 50 nm gold core nanoparticle did alter the tuning curves, shown in Figure 3, characterized by a notch at 4 kHz. It should be noted that there was not a decrease in sensitivity. We hypothesize that these tuning curve changes with gold nanoparticle perfusion is due to the weight of metal depositing onto the basilar membrane.

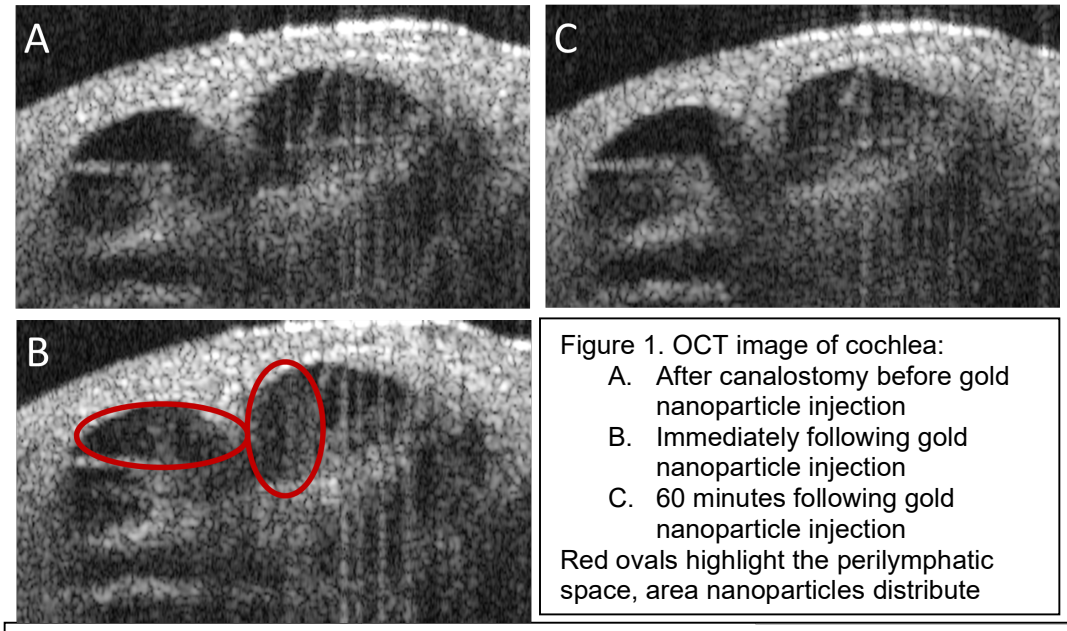

Figure 1. OCT image of cochlea:
A. After canalostomy before gold nanoparticle injection
B. Immediately following gold nanoparticle injection
C. 60 minutes following gold nanoparticle injection
Red ovals highlight the perilymphatic space, area nanoparticles distribute

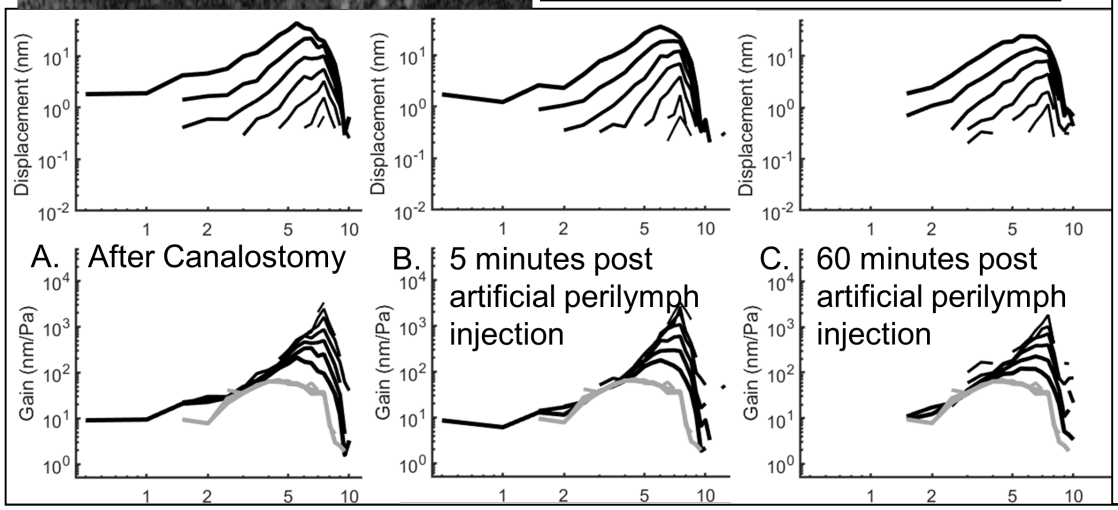

Figure 2. Artificial Perilymph (Control) injection into PSCC causes minimal change in tuning curve measurements at the basilar membrane. Displacement and gain curves shown for 1 representative mouse. Similar results obtained for n=5 mice.
Gray gain curve represents passive response of dead mouse.

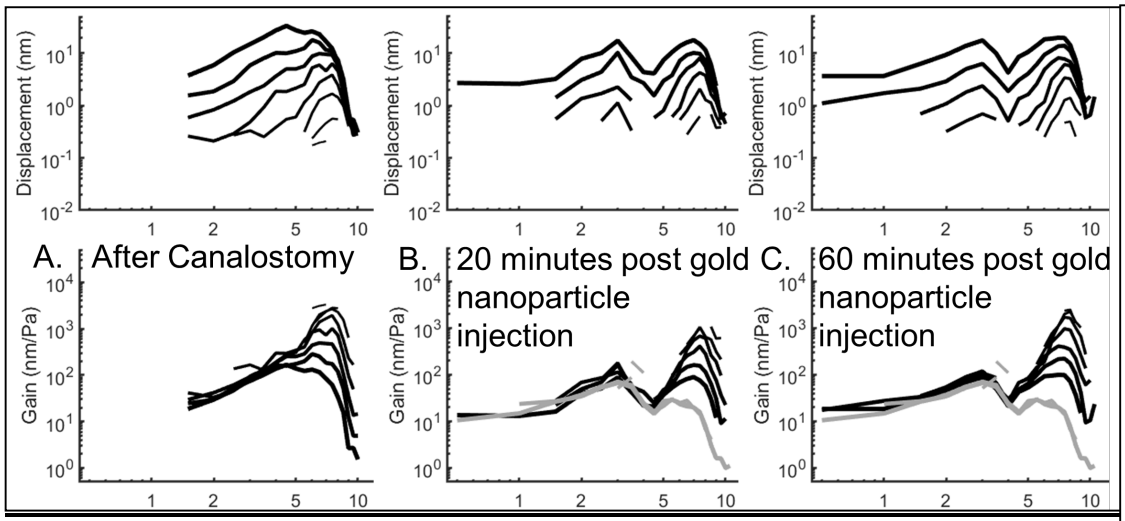

Figure 3. Gold Nanoparticle injection into PSCC causes mild changes in cochlear physiology measurements at the basilar membrane characterized by a notch in the tuning curve at 4 kHz. Displacement and gain curves shown for 1 representative mouse. Similar results obtained for n=5 mice.
Gray gain curve represents passive response of dead mouse.

Future Directions
We plan to perfuse smaller 20 nm gold core nanoparticles to see how the size difference of the nanoparticle changes cochlear mechanics. We may also test polymeric nanoparticles, which are able to encapsulate therapeutics, of similar size to the gold nanoparticles but lower in mass to see whether they cause less of a change in basilar membrane tuning curves. We also anticipate performing survival surgery with posterior semicircular canal perfusion and measuring tuning curves one week after perfusion of artificial perilymph or nanoparticles to determine the long-term effects of posterior semicircular canal injection. At the conclusion of these vibrometry measurements we plan to harvest the mouse cochlea and perform histology for silver enhancement staining of the gold nanoparticles to determine where in the cochlear membranes the nanoparticles deposit.

Summary
We have realized that nanoparticle transit through the round window membrane may not be the most effective for therapeutic delivery, and thus we have transitioned to posterior semicircular canal injection. We have made significant progress in combining posterior semicircular canal injection of gold nanoparticles and optical coherence tomography imaging and cochlear mechanics measurements. Visualizing gold nanoparticles in the perilymphatic space throughout the cochlea including the apical turn after injection and determining how nanoparticles affect vibrometry tuning curves once in the cochlea is crucial in understanding how using nanoparticles as therapeutics may affect hearing. We have shown that posterior semicircular canal injection can be performed without affecting cochlear physiology and allows delivery of the desired therapeutic concentration throughout the entire cochlea. We anticipate preparing a manuscript and publishing this work on posterior semicircular canal injection of gold nanoparticles and vibrometry measurements later this spring once we have completed experiments to determine longer term effects on hearing and histology imaging.

Presentations
Pan, D.W.; Kim, J.; Ricci, A.; Oghalai, J.S. Optical coherence tomography imaging of gold nanoparticles after posterior semicircular canal injection in mice. Poster presented at the Association for Research in Otolaryngology 45th Annual Midwinter Meeting. 2022 February 5.

Title: Identification of Biomarkers in Human Plasma for Diagnosis of Vestibular Migraine

I. Background

Various mechanisms have been postulated for vestibular migraine (VM), some of which overlap with other common migraine disorders. It has been theorized that sensitization of the trigeminovascular neurons, which may be linked indirectly to cortical spreading depression, causes activation of the dural and pial blood vessel nociceptors, which in turn causes a release of vasoactive neuropeptides such as calcitonin gene-related peptide (CGRP), a process known as sterile neurogenic inflammation[1]. Our goal was to determine if CGRP can be detected in plasma and potentially utilized as a sensitive biomarker for VM using proteomic methods such as enzyme –linked immunosorbent assay (ELISA).

II. Progress report

Aim 1: To characterize differences in plasma inflammatory neuropeptide levels in patients with VM and control populations with and without migraine to determine relevant biochemical markers
Aim 2: To characterize the association between plasma peptide levels and disease activity as well as various other clinical parameters in patients with VM

Before enrolling patients for these Aims, we wanted to ensure that our proposed assay yielded appropriate results in both negative and positive control experiments. All ELISA-based studies for CGRP must utilize a known solution of CGRP in proprietary buffer to establish a calibration curve of absorbance vs concentration. However, we believed that it was essential to ensure that the assay would also accurately reflect known concentrations of CGRP added or "spiked" into plasma samples as positive controls because plasma may contain factors that could block antibody binding to CGRP or degrade the peptide. It is fortunate that we did this control, as our results to date indicate that more work needs to be done to optimize the commercially available CGRP ELISA assays before we can enroll patients in our proposed studies. We have found that our validation studies did not yield the results suggested by the suppliers of these kits.

We first set out to validate two commercially available CGRP ELISA kits (Bertin Bioreagent, Antibodies Online). After establishing a sample preparation protocol and a valid standard curve, we proceeded to run spike-and-recovery and linearity of dilution experiments. The percent recoveries we found were much lower than expected (Table 1), and similar results were obtained with the kit from Antibodies Online. We suspect that this indicates that plasma interferes with CGRP capture, perhaps through binding to other proteins, degradation by serine proteases, or competitive binding of off-target proteins to the ELISA substrate.

To control for these possible confounders, we first tried to purify plasma through extraction with a proprietary sorbent, a novel step recommended by the manufacturer, prior to ELISA. This sorbent ostensibly isolates polar molecules such as CGRP from plasma. We spiked the plasma samples with known concentrations of CGRP to yield positive controls then proceeded with extraction and subsequent ELISA. These spiked samples yielded only ~50-60% percent recovery. The latter results suggest that even exogenously-added CGRP is not detected as expected in plasma. We have optimized various parts of the protocol: adding protease inhibitors to whole blood samples before centrifugation to prevent enzymatic degradation, lowering the temperature of vacuum centrifugation, adjusting time under centrifugation, and adjusting post-centrifugation resuspension methods. We also had several productive meetings with the manufacturers to discuss possible discrepancies in their protocols, which have led to changes in their protocols for newer kits. Attempting another spike-and-recovery experiment with a refined extraction protocol yielded unrealistically high CGRP concentrations (Table 2). Reassuringly, higher-than-expected values were also recently reported after extraction with the same assay by Messlinger et al (2021)[2] indicating that we are not alone in finding these problems.

Our alternative plan to control for the possible confounders between plasma and CGRP capture is to construct our standard curve using CGRP-free plasma instead of proprietary buffer. We plan to create CGRP-free plasma using a CGRP sorbent antibody that we just obtained. These unexpected extra

experiments have required kits and reagents not originally anticipated, and the ongoing global supply chain disruptions due to the COVID-19 pandemic have also hindered progress. For example, it has taken 4 months just for us to receive the CGRP sorbent. We also plan to test serum (instead of plasma) using the Antibodies Online kit, which this manufacturer recommended to us after inquiry. We believe that they may be coming to the realization that plasma (which contains clotting proteins) confounds the ELISA assay for CGRP in a way that serum (free of clotting proteins) does not.

Thus, as of yet, we have been unable to obtain satisfactory percent recovery (80-120%) from our spiked positive controls. Although we are disappointed by these setbacks, we believe that they are scientifically important findings and will put future work on better footing once we determine if using serum, adding a critical cocktail for protease inhibition, or some other modification will yield expected results in positive controls before using the techniques on our unknown samples. We would note that these validation experiments did not appear to have been done by authors of previous such studies[3-5]. The recent review by Messlinger et al (2021)[2] emphasizes the need for such controls and calls into question studies that have not done them.

Table 1.

	Percent recovery	
	Buffer	**Plasma**
1:1	94%	12%
Diluted 1:2	78%	20%
Diluted 1:4	56%	20%
Diluted 1:8	25%	2%

Table 2.

Spiked concentrations (pg/ml):	**Interpolated concentrations (pg/ml):**	**Percent recovery:**
100	206	206 %
400	556	139%
800	893	112%

Alternative approaches:

We recognize that a liquid assay of CGRP may ultimately prove unreliable because of rapid degradation of the peptide that occurs outside of cells. CGRP has been estimated to have a half-life of 6.9 minutes in blood[6]. This short half-life may be due to spontaneous degradation or the proteolytic activity of multiple metallopeptidases. Thus, we have also begun to investigate ways to measure intracellular CGRP. We will attempt immunohistochemical methods for detecting CGRP in human salivary tissue, which is rich in trigeminal efferent nerve endings. Labial salivary gland (LSG) tissue vasculature is innervated by CGRP-immunoreactive nerves[7]. Our null hypothesis is that there will be no difference in CGRP concentration in LSG tissue between controls and patients with VM or classic migraine. With the help of our Head & Neck pathologist and Oncology Tissue Service core, we will perform antibody optimization and immunostaining. We are making initial efforts utilizing the reliable flow of incoming lip biopsies done for suspected Sjögren' syndrome. Another alternative is to assay for mRNA or DNA for CGRP, as these upstream blueprints for the peptide are typically much more stable. We are working with colleagues who assay DNA and RNA in head and neck cancer research to develop techniques for identifying these molecules in blood or saliva.

III. Training progress

I have helped organize and lead a reading group composed of Hopkins otolaryngologists, neurologists, physiologists, audiologists, fellows, and residents reviewing *Physiology of the Vestibular Organs* (Goldberg et al, 2012). I have also started multiple clinical research projects and a systematic review; such projects include validating a patient-reported outcome measure for superior canal dehiscence syndrome, evaluating the effect of weather parameters on vestibular disorders, and reviewing race/ethnicity in temporal bone histopathology studies. Additionally, I will be presenting a poster for a clinical project characterizing social media perspectives of vestibular disorder patients at the 2022 Association for Research in Otolaryngology MidWinter Meeting.

This project's setbacks have shown me that the scientific community's paradigms are only as accurate as its experiments are scientifically rigorous. These experiences have revealed the difficulty of

strict application of the scientific method. Yet I remain undeterred, as the results of our labors will help propel our community's understanding of vestibular disorders and migraine to new heights—therein allowing for rapid translation to improved diagnostic strategies at the bedside. Thus, my aspirations to become a surgeon-scientist in this field have only strengthened. I am deeply grateful for Dr. Carey's generous mentorship and funding from the AOS to support me during such a formative period of my training.

References:

1. Marano, E. et al. Trigeminal stimulation elicits a peripheral vestibular imbalance in migraine patients. *Headache.* **45**, 325–331 (2005).
2. Messlinger, K. et al. CGRP measurements in human plasma – a methodological study. *Cephalalgia*. **41**, 1359-1373 (2021).
3. Fan, P., et al. Plasma Calcitonin Gene-Related Peptide: A Potential Biomarker for Diagnosis and Therapeutic Responses in Pediatric Migraine. *Front. Neurol.* **10**, 10 (2019).
4. Raffaelli, B., et al. Plasma calcitonin gene-related peptide (CGRP) in migraine and endometriosis during the menstrual cycle. *Ann Clin Transl Neurol.* **8**, 1251-1259 (2021).
5. Irimia, P., et al. Interictal amylin levels in chronic migraine patients: A case-control study. *Cephalalgia.* **41**, 604-612 (2021).
6. Kraenzlin, M.E., et al. Infusion of a novel peptide, calcitonin gene-related peptide (CGRP) in man. Pharmacokinetics and effects on gastric acid secretion and on gastrointestinal hormones. *Regul Pept.* **10**, 189-97 (1985).
7. Konttinen, Y.T. et al. Peptide-containing nerves in labial salivary glands in Sjögren's syndrome. *Arthritis Rheum*. **35**, 815-820 (1992).

American Otological Society Fellowship Grant
Funding Period: 7/1/21 – 6/30/22
Progress Report Date: 2/7/22
Principal Investigator: Stephen Leong

Project Title: Microneedle-Assisted Intracochlear Glucocorticoid Delivery and Sequential Proteomic Characterization

Background: Due to its ease in accessibility, the round window membrane (RWM) has become a popular target for direct intracochlear delivery of agents. However, many technologies developed for intracochlear access are inherently traumatic to the inner ear or require implantation of a permanent prosthetic into the cochlea[1]. To circumvent these issues, our lab has developed 3D-printed microneedles that allow for perforation of the RWM with minimal trauma and full reconstitution of the RWM structure within 48-72 hours[2–4]. We have demonstrated that solid microneedle perforation of the RWM significantly enhances diffusion of agents into the cochlea *in vitro*[5], and we have successfully aspirated perilymph fluid using a hollow, lumenized microneedle[6–8]. In **Specific Aim 2**, we test the efficacy of microneedles for direct intracochlear injection of artificial perilymph, fluorescent agents, and steroids.

The advent of intracochlear gene therapies, especially long-lasting viral-mediated therapies, necessitates a means for extended treatment monitoring to ensure continued efficacy and safety[9–12]. In **Specific Aims 1 and 3**, we test the efficacy of microneedles for perforation of the same RWM at two distinct timepoints for perilymph aspiration and proteomic characterization. By doing so, we establish a methodology for monitoring the response to inner ear interventions over an extended period of time.

Specific Aim 2: *To characterize the proteomic changes in the inner ear over the span of days after intracochlear injection of glucocorticoids*. We begin with accessing the safety and efficacy of microneedles for injection of various amounts of artificial perilymph, ranging from 1 μL to 5 μL. We then inject the fluorescent agent FM 1-43 FX to characterize the distribution of agent within the cochlea, and conclude with injection of dexamethasone to assess microneedles as a means of drug delivery.

Progress:

A post-auricular incision was made to expose the tympanic bulla and the facial nerve emerging from bone. A hollow microneedle, mounted on a 2-inch, 30-gauge, blunt, small hub removable needle, was attached to a 10 μL Gastight Hamilton syringe; the syringe in turn was secured to a UMP3 UltraMicroPump, which was fixed to a micromanipulator. Using the micromanipulator, the hollow microneedle was advanced into the middle ear space and the RWM was perforated. Downward RWM displacement with initial microneedle contact was noted, followed by upward deflection of the RWM upon microneedle entry into the inner ear space. 1 μL, 2.5 μL, or 5 μL of artificial perilymph was subsequently injected into the cochlea at a rate of 1 μL/min. Hearing tests in the form of compound action potential (CAP) and distortion product otoacoustic emission (DPOAE) were performed immediately before and after perforation, and 48 hours after perforation, to assess for hearing loss. RWMs were harvested 48 hours after perforation for confocal microscopy.

We demonstrate that direct intracochlear injection of 1 μL of artificial perilymph *in vivo* is safe and does not result in hearing loss; CAP results are displayed in Figure 1. Additionally, assessment of RWMs 48 hours after perforation revealed no inflammatory changes or residual scarring in the majority of samples. However, injection of 2.5 μL and 5 μL of artificial perilymph into the cochlea produced statistically significant high-frequency hearing loss, with an average threshold shift of 19.3 dB SPL in the 36-40 kHz range in the 2.5 μL group and an average shift of 16.4 dB SPL in the 32-40 kHz range in the 5 μL group (Figure 1). Assessment of RWMs 48 hours after perforation revealed no inflammatory changes or residual scarring in the majority of samples.

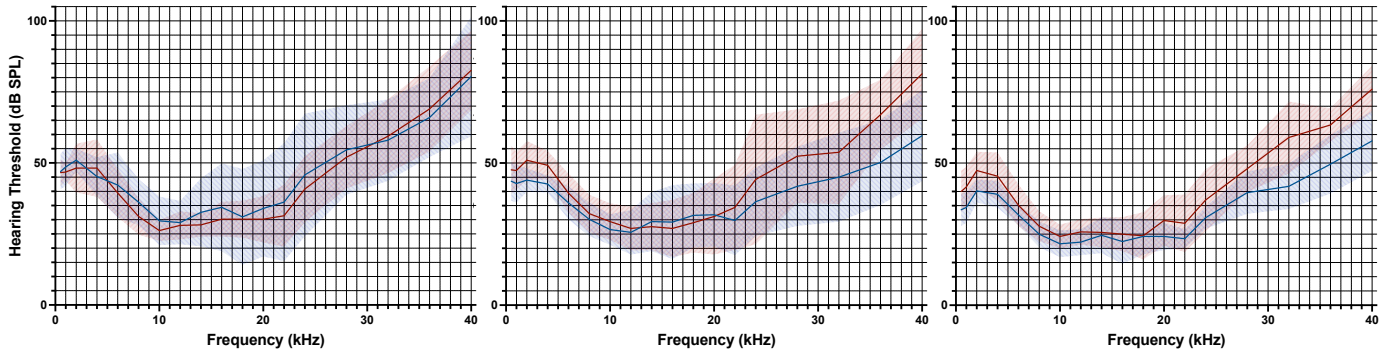

Figure 1. CAP results for microneedle injection of 1.0 μL (left), 2.5 μL (middle), and 5.0 μL (right) of artificial perilymph. The blue line indicates pre-perforation CAP and the red line indicates CAP obtained 48 hours post-perforation. 95% confidence intervals are bound by shaded areas.

Based on the above findings, we have injected 1 μL of FM 1-43 FX into the cochlea *in vivo* to characterize the basal-apical distribution of agent. We then performed a whole mount cochlear dissection after fixation and decalcification, and imaged inner and outer hair cells using confocal microscopy. Figure 2 displays an *ex vivo* cochlea treated with

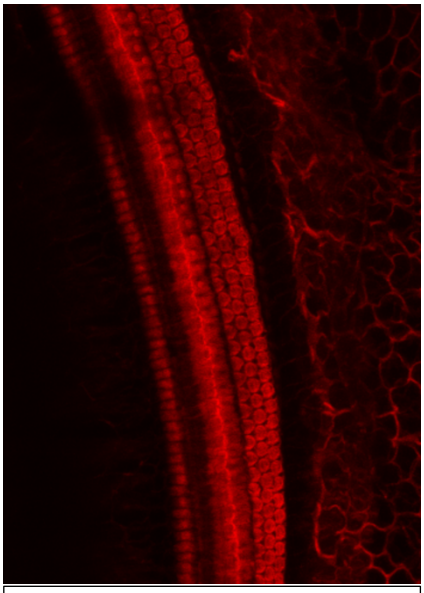

Figure 2. Whole mount dissected cochlea (basal turn) treated with ActinRed *ex vivo*.

ActinRed (phalloidin-rhodamine); we expect to see similar results with *in vivo* injection of FM 1-43 FX. Additionally, we plan to inject 1 μL of dexamethasone into the cochlea and assess proteomic changes 6 hours following injection.

Specific Aims 1 and 3: *To characterize the proteomic changes in the inner ear over the span of days after systemic administration of glucocorticoids. To assess the structural and functional consequences of repeated perforations of the RWM over time.* We have completed the majority of work for these specific aims.
Progress:

The tympanic bulla was accessed as described above and the RWM was perforated; 1 μL of perilymph was aspirated from the inner ear space over the course of 45 seconds. After withdrawal of the microneedle from the RWM, perilymph aspirate was ejected into a microcentrifuge tube and immediately stored in a -80°C freezer. 72 hours following initial perforation, guinea pigs received a second perforation and aspiration with the same procedures described above. CAP and DPOAE were performed before and after perforations, and 72 hours after the second perforation, to assess for hearing loss. RWMs were harvested 72 hours after the second perforation for confocal microscopy. Proteomic analysis of perilymph aspirate was performed with liquid-chromatography mass spectrometry.

CAP results demonstrate mild hearing loss in the 1-4 kHz range following two perforations of the RWM, consistent with conductive hearing loss (Figure 3); we note that a significant amount of middle ear effusion and debris were present in the final surgery, likely due to repeated access to the middle ear over a relatively short timeframe. Notably, DPOAEs were comparable before and after perforations, and RWMs were fully healed after two perforations, providing additional evidence that multiple perforations of the RWM are safe. Proteomic analysis revealed 13 out of 1855 identified proteins (0.7%) with significant changes ($p < 0.01$) between the first and second perforations; the discovery rate of 0.7% is below the accepted type I error rate of 1%. The functional relationship between these proteins is unclear, and none of the identified proteins are involved in inflammation or inner ear function (Figure 4). These results indicate that the proteomic profile is not significantly different between the first and second perforations.

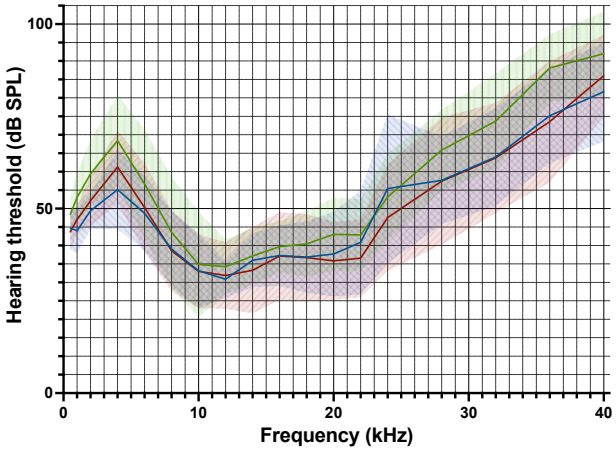

Figure 3. CAP results for multiple aspirations, obtained prior to perforations (perforation 1, blue; perforation 2, red), and 72 hours following the second perforation (green). 95% confidence intervals are bound by shaded areas.

Summary and Future Directions: Work on the project has progressed well and only a handful of experiments remain to be completed. As these experiments are finished, a number of tasks will be completed to set up future experiments:

1. *Testing and optimization of a dual lumen hollow microneedle*. We have successfully developed a dual lumen microneedle that allows for simultaneous injection and aspiration, which maintains constant volume inside the cochlea during injection of agents.
2. *Testing and optimization of intracochlear gene therapy*. In collaboration with the University of Geneva Inner Ear and Olfaction Lab, we have acquired various forms of gene therapy targeting the NOX3 protein, which we aim to inject into the cochlea using microneedles.

As part of his career development, the primary investigator will transition back to clinical duties after the conclusion of his research year; he will be responsible for the training and mentorship of new students in the laboratory such that experiments may continue at the current pace.

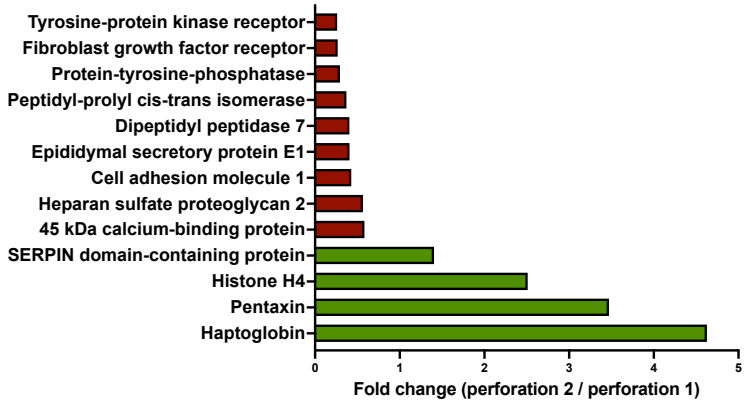

Figure 4. Proteins with significant changes between the first and second perforations. Fold changes are displayed, with red bars indicating a decrease in intensity and green bars indicating an increase in intensity.

References

1. Szeto B, Chiang H, Valentini C, Yu M, Kysar JW, Lalwani AK. Inner ear delivery: Challenges and opportunities. *Laryngoscope Investig Otolaryngol*. 2020;5(1):122-131. doi:10.1002/lio2.336

2. Aksit A, Arteaga DN, Arriaga M, et al. In-vitro perforation of the round window membrane via direct 3-D printed microneedles. *Biomed Microdevices*. 2018;20(2):47. doi:10.1007/s10544-018-0287-3

3. Yu M, Arteaga DN, Aksit A, et al. Anatomical and Functional Consequences of Microneedle Perforation of Round Window Membrane. *Otol Neurotol Off Publ Am Otol Soc Am Neurotol Soc Eur Acad Otol Neurotol*. 2020;41(2):e280-e287. doi:10.1097/MAO.0000000000002491

4. Chiang H, Yu M, Aksit A, et al. 3D-Printed Microneedles Create Precise Perforations in Human Round Window Membrane in Situ. *Otol Neurotol Off Publ Am Otol Soc Am Neurotol Soc Eur Acad Otol Neurotol*. 2020;41(2):277-284. doi:10.1097/MAO.0000000000002480

5. Kelso CM, Watanabe H, Wazen JM, et al. Microperforations significantly enhance diffusion across round window membrane. *Otol Neurotol Off Publ Am Otol Soc Am Neurotol Soc Eur Acad Otol Neurotol*. 2015;36(4):694-700. doi:10.1097/MAO.0000000000000629

6. Watanabe H, Cardoso L, Lalwani AK, Kysar JW. A dual wedge microneedle for sampling of perilymph solution via round window membrane. *Biomed Microdevices*. 2016;18(2):24. doi:10.1007/s10544-016-0046-2

7. Szeto B, Aksit A, Valentini C, et al. Novel 3D-printed hollow microneedles facilitate safe, reliable, and informative sampling of perilymph from guinea pigs. *Hear Res*. 2021;400:108141. doi:10.1016/j.heares.2020.108141

8. Szeto B, Valentini C, Aksit A, et al. Impact of Systemic versus Intratympanic Dexamethasone Administration on the Perilymph Proteome. *J Proteome Res*. 2021;20(8):4001-4009. doi:10.1021/acs.jproteome.1c00322

9. Valentini C, Szeto B, Kysar JW, Lalwani AK. Inner Ear Gene Delivery: Vectors and Routes. *Hear Balance Commun*. 2020;18(4):278-285. doi:10.1080/21695717.2020.1807261

10. Ren Y, Landegger LD, Stankovic KM. Gene Therapy for Human Sensorineural Hearing Loss. *Front Cell Neurosci*. 2019;13. Accessed January 17, 2022. https://www.frontiersin.org/article/10.3389/fncel.2019.00323

11. Zhang W, Kim SM, Wang W, et al. Cochlear Gene Therapy for Sensorineural Hearing Loss: Current Status and Major Remaining Hurdles for Translational Success. *Front Mol Neurosci*. 2018;11. Accessed January 17, 2022. https://www.frontiersin.org/article/10.3389/fnmol.2018.00221

12. Lustig L, Akil O. Cochlear Gene Therapy. *Cold Spring Harb Perspect Med*. 2019;9(9):a033191. doi:10.1101/cshperspect.a033191

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1997 - 2002	Horst R. Konrad, MD
2002 - 2007	Clough Shelton, MD
2007 - 2012	Paul R. Lambert, MD
2012 - 2017	Steven A. Telian, MD
2017 - Present	Sujana S. Chandrasekhar, MD

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1952	Edmund P. Fowler, Sr., MD
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2022	Timothy D. Griffiths, FMedSci

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New York, New York
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Allan M Rubin, MD, PhD
Perrysburg, Ohio
Senior

Jay T Rubinstein, MD, PhD
Seattle, Washington
Active

Michael J Ruckenstein, MD
Philadelphia, Pennsylvania
Active

Christina L Runge, PhD
Milwaukee, Wisconsin
Associate

Leonard P Rybak, MD, PhD
Springfield, Illinois
Emeritus

Hamed Sajjadi, MD
San Jose, California
Active

Masafumi Sakagami, MD, PhD
Hyogo, Japan
Corresponding

Ravi N Samy, MD
Cincinnati, Ohio
Active

Robert T Sataloff, MD
Philadelphia, Pennsylvania
Active

James E Saunders, MD
Lebanon, New Hampshire
Active

Jochen Schacht, PhD
Ann Arbor, Michigan
Senior Associate

Arnold G Schuring, MD
Warren, Ohio
Emeritus

Mitchell K Schwaber, MD
Nashville, Tennessee
Senior

Michael D Seidman, MD
Celebration, Florida
Active

Samuel H Selesnick, MD
New York, New York
Active

Clough Shelton, MD
Walla Walla, Washington
Senior

Neil T Shepard, PhD
Missoula, Montana
Senior Associate

Jack A Shohet, MD
Newport Beach, California
Active

Herbert Silverstein, MD
Sarasota, Florida
Senior

George T Singleton, MD
Gainesville, Florida
Emeritus

Aristides Sismanis, MD
Richmond, Virginia
Senior

Henryk Skarzynski, MD, PhD
Warsaw, Poland
Corresponding

William H Slattery III, MD
Los Angeles, California
Active

Richard JH Smith, MD
Iowa City, Iowa
Honorary

Eric E Smouha, MD
New York, New York
Active

James B Snow Jr., MD
West Grove, Pennsylvania
Emeritus

Gershon J Spector, MD
St. Louis, Missouri
Emeritus

Hinrich Staecker, MD, PhD
Kansas City, Kansas
Active

Konstantina M Stankovic, MD, PhD
Palo Alto, California
Active

Ronald Steenerson, MD
Atlanta, Georgia
Associate

Olivier Sterkers, MD, PhD
Paris, France
Corresponding

Steven A Telian, MD
Ann Arbor, Michigan
Senior

Fred F Telischi, MD
Miami, Florida
Active

Norman Wendell W Todd Jr., MD
Marietta, Georgia
Senior

Daniel J Tollin, PhD
Aurora, Colorado
Associate

Debara L Tucci, MD, MS, MBA
Bethesda, Maryland
Active

Andrea Vambutas, MD
New Hyde Park, New York *Active*

Jeffrey T Vrabec, MD
Houston, Texas
Active

P. Ashley Wackym, MD
New Brunswick, New Jersey
Active

George B Wanna, MD
New York, New York
Active

Jack J Wazen, MD
Sarasota, Florida
Senior

Peter C Weber, MD, MBA Boston, Massachusetts
Active

Roger E Wehrs, MD
Tulsa, Oklahoma
Emeritus

D. Bradley Welling, MD, PhD
Boston, Massachusetts
Active

Stephen J Wetmore, MD
Morgantown, West Virginia
Emeritus

Richard J Wiet, MD
Sawyer, Michigan
Emeritus

Eric P Wilkinson, MD
Boise, Idaho
Active

Erika Woodson, MD
Shaker Heights, Ohio
Active

Sabina R Wullstein, MD
Wurzburg,
Senior Associate

Thomas P Wustrow, MD
Munchen, Germany
Corresponding

Naoaki Yanagihara, MD
Matsyama, Japan
Honorary

Eiji Yanagisawa, MD
New Haven, Connecticut
Emeritus

Nancy M Young, MD
Wilmette, Illinois
Active

in Memoriam

(in alphabetical order)

The AOS Administrative office was notified of the following members death since the last Spring meeting.

Please take a moment of silence to remember these outstanding colleagues & friends.

C. Phillip Daspit, MD - Inducted in 1995
Served as AOS President in 2011

Arvind Kumar, MD - Inducted in 1992

Clarence T. Sasaki, MD - Inducted in 1992