PROGRAM and ABSTRACTS

of the

One Hundred Fifty Forth Annual Meeting

AMERICAN OTOLOGICAL SOCIETY

April 11, 2021
VIRTUAL MEETING

Table of Contents

(2021 AOS Program Book)

OFFICERS
JULY 1, 2020 - JUNE 30, 2021

PRESIDENT
Patrick J. Antonelli, M.D. - University of Florida
Gainesville, FL

PRESIDENT – ELECT/ EDUCATION DIRECTOR
Marlan R. Hansen, M.D. - University of Iowa
Iowa City, IA

SECRETARY - TREASURER
Sujana S. Chandrasekhar, M.D. - ENT & Allergy Associates, LLP
New York, NY

EDUCATION DIRECTOR – ELECT
Nancy M. Young, M.D. - Lurie Children's Hospital of Chicago
Chicago, IL

COUNCIL
The above officers and

PAST PRESIDENT
Carol A. Bauer, M.D. - Southern Illinois University School of Medicine - Springfield, IL

IMMEDIATE PAST PRESIDENT
John P. Carey, M.D. - Johns Hopkins - Baltimore, MD

Lawrence R. Lustig, M.D. - New York - Presbyterian Hospital/Columbia - New York, NY

William H. Slattery III, M.D. - House Ear Clinic - Los Angeles, CA

American Otological Society, Inc.
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.

Disclosure Information

Please see the COSM website for all program COI and Disclosure information for the 2021 program.

https://cosm.md/cme/

PUBLICATION /SUBMISSION STATEMENT

The material in this abstract, has not been submitted for publication, published, nor presented previously at another national or international meeting and is not under any consideration for presentation at another national or international meeting.
The penalty for duplicate presentation/publication is prohibition of the author and co-authors from presenting at a COSM society meeting for a period of three years. Submitting Author's Signature (required All authors were advised that the submitted paper becomes the property of Otology & Neurotology and cannot be reprinted without permission of the Journal.
Duplicate abstract submission to more than one Society will result in the abstract being disqualified and it will not be considered for presentation on either the AOS or ANS programs.

THE AMERICAN OTOLOGICAL SOCIETY WOULD LIKE TO THANK THE FOLLOWING MEMBERS FOR THEIR CONTRIBUTION TO THE 2021 AOS SCIENTIFIC PROGRAM

Program Advisory Committee

Patrick J. Antonelli, MD - Chair
Marlan Hansen, MD – Education Director
Nancy Young, MD – Education Director Elect
Stephen Cass, MD
Douglas Chen, MD
Karen Doyle-Enright, MD, PhD
David Friedland, MD, PhD
Soha Ghossaini, MD
Samuel Levine, MD
Larry Lundy, MD
Jennifer Maw, MD
Lorne Parnes, MD
Jeffrey Vrabec, MD

Poster Judges

Douglas Chen, MD
Karen Doyle-Enright, MD, PhD
Soha Ghossaini, MD
Larry Lundy, MD

AOS Program Session Moderators

John Carey & Marlan Hansen
Sujana Chandrasekhar & Bill Slattery
Stephen Cass & Lorne Parnes
Jennifer Maw & Jeff Vrabec

VIRTUAL COSM AOS PROGRAM LINK - AVAILABLE FOR REGISTERED ATTENDEES
https://www.eventscribe.net//2021/COSM/index.asp

COSM REGISTRATION LINK
https://cosm.md/registration-information/

The Abstract deadline for the AOS 155th Annual meeting is Friday, October 15, 2021.
Abstract Instructions and submission form will be available on website August 15 - October 15, 2021
Website - www.americanotologicalsociety.org

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

Journal Requirements/Instructions to Primary Authors

Manuscripts are required of ALL ORAL presentations. Manuscripts must be submitted online a minimum of four weeks prior to the annual meeting, via the journal's website. Instructions for registering, submitting a manuscript, and the author guidelines can be found on the Editorial Manager site: https://www.editorialmanager.com/on/

The journal of OTOLOGY & NEUROTOLOGY does not accept paper manuscripts. Manuscripts will be peer reviewed prior to the Annual meeting for conflict of interest review and resolution.

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.

For Society business, please forward all inquiries to the AOS Administrative Team.

Kristen Bordignon, Administrator
AOS Administrative Office
5830 1st St. N. Petersburg, FL 33703
Ph: 217-638-0801
Fax: 727-800-9428
Email: administrator@americanotologicalsociety.org
Website: www.americanotologicalsociety.org

Ashley Eikenberry
AOS/ANS Administrative Assistant
Ph: 217-381-4668
Email: administrator@americanotologicalsociety.org

AMERICAN OTOLOGICAL SOCIETY
154th Annual Spring Meeting
VIRTUAL PROGRAM
ALL TIMES listed are Central Time

SUNDAY, APRIL 11, 2021

SCIENTIFIC PROGRAM

9:00 WELCOME AND OPENING REMARKS
Patrick J. Antonelli, MD

9:02 PRESIDENTIAL CITATIONS
Samuel C. Levine, MD
Larry B. Lundy, MD
George T. Singleton, MD

9:10 GUEST OF HONOR LECTURE (25 min)
"Noise-Induced Hearing Loss: Pathophysiology, Treatment, and Prevention"
Colleen G. Le Prell, PhD
Professor; Chair, Department of Speech, Language, and Hearing Science
Emilie and Phil Schepps Professorship in Hearing Science
University of Texas, Dallas, TX

9:35 DISCUSSION (5 min)

9:42 INTRODUCTION of ABSTRACTS – *John Carey, MD & Marlan Hansen, MD, Moderators*

9:43 Does Frailty or Age Increase the Risk of Postoperative Complications following Cochlear Implantation?
Steven A. Gordon, MD, MPH
Neil S. Patel, MD
Richard K. Gurgel, MD, MSCI

9:49 Cochlear Implantation and Risk of Falls in Older Adults
David R. Grimm, MS
Shayan Fakurnejad, MD
Jennifer C. Alyono, MD

9:55 Caregiver Quality of Life after Cochlear Implantation in Older Adults
Alana Aylward, MD
Morganne Murphy-Meyers, BS
Chelsea McCarty Allen, PhD
Steven A. Gordon, MD, MPH
Neil S. Patel, MD
Richard K. Gurgel, MD, MSCI

10:01 RESIDENT RESEARCH TRAVEL AWARD
Utilization of Aural Rehabilitation and Listening Activities and Its Influence on 3-6 Month Cochlear Implant Outcomes in Adults
James R. Dornhoffer, MD
Priyanka Reddy, BS
Cheng Ma, BS
Judy R. Dubno, PhD
Theodore R. McRackan, MD, MSCR

10:07 Insertion Depth and Cochlear Implant Speech Recognition Outcomes: A Comparative Study of 28- and 31.5-mm Lateral Wall Arrays
Michael W. Canfarotta, MD
Margaret T. Dillon, AuD
Kevin D. Brown, MD, PhD
Matthew M. Dedmon, MD, PhD
Harold C. Pillsbury, MD
Brendan P. O'Connell, MD

10:13 DISCUSSION (8 min) - *John Carey, MD & Marlan Hansen, MD, Moderators*

10:23 Comparing Tympanoplasty Outcomes for Porcine Small Intestinal Submucosal Grafting with Temporalis Fascia, Regenerative Tissue Matrix, and Tragal Cartilage Grafting
Evan Cumpston, MD
Brian P. Perry, MD

10:29 Mesenchymal Stem Cells for Treatment of Delayed-Healing Tympanic Membrane Perforations Using Hyaluronate-Based Laminas as a Delivery System: An Animal Model with Histopathologic Study
David Shahal, MD
Stefania Goncalves, MD
Simon I. Angeli, MD

10:35 Topical Fibroblast Growth Factor-2 for Treatment of Chronic Tympanic Membrane Perforations
Felipe Santos, MD
Edina Shu
Daniel J. Lee, MD
David H. Jung, MD, PhD
Alicia M. Quesnel, MD
Konstantina M. Stankovic, MD, PhD
D. Bradley Welling, MD, PhD

10:41 Topical Therapy Failure in Chronic Suppurative Otitis Media Is Due to Persister Cells in Biofilms
Anthony Thai, MS
Peter L. Santa Maria, MBBS, PhD
Adam C. Kaufmann, MD, PhD
Brian Bacacao, BS
Xiaohua Chen, MD, MS
Ayman Elsheikh, MD
Laurent A. Bekale, PhD

10:47 Quinolone Ear Drops Linked to Tendinopathy & Tendon Rupture
Phuong T. Tran, MPH
Patrick J. Antonelli, MD
Almut G. Winterstein, PhD

10:53 DISCUSSION (7 min) - *John Carey, MD & Marlan Hansen, MD, Moderators*

11:00 BREAK

11:15 INVITED LECTURE (25 min)
"Ethical Hazards in Surgical Practice"
Casey Jo Humbyrd, MD, MBE
University of Pennsylvania
Associate Professor of Orthopedic Surgery
Chief, Foot and Ankle Division
Director of the Program in Surgical Ethics
Philadelphia, PA

11:40 DISCUSSION (5 Min)

11:47 INTRODUCTION of ABSTRACTS – *Sujana Chandrasekhar, MD & Bill Slattery, MD, Moderators*

11:48 Does Otologic Surgery Result in Meaningful Hearing Improvement?
Priyanka Reddy, BS
Terral Patel, MD
Ted A. Meyer, MD, PhD
Paul R. Lambert, MD
Theodore R. McRackan, MD, MSCR

11:54 Audiologic Outcomes of Footplate Drillout for Obliterative Otosclerosis
Robert M. Conway, DO
Pedrom C. Sioshansi, MD
Amy Schettino MD
Dennis I. Bojrab MD
Seilesh C. Babu MD
Christopher A. Schutt, MD

12:00 Audiologic Outcomes following Transmastoid and Middle Cranial Fossa Approaches for SSCD Repair
Susan Ellsperman, MD
Steven A. Telian, MD
Paul R. Kileny, PhD
Christopher M. Welch, MD, PhD

12:06 Hearing Outcomes in Superior Canal Dehiscence Syndrome with Concurrent Tegmen Tympani Defects
Eric J. Formeister, MD, MS
Lisa Zhang, BS
John P. Carey, MD

12:12 Otologists Are at Risk for Surgical Noise-Induced Hearing Loss
Nathan D. Cass, MD
Elizabeth L. Perkins, MD
Todd A. Ricketts, PhD
Marc L. Bennett, MD

12:18 DISCUSSION (7 min) - *Sujana Chandrasekhar, MD & Bill Slattery, MD, Moderators*

12:25 INTRODUCTION of 12 NEW AOS MEMBERS from 2020 & 2021
Sujana Chandrasekhar, MD & Bill Slattery, MD

12:53 RECOGNITION OF POSTER WINNERS - *Patrick J. Antonelli, MD*

12:55 LUNCH BREAK

1:45 BUSINESS MEETING - *Patrick J. Antonelli, MD*

1:58 INTRODUCTION MERCHANT LECTURER – *Lorne Parnes, MD*

2:00 SAUMIL N. MERCHANT MEMORIAL LECTURE
"Unlocking the Inner Ear with Synchrotron Phase-Contrast Imaging"
Sumit K. Agrawal, MD
Associate Professor
Neurotology & Skull Base Surgery
Department of Otolaryngology - Head & Neck Surgery
University Hospital
London Health Sciences Centre
Ontario, Canada

2:25 DISCUSSION (5 min)

2:30 INTRODUCTION of ABSTRACTS – *Stephen Cass, MD & Lorne Parnes, MD, Moderators*

2:31 RESIDENT RESEARCH TRAVEL AWARD
Histopathologic Analysis of Temporal Bones with Otosclerosis following Cochlear Implantation
Sarah E. Hodge, MD
Gail Ishiyama, MD
Ivan Lopez, PhD
Akira Ishiyama, MD

2:37 Cochlear Implantation through Intracochlear Fibrosis: A Comparison of Surgical Techniques
Anne K. Maxwell, MD
Jacob B. Kahane, MD
Rahul Mehta, MD
Moises A. Arriaga, MD, MBA

2:43 Understanding Public Perceptions Regarding Cochlear Implant Surgery in Adults
Lisa Zhang, BS, BA
Andy S. Ding, BA
Deborah X. Xie, MD
Francis X. Creighton, MD

2:49 Hearing Loss and Incident Dementia: Claims Data from the New York SPARCS Database
Alexander Chern, MD
Rahul K. Sharma, BS
Justin S. Golub MD, MS

2:55 Association of Vitamin D Levels with Benign Paroxysmal Positional Vertigo Outcomes
Leah H. Cobb, MSc
Victoria O. Bailey, BSc

Yuan F. Liu, MD
Michael T. Teixido, MD
Habib G. Rizk, MD

3:01 **DISCUSSION** (7 min) - *Stephen Cass, MD & Lorne Parnes, MD, Moderators*

3:08 **BREAK**

3:23 **INTRODUCTION of ABSTRACTS –** *Jennifer Maw, MD & Jeff Vrabec, MD, Moderators*

3:24 **The Correlation of Clinical Corticosteroid Responsiveness with Expression of IL-6 in Peripheral Blood Immune Cells (PBMC) in Patients with Autoimmune Inner Ear Disease (AIED)**
Scott W. Gorthey, MD
Shresh Pathak, PhD
Andrea Vambutas, MD

3:30 **Utilizing Single Cell RNA-Sequencing to Implicate Cell Types and Therapeutic Targets for SSNHL in the Adult Cochlea**
Lacey Nelson, BS
J. Dixon Johns, MD
Shoujun Gu, PhD
Michael Hoa, MD

3:36 **Opioids Are Infrequently Required following Ambulatory Otologic Surgery**
Maria A. Mavrommatis, BA
Vivian F. Kaul, MD
Zachary G. Schwam, MD
Dillan F. Villavisanis, BA
Enrique Perez, MD, MBA
George B. Wanna, MD
Maura K. Cosetti, MD

3:42 **The Cell Phone Vibration Test: A Telemedicine Substitute for the Tuning Fork Test**
Alex Yang, BA
Nora Watson, PhD
Robert J. Lewis, MD
Anthony M. Tolisano, MD

3:48 **DISCUSSION** (6 min) - *Jennifer Maw, MD & Jeff Vrabec, MD, Moderators*

3:54 **Developmental Disruptions of the Human Stapes**
Felipe Santos, MD
Thais Abrahão, MD, PhD (Presenter)

4:00 **Congenital Aural Atresia with Cholesteatoma - Diagnosis and Outcome**
Geoffrey C. Casazza, MD
Rachel H. Jonas, MD
Bradley W. Kesser, MD

4:06 **Epidemiological and Long-term Medical and Surgical Outcomes in Chronic Suppurative Otitis Media**
Anthony Thai, MS
Ksenia A. Aaron, MD
Adam C. Kaufman, MD, PhD
Peter L. Santa Maria, MBBS, PhD

4:12 **Eustachian Tube Dilation Outcomes at a Tertiary Academic Center**
Micah Gibson, MD
Shubham Patel, BS
Esther X. Vivas, MD

4:18 **DISCUSSION** (7 min) - *Jennifer Maw, MD & Jeff Vrabec, MD, Moderators*

4:28 **PANEL COLLABORATION with AOS/ASGO - "What's New in Geriatric Otology?"**
Kourosh Parham, MD, PhD, Moderator
Steven M. Parnes, MD
Selena E. Briggs, MD, PhD, MBA
Cameron C. Wick, MD
Yuri Agrawal, MD, MPH

5:20 **DISCUSSION WITH PANEL** (10 min)

5:31 **OTOLOGY & NEUROTOLOGY OPEN (ONO) ANNOUNCEMENT**
Michael E. Hoffer, MD, ONO Editor-in-Chief

5:34 **INTRODUCTION OF NEXT AOS PRESIDENT - Marlan R. Hansen, MD**
Patrick J. Antonelli, MD

5:36 **ANNOUNCEMENT OF THE 2020 AWARD OF MERIT RECIPIENT!**
Marlan R. Hansen, MD, AOS President-Elect
Awarded by 2018 AOS President, Roberto A. Cueva, MD

5:38 **ANNOUNCEMENT OF THE 2021 AWARD OF MERIT RECIPIENT!**
Marlan R. Hansen, MD, AOS President-Elect
Awarded by 2019 AOS President, Carol A. Bauer, MD

5:40 **CLOSING REMARKS,** *Patrick J. Antonelli, MD*

5:45 **ADJOURN**

SELECTED ABSTRACTS

ORAL PRESENTATIONS

IN ORDER OF PRESENTATION

154th Annual Meeting

April 11, 2021

AMERICAN OTOLOGICAL SOCIETY

Does Frailty or Age Increase the Risk of Postoperative Complications following Cochlear Implantation?

Steven A. Gordon, MD, MPH; Neil S. Patel, MD
Richard K. Gurgel, MD, MSCI

Objective: Evaluate whether frailty or age increase the risk of postoperative complications following cochlear implant (CI) surgery.

Study Design: Retrospective cohort study

Setting: Tertiary academic center

Patients: Adult patients undergoing CI surgery from 2006-2020.

Interventions: In addition to demographics and postoperative complications, the modified 5-item frailty index (mFI, comprised of pre-operative history of pulmonary disease, heart failure, hypertension, diabetes, and partially/totally-dependent functional status) was calculated for all patients included in analysis.

Main Outcome Measures: The primary outcome was postoperative complications following CI within a three-month period. Major complications included myocardial infarction, bleeding, and CSF leak, among others. Predictors of post-operative complications were examined using odds ratios (OR) and multivariate logistic regression.

Results: There were 520 patients included for review with a mean age of 62.5±0.9 (range 18-94) and a slight male predominance (n=283, 54.4%). There were 340 patients (65.4%) who were robust (non-frail) with an mFI of 0, while 180 (34.6%) had an mFI of ≥1. There were 20 patients who experienced a postoperative complication (3.85%). There was no statistically significant correlation between post-operative complications as a result of pre-operative frailty with either mFI≥1 (OR 1.56 CI .98-2.48 p=0.06) or age as a continuous variable (OR 0.99 CI 0.97-1.02 p=0.51).

Conclusions: CI is safe for elderly and frail patients and carries no additional risk of complications when compared to younger, healthier patients. While medical comorbidities should always be considered perioperatively, this study supports the notion that implantation is low risk in older, frail patients.

***Define Professional Practice Gap & Educational Need:** Anecdotally, patients and clinicians may believe that the very elderly should not be considered for cochlear implantation due to the risk of surgery and general anesthesia. While much literature has been devoted to the safety of cochlear implantation in older patients, there is a paucity of studies focused on how an accurate metric for significant medical comorbidities (frailty) directly impacts the postoperative course of these patients. This study suggests that CI is safe for even very frail patients who are deemed potential surgical candidates.

***Learning Objective:** Understanding frailty's predictive ability on postoperative complications following cochlear implantation

***Desired Result:** To offer an additional means to measure pre-operative risk of adult CI patients

Level of Evidence - Level III

Indicate IRB or IACUC: University of Utah IRB: IRB_00105049

Cochlear Implantation and Risk of Falls in Older Adults

David R. Grimm MS, Shayan Fakurnejad, MD; Jennifer C. Alyono, MD

Objective: To examine whether cochlear implantation(CI) increases the risk of falls in older adults.

Study Design: Retrospective analysis of de-identified administrative claims from a US commercial insurance database.

Setting: US hospital and outpatient facilities serving commercially insured patients documented through the Optum database.

Patients: Individuals undergoing CI over age 50.

Interventions: Cochlear implantation.

Main Outcome Measures: Gender, race, income, age, fall diagnosis days one year pre/post CI, and comorbidities documented via ICD9/10 codes.

Results: Between 2003-2019, 3773 patients over the age of 50 underwent CI. Of these patients, 139(3.68%) patients recorded at least one fall diagnosis a year prior to CI, and 142(3.76%) patients recorded at least one fall diagnosis post-CI. The average numbers of days with fall diagnoses per patient with a recorded fall was 3.12 prior to CI, and 2.04 post-CI. In bivariate analysis, age($p<0.0001$) and Charlson Comorbidity Index($p<0.0001$) were predictive of falls, but gender($p<0.10$), race($p<0.72$), and income($p<0.51$) were not. Significant covariates were incorporated into a generalized estimating equation Poisson regression along with fall counts before and after CI. The Poisson regression demonstrated a statistically significant association between Charlson Comorbidity Index and days with fall diagnoses(RR 1.39[95% CI, 1.30-1.49; $p<0.0001$]). No statistically significant difference in falls was seen pre-CI vs post-CI(RR 0.67[95% CI; 0.34-1.33; $p<0.25$]). Age also was not predictive of falls in multivariate analysis.

Conclusions: CI does not appear to increase the risk of falls in older adults. Patient comorbidities correlate most strongly with fall risk, and should be considered in patient selection for CI.

Define Professional Practice Gap & Educational Need: Prevalence of cochlear implantation in an aging population has increased over the past decade and a half. We aim to address concerns whether cochlear implantation will lead to increased fall risk by utilizing a large scale real-world medical claims database.

Learning Objective: To better understand factors contributing to fall risk post cochlear implantation in older adults receiving a cochlear implant for the first time.

Desired Result: Among the patients selected to undergo CI in the United States, cochlear implantation does not appear to increase fall risk.

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

Indicate IRB or IACUC: Exempt

Caregiver Quality of Life after Cochlear Implantation in Older Adults

Alana Aylward, MD; Morganne Murphy-Meyers, BS; Chelsea McCarty Allen, PhD; Steven A. Gordon, MD, MPH; Neil Patel, MD; Richard K. Gurgel, MD, MSCI

Objective: To evaluate factors affecting quality of life (QOL) in caregivers of older cochlear implant (CI) recipients.

Study Design: Cross sectional survey

Setting: Academic medical center

Patients: Adults over age 65 receiving CI between 7/13/2000 and 4/3/2019.

Interventions: Cochlear implantation

Main Outcome Measures: Linear regression models for caregiver QOL measured by Significant Other Scale for Hearing Disability (SOS-HEAR), with independent variables: caregiver role, patient gender, 11 factor modified frailty index (mFI), duration of hearing loss, hearing aid use, age at surgery, time since surgery, change in pure tone average (PTA), processor input type and Nijmegen Cochlear Implant Questionnaire (NCIQ). Correlations between SOS-HEAR and patient speech recognition scores.

Results: Questionnaires were mailed to all 294 living CI recipients. Seventy-one caregivers completed the questionnaire. Only patient gender and mFi were significant predictors of caregiver QOL on both univariate ($p<0.001$, β=-20.26 (95% confidence interval -30.21, -10.3); 0.005, -0.72 (-1.20, -0.23) respectively) and multivariate ($p=0.005$, β=-20.09, -33.05 to -7.13; 0.003, -0.93 (-1.50, -0.37)) analysis, where caregivers of male patients and those with lower mFI (better health) had better QOL scores. Caregiver QOL was significantly associated with patient's change in PTA and self-reported QOL scores on univariate ($p=0.041$,β=-0.27 (-0.52, -0.02) ; 0.024, 0.52 (0.08, 0.96)) but not multivariate analysis. Time since CI was significant only on multivariate analysis (0.041, -0.17 (-0.33, -0.01)). Caregiver QOL did not correlate with patient speech recognition scores.

Conclusions: Caregivers of older CI recipients who have better health and/or are male have higher QOL scores. Patient hearing measurements did not correspond with better caregiver QOL.

***Define Professional Practice Gap & Educational Need:** While it is recognized that CIs benefit older adults, little is known about how CIs affect the caregivers of those older adults.

***Learning Objective:** Understand what factors impact quality of life in caregivers of older patients with CIs.

***Desired Result:** To describe the QOL benefits to caregivers when applicable for CI recipients.

Level of Evidence – Level III

Indicate IRB or IACUC: IRB approved, University of Utah IRB_00088392

Utilization of Aural Rehabilitation and Listening Activities and Its Influence on 3-6 Month Cochlear Implant Outcomes in Adults

James R. Dornhoffer, MD; Priyanka Reddy, BS, Cheng Ma, BS
Judy R. Dubno, PhD; Theodore R. McRackan, MD, MSCR

Objective: Assess associations between post-cochlear implant (CI) aural rehabilitation/listening activities and outcomes related to speech recognition and CI quality-of-life (CIQOL).

Study Design: Longitudinal, prospective assessment of aural rehabilitation and listening activity utilization.

Setting: Tertiary academic center

Patients: 64 adults undergoing cochlear implantation for bilateral severe-to-profound hearing loss

Interventions: Self-reported use of three categories of aural rehabilitation at 3-months post-CI: (1) clinician-directed (e.g., speech pathologist, (2) passive patient-directed (e.g., listening to audiobooks), and (3) active patient-directed (e.g., interactive software).

Main Outcome Measures: Consonant-Nucleus-Consonant (CNC) word, AzBio sentence, and CIQOL-35 Profile global and domain scores, at 3- and 6-months post-CI.

Results: Of 64 patients, 41 (64%) used one or more rehabilitation resources. Of those, 19% used clinician-directed, 52% passive patient-directed, and 31% active patient-directed. At 3-months post-CI, use of rehabilitation in any category was associated with better speech recognition (*d*=1.17-1.18) and improved global and domain-specific CIQOL scores (*d*-range=0.15-1.26) at the same timepoint. Use of active patient-directed resources demonstrated greatest effect, with better speech recognition (CNC: *d*=0.89[0.24, 1.55]; AzBio: *d*=1.14[0.47,1.81]) and global and domain-specific CIQOL (*d*-range=0.07-1.09). Similar effects were seen 6-months post-CI, with active resources utilization showing the most consistent benefits. Controlling for age, sex, income, and simultaneous utilization of multiple rehabilitation resources, active patient-directed resources at 3-months remained the strongest predictor of CNC, AzBio, and CIQOL scores at 3 months (ß=20.6[2.46,38.73], ß= 25.18[7.12,43.23], and ß-range=6.7-18.7, respectively).

Conclusions: These results suggest that aural rehabilitation and listening activities, especially self-directed, improves early outcomes for CI recipients. Randomized controlled studies are needed to confirm findings and better examine the impact of clinician-directed rehabilitation.

Define Professional Practice Gap & Educational Need: Adult CI recipients are generally recommended to pursue post-implant aural rehabilitation exercises; however, evidence demonstrating the benefit is largely anecdotal or absent.

Learning Objective: To explore patterns of aural rehabilitation that may be associated with improved speech recognition and CI-specific quality of life.

Desired Result: Practitioners and researchers will recognize that the utilization of post-implant aural rehabilitation is associated with improved CI outcomes, and active forms of rehabilitation (e.g., computer programs) may have the strongest impact. As such, clinicians may offer evidenced-based recommendations for specific exercises to optimize outcomes for first-time CI recipients.

Level of Evidence – Level III: Cohort or case-control studies.

Indicate IRB or IACUC: Pro00077593

Insertion Depth and Cochlear Implant Speech Recognition Outcomes: A Comparative Study of 28- and 31.5-mm Lateral Wall Arrays

Michael W. Canfarotta, MD; Margaret T. Dillon, AuD; Kevin D. Brown, MD, PhD
Matthew M. Dedmon, MD, PhD; Harold C. Pillsbury, MD; Brendan P. O'Connell, MD

Objectives: 1) To compare speech recognition outcomes between cochlear implant (CI) recipients of 28- and 31.5-mm lateral wall electrode arrays and 2) to characterize the relationship between angular insertion depth (AID) and speech recognition.

Study Design: Retrospective review.

Setting: Tertiary academic referral center.

Patients: Seventy-five adult CI recipients of fully inserted 28- (n=28) or 31.5-mm (n=47) lateral wall arrays.

Interventions: Cochlear implantation with postoperative computed tomography.

Main Outcome Measures: Consonant-nucleus-consonant (CNC) words assessed with the CI-alone at 12 months post-activation.

Results: The mean AID of the most apical electrode contact for 31.5-mm array recipients was significantly deeper than 28-mm array recipients (628° vs 571°, $p<0.001$). Following 12 months of listening experience, mean CNC word scores were significantly better for recipients of 31.5-mm arrays compared with those implanted with 28-mm arrays (59.6% vs 48.3%, $p=0.004$). There was a significant positive correlation between AID and CNC scores ($r=0.372$, $p=0.001$); however, a plateau in performance was noted around 600°.

Conclusions: On average, CI recipients implanted with a 31.5-mm array experienced better speech recognition than those with a 28-mm array at 12 months post-activation. Deeper insertion of a lateral wall array confers speech recognition benefit up to ~600°, with a plateau noted thereafter. These data provide preliminary evidence of the insertion depth necessary to optimize speech recognition outcomes among CI recipients of lateral wall electrode arrays.

Define Professional Practice Gap & Educational Need: The relationship between angular insertion depth and speech recognition outcomes among cochlear implant recipients remains incompletely understood.

Learning Objective: To understand the non-linear relationship between insertion depth and speech recognition outcomes with lateral wall electrode arrays and to discuss potential underlying mechanisms.

Desired Result: Attendees will be able to apply the knowledge to their cochlear implant practices in regard to the desired insertion depth necessary to optimize outcomes with lateral wall electrode arrays.

Level of Evidence - III

IRB: Approved 10/29/2019 (University of North Carolina at Chapel Hill, # 09-2328)

Comparing Tympanoplasty Outcomes for Porcine Small Intestinal Submucosal Grafting with Temporalis Fascia, Regenerative Tissue Matrix, and Tragal Cartilage Grafting

Evan C. Cumpston, MD; Brian P. Perry, MD

Objective: Porcine small intestinal submucosal (PSIS) grafts have been shown to be effective for tympanic membrane repair in small studies. However, published data regarding outcomes of these grafts is lacking. This study reviews a series of patients who underwent tympanoplasty with PSIS grafts and compares outcomes with patients who underwent tympanoplasty with temporalis fascia, regenerative tissue matrix (RTM), or tragal cartilage.

Study Design: Case Series with Planned Data Collection

Setting: Outpatient Otology Clinic

Patients: Patients undergoing tympanoplasty

Interventions: Patients underwent tympanoplasty for repair of tympanic membrane defects with either PSIS, temporalis fascia, RTM, or tragal cartilage grafts, determined by the surgeon.

Main Outcome Measures: Percentage of grafts intact on post-operative evaluation

Results: 241 patients underwent tympanoplasty between 2016 and 2020. Six patients were lost to follow-up. Overall, 91.00% of grafts were intact on follow-up. Of porcine PSIS grafts, 95.83% were intact on follow-up. 17 of these cases were primary, 10 were revision (37.00% revision cases). Of temporalis fascia grafts, 91.47% were intact on follow-up. 117 of these cases were primary, 23 were revision (16.43% revision cases). Of RTM grafts, 79.41% were intact on follow-up. 23 of these vases were primary, 16 were revision (43.90% revision cases). Of tragal cartilage grafts, 93.55% were intact on follow-up. 28 of these cases were primary, 5 were revision (15.15% revision cases).

Conclusions: PSIS grafts appear to be as effective as autogenous tissue for tympanic membrane repair and may be superior to RTM grafts. PSIS grafts may be especially useful for revision tympanoplasties or with minimally invasive techniques.

***Define Professional Practice Gap & Educational Need:** Many graft materials for tympanoplasty have been previously described. Several allogenic graft materials have become available that may be especially useful in minimally invasive tympanoplasties and myringoplasties that avoid a graft site incision as well as for revision tympanoplasties in which autogenous grafts are not readily available. Recently, porcine small intestinal submucosal grafts are one such allogenic graft that have become available. To date, published data regarding outcomes of these grafts is limited to a case-series evaluating outcomes of grafts placed endoscopically, a case series evaluating outcomes of grafts used in myringoplasties. This study was performed to review a series of patients who underwent tympanoplasty with porcine small intestinal submucosal grafts with outcomes compared to patients within the same cohort who underwent tympanoplasty with temporalis fascia, regenerative tissue matrix, or tragal cartilage grafting by a single surgeon.

***Learning Objective:** The learner will understand the current gaps in knowledge regarding porcine small intestinal submucosal matrix grafting for repair of tympanic membrane perforations, outcomes of these grafts compared to other commonly grafted materials, and possible applications of these grafts in revision or minimally invasive cases.

***Desired Result:** To provide data regarding tympanoplasty outcomes using porcine small intestinal submucosal matrix grafts which may influence future graft selection with considerations for graft material success, donor site morbidity, and autogenous tissue availability. This study will hopefully also direct further studies regarding these grafting materials in order to further elucidate superior practice patterns and outcomes.

Level of Evidence - Level IV

Indicate IRB or IACUC: Exempt

Mesenchymal Stem Cells for Treatment of Delayed-Healing Tympanic Membrane Perforations Using Hyaluronate-Based Laminas as a Delivery System: An Animal Model with Histopathologic Study

David Shahal, MD; Stefania Goncalves, MD; Simon I. Angeli, MD

Hypothesis: Bone marrow derived-mesenchymal stem cells (BM-MSCs) improve the healing of chronic tympanic membrane perforations (cTMPs) in an animal model.

Background: cTMPs generate significant morbidity and reduced quality of life, usually requiring advanced surgical assistance. With growing interest in alternative therapies, we sought to evaluate the effect of BM-MSC-therapy on the healing of cTMPs.

Methods: 60 cTMPs were established in C57Bl/6 mice and divided into four groups: hyaluronate scaffold plus BM-MSCs (n = 19 ears), scaffold plus cell culture media (n = 16), scaffold plus phosphate-buffered saline (PBS, n = 12), and no intervention (n = 13). Hyaluronate scaffolds with or without BM-MSCs were applied on 8-week perforated eardrums. After a blinded assessment of perforation sizes at baseline and 2 weeks after treatment, mean perforation reduction rates (%) were compared. Histology characterization was then performed.

Results: Mean perforation size reduction rates were significantly higher for cTMPs that received scaffolds plus BM-MSCs (ANOVA test, p=0.0207, 12.3% [95%CI: 7.8-16.7]) and scaffolds plus cell culture media (p=0.0477, 11.3% [95%CI: 4.4-18.2]) when compared to no intervention (4.2% [95%CI: 1.2-7.2]). This was not observed when treating eardrums with scaffolds plus PBS alone (7.3% [95%CI: 2.7-11.9]). On histology, BM-MSC-treated eardrums demonstrated restoration of the trilaminar configuration and reduced inflammatory changes, while other groups developed tissue architecture disorganization and hypercellular infiltrates surrounding the perforation site.

Conclusions: BM-MSCs and cell culture media increased cTMP closure rates. Cell-therapy conferred a restoration of the trilaminar configuration of the eardrum and reduced inflammatory response.

***Define Professional Practice Gap & Educational Need:** cTMPs usually require advanced surgical assistance, with variable healing results. Although recent animal studies suggest a role of mesenchymal stem cells in the healing of acute tympanic membrane perforations, there is a lack of evidence in its more clinically relevant chronic counterpart.

***Learning Objectives:** After completing this activity, participants will learn the effects of topical mesenchymal stem cell therapy on cTMPs using hyaluronate-based scaffolds, including an assessment of perforation closure rates and histologic characterization.

***Desired Result:** Attendees will learn the current evidence on mesenchymal stem cell therapy as a potential nonsurgical alternative to tympanoplasty in a reliable model of cTMP.

Level of Evidence – Does not apply

IACUC: Protocol 19-060 approved by the University of Miami Institutional Animal Care and Use Committee.

Topical Fibroblast Growth Factor-2 for Treatment of Chronic Tympanic Membrane Perforations

Felipe Santos, MD; Edina Shu; Daniel J. Lee, MD; David H. Jung, MD, PhD; Alicia M. Quesnel, MD Konstantina M. Stankovic, MD, PhD; D. Bradley Welling, MD, PhD

Objective: To determine the efficacy of fibroblast growth factor-2 (FGF-2) in treating chronic nonhealing tympanic membrane (TM) perforations.

Method: Double-blinded, randomized placebo-controlled phase 2 clinical trial for patients with chronic TM perforations of more than 3 months duration with a cross-over arm. Patients received either FGF-2 or placebo (sterile water) saturated gelatin sponge in the perforation after rimming the perforation under topical anesthesia. The perforation was then covered with Tisseel fibrin glue. The primary endpoint was complete closure of the TM perforation. Secondary end points included change in hearing and partial TM closure rates. The TM was examined every 3 weeks with otoendoscopy for closure. The treatment was repeated if there was incomplete closure every 3 weeks up to a total of three treatments per arm.

Results: Seventy-four patients were recruited for the study. Fifty-seven met eligibility criteria and fifty-four completed the study. Ten of 14 perforations closed completely in the placebo group (71.4%) and 23 of 40 perforations closed completely in the FGF-2 treatment group (57.5%), *P* value = .36. Pure tone averages and word recognition scores were not statistically significantly different between study groups post-treatment. After initial complete closure, re-perforation occurred in seven FGF-2 treated patients and two placebo patients making the effective final closure rate 40% for FGF and 57% for placebo, respectively.

Conclusion: No statistically significant difference in tympanic membrane perforation closure rate was found between the FGF-2 and placebo groups. There were no differences in hearing outcomes between the groups.

***Define Professional Practice Gap & Educational Need:** To assess the efficacy of a novel treatment for the closure of chronic tympanic membrane perforations.

***Learning Objective:** Participants will learn that in our study the use of FGF-2 to promote closure of chronic tympanic membrane perforations was not different from placebo.

***Desired Result:** Participants will learn the outcomes of a double blinded placebo-controlled phase 2 clinical trial for patients with chronic tympanic membrane perforations.

Level of Evidence – 1b

Indicate IRB or IACUC: The study was approved by the Massachusetts Eye and Ear Institutional Review Board #2019P000592

Topical Therapy Failure in Chronic Suppurative Otitis Media Is Due to Persister Cells in Biofilms

Anthony Thai, BA; Peter L. Santa Maria, MBBS, PhD; Adam C. Kaufmann, MD, PhD; Brian Bacacao, BS
Xiaohua Chen, MD, MS; Ayman Elsheikh, MD; Laurent A. Bekale, PhD

Hypothesis: Persister cells mediate treatment failure in chronic suppurative otitis media (CSOM).

Background: CSOM, often caused by Pseudomonas aeruginosa (PA) or Staphylococcus aureus (SA), is the most common cause of sensorineuronal hearing loss among children in developing countries. Current therapy fails to prevent recurrent otorrhea. Persister cells, which survive antibiotic attack due to low metabolism and robust repair mechanisms, have been implicated in other chronic bacterial infections but not in CSOM.

Methods: Bacterial resistance to ofloxacin and antiseptics was measured via minimum inhibitory concentration (MIC), minimum biofilm eradication concentration (MBEC) and bacterial inhibition zone assay. Persister cell percentages were measured in laboratory strains (PA01, SA25923) and clinical isolates (PA CSOM-1, SA CSOM-1). Colony forming units (CFUs/ml) was measured in a validated PA-01 CSOM murine model treated with trans-tympanic phosphate-buffered saline (PBS) or ofloxacin.

Results: Bacterial strains displayed higher MBEC compared to MIC for ototopical therapies, at higher than clinically achievable levels. Compared to PA-01, PA CSOM-1 displayed more persister cells (0.003% versus 0.0003%, $p<0.001$), higher MBEC (>3,000 µg/mL versus 750 µg/ml) and smaller inhibition zone (6.0 mm versus 38.72) for ofloxacin. Ofloxacin demonstrates lower MBEC and larger inhibition zone compared to antiseptics in most strains. Bacterial load (CFU/mL) *in vivo* was similar for ofloxacin (6.98) and PBS (7.69, $p>0.05$).

Conclusions: Clinical isolates displayed more persister cells and ototopical resistance compared to laboratory strains. No therapies eradicated biofilms at clinically achievable concentrations. Ofloxacin has limited impact on bacterial load *in vivo*. These data confirm that persister cells mediate CSOM treatment failure.

***Define Professional Practice Gap & Educational Need:**
Current CSOM medical therapies are successful in converting active disease to inactive disease in the short term, but many patients relapse over time. The presence of metabolically inactive persister cells may mediate this treatment failure. Although this cell population represents a small fraction of cells in CSOM biofilms, these cells can evade topical medical therapy and lead to recurrence of active CSOM.

***Learning Objective:**

- CSOM is a chronic infectious disease of the middle ear that involves recurrent episodes of otorrhea despite current medical therapies.
- Persister cells are metabolically inactive cells in CSOM biofilms that can evade topical antibiotic and antiseptic treatments. These cells have been shown to play an important role in numerous chronic bacterial infections.
- Clinical CSOM isolates contain a higher percentage of persister cells and are resistant to common CSOM therapies at higher than clinically achievable concentrations.

***Desired Result:**
Persister cells play a key role in CSOM. These cells can survive topical medical therapy due to low metabolism and robust repair mechanisms, and may account for high rates of CSOM recurrence.

Level of Evidence – Does not apply- basic science study.

IACUC: IACUC 32855, Stanford University

Quinolone Ear Drops Linked to Tendinopathy & Tendon Rupture

Phuong T. Tran, MPH; Patrick J. Antonelli, MD; Almut G. Winterstein, PhD

Objective: Delayed eardrum healing has been observed contralateral to otic quinolone (OQ) exposure in rats. One case report described tendon rupture after OQ. Thus, OQs may have systemic side effects. The aim of this study was to estimate the risk for tendinopathies after OQs.

Study Design: This retrospective cohort study included patients with outpatient diagnosis of otitis externa or media from MarketScan 2005-2015 and Medicaid Analytical eXtrac 1999-2012 databases. We applied a new user, active comparator design with 1-year look-back for baseline characteristics and ceased follow-up at initiation of systemic steroids or quinolones, switch to OQ in the comparator group, external injury, hospitalization and at a maximum of 35 days. We used stabilized inverse probability of treatment weighting to balance comparison groups. Adjusted hazard ratios (HRs) from Cox models were pooled across databases with fixed-effects models. Risk of sport injuries was examined to rule out differences due to varied mobility.

Setting: U. S. outpatient encounters

Patients: < 65 years with private or public insurance.

Intervention/Exposure: OQ versus otic neomycin, amoxicillin or azithromycin

Main Outcome Measures: Achilles or all-type tendon rupture or Achilles tendinitis

Results: We examined 11,288,246 treated otitis episodes. Pooled HRs for OQ exposure were 2.44 (1.46-3.42) for Achilles tendon rupture, 1.20 (1.01-1.39) for Achilles tendinitis, 1.24 (0.96-1.52) for all tendon rupture, and 1.07 (0.89-1.26) for sport injuries.

Conclusions: OQ exposure is associated with increased risk of tendinopathy. Clinicians should consider risk-benefit and counsel patients accordingly. Risk factors for this rare, serious adverse effect deserve further evaluation.

Define Professional Practice Gap & Educational Need: OQ exposure has been linked to the development of tympanic membrane perforations. Less well appreciated from these studies has been the potential for adverse systemic effects.

Learning Objective: To better understand the potential adverse systemic effects with OQ therapy.

Desired Result: Prescribers will more rigorously consider the potential side effects and counsel patients on the risks of commonly used OQs.

Level of Evidence - IV

Indicate IRB or IACUC: University of Florida IRB201903041 (for MAX data) and IRB201701362 (for MarketScan data).

Does Otologic Surgery Result in Meaningful Hearing Improvement?

Priyanka Reddy, BS; Terral Patel, MD; Ted A. Meyer, MD, PhD
Paul R. Lambert, MD; Theodore R. McRackan, MD, MSCR

Objective: Little is currently known regarding patients' perception of hearing benefit after otologic surgery. This study examines the degree of meaningful improvement in hearing, as measured using the minimally important difference (MID) using patient-reported outcomes measures (PROMs), and its association with audiological improvement.

Study Design: Retrospective review of a prospectively maintained database

Setting: Tertiary academic center

Patients: 102 adults undergoing otologic surgery

Interventions: Stapedectomy, tympanoplasty/mastoidectomy with/without ossicular chain reconstruction (OCR)

Main Outcome Measures: Whether or not patients obtained a MID in PROMs scores (HHIA and SSQ) and various audiologic measures [post-surgical interaural pure tone average (PTA) difference, ipsilateral low frequency PTA (LF PTA), four frequency PTA (PTA), word recognition score and air-bone gap (ABG)]

Results: Overall, 34 (33.3%) and 32 (31.4%) patients reported obtaining a MID (+MID) using the HHIA and SSQ, respectively. All patients receiving stapedectomy reported either +MID (75-76.2%) or no change (23.8-25%) in PROM scores. For those undergoing OCR, 23.1-41.7% of patients obtained +MID, 41.7-65.1% no change, and 7.7-16.7% worse PROM scores (-MID). Change in PTA and change in LF PTA had the greatest associations with PROM scores, demonstrating low to moderate correlation values (r=0.45-0.54). Using ROCs, improvement in PTA, LF PTA, and ABG had a fair capacity to differentiate +MIDs (AUC=0.775-0.786).

Conclusions: Although there might be improvements in audiological outcomes after a patient undergoes otologic surgery, this does not definitively result in patient-perceived functional improvement. This study provides support for the use of PROMs to monitor patient outcomes after otologic surgery and preliminary evidence for the relation between change in audiologic measures and patient-perceived benefit.

Define Professional Practice Gap & Educational Need: The effect of otologic surgery on a patient's real world, functional perception of hearing is not well described. The standard method of determining post-surgical improvement, audiologic measures, also has yet to be detailed in relation to patients' perceived hearing benefit.

Learning Objective: This study will examine the degree of hearing improvement after otologic surgery based on PROMs and will determine the association between audiologic outcomes and PROMs.

Desired Result: Clinicians will be more cognizant of the effect of otologic surgery on patients' functional improvements and may consider using PROMs as a routine outcome measure.

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

Indicate IRB or IACUC : The study was approved by the Medical University of South Carolina IRB - Pro00071518

Audiologic Outcomes of Footplate Drillout for Obliterative Otosclerosis

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

Objective: Examine the audiologic outcomes of thickened stapes footplates requiring drill out for obliterative otosclerosis.

Study Design: Retrospective chart review of patients undergoing stapedotomy

Setting: Single tertiary care center

Patients: Adult patients undergoing primary stapedotomy with laser fenestration. Drill out was performed for cases of obliterative otosclerosis with thickened footplates.

Interventions: Stapedotomy with either laser fenestration or footplate drill out.

Main Outcome Measures: Audiologic outcomes were based on pre- and postoperative pure tone averages (PTA) and air-bone gap (ABG) in decibels (dB). Complications compared between the two groups include postoperative perilymphatic fistula, facial paralysis, BPPV, or reparative granuloma.

Results: Five hundred eighty-eight patients underwent primary stapedotomy and were included: 518 with standard laser fenestration and 70 with thickened footplates requiring additional drill out. Pre-operative ABG for laser and drill groups were 26.47 dB and 26.55 dB, respectively ($p=.949$). Initial post-operative ABGs were 8.61 dB and 10.16 dB for the laser and drill group, respectively, which were not significantly different ($p=.058$). Average bone conduction threshold improved from 29.8 dB preoperatively to 25.7 dB postoperatively ($p<.001$). There was no difference in complications between the two groups.

Conclusions: Audiologic outcomes are excellent following stapedotomy for obliterative otosclerosis. Hearing is comparable in cases of thickened footplate drillout and standard laser fenestration without increased risk of sensorineural hearing loss or surgical complications.

***Define Professional Practice Gap & Educational Need:** Establish outcomes of footplate drillout stapedotomy for obliterative otosclerosis.

***Learning Objective:** Understand the audiologic outcomes and complication profile of drill and laser stapedotomy

***Desired Result:** Expand evidence for utilization of fenestration using drill if required by certain circumstances/physician preference

Level of Evidence - IV

Indicate IRB or IACUC: 1130957-4

Audiologic Outcomes following Transmastoid and Middle Cranial Fossa Approaches for SSCD Repair

Susan E. Ellsperman, MD; Steven A. Telian, MD; Paul R. Kileny, PhD
Christopher M. Welch, MD, PhD

Objective: To describe postoperative hearing outcomes following transmastoid (TM) and middle cranial fossa (MCF) approaches for semicircular canal dehiscence (SSCD) repair

Study Design: Retrospective review

Setting: Academic, tertiary referral center

Patients: Adults with SSCD who underwent repair between 2005 and 2019

Interventions: Pure tone audiometry pre- and postoperatively after SSCD repair

Main Outcome Measures: Change in air-bone gap (ABG) at 250 and 500 Hz, pure tone average (PTA) bone conduction (BC) and air conduction (AC) thresholds at 500, 1000, 2000, and 4000 Hz for patients undergoing TM and MCF approaches for SSCD repair

Results: The average change in AC and BC PTA for patients undergoing TM (n = 29) and MCF (n = 25) SSCD repair was not significantly different between the two groups. The first and final postoperative PTAs were recorded an average of 3.3 (range 0.30 to 34.9) and 31.9 (range 1.9 to 154) months postoperatively. The average changes in AC PTA for patients who underwent MCF repair were 2.5 dB (*p* 0.44) and -0.4 dB (*p* 0.92*)* at first and final audiogram respectively compared to – 0.04 dB (*p* 0.99) and -4.0 dB (*p* 0.43) for patients who underwent TM repair. The average changes in BC PTA for patients who underwent MCF repair were 2.3 dB (*p* 0.35) and 0.5 dB (*p* 0.86) at first and final audiograms respectively compared to 0.0 dB *(p* 0.99) and -3.2 dB *(p* 0.47) for patients who underwent TM repair. The average changes in ABG for patients undergoing MCF repair were – 6.3 dB (*p* 0.38) and -6.8 dB (*p* 0.04) at first and final audiograms respectively compared to – 2.9 dB (*p* 0.27) and -4.7 dB (*p* 0.08) for patients who underwent TM repair. These ABG closures did not differ between the two approaches (*p* 0.44)

Conclusions: Both TM and MCF approaches to SSCD repair can be performed with long-term preservation or improvement in AC thresholds, though not statistically significant. ABGs were reduced in each treatment group, and were not statistically different depending on the approach.

***Define Professional Practice Gap & Educational Need:** To establish that SSCD repair can be consistently performed with preservation of preoperative audiologic function

***Learning Objective:** To demonstrate audiometric outcomes for different approaches to SSCD repair

***Desired Result:** To document stable hearing after SSCD repair and affirm use of either TM or MCF approach for SSCD repair depending on surgeon preference and patient selection

Level of Evidence - Level V

Indicate IRB or IACUC: IRB review considers this study exempt (HUM00169949)

Hearing Outcomes in Superior Canal Dehiscence Syndrome with Concurrent Tegmen Tympani Defects

Eric J. Formeister, MD, MS; Lisa Zhang, BS; John P. Carey, MD

Objectives: To describe the prevalence and audiometric profiles of subjects with superior canal dehiscence syndrome (SCDS) with concurrent tegmen mastoideum or tegmen tympani dehiscences (TMD, TTD).

Study Design: Retrospective case-control study.

Setting: Tertiary referral center.

Patients: Subjects with SCDS who underwent middle fossa craniotomy (MFC) for plugging/resurfacing.

Main Outcome Measures: Operative findings of TTD and/or TMD, pre- and postoperative low frequency air-bone gaps (LF-ABGs, in dB HL) and ocular vestibular evoked myogenic potential (oVEMP) amplitudes in those with and without TTD with dural contact of the ossicles.

Results: 136 patients (avg. age, 56 years, 55.1% female) underwent MFC for repair of SCDS. Concurrent tegmen dehiscences were commonly found intraoperatively (TTD 19.9% [15% with dural herniation onto exposed ossicles], TMD 28.7%, both 5.9%). There were no differences in preoperative LF-ABGs between patients with TTD with dural herniation and those without (average 250 Hz and 500 Hz ABG 28 dB and 18 dB vs. 27 and 16 dB; p=0.77 and p=0.51, respectively) nor at long-term follow-up (average reduction at 250 Hz and 500 Hz, 22 dB and 13 dB vs. 19 dB and 9 dB; p=0.48; p=0.32, respectively). Finally, oVEMP amplitudes did not differ between those with and without a TTD (average 25.4 μV versus 31.4 μV, respectively; p=0.25).

Conclusions: Preoperative oVEMP amplitude and correction of LF-ABG postoperatively does not differ in those with SCDS and TTD with dural herniation compared to those with SCDS alone after MFC for canal plugging and resurfacing. Ipsilateral concurrent tegmen dehiscences are extremely common in SCDS.

***Define Professional Practice Gap & Educational Need:** Audiologic improvement in air-bone gap after superior canal plugging surgery is variable, and may be related to concurrent tegmen tympani dehiscence with dural herniation onto the ossicular chain. However, no prior study exists that examines intraoperative findings and pre- and postoperative audiometric findings. Similarly, oVEMP findings could be less sensitive for subjects with an additional cause for conductive hearing loss, such as in the case of concurrent tegmen tympani dehiscence with impingement of dura on the head of the malleus, but no report has been generated to address this.

***Learning Objective:** The learning objectives are to describe the prevalence of concurrent tegmen dehiscences, both tympani and mastoideum, in subjects with SCDS and to examine audiologic outcomes after repair in those with dehiscences compared to those without concurrent dehiscences.

***Desired Result:** Improved understanding of the high prevalence of concurrent tegmen dehiscences in subjects with SCDS and enhanced education regarding expected audiologic outcomes according to the presence or absence of concurrent tegmen dehiscences.

Level of Evidence - IV

Indicate IRB or IACUC : The following study was approved by the Johns Hopkins University Institutional Review Board, IRB Number 00192330, effective 12/10/2018.

Otologists Are at Risk for Surgical Noise-Induced Hearing Loss

Nathan D. Cass, MD; Elizabeth L. Perkins, MD
Todd A. Ricketts, PhD; Marc L. Bennett, MD

Objective: Evaluate surgeon, staff, and patient risk for noise-induced hearing damage as a result of otologic procedure-related noise exposure.

Background: The National Institute for Occupational Safety and Health (NIOSH) recommends regulation of occupational noise exposures above 85 dBA. Recent research indicates that noise levels causing transient threshold shifts, previously believed to be safe and without long-term consequence, result in cochlear synaptopathy with resultant degeneration of spiral ganglion neurons, degradation of neural transmission in response to suprathreshold acoustic stimuli, and difficulty understanding in background noise.

Study Design: Prospective observational.

Setting: Tertiary care center.

Subjects: Surgeons.

Main Outcome Measures: Surgeon noise exposure in A- and C-weighted decibel scales (dBA, dBC), including average equivalent (LA_{eq}) and peak (LA_{peak}, LC_{peak}) levels, time-weighted averages (TWA), and projected daily noise dose.

Results: Sound measurements taken at the ear with continuous recording equipment during otologic surgery demonstrated LA_{eq} 80-83 dBA, LA_{peaks} of over 100 dBA, and LC_{peaks} of nearly 130 dBC. TWA was approximately 70 dBA, and projected daily noise dose even for sessions 20–40 minutes long was between 28–61%.

Conclusions: Noise exposure to surgeons, staff, and patients in the operating room (resulting from high-speed otologic drill systems, suctions and suction irrigators, other powered equipment, instruments, music, and conversation) reach unacceptably high levels which may be dangerous to cochlear health. Such noise exposures may be powerful enough to result in noise-induced cochlear synaptopathy, with concomitant functional difficulty achieving suprathreshold word discrimination in background noise.

Define Professional Practice Gap & Educational Need: Otologic surgeons, while offering hearing health care and hearing rehabilitation to patients, expose themselves, their staff, and their patients, to high levels of noise in the operating room. Recent developments regarding the far-reaching consequences of previously believed 'safe levels' of noise, now known to cause permanent reduction in neural signal transmission due to cochlear synaptopathy, merit evaluation of operating room noise exposure to those tasked with safeguarding hearing health.

Learning Objective: Characterize noise exposure of surgeons during otologic surgery.

Desired Result: This study provides context for discussion regarding reducing noise exposure to surgeons, staff, and patients during otologic surgery.

Level of Evidence: III

Indicate IRB or IACUC: Exempt

Histopathologic Analysis of Temporal Bones with Otosclerosis following Cochlear Implantation

Sarah Hodge, MD; Gail Ishiyama, MD; Ivan Lopez, PhD; Akira Ishiyama, MD

Hypothesis: Osteoneogenesis following cochlear implant (CI) surgery in patients with otosclerosis is significantly affected by surgical techniques which affects the outcome on hearing function**.**

Background: When advanced otosclerotic disease extends to the otic capsule, severe and profound sensorineural hearing loss necessitates consideration of a cochlear implant. Histopathological analysis of the human temporal bone after implantation in the patient with otosclerosis may reveal important variables that predict CI success.

Methods: Histopathological evaluation of archival human temporal bones from subjects with a history of CI for cochlear otosclerosis. 7 human temporal bones (HTB) were analyzed.

Results: Histopathological studies revealed extensive osteoneogenesis from the site of insertion extending throughout the temporal bone along the electrodes, more prominent in the basal turn when cochleostomy insertion technique had been used. In cases with translocation, the degree of osteoneogenesis in patients with otosclerosis was more severe. In cases of cochleostomy insertion of CI, there was concomitant fibrosis and tissue formation near the ductus reuniens, which was associated with cochlear hydrops. Osteoneogenesis and/ or fibrosis was much more prominent at the cochleostomy insertion site in the basal turn of the cochlea, when compared with the osteoneogenesis and / or fibrosis in the case of round window insertion.

Conclusion: Round window insertion is preferred when performing CI surgery in otosclerosis patients given the extensive amount of osteoneogenesis and fibrosis seen with cochleostomy. The soft technique is preferred to minimize translocation which triggers more pronounced osteoneogenesis. The round window technique should be prioritized in this patient population to optimize hearing outcomes.

***Define Professional Practice Gap & Educational Need:** Clinical outcomes of cochlear implantation in patients with otosclerosis has been widely studied. However, detailed histopathologic study of CI patients with otosclerosis has not yet been performed. This study will thus help elucidate histologic changes in the cochlea to ultimately highlight important surgical considerations in this patient population.

***Learning Objective:** To describe the fundamental anatomical changes of the cochlea after CI surgery in patients with otosclerosis using histopathologic analysis.

***Desired Result:** To provide evidence of the different histopathologic changes seen in the cochlea after CI using different insertion techniques in patients with otosclerosis.

Level of Evidence – Level IV

Indicate IRB or IACUC : #10-001449, UCLA

Cochlear Implantation through Intracochlear Fibrosis:
A Comparison of Surgical Techniques

Anne K. Maxwell, MD; Jacob B. Kahane, MD; Rahul Mehta, MD
Moises A. Arriaga, MD, MBA

Objective: While the implications of ossification on cochlear implantation (CI) have been extensively described, there is a paucity of data regarding the fibrotic stage. We examined the outcomes of different insertion techniques for managing intracochlear fibrosis.

Study Design: Retrospective review of case series with case-control comparison

Setting: University-based tertiary-referral otology-neurotology practice

Patients: Between 2009 to 2020, 384 patients underwent CI. Of those, 7 patients (8 ears) demonstrated intracochlear fibrosis. Etiology was meningitis (63%), labyrinthitis (13%), or idiopathic (25%).

Interventions: CI performed 1-4 months following meningitis/labyrinthitis and 12-24 months after idiopathic sudden SNHL. Fibrosis removal (38%, using microsurgical dissection ± laser) or dilation (63%, using depth gauge and/or angiocatheters) permitted implantation. Round window insertion was achieved in 88%; cochleostomy was required to bypass obstruction in 13%. A styleted electrode was used in 63% due to dense fibrosis.

Main Outcome Measures: Postoperative audiometry with CI in place, additional comparisons with audiometric outcomes in age-matched controls.

Results: Full insertion achieved in all except one ear with partial ossification. Mean ipsilateral pure tone average (PTA) improved to 29±15dB (range 13-55dB) and speech discrimination to 72±28% (range 32-96%). Fibrosis removal vs. dilation resulted in no PTA differences (p=0.76). Poorest outcomes occurred with the longest time to surgery: 4 months after meningitis (50dB PTA), and 24 months after idiopathic SSNHL (55dB PTA). Follow up duration ranged from 1-62 months.

Conclusions: Good CI audiologic outcomes in the setting of cochlear fibrosis can be achieved and are independent of technique. Instead, they vary with time to implantation. Every attempt should be made to intervene as early as possible.

Define Professional Practice Gap & Educational Need: Limited data exists on cochlear implantation techniques in the setting of intracochlear fibrosis.

Learning Objective: To compare different surgical techniques to manage intracochlear fibrosis including microdissection, laser vaporization, various dilation methods.

Desired Result: To understand the outcomes of fibrosis dissection and dilation techniques.

Level of Evidence: Level V

Indicate IRB or IACUC: Louisiana State University Health Sciences Center-New Orleans IRB, protocol #19-971.

Understanding Public Perceptions Regarding Cochlear Implant Surgery in Adults

Lisa Zhang, BS, BA; Andy S. Ding, BA; Deborah X. Xie, MD
Francis X. Creighton, MD

Background and Objective: Approximately 6% of adults eligible for cochlear implantation (CI) undergo surgery. We aim to understand general perceptions about CI to investigate barriers explaining this low utilization.

Methods: Participants completed an online survey regarding their perceptions about cochlear implantation. They were asked to rank CIQOL-10 Global priorities and corresponding risk tolerance for minor complications (changes in taste, vertigo) and major complications (infections requiring hospitalization, meningitis, reimplantation, facial paralysis, and cerebrospinal fluid [CSF] leak).

Results: A total of 249 responses (male 60%, mean age 38 years [range 20-75]) were included. Respondents identified issues with insurance (31%) and fear of undergoing surgery (29%) as barriers preventing eligible adults from receiving CI. Regarding surgical risk, respondents significantly underestimated rates of minor complications ($p<0.01$) and overestimated rates of major complications (all $p <0.0001$). The ability to hear strangers in noisy environments was identified as the highest priority for CI (33%). Respondents were willing to accept higher rates of most complications except vertigo to achieve their highest quality of life priority (all $p<0.005$). With the option to improve hearing loss without surgery, older age and occupation in healthcare were significant positive predictors of higher willingness to pay ($p=0.006$, $p=0.003$, respectively).

Conclusions: Respondents identify insurance coverage and fear of surgery as primary reasons for low utilization of adult CI in the US, but also significantly overestimate the rate of major postoperative complications. Respondents also indicate they are willing to accept much higher complication rates than existing to achieve their highest quality of life priorities.

***Define Professional Practice Gap & Educational Need:** Many previous studies have identified low rates of cochlear implantation in the United States versus other developed nations and have postulated various reasons explaining this trend. However, to our knowledge, there have been no studies that have directly assessed public opinions on cochlear implantation to understand their most pressing priorities with regard to postoperative quality of life and risk tolerance. Our study investigated possible causes of this discrepancy and identified concerns about surgical risk and insurance coverage as primary reasons, opening the door for public education discussions centered on these topics.

***Learning Objective:** The learning objectives were to understand the general public's perceptions on quality of life priorities following cochlear implantation and their associated tolerance for postoperative complications.

***Desired Result:** We hope our study will help frame discussions about cochlear implantation in the clinical setting with regard to identifying top quality of life priorities and managing expectations in risk tolerance.

Level of Evidence - NA

Indicate IRB or IACUC: Exempt

Hearing Loss and Incident Dementia:
Claims Data from the New York SPARCS Database

Alexander Chern, MD; Rahul K. Sharma, BS; Justin S. Golub MD, MS

Objective: Hearing loss (HL) may be a risk factor for incident dementia. The objective was to use population-based claims data from the New York Statewide Planning and Research Cooperative System (SPARCS) to establish if HL is associated with incident dementia.

Study Design: Secondary analysis of prospective claims database

Setting: Comprehensive all-payer data reporting system established by the New York State Department of Health (2007-2017)

Patients: 217,694 subjects >60 years (15,323 with HL, random sample of 202,371 without HL)

Interventions: none

Main Outcome Measures: The main outcome was incident dementia, measured by initial dementia diagnosis (ICD-9/ICD-10 code) associated with a patient visit/insurance claim. The main exposure was HL, measured by at least 2 separate HL diagnoses associated with claims prior to dementia diagnosis. Cox proportional-hazards models were used to examine the relationship of baseline HL with incident dementia, adjusting for age, gender, cardiovascular disease, cerebrovascular disease, diabetes, and smoking.

Results: Dementia incidence rates per 1000 person-years were 16.3 (subjects with HL) and 9.13 (subjects without HL). HL associated with fewer (2-10) claims (n=14,175) was associated with 1.17 (95% CI=1.09-1.26, $p<0.001$) times the hazard of incident dementia, adjusting for covariates. HL associated with greater (>10) claims (n=1,148) was associated with 1.36 (95% CI=1.09-1.68, p=0.006) times the hazard of incident dementia, adjusting for covariates.

Conclusions: HL diagnosis was associated with increased risk of incident dementia based on a comprehensive all-payer data reporting system. Individuals with a more established diagnosis of HL (more HL diagnoses associated with claims) demonstrated an increased hazard ratio.

Define Professional Practice Gap & Educational Need: Hearing loss is highly prevalent and severely undertreated. Studies have suggested that hearing loss may be a risk factor for incident dementia. However, this finding needs replication and extension through novel and unique methods of analysis for generalizability. Understanding this association will help inform healthcare personnel of hearing loss as a risk factor for incident dementia

Learning Objective: After this presentation, the learner will be able to describe the relationship between age-related hearing loss and incident dementia.

Desired Result: Otolaryngologists will better understand the relationship between hearing loss and incident dementia.

Level of Evidence – Level III

Indicate IRB or IACUC: Columbia Irving University Medical Center IRB-AAAT2769 (ENT Outcomes in SPARCS)

Association of Vitamin D Levels with Benign Paroxysmal Positional Vertigo Outcomes

Leah H. Cobb, MSc; Victoria O. Bailey, BSc; Yuan F. Liu, MD
Michael T. Teixido, MD; Habib G. Rizk, MD

Objective: To determine the effects of vitamin D levels and supplementation on occurrence and recurrence of benign paroxysmal positional vertigo (BPPV) symptoms.

Study Design: Retrospective chart review with follow-up phone surveys. The National Health and Nutrition Examination Survey (NHANES) database was utilized as a control group.

Setting: Tertiary referral center, neurotology clinic (Medical University of South Carolina Department of Otolaryngology)

Patients: Patients seen between 5/2017-5/2020 who met the criteria of: ≥18 years old, diagnosed with BPPV (confirmed by positive Dix-Hallpike), with vitamin D levels collected within 6 months of diagnosis.

Interventions: Vitamin D supplementation for treatment of BPPV

Main Outcome Measures: BPPV recurrence rates, ranking of recurrence severity, number of series, date of last visit

Results: 174 patients met the criteria for inclusion in the study. Of these, 75.3% were female with an average age of 65.9 ±12.3 years. The most common co-morbidities were hyperlipidemia (38.5%), hypertension (23.6%), and thyroid disease (19.0%). Our patient demographics had a significantly greater proportion of Caucasians (d=0.411 [0.194,0629]), higher average age (d=1.709[1.556,1.863) and females (d=0.231[0.056,0.406]) than the NHANES group. Furthermore, our patients had a higher mean vitamin D level at diagnosis (31.3 ng/nL, ±16.5) than the NHANES control (26 ng/nL, ±11.2).The mean vitamin D level of patients who had no recurrences (37.6 ng/nL) was significantly greater than those who had ≥ 1 recurrence (29.0 ng/nL) (d=0.571, [0.139,1.001]). No other significant associations were determined when comparing our patient population to the NHANES national data, in terms of Vitamin D levels and BPPV outcomes.

Conclusions: Based on our findings, Vitamin D levels may indicate a propensity for BPPV recurrence. Vitamin D supplementation may serve as a cost-effective, positive prophylactic treatment in those with BPPV. Interestingly, it was not significantly correlated with initial BPPV occurrence, as the average vitamin D level of our patient population was actually higher than that of the NHANES group. The significant differences in demographics between our patient population and the NHANES database (race, age, and sex) appear to validate known risk factors for BPPV. In the future, comparison of our patient population to age and sex-matched loco-regional data may provide clarity of associations of BPPV to vitamin D levels.

***Define Professional Practice Gap & Educational Need:** Therapeutic options for BPPV are limited. Previous studies have shown a correlation of osteoporosis to BPPV, stimulating the hypothesis that there may be a role of vitamin D in BPPV pathogenesis. If related, Vitamin D supplements could become a first-line treatment for an otherwise debilitating disease.

***Learning Objective:** First, to confirm whether Vitamin D levels are a predictive factor for BPPV occurrence and subsequent recurrence. Second, to objectively evaluate the utility of Vitamin D supplementation in the treatment of BPPV.

***Desired Result:** If vitamin D levels are indeed related to BPPV occurrence and recurrence, Vitamin D supplements may serve as a cost effective and attractive therapeutic option. Currently, there are limited treatment options for BPPV, despite how common the disease is and the discomfort it inflicts on those afflicted.

Level of Evidence – Level III

IRB: Pro00095413 Medical University of South Carolina

The Correlation of Clinical Corticosteroid Responsiveness with Expression of IL-6 in Peripheral Blood Immune Cells (PBMC) in Patients with Autoimmune Inner Ear Disease (AIED)

Scott W. Gorthey, MD; Shresh Pathak, PhD; Andrea Vambutas, MD

Hypothesis: AIED patients will differentially express IL-6 based on clinical corticosteroid responsiveness.

Background: AIED is characterized by periods of acute sensorineural hearing loss (SNHL). Seventy percent of these patients will respond to corticosteroids, however, after 3 years only 14% remain responsive. The mechanisms that controls corticosteroid responsiveness have not been fully elucidated.

Methods: Thirty five AIED patients and 13 control subjects were enrolled in this study. Steroid responsive (n=15) and steroid resistant AIED patients (n=20), were characterized based on audiometry before and after treatment for acute SNHL. Plasma and PBMC were obtained at the time of acute SNHL to quantify plasma IL-6, sIL-6R and CCL3. PBMCs were treated with dexamethasone. Release of soluble IL-6, sIL-6R, and CCL3 protein into conditioned supernatants from stimulated PBMC was measured. Plasma IL-6 was also correlated to serum CRP, cardiac CRP, ESR.

Results: Statistically significant differences were seen in the plasma IL-6 between AIED patients and controls (2.37 vs. 2.03 pg/mL, $p<0.01$), plasma IL-6 and CCL3 between responders and nonresponders (0.136 vs. 3.84 pg/mL, $p<0.005$; 30.5 vs. 32.4, $p<0.05$) and released IL-6 from dexamethasone stimulated PBMC in AIED patients compared to controls (0.54 vs. 1.12 pg/mL, $p<0.001$). There was a correlation between plasma IL-6 levels of AIED patients to both serum CRP and cardiac CRP ($R^2=0.83$, $R^2=0.88$).

Conclusions: We observed AIED patients and specifically nonresponders expressed greater levels of IL-6. Elevated IL-6 levels in AIED patients correlated with CRP levels, potentially providing a commonly available laboratory test that may aid in rapid clinical decision-making in these patients.

***Define Professional Practice Gap & Educational Need:** Further investigation into the pathophysiology of AIED is required to elucidate potential treatments as well as guide clinician's plan of care for these patients.

***Learning Objective:** 1. The pathophysiology of AIED includes alteration in the IL-6 inflammatory pathway.
2. Variations in IL-6 expression between corticosteroid responders and nonresponders suggest differing inflammatory responses between these two groups of patients.
3. There may be useful correlations between the diagnostic and prognostic value of IL-6 levels with common clinical laboratory tests.

***Desired Result:** Provide learner with evidence to support a clearer understanding of the pathophysiology of autoimmune inner ear disease that includes the differential production of the cytokine IL-6 between AIED patients and controls as well as between steroid responders and nonresponders.

Level of Evidence – Level V

Indicate IRB or IACUC: 05-110T, 9/11/2017, Feinstein Institute for Medical Research

Utilizing Single Cell RNA-Sequencing to Implicate Cell Types and Therapeutic Targets for SSNHL in the Adult Cochlea

Lacey Nelson, BS; J. Dixon Johns, MD; Shoujun Gu, PhD; Michael Hoa, MD

Objective: To identify genetic targets implicated in sudden sensorineural hearing loss (SSNHL) and localize their expression in the cochlea in order to further explore potential pathogenic mechanisms and treatment strategies.

Study Design: Systematic literature review and bioinformatics analysis

Data Sources: The following databases and grey literature sources were searched from inception through July 2, 2020: PubMed-NCBI, MEDLINE, Embase, CINAHL, Cochrane Library, ClinicalTrials.gov, OpenGrey, GreyNet, GreyLiterature Report, and European Union Clinical Trials Registry.

Study Selection: Studies with a primary focus on genetic targets associated with SSNHL were included. Exclusion criteria included studies unrelated to SSNHL, studies that did not include genetic analysis, full-text articles in a foreign language, and other systematic reviews.

Data Extraction: Data from included studies was extracted and compiled using a standardized electronic data collection sheet. The Oxford Centre for Evidence-Based Medicine levels of evidence was used to grade the strength of clinical data.

Data Synthesis: Previously published single-cell and single-nucleus RNA-Seq datasets of the adult mouse stria vascularis were utilized for localization of SSNHL-related genes curated through literature review. Gene ontology analyses were performed using EnrichR. Potential therapeutic gene targets and associated pharmacologic agents were identified.

Conclusions: We report 92 unique polymorphisms in 76 different genes that have been investigated in relation to SSNHL in the literature. Gene ontology analysis identifies potentially involved biological processes. We demonstrate that a subset of these genes are expressed by cell types in the adult mouse stria vascularis.

***Define Professional Practice Gap & Educational Need:** To better understand cell types and potential therapeutic targets involved in SSNHL.

***Learning Objective:** Identify potential genetic targets involved in SSNHL and describe their localization in the cochlea.

***Desired Result:** Increase understanding of the role of genetics in SSNHL pathogenesis, and use knowledge of potential genetic targets to guide treatment strategies.

Level of Evidence – N/A

Indicate IRB or IACUC: Exempt

Opioids Are Infrequently Required following Ambulatory Otologic Surgery

Maria A. Mavrommatis, BA; Vivian F. Kaul, MD; Zachary G. Schwam, MD
Dillan F. Villavisanis, BA; Enrique Perez, MD, MBA
George B. Wanna, MD; Maura K. Cosetti, MD

Objective: To determine the frequency with which ad hoc opioid prescriptions are used in ambulatory otologic surgery.

Study Design: Retrospective chart review

Setting: Tertiary otology-neurotology practice

Patients: Patients (n= 218) given over-the-counter acetaminophen and ibuprofen following ambulatory otologic surgery between July 1, 2019 and June 30, 2020.

Interventions: Opioid prescription upon request due to unresponsive pain.

Main Outcome Measures: Patient, disease, and surgical variables such as age, sex, past medical history (PMHx), chronic pain condition, surgical procedure, primary versus revision surgery, and endoscopic versus microscopic approach were examined for relationship to ad hoc opioid prescription rate.

Results: Of 218 patients (mean age 43.9 years, range 8.4 months - 88.5 years), 7 were taking opioids at baseline for external medical conditions. 37 (17.0%) patients were prescribed opioid analgesia for postoperative pain, most commonly oxycodone-acetaminophen 5/325 mg on the day of surgery or postoperative day (POD) one (range, POD 0–11). Procedures with concurrent canaloplasty ($p= 0.004$), PMHx of a chronic pain syndrome or cancer diagnosis ($p< 0.001$), and baseline opioid prescription ($p= 0.002$) were associated with need for opioids. Mastoidectomy - including canal wall up (CWU), canal wall down (CWD) and radical -, cochlear implantation, stapedectomy, and tympanoplasty were not. Age (when controlled for pediatric cases), sex, other PMHx, revision surgery, and endoscopic vs. microscopic techniques were not predictive of opioid prescription.

Conclusions: Pain following ambulatory otologic surgery may be adequately managed with OTC pain medication in the majority of cases. Opioids may be necessary in those with pre-existing pain conditions or in those taking opioid prescriptions at baseline.

Define Professional Practice Gap & Educational Need: Opioids may be prophylactically prescribed following ambulatory otologic surgery despite adequate pain control with OTC pain medications for the majority of procedures.

Learning Objective: Postoperative pain following ambulatory otologic surgery is often sufficiently managed with OTC pain medication, and opioids should only be prescribed due to recalcitrant pain.

Desired Result: Reduction in rate of opioid prescription for ambulatory otologic surgery.

Level of Evidence – Level IV

Indicate IRB or IACUC: Exempt

The Cell Phone Vibration Test: A Telemedicine Substitute for the Tuning Fork Test

Alex Yang, BA; Nora Watson, PhD
Robert J. Lewis, MD; Anthony M. Tolisano, MD

Objective: An at home test for differentiating between conductive and sensorineural hearing loss remains elusive. With the rise of telemedicine, virtual physical examination maneuvers are increasingly important. Our goal was to validate the novel cell-phone vibration test (CPVT) against the Weber tuning fork test (WTFT) and to assess if the CPVT can be reliably self-administered by patients.

Study Design: Cross-sectional.

Setting: Academic otolaryngology clinic.

Patients: Consecutive adults with a recent audiogram within 6 months and no report of recent hearing changes.

Interventions: The CPVT involves placement of a vibrating cell-phone on the center of the forehead to determine which ear is subjectively louder. Group 1 consisted of 20 patients who were examined by the provider with the CPVT and WTFT using various tuning forks (256Hz, 512Hz, 1024Hz). Group 2 consisted of an additional 20 patients who received instructions on self-administering the CPVT.

Main Outcome Measures: Kappa statistics were calculated to assess concordance between the CPVT, WTFT, and audiometric findings for Group 1 and between patient self-administered and provider administered CPVT and WTFT for Group 2.

Results: Concordance between CPVT and WTFT in Group 1 was high (Kappa coefficient: 0.76 for 256Hz, 0.92 for 512Hz, 0.92 for 1024Hz) with similar concordances between actual and expected results based on audiogram (Kappa coefficient: 0.49 for CPVT, 0.59 for WTFT). Concordance between patient-administered and provider-administered CPVT showed perfect agreement (Kappa coefficient: 1.0).

Conclusions: The CPVT provides consistent results when compared to a formal WTFT and can be reliably self-administered by patients with appropriate instructions.

Define Professional Practice Gap & Educational Need: The ability to perform simple and effective physical examination of the ear and differentiate sensorineural and conductive hearing loss is limited when patients are evaluated via telemedicine.

Learning Objective: To describe a simple at home test for differentiating between conductive and sensorineural hearing loss for the otologic patient treated via telemedicine.

Desired Result: Physicians will be able to reliably differentiate between conductive and sensorineural hearing loss for their patients treated via telemedicine.

Level of Evidence – Level V

Indicate IRB or IACUC: Department of Research Programs, Walter Reed National Military Medical Center (IRB #WRNMMC-EDO-2020-0553)

Developmental Disruptions of the Human Stapes

Thais Abrahao, MD, PhD; Felipe Santos, MD

Objective: To evaluate and classify developmental malformations of the human stapes.

Method: 25 temporal bone specimens from 18 patients with congenital stapes malformations were identified in the Mass Eye and Ear temporal bone collection. Serial sections stained with Hematoxylin and Eosin were examined by light microscopy and the morphology of the stapes was compared to age matched controls.

Results: Each case of stapes malformation could be classified into one of four malformation types based on our current understanding of the embryologic origin of the subunits of the stapes and timing of development. 27% of stapes malformations had a Type I morphology characterized by a hypoplastic or absent inner footplate and hypoplastic to absent mesoderm footplate or oval window. The crura and capitulum may be absent, monopodal or dysmorphic. 11% expressed a Type II malformation with dysmorphic or monopodal capitulum and crura and a fixed footplate. 27% were of Type III with a dysmorphic or monopodal capitulum and or crura. The footplate, and thereby oval window is present and without fixation. The most common malformation, Type IV, was isolated footplate fixation observed in 33% of cases.

Conclusion: Malformations of the human stapes follow consistent patterns of early or late disruptions of the stapes subunits of mesodermal and/or neural crest origin. While the molecular events, including temporal coordination, that lead to a normally formed stapes are not yet fully understood, the observed patterns of human stapes malformation can be consistently classified into one of four patterns of developmental disruption.

***Define Professional Practice Gap & Educational Need:** New findings in animal studies of the embryologic development of the ossicles inform previously unrecognized patterns in human stapes malformations.

***Learning Objective:** To provide a better understanding of stapes malformation based on the embryologic origin of the stapes subunits.

***Desired Result:** Participants will have a better understanding on the embryologic origin of the stapes and why specific malformations are observed.

Level of Evidence - III

Indicate IRB or IACUC: Exempt

Congenital Aural Atresia with Cholesteatoma – Diagnosis and Outcome

Geoffrey C. Casazza, MD; Rachel H. Jonas, MD; Bradley W. Kesser, MD

Objective: Compare outcomes of congenital aural atresia (CAA) with/without cholesteatoma

Study Design: Retrospective case control

Setting: Tertiary care center

Patients: CAA patients

Interventions: surgery for CAA

Main Outcome Measures: Patients with CAA undergoing surgical repair from June 2004 to July 2020 were identified from an institutional database. Included patients were divided by presence of a canal cholesteatoma. Clinical history, pre- and post-operative audiometric data, and clinical outcomes were compared.

Results: Of the 283 patients (300 ears), 18 (19 ears) had a canal cholesteatoma. Patients with cholesteatoma were more likely to be younger (9.2 ±6.6 vs. 11.5 ±9.2; p =0.015), female (66.7% vs. 38.1%; p =0.02; OR 3.2, 95% CI 1.18-8.9), and have normal/Grade I microtia (47.4% vs. 9.6%; p <0.0001; OR 0.12, 95% CI 0.044-0.32), but not a history of draining ear (5.3% vs. 0%; p =0.05; OR 0.06, 95% CI 0.004-0.999). Pre-operative audiometric data demonstrated a lower mean air-bone gap (ABG) (45.8 dB vs. 52.3 dB; p =0.009) and better speech reception threshold (48.7 dB vs. 57.4 dB; p = 0.0004) in cholesteatoma patients. Post-operatively, patients with cholesteatoma were more likely to close the ABG within 20 dB (p =0.001; OR 0.19, 95% CI 0.072-0.52). No patient in the cholesteatoma group developed post-operative bony/soft-tissue stenosis (0% vs. 9.7%; p =0.65; OR 1.61; 0.21-12.6) or required revision surgery (0% vs. 11%; p =0.38; OR 2.46, 0.32-19).

Conclusions: Patients with CAA and cholesteatoma have better audiometric outcomes and likely a more durable repair with a decreased need for revision possibly secondary to greater development of the ear canal and middle ear space despite the cholesteatoma.

***Define Professional Practice Gap & Educational Need:** management of congenital aural atresia/stenosis with cholesteatoma

***Learning Objective:** to better understand clinical characteristics of patients with congenital aural atresia and their outcomes after surgery

***Desired Result:** improved understanding of clinical characteristics of patients with congenital aural atresia/stenosis with cholesteatoma

Level of Evidence – Level IV

Indicate IRB or IACUC : Approved, University of Virginia IRB no. 22575

Epidemiological and Long-term Medical and Surgical Outcomes in Chronic Suppurative Otitis Media

Anthony Thai, BA; Ksenia A. Aaron, MD; Adam C. Kaufman, MD, PhD; Peter L. Santa Maria, MBBS, PhD

Objective: Report epidemiological and long-term outcomes in chronic suppurative otitis media (CSOM), given paucity of such data in developed countries

Study Design: Retrospective cohort study; medical claims analysis

Setting: Tertiary referral center; national claims databases

Patients: Patients with ICD diagnosis of CSOM in MarketScan and Optum databases were included in national claims analysis. For the tertiary center cohort, patients with ICD diagnosis of CSOM, at least 6 months of follow up, and at least one documented episode of active CSOM (defined as tympanic membrane perforation with otorrhea) were included. This cohort included 48 patients (mean age 48.2 years, 56.3% female).

Interventions: Retrospective analysis

Main Outcome Measures: CSOM prevalence; number of healthcare visits; recurrence rate of active CSOM.

Results: CSOM prevalence ranges from 0.05% to 0.47% in the US. In our tertiary center cohort, patients displayed average follow-up time of 6.8 ± 3.8 years, with an average of 13.3 ± 9.7 visits. Following medical management, 86.4% either continued to display active CSOM, or temporarily converted to inactive CSOM prior to recurrence (mean time to recurrence: 4.4 months). Patients undergoing surgical management underwent an average of 2.2 CSOM surgeries, with a recurrence rate of 51.9% (mean time to recurrence: 45.5 months). On the most recent audiogram, 70% of patients displayed sensorineuronal hearing loss in the affected ear.

Conclusions: In our cohort, CSOM patients display high healthcare utilization. Surgical management was superior to medical management in both relapse rate and mean time to relapse and should be considered earlier in the disease course.

***Define Professional Practice Gap & Educational Need:**
Although previous studies indicate high resolution rates for CSOM with topical antibiotics and antiseptics, these studies often have short follow-up periods of less than one month. This long-term study indicates that current therapies for CSOM display poor outcomes, and argues for consideration of surgical management earlier in the disease course.

***Learning Objective:**
CSOM prevalence in the United States is similar to slightly lower than other developed countries.
CSOM patients often have multiple episodes of active disease leading to high healthcare utilization, including numerous visits, prescriptions and surgeries.
Surgical management is superior to medical therapy for CSOM, although both have poor long-term outcomes.

***Desired Result:** Long-term outcomes in CSOM patients are inferior compared to previous reports with shorter follow-up time. Surgical management is superior to medical management and should be considered earlier in treatment.

Level of Evidence - IV

Indicate IRB or IACUC : IRB Protocol 56466, Stanford University

Eustachian Tube Dilation Outcomes at a Tertiary Academic Center

Micah M. Gibson, MD; Shubham Patel, BS; Esther X. Vivas, MD

Objective: To investigate and report the subjective and objective outcomes for balloon dilation of the Eustachian tube (BDET) in patients with Eustachian tube dilatory dysfunction (ETDD).

Study Design: Retrospective case series

Setting: Tertiary referral center

Patients: Patients18 years of age or older who underwent BDET between 01/01/2017 to 2/28/2020.

Interventions: BDET using the ACCLARENT AERA^{TM}. Patients responded to the Eustachian Tube Dysfunction Questionnaire (ETDQ-7) before and after BDET. Pre- and post-operative pure tone audiometry was performed.

Main Outcome Measures: Pre-and post-operative ETDQ-7, pure tone audiometry, tympanometry, otomicroscopic examination.

Results: BDET was performed on 42 ears. There were no complications. Mean follow up was 8.4 months (range 1-23 months). ETDQ-7 score improved in 83% of ears. Mean ETD-7 score improved from 5.10 to 2.55. 78.6% of middle ear effusions resolved with BDET. Of 6 patients undergoing simultaneous BDET and tympanoplasty, all grafts were intact at follow up. 7 out of 8 patients undergoing BDET with tympanoplasty or other middle ear surgery demonstrated improved air conduction thresholds. Follow up has been hindered by limited clinical access during the COVID-19 pandemic.

Conclusions: BDET demonstrates subjective and objective measures of improvement in treating ETDD. It may be a useful adjunct to improving tympanoplasty outcomes.

***Define Professional Practice Gap & Educational Need:** In 2016, the FDA approved a device that employs a balloon to endoscopically dilate the Eustachian tube. According to a clinical consensus statement from the AAO-HNSF, the benefit of BDET performed with concurrent tympanoplasty or other middle ear surgery has not been determined, and more outcomes assessments are needed. The purpose of this work is to support the utility of BDET by reporting outcomes in a single-surgeon case series.

***Learning Objective:** BDET is a safe treatment for ETDD demonstrating subjective and objective results, and BDET may be beneficial when performing tympanoplasty.

***Desired Result:** BDET leads to improved ETDQ-7 scores, air conduction hearing thresholds, and tympanograms in patients with ETDD.

Level of Evidence - V

Indicate IRB or IACUC : Approved by Emory University Institutional Review Board

SELECTED ABSTRACTS

POSTER PRESENTATIONS

154th Annual Meeting
AMERICAN OTOLOGICAL SOCIETY

Cochlear Nerve Deficiency in Pediatric Single-Sided Deafness and Asymmetric Hearing Loss

Teresa G. Vos, MD; Lisa R. Park, AuD; Amy S. Noxon, BS; Kevin D. Brown, MD, PhD

Objective: To investigate the incidence of cochlear nerve deficiency (CND) in pediatric patients with single-sided deafness (SSD) or asymmetric hearing loss (AHL).

Study Design: Retrospective chart review

Setting: Tertiary referral center

Patients: Pediatric patients <18 years of age evaluated for SSD or AHL with magnetic resonance imaging (MRI) between January 2014 and October 2019 (n=309).

Methods: MRI brain and computed tomography (CT) temporal bone were reviewed.

Main Outcome Measures: Status of cochlear nerve and cochlea were evaluated.

Results: Preliminary data analysis demonstrated concern for cochlear nerve deficiency (aplasia, hypoplasia or cochlear aperture stenosis) in approximately a quarter of pediatric patients with SSD or AHL. Ipsilateral cochlear malformations were noted in over 10% of the cohort and an enlarged vestibular aqueduct was found in approximately 10% of ipsilateral ears.

Conclusions: Imaging demonstrated a high incidence of inner-ear malformations, particularly CND, in pediatric patients with unilateral hearing loss. Radiologic evaluation should be performed in all patients within this population to guide counseling and management of hearing loss based on etiology, with implications on candidacy for cochlear implantation.

Professional Practice Gap & Educational Need: There is conflicting literature on the rates of cochlear nerve abnormalities and cochlear malformations in pediatric unilateral hearing loss, with important implications on management.

Learning Objective: To understand the incidence of cochlear abnormalities in pediatric SSD/AHL and the importance of imaging to recommended management.

Desired Result: Improved understanding of cochlear nerve deficiency in pediatric unilateral hearing loss.

Level of Evidence - Level IV

Indicate IRB or IACUC: Approved by the University of North Carolina at Chapel Hill**,** IRB#19-2622.

Prognostic Factors for Tympanoplasty: A Systematic Review

Jorge A. Gutierrez III, BA; Claudia Cabrera-Aviles, MD; Sarah E. Mowry, MD

Objective: To assess the prognostic factors for anatomic and hearing success after tympanoplasty.

Data Sources: PubMed, Cochrane Library, MEDLINE, and manual search of bibliographies.

Study Selection: A systematic review was performed in May 2020. English-language articles describing outcome data for tympanoplasty repair variables including underlying pathology, perforation location, smoking status, graft material, graft technique, reconstruction material, anatomic success, and hearing success were extracted. Articles were excluded when tympanosclerosis, retraction pockets, adhesions, cholesteatoma, chronic suppurative otitis media (CSOM), anterior perforations, and smoking were excluded.

Data Extraction: Underlying pathology, perforation location, smoking status, graft material, graft technique, reconstruction material, anatomic success, and hearing success were extracted. Any factors analyzed as potential indicators of success were sought out.

Data Synthesis: Systematic Review.

Conclusions: 60 articles met final criteria, which accounted for 3,831 patients. 32 articles presented data on both anatomic and hearing outcomes, 20 articles presented data on anatomic outcomes only, and 8 articles presented data on hearing outcomes only. This systematic review found that adhesions and tympanosclerosis were prognostic factors for poorer hearing. Cholesteatoma, smoking, retraction pockets, and anterior perforations did not significantly impact hearing outcomes. None of the assessed variables were predictive of anatomic tympanoplasty success. However, this analysis is significantly limited by both the heterogeneity within the patients and the lack of controls. This study illustrates the myriad of potential opportunities for future studies, which could further define prognostic factors involved in these tympanoplasty procedures.

Define Professional Practice Gap & Educational Need: Medical knowledge – lack of clear understanding regarding which surgical approach or grafting material should be used in patients with complex tympanic membrane perforations.

Learning Objective: Recognize the need for additional research into prognostic factors affecting tympanoplasty outcomes.

Desired Result: Spur research in prospective evaluations of both grafting material and surgical approach for complex tympanoplasty surgery. Recognize that the underlying pathology of chronic ear disease may play a role in the success or failure of a tympanic membrane repair. Encourage systematic reporting standards.

Level of Evidence – N/A

Indicate IRB or IACUC: Exempt

Review of Speech Outcomes in Cochlear Implant Recipients at an Evolving Cochlear Implant Program

Nathan Aminpour, MS, Laura Levin, AuD, Mary Finkbone, AuD, Michael Morikawa, AuD, Melissa Blumgart, AuD, H. Jeffrey Kim, MD, Michael Hoa, MD

Objective: To examine the percentage of adult patients in a heterogeneous group of cochlear implant (CI) recipients at an evolving CI program who demonstrate improvements in speech outcomes.

Study Design: Retrospective chart review

Setting: Tertiary academic center

Patients: Adult cochlear implant recipients from 9/2014 – 12/2019 with at least 3 months of audiologic follow up post-activation.

Interventions: Cochlear Implantation

Main Outcome Measures: Speech outcome scores were assessed preoperatively and postoperatively at 3, 6 and 12 month intervals using Consonant-Nucleus-Consonant words (CNC) and AzBio sentences in quiet (AzBio). Mean speech outcome scores at each time point and binomial distribution tables with 95% confidence intervals were used to assess individual improvement in speech understanding.

Results: 45 patients underwent a total of 49 cochlear implantation surgeries. Mean age at surgery was 62**.** Mean preoperative CNC score in the ear to be implanted was 18%±18%**,** while the mean postoperative CNC score at 3, 6 and 12 months was 35%±21%, 44%±23% and 45%±25%, respectively. Mean preoperative AzBio score in the ear to be implanted was 22%±26% while the mean postoperative AzBio score at 3, 6 and 12 months was 50%±29%, 56%±27% and 63%±26%, respectively. 74% (32 of 43) and 69% (22 of 32) of recipients showed significant improvement at 6 months or 1 year in the implanted ear using AzBio and CNC binomial distribution tables, respectively.

Conclusions: Findings demonstrate significant improvement in speech perception following cochlear implantation for patients not benefiting from hearing aid aural rehabilitation. The study provides realistic expectations for new cochlear implant programs hoping to demonstrate their utility in improving patient speech outcomes.

Define Professional Practice Gap & Educational Need: Expectations regarding likelihood and predicted improvement in speech understanding after cochlear implantation in adults remains poorly defined outside of data from large, established CI centers. This data provides reasonable expectations for CI outcomes at small to medium sized growing CI centers.

Learning Objective: To understand the likelihood and expected improvements in speech understanding after cochlear implantation in adults.

Desired Result: To provide physicians, audiologists, and patients realistic expectations for speech performance outcomes post-cochlear implantation.

Level of Evidence - IV

Indicate IRB or IACUC: This project was approved on 1/14/2020 and is in compliance with Medstar-Georgetown University Hospital IRB (STUDY00001609).

A Web-Based Deep Learning Model for Automated Diagnosis of Otoscopic Images

Kotaro Tsutsumi, BA; Khodayar Goshtasbi, MS; Pooya Khosravi, BS; Adwight Risbud, BS
Harrison W. Lin, MD; Hamid R. Djalilian, MD; Mehdi Abouzari, MD, PhD

Objective: To develop a multiclass-classifier deep learning (DL) model and website for distinguishing tympanic membrane (TM) pathologies based on otoscopic images.

Study Design: Development of DL multiclass-classifier models for TM images.

Setting: Tertiary academic center.

Patients: Patients who underwent TM image acquisition.

Interventions: Creation of an otoscopic image database using the Van Akdamar Hospital eardrum database and google search and its assessment by convolutional neural network (CNN) models developed by modifying publicly available models: ResNet-50, Inception-V3, Inception-Resnet-V2, MobileNetV2. Training and testing were conducted with a 75:25 breakdown.

Main Outcome Measure(s): Area under the curve of receiver operating characteristics (AUC-ROC), accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of CNN for classifying TM images.

Results: Our database included 400 images, organized into normal (n=196) and abnormal classes (n=204), including acute otitis media (n=116), otitis externa (n=44), chronic suppurative otitis media (n=23), and cerumen (n=21). For binary classification between normal versus abnormal TM, the best performing model had average AUC-ROC of 0.902 (MobileNetV2), followed by 0.745 (Inception-Resnet-V2), 0.731 (ResNet-50), and 0.636 (Inception-V3). Accuracy ranged between 0.73-0.77, sensitivity 0.72-0.88, specificity 0.58-0.84, PPV 0.68-0.81, and NPV 0.73-0.83. Macro-AUC-ROC for MobileNetV2 based multiclass-classifier was 0.91, with accuracy of 66%. Binary and multiclass-classifier models based on MobileNetV2 were loaded onto a publicly accessible and user-friendly website (https://headneckml.com/tympanic). This allows the readership to upload TM images for real-time predictions with the associated probability.

Conclusions: Novel CNN algorithms were developed with high AUC-ROCs for differentiating between various TM pathologies. This was further deployed as a proof-of-concept publicly accessible website for real-time predictions.

REQUIRED:
Define Professional Practice Gap & Educational Need: Many otologic diseases have been shown to be more prevalent among the low and middle-income countries. This situation is further complicated by the severe limitations in the number of otolaryngologists available in these countries. Consequently, there is a great need to develop automated diagnostic technologies that allow for early and effective diagnosis of such diseases among these underserved regions.

Learning Objective: To explain the ability of a DL model and its web-based interface to classify TM images based on various pathologies.

Desired Result: Informing otologists of a novel web platform for classifying TM images.

Level of Evidence – IV

Indicate IRB or IACUC: Exempt

Single-stage Conversion of Bone-Anchored Hearing Implant to Cochlear Implant: Surgical Technique and Literature Review

Sina Koochakzadeh, MD; Dustin M. Lang, MD
Patrick J. Antonelli, MD;Si Chen, MD

Objective: Describe surgical technique for single-stage conversion of bone-anchored hearing implant (BAHI) to cochlear implant (CI) and evaluate post-operative wound complications.

Study Design: Retrospective case series

Setting: Tertiary academic center

Patients: Patients with BAHI who underwent single-stage conversion to CI

Interventions: Removal of BAHI and placement of CI by utilizing landmarks of posterior insertion of temporalis muscle or lambdoid suture for separation of CI receiver-stimulator (RS) from BAHI site

Main Outcome Measures: Post-operative wound complications

Results: Four patients underwent single-stage conversion from BAHI to CI. The average duration of BAHI use was 5.75 years (range 2 – 13 years). There were 3 percutaneous BAHIs and one transcutaneous device. All 3 percutaneous BAHI patients had chronic abutment site issues. Two had extensive scalp thinning and hair removal at the time of BAHI placement. All except one had CI RS placed posterior to the BAHI site. One patient required scalp advancement flap for closure at BAHI site. Follow up ranged from 3 – 87 months (mean 26.3 months) after CI placement. One patient with scalp thinning, 13 years of BAHI use, and closure with an advancement flap experienced wound infection and BAHI closure breakdown. This resolved with oral antibiotics. CI RS site and performance were not affected.

Conclusions: Single-stage conversion of BAHI to CI can be performed safely. The CI RS can be preserved in the event of BAHI site wound breakdown. Scalp wound tension, inflammation around the abutment, and longer BAHI use may contribute to wound issues after BAHI removal.

***Define Professional Practice Gap & Educational Need:**
Cochlear implant candidacy has expanded to include patients with single-sided deafness and residual sensorineural hearing. A growing number of BAHI recipients may now meet criteria for CI placement. Due to chronic skin inflammation and/or infection, the BAHI site poses risks of infection and poor wound healing for CI surgery. The safety and efficacy of single-stage versus two-stage removal of BAHI and placement of the CI is a serious concern. The literature includes 7 reports with 17 patients that received CIs after BAHI, and 17% experienced postoperative infections. Only 1 study with 3 patients reported single-stage removal of BAHI and placement of CI, however there was no description of how to keep the contaminated BAHI site separate from CI RS. Three studies described leaving the BAHI in place. Our study is the first to describe using temporalis pocket landmarks to ensure that the CI RS is anatomically separate from the BAHI, which is important for safe single-stage conversion of BAHI to CI.

***Learning Objective:** To gain surgical technique for single-stage conversion of BAHI to ipsilateral CI.

***Desired Result:** To be able to identify landmarks that separate BAHI site from CI RS during single-stage surgery.

Level of Evidence - V

Indicate IRB or IACUC : University of Florida Institutional Review Board, IRB201903352

Iatrogenic Seeding of Cholesteatoma in Rare Planes

Enter up to 7 author names (in 2 lines) as follows:
Cameron Todd, MD; Michele Gandolfi, MD

Objective: Discuss the risk of seeding cholesteatoma during surgery, and the growth rate of recurrent disease

Study Design: Retrospective Case Report

Setting: Academic Tertiary Care Hospital

Patients: A 29 year old male who had a left tympanomastoidectomy and then staged second look with ossicular chain reconstruction for cholesteatoma 6 years prior to presenting with a left pre and post-auricular mass measuring 8.2 x 2.9 x 6cm. He was found to have cholesteatoma extending from a defect in the mastoid cavity into the pre-auricular and post-auricular soft tissue, which was felt to be recurrent disease seeded from his initial surgery.

Interventions: Combined surgical excision of the mass with facial plastic surgery and neuro-otology.

Results: To our knowledge, we present the largest iatrogenic cholesteatoma reported in the literature, and one that had explosive growth in a relatively short time period with extension into an unusual location due to presumed iatrogenic causes.

Conclusions: Our case highlights the potential to seed cholesteatoma in previously disease free areas when performing cholesteatoma surgery. It also demonstrates the aggressive nature of pediatric cholesteatomas, and is in line with the literature in that regard. The case enforces the extreme care that needs to be taken when performing cholesteatoma surgery to ensure that disease is not introduced in areas of the head and neck. It also stresses the importance of close, long term follow up for pediatric cholesteatoma given the potential for aggressive reoccurrence and growth.

***Define Professional Practice Gap & Educational Need:** To highlight key points in cholesteatoma surgery to avoid reoccurrence and discuss recommended follow up course in acquired pediatric cholesteatomas.

***Learning Objective:** 1. To emphasize techniques in cholesteatoma surgery to improve recidivism rates in cholesteatoma surgery. 2. Help broaden differentials for superficial masses in patient who have undergone cholesteatoma surgery.

***Desired Result:** Physicians should take extreme care to avoid iatrogenically seeding cholesteatoma in adjacent areas during removal of cholesteatomas and taking care to avoid placing disease in the soft tissue. Physicians should consider recurrent disease and then early intervention when masses appear near the middle ear after surgery.

Level of Evidence - V

Indicate IRB or IACUC : Exempt

Subtotal Petrosectomy with Cochlear Implantation or Osseointegrated Hearing Rehabilitation: A Single Institutional Study

Kathy Zhang, BS; Flora Yan, BA; Shaun A. Nguyen, MD
Ted A. Meyer, MD, PhD

Objective: To examine audiologic outcomes and operative considerations for patients undergoing subtotal petrosectomy followed by implantable hearing restoration.

Study Design: Retrospective review

Setting: Tertiary academic referral hospital

Patients: All patients who underwent subtotal petrosectomy and implantable hearing restoration from 2014-2020.

Interventions: Subtotal petrosectomy (STP) in a single or staged procedure with cochlear implantation (CI) or placement of a bone-anchored hearing aid (BAHA).

Main Outcome Measures: Indications for subtotal petrosectomy and staged CI or BAHA in this cohort; post-operative complication and re-operation rates; audiologic outcomes through speech recognition thresholds (SRT) and AzBio sentence scores.

Results: Twenty-six adults (age range 33-85) and six children (age range 1-17) underwent 37 STP procedures with placement of 33 CI and 4 BAHA. Twenty-five cases were single-procedure and 12 were staged, mean interval of 7 months. Indications for staged procedures included extensive cholesteatoma (n=5, 42%), chronic middle ear inflammation (n=5, 42%), and osteoradionecrosis (n=2, 17%). Six cases (16%) required revision surgery due to refractory post-auricular infection and breakdown of wound closure; Out of six revision surgeries, five were initially single-procedure and four identified intra-operative inflammation. No patients with BAHA required revision surgery. The mean SRT decreased from 79±18 dB to 31±8 dB ($p<0.001$). For patients undergoing CI, mean AzBio scores improved from 11% to 43% ($p=0.002$).

Conclusions: Subtotal petrosectomy is effective for creating a safe, dry ear in chronic inflammation or anatomically challenging cases. Rehabilitative hearing options following STP can be achieved safely, restoring hearing to an acceptable level with CI or BAHA. Careful consideration should be undertaken to approach as a single or staged procedure.

***Define Professional Practice Gap & Educational Need:** Subtotal petrosectomy has been detailed as a safe and effective procedure to obtain a dry ear for patients with chronic otitis media or anatomically unfavorable ear, however not many studies report on audiologic outcomes for these patients or technique involving STP and BAHA.

***Learning Objective:** To describe indications for staged procedure. To identify audiologic outcomes of cochlear implantation or BAHA for patients after STP; To identify factors that may lead to increased risk of post-operative complications and ex-plantation or re-implantation.

***Desired Result:** To characterize and identify operative technique, timing for staged procedures, and audiologic outcome results for patients requiring STP with CI or BAHA.

Level of Evidence - IV

Indicate IRB or IACUC: Approved by the Medical University of South Carolina Institutional Review Board. IRB Approval Pro#00098273.

Audiologic Evaluation in Patients with External Ear Abnormalities

Jennifer N. Shehan, MD; Asel Mustafa, BS
Akhil V. Uppalapati, BA; *Jessica R. Levi, MD*

Hypothesis: Children diagnosed with external ear abnormalities (EEA) do not routinely undergo recommended audiologic evaluation.

Background: Current guidelines by the American Academy of Audiology recommend that patients with EEA undergo audiologic evaluation. This study aims to determine the prevalence and demographic features of children with EEA who were referred for audiologic evaluation as well as their hearing status to better understand current and possible future guidelines.

Methods: A retrospective review at a tertiary academic medical center was performed of 723 patients ≤18 years old with EEAs (2012 -2020). Internal Classification of Diseases-9 and 10 codes were used for EEAs. Demographic factors (age, sex, race/ethnicity, language) and clinical findings (diagnoses, relevant exam, newborn hearing test results, hearing abnormalities, audiology results, surgical plan) were evaluated. Odds ratios and binary logistic regression methods were used to compare demographic factors and audiologic evaluation with a significant p value<0.05.

Results: Most patients were not evaluated by audiology (54.8%, n=396) or otolaryngology (54.8%, n=396). Patients with microtia were more likely (OR=5.025, 95% CI 2.035-17.840, p=.001) to undergo audiologic evaluation. Race/ethnicity and sex were not significant factors. Of those who had obtained audiograms, 17% (n=63) had hearing abnormalities, and conductive hearing loss was the most common hearing abnormality (n=41, 11%).

Conclusions: Most patients with EEAs do not undergo recommended evaluation. A majority of the patients evaluated do not have hearing abnormalities. Consideration should be taken to adjust evaluation guidelines for patients with EEAs.

***Define Professional Practice Gap & Educational Need:** American Academy of Audiology recommends patients with EEA for audiologic evaluation, and this guideline has not been thoroughly assessed or supported in the literature.

***Learning Objective:** To understand how to should counsel patients with EEAs in regards to audiologic and otolaryngologic evaluation.

***Desired Result:** To support or reject the American Academy of Audiology's guidelines for evaluation in patients with EEAs.

Level of Evidence – Level IV

Indicate IRB or IACUC: Exempt

Reconstruction of the Anterior External Auditory Canal with Mastoid Cortex Autologous Bone Graft

Braeden L. Lovett, BA; Sarah C. Shearer, MD; H. Jeffrey Kim, MD

Objective: To describe the surgical management of temporomandibular joint (TMJ) herniation with external auditory canal (EAC) reconstruction using autologous bone grafting from the mastoid cortex.

Study Design: Retrospective case series

Setting: A tertiary university medical center

Patients: Three patients who presented to our Otolaryngology clinic with evidence of TMJ herniation through an anterior EAC defect, both on otoscopy and computed tomography (CT) imaging.

Interventions: Reconstruction of the anterior EAC with mastoid cortex bone grafting using an endaural approach.

Main Outcome Measures: Successful reconstruction of anterior EAC bony defect without recurrence of herniation.

Results: All three patients presented with otalgia, hearing loss, and either tinnitus or a clicking sensation with jaw movement. Etiologies for TMJ herniation included osteoradionecrosis following extended beam radiation therapy (EBRT) for head and neck carcinoma and iatrogenic following multiple tympanoplasties and canalplasties. A mastoid cortex bone graft was placed and secured anterior to the bony EAC defect through an endaural approach. Two patients wore a dental retainer postoperatively to keep the condyle in an open position. After reconstruction, patients reported an improvement in their presenting symptoms. There was no recurrence of TMJ herniation in all cases after 1, 4, and 7 years, respectively.

Conclusions: Anterior EAC reconstruction with autologous bone grafting can be an effective definitive treatment in TMJ herniation. To our knowledge, this is the first report of the use of bone grafting to reconstruct the canal defect in TMJ herniation.

***Define Professional Practice Gap & Educational Need:** TMJ herniation to the anterior EAC is a rare otologic problem. Once it is properly diagnosed, the defect can be successfully reconstructed.

***Learning Objective:** Reconstruction of the anterior EAC with mastoid cortex autologous grafting

***Desired Result:** Diagnose and repair anterior EAC defects

Level of Evidence: V

Indicate IRB or IACUC: Exempt per Georgetown University Institutional Review Board

Human Otopathology in Scleroderma

Melissa Castillo-Bustamante, MD; Prithwijit Roychowdhury,BS, Dhrumi Gandhi, MS
Elliott Kozin, MD; Aaron Remenschneider, MD, MPH

Objective: Scleroderma is a chronic progressive multisystem disease that results in vascular insufficiency, collagen deposition and fibrosis. Hearing loss and vestibular dysfunction have been clinically reported in scleroderma, but evidence of systemic sclerosis within the temporal bone has not been well described. Herein, we review two cases of scleroderma from a temporal bone repository.

Study Design: Clinical case review and correlative otopathologic analysis

Methods: The national temporal bone database was reviewed for cases with scleroderma. Middle and inner ear otopathologic analysis was performed following hematoxylin and eosin staining under light microscopy. Findings were compared to age-matched controls.

Results: Two patients (three ears) with a history of serologically confirmed scleroderma were identified. Both individuals reported tinnitus and demonstrated bilateral moderate to severe down-sloping sensorineural hearing loss on audiometry. Histologically, the incudomallear joint space was diminished and ossicles appeared demineralized. A loss of hyaline and calcified cartilage, and obliteration of the incudomallear and incudostapedial joint synovial spaces was observed. Decreased caliber and intimal hyperplasia of arteries adjacent to ossicles was also identified. Mild diffuse atrophy of stria vascularis in the middle and apical turns of cochlea were found. Hair cell populations were normal. Total spiral ganglion neurons were lower in cases of scleroderma (range 29%-51%) compared to age-matched controls. Atrophic changes on the sensory epithelium of the saccule was also found.

Conclusions: Fibrosis, inflammation, and vascular changes were observed in the middle and inner ear in patients with scleroderma. Findings have implications for understanding hearing and vestibular dysfunction in this patient population.

***Define Professional Practice Gap & Educational Need:** Scleroderma (systemic sclerosis) is a multi-systemic disease characterized by small vessel vasculopathy and diffuse fibrosis. Clinical studies have reported hearing loss as an uncommon manifestation of scleroderma. The pathogenesis of hearing loss in scleroderma is poorly understood.

***Learning Objective:** Participants will gain an understanding of systemic, audiologic and vestibular symptoms in scleroderma (systemic sclerosis) with correlation to human temporal bone histopathology.

***Desired Result:** Following this presentation, participants will be better able to identify relevant audiovestibular symptoms in patients with scleroderma with histopathologic correlations; such an understanding has implications for management of patients with scleroderma.

Level of Evidence: Level IV

Indicate IRB or IACUC: MEE IRB: 2019P003755

Audiometric Outcomes of Endoscopic and Microscopic Ossiculoplasty

Mark Sakai, MD; Daniel E. Killeen, MD; Jonathon Korpon, MD; Connie Ma
Jacob B. Hunter, MD; Brandon Isaacson, MD; Joe Walter Kutz, MD

Objective: To assess endoscopic and microscopic ossiculoplasty audiometric outcomes

Study Design: Retrospective Review

Setting: Tertiary Academic Center

Patients: Adult patients who underwent ossiculoplasty with either partial ossicular replacement prosthesis (PORP) or total ossicular replacement prosthesis (TORP) from 2010 to 2019 with at least one year of audiometric follow-up

Interventions: Endoscopic or microscopic ossiculoplasty

Main Outcome Measures: Post-operative Air-Bone Gap (ABG) after at least 1 year.

Results: A total of 198 patients, 53.5% female, and a median age of 47.5 years (18-88), met inclusion criteria. Overall, 64.1% of patients were reconstructed with a PORP, and 65.2% of all patients underwent microscopic ossiculoplasty, compared with endoscopic ossiculoplasty in 34.8%. The median audiometric follow-up was 27 months (12-122). The median post-operative ABG was 16.9 dB (-0.6-66.9) overall, 15.6 dB (-0.6-65.6) for PORP reconstruction and 19.4 db (2.5-66.9) for TORP reconstruction (PORP vs. TORP, p=0.002). For TORP reconstructions, the median ABG for endoscopic TORP was 19.4 dB (6.9-59.4) compared to 19.4 dB (2.5-66.9) for microscopic TORP (p=0.92). For PORP reconstructions, the median ABG for endoscopic PORP was 13.1 dB (1.3-37.5) compared to 16.3 dB (-0.6-65.6) for microscopic PORP (p=0.03). Using multivariate linear regression to predict post-operative PORP ABG, and controlling for ipsilateral middle ear atelectasis, ipsilateral myringitis, any previous contralateral middle ear disease, and a diagnosis of diabetes, endoscopic PORP was associated with improvement in ABG by 4.8 dB (p=0.02), while prior ipsilateral ossiculoplasty was associated with worsening of ABG by 5.5 dB (p=0.03).

Conclusions: Endoscopic ossiculoplasty is associated with improved ABG, while previous ipsilateral ossiculoplasty was associated with worse ABG for PORP reconstruction.

***Define Professional Practice Gap & Educational Need:** There is limited data on audiometric outcomes following endoscopic ossiculoplasty, as well as comparing them to microscopic ossiculoplasty outcomes, which will allow evaluation of potential factors that could influence outcomes.

***Learning Objective:** Identify factors that may influence ossiculoplasty outcomes, specifically looking at endoscopic compared to microscopic approaches.

***Desired Result:** To better elucidate factors that may influence ossiculoplasty outcomes in order to improve future ossiculoplasty outcomes.

Level of Evidence – Level IV

Indicate IRB or IACUC: IRB #STU- 2019-1673, UT Southwestern.

The Effect of Cochlear Implantation on Tinnitus and Quality of Life: A Systematic Review and Meta-analysis

Cheng Ma, BS; Erick Yuen, BA; Shaun A. Nguyen, MD
Ted A. Meyer MD, PhD; Paul R. Lambert MD

Objective: To explore the effect of cochlear implantation (CI) on tinnitus and quality of life.

Data Sources: Pubmed, SCOPUS, Web of Science, and Cochrane Library were searched through August 21, 2020 using a combination of subject headings and keywords related to cochlear implantation (CI) and tinnitus.

Study Selection: English articles reporting on pre-intervention tinnitus-related patient-reported outcome measures (e.g. Tinnitus Handicap Inventory [THI], Tinnitus Questionnaire [TQ], Visual Analogue Scale [VAS] for loudness, etc) and quality of life measures (e.g. Nijmegen Cochlear Implantation Questionnaire [NCIQ] and Hospital Anxiety and Depression Scale [HADS]) for CI recipients were included.

Data Extraction: Demographics, baseline, and follow-up outcomes data.

Data Synthesis: Meta-analysis of continuous variables and proportions were performed for the included studies. A total of 27 articles reporting on 1,285 patients (mean age 54.5 years, range 14-81) were included. Meta-analysis of all tinnitus-related measures demonstrated improvement following implantation, with a mean difference of -23.2 [95% CI: -28.8 to -17.7], -12.6 [95% CI: -17.5 to -7.8], and -4.5 [95% CI: -5.5 to -3.4], ($p < 0.05$ for all) for THI, TQ, and VAS, respectively. NCIQ increased 12.2 points [95% CI: 8.2 to 16.2], ($p < 0.05$), indicating improved quality of life among CI recipients. Psychological comorbidities were also ameliorated, as evidenced by reductions in HADS depression (-1.7 [95% CI: -2.4 to -0.9]) and anxiety (-1.3 [95% CI: -2.1 to -0.5]), ($p < 0.05$ for both) scores.

Conclusions: Following CI, patients reported significant improvement in tinnitus via several validated questionnaires. Additional benefits include improved quality of life and reduction in psychological comorbidities.

Define Professional Practice Gap & Educational Need: Lack of understanding of the secondary benefits of cochlear implantation on patients with hearing loss with concurrent tinnitus and its effect on quality of life.

Learning Objective: To understand how cochlear implantation improves tinnitus-related symptoms and quality of life in patients with hearing loss requiring CI and compare pre-operative and post-operative tinnitus outcome measures.

Desired Result: Attendees will: (1) understand how cochlear implantation improves tinnitus in patients with concurrent hearing loss; 2) understand how a reduction in tinnitus symptoms relates to improved quality of life as reported by patients

Level of Evidence – Level II

Indicate IRB or IACUC: Exempt

Characterization of Vestibular Test Results in Patients with Horizontal Canal Benign Paroxysmal Positional Vertigo (BPPV)

Eric K. Kim, BA; Lauren Pasquesi, AuD; Kristen Steenerson, MD; Jeffrey D. Sharon, MD

Objective: Analyze vestibular test results of patients with horizontal canal BPPV with ageotropic nystagmus (AHC) and geotropic nystagmus (GHC) in comparison to patients with posterior canal BPPV (PC).

Study Design: Retrospective chart review.

Setting: Tertiary referral center.

Patients: Adults with BPPV from 1/1/2015 to 6/30/20.

Interventions: We reviewed patient questionnaires, notes, and testing results of patients with BPPV.

Main Outcome Measures: We compared caloric tests, subjective visual vertical (SVV)/ Subjective visual horizontal (SVH), and vestibular evoked myogenic potential (VEMP) results between groups.

Results: We included 11 AHC and seven GHC patients and randomly selected 20 PC patients as the comparison group. All groups had a high rate of migraines but no difference between groups (3/10 AHC, 5/7 GHC, 10/20 PC). Ipsilateral caloric weakness was more prevalent in AHC and GHC groups compared to the PC group ($p=0.01$). One of two AHC patients and both GHC patients who had SVV/SVH testing had abnormal findings. The only AHC patient who had ocular VEMP testing had abnormal results. Additionally, we observed significant downbeating nystagmus (4 deg/sec or greater) exclusively in the AHC group (5/10 patients).

Conclusions: We demonstrated that patients with AHC and GHC have unique vestibular testing results, including ipsilateral caloric weakness and abnormal SVV/SVH results. Furthermore, only AHC patients showed downbeating nystagmus.

***Define Professional Practice Gap & Educational Need:** Insufficient literature examining the vestibular testing results in patients with horizontal canal BPPV.

***Learning Objective:** Describe the vestibular test patterns of AHC and GHC patients.

***Desired Result:** Identify patterns of clinical factors and vestibular test results that can help providers better identify and gain a deeper understanding of the pathogenesis of horizontal canal BPPV.

Level of Evidence - III

IRB: Approved 2/12/19, UCSF IRB 18-25365

Middle Ear Adenoma: A Systematic Review

Peter E. Ashman, MD; Andrew R. Magdich, BS; Zachary T. Grace, BS
Guy Talmor, MD; Brian Benson, MD; Dennis I. Bojrab II, MD; Peter F. Svider, MD

Objective: To perform a systematic review of the diagnosis, treatment, and prognosis of patients with a middle ear adenoma (MEA).

Data Sources: PRISMA guidelines were followed and the PubMed, Embase, Cochrane databases were searched from January 1, 1960 to July 1, 2020 with the following terms: [(middle ear) OR (adenoma) OR (otology) OR (neuroendocrine adenoma)].

Study Selection: Studies reporting on patients diagnosed with MEA detailing patient characteristics, diagnosis, management, and prognosis were included. Excluded studies were either non-English, not relevant to search terms or examined irrelevant parameters, or reported on non-human populations.

Data Extraction: All studies were assessed for quality and risk of bias either via the Modified Newcastle-Ottowa Scale for non-comparative studies or the Methodological Index for Non-Randomized Studies (MINORS) criteria for non-randomized studies. Data were collected on patient demographics, presenting signs and symptoms, diagnosis, treatment and management, as well as prognosis and recurrence.

Data Synthesis: Seventy-seven articles encompassing 250 patients met inclusion criteria including sixty-four case reports, seven case series, and seven retrospective reviews. Descriptive statistics were used to organize the data for further analysis.

Conclusions: Hearing loss and a middle ear mass are the most common presenting manifestations of MEA. Facial nerve involvement is rare but can occur more than expected. Primary treatment consists of surgical resection. Radiation and chemotherapy have little role in this disease. Recurrence is uncommon but can occur with incomplete resection.

***Define Professional Practice Gap & Educational Need:** 1) Need for systematic literature review of this rare tumor 2) Lack of awareness of this rare tumor when formulating a differential of a middle ear/mastoid mass. 3) Lack of awareness of diverse nomenclature regarding middle ear adenomas 4) Unclear long-term prognosis of this rare tumor

***Learning Objective:** 1) To learn about an uncommon disease entity and its presentation, diagnosis, treatment, and management. 2) To learn to differentiate neuroendocrine tumors 3) To learn history of nomenclature regarding middle ear adenomas 4) To understand further the prognosis of this rare tumor

***Desired Result:** Attendees will use the information obtained from this presentation to help diagnose and manage this uncommon tumor. They will also be able to differentiate neuroendocrine tumors of the middle ear based on staining and pathologic examination. They will learn about the prognosis and recurrence of MEA.

Level of Evidence – N/A

Indicate IRB or IACUC: Exempt

The Top 100 Cited Articles in Otology and Neurotology

Omid S. Dehghan; Kotaro Tsutsumi, BA; Khodayar Goshtasbi, MS
Elaine Martin, MD; Ethan Muhonen, MD; Mehdi Abouzari, MD, PhD; Hamid R. Djalilian, MD

Objective: To perform a bibliometric analysis of top 100 cited *Otology and Neurotology* (*O&N*) articles and elucidate important research topics and trends over the past 40 years.

Data sources: Articles published in the *O&N* Journal (previously American Journal of Otology) from 1980-2020 were identified through the Scopus database and evaluated.

Study selection: Top 100 articles ranked by citation rate were selected. All types of articles were included.

Data extraction: Articles were assessed for year of publication, subjects and types of study, country of origin, and affiliated institutions.

Data Synthesis: A total of 5430 *O&N* articles published between 1980-2020 were reviewed and top 100 cited studies (1.8%) were identified. Year 2001 and 2004 had most highly cited studies (n=13 each). Topics of discussion in top 100 were heavily weighted towards cochlear implants (n=38), vestibular disorders (n=15), and sensorineural hearing loss and tinnitus (n=11). Top 3 countries with highest numbers of articles published included U.S. (n=56), United Kingdom (n=11), and Australia (n=9). The top 5 contributing institutions included Massachusetts Eye and Ear Infirmary (n=13), Johns Hopkins University (n=7), University of Washington (n=6), University of California San Francisco (n=3), and University of Sydney (n=2). After adjusting the citation ranking for year of publication, 39 of the original top 50 studies (78%) remained among the adjusted top 50 highly cited studies.

Conclusions: This study provides important historical and topical trends within the top 100 articles of *O&N*, providing otolaryngologists and other research scientists with a better comprehension of the developments and discoveries regarding otology and neurotology topics.

Define Professional Practice Gap & Educational Need: Bibliometric analyses of journals could present researchers and physicians with a broad perspective on general trends of their respective fields. This applies to the fields of otology and neurotology as well, and a need for a bibliometric analysis of the *O&N* Journal is warranted.

Learning Objective: To explain prominent research topic and trends within the *O&N* Journal through identification of its top 100 cited articles.

Desired Result: Informing otologists of important research topics and trends in the fields of otology and neurotology over the past 40 years.

Level of Evidence – N/A

Indicate IRB or IACUC: Exempt

Optimal Number of Intratympanic Steroid Injections in Sudden Sensorineural Hearing Loss

Ariel Lee, BS; Mehdi Abouzari, MD, PhD; Adwight Risbud, BS
Janice T. Chua, BS; Emily Nguyen, BS; Elaine Martin, MD; Hamid R. Djalilian, MD

Objective: To identify the optimal number of intratympanic steroid injections for treatment of sudden sensorineural hearing loss (SSNHL).

Study design: Retrospective chart review.

Setting: Tertiary care neurotology clinic.

Patients: Patients presenting to a referral otology clinic with SSNHL were included. All patients received at least two intratympanic steroid injections.

Interventions: Prednisone 1 mg/kg (up to 80 mg) daily for 7 days and a 6-day taper. In addition, all patients were injected with dexamethasone 10 mg/mL intratympanically at least twice, on a frequency of 2 times a week. If there was improvement in the word discrimination (>15%), at least 10 dB improvement in two adjacent frequencies, or a subjective qualitative improvement reported by the patient, a third injection was given. Injections were continued until there was no change from one visit to the next.

Main outcome measure(s): Post-injection improvements in hearing thresholds, low and high-frequency pure tone average (PTA), word recognition score (WRS), and speech recognition threshold (SRT).

Results: 106 patients (43% female) with a mean age of 62 years were included. Post-third steroid injection hearing thresholds significantly improved at 250 Hz (p=0.02), 500 Hz (p=0.01), 1000 Hz (p<0.001), 2000 Hz (p=0.03), and 4000 Hz (p=0.03). Low-frequency PTA (p<0.001), high-frequency PTA (p=0.03), WRS (p=0.02), and SRT (p=0.04) were also significantly improved after third injection. The improvement after the third injection was greater than the improvement after the first or second injections. Detailed data on pre- and post-each injection will be presented.

Conclusions: Intratympanic dexamethasone injections significantly improved hearing frequencies, low- and high-frequency PTA, WRS, and SRT, after the third injection. These findings suggest that the three IT steroid injections are optimal for the treatment of SSNHL.

Define Professional Practice Gap & Educational Need: Although the effectiveness of treatment of SSNHL with IT steroid injections has been clearly studied, the number of injections has not been clearly identified. For this reason, a need to educate clinicians on the clinical efficacy of a specific number of IT steroid injections for SSNHL is warranted.

Learning Objective: To propose an evidence-based best practice in treatment of SSNHL patients.

Desired Result: Informing clinicians of an evidence-based practice that can inform better treatment for patients with SSNHL.

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.

Risk Factors Associated with Development of Post-Craniotomy Headache after Retrosigmoid Resection of Vestibular Schwannoma

Yin Ren, MD, PhD; Marin A. McDonald, MD; Paul Manning, MD; Bridget V. Macdonald, BS
Marc S. Schwartz, MD; Rick A. Friedman, MD, PhD; Jeffrey P. Harris, MD, PhD

Objective: Dispersion of bone dust in the posterior fossa during retrosigmoid craniectomy could lead to meningeal irritation and development of persistent headaches. We aim to determine risk factors, including whether the presence of bone spicules, that influence postoperative headaches after retrosigmoid resection of vestibular schwannoma.

Study Design: Retrospective case series.

Setting: Tertiary skull-base referral center.

Patients: Adult patients undergoing VS resection between November 2017 and February 2020.

Interventions: Retrosigmoid craniectomy.

Main Outcome Measures: Development of persistent post-operative headache lasting ≥ 3 months.

Results: Of 64 patients undergoing surgery, 49 had complete data (mean age, 49 years; 53% female). Mean follow-up time was 1.4 years. At latest follow up, 16 (32.7%) had no headaches, 14 (28.5%) experienced headaches lasting < 3 months, 19 (38.8%) reported persistent headaches lasting ≥ 3 months. Twenty-seven (55.1%) patients had posterior fossa bone spicules detectable on postoperative CT. Age, gender, body-mass index, length of stay, tumor diameter, size of craniectomy, the presence of posterior fossa bone spicules or the amount of posterior petrous temporal bone drilled did not differ significantly between patients with persistent headaches and those without. On multivariate logistic regression, patients with persistent headaches were less likely to have preoperative brainstem compression by the tumor (Odds ratio [OR]=0.21, p=0.028) and more likely to have higher opioid requirements during hospitalization (OR=1.023, p=0.045).

Conclusions: The presence of bone spicules in the posterior fossa did not contribute to headaches following retrosigmoid VS resection. Preoperative brainstem compression may be associated with a decreased risk of persistent headaches.

***Define Professional Practice Gap & Educational Need:** The incidence of post-craniotomy headache after retrosigmoid approach to vestibular schwannoma resection is variable. The exact cause of these headaches is still poorly understood. It has been hypothesized that chemical meningitis from bone dust in the subarachnoid space of posterior fossa may result in persistent headaches. Therefore, there is a need to better define risk factors for the development of headaches after retrosigmoid resection.

***Learning Objective:** To characterize the intensity, frequency, and duration of post-craniotomy headaches and determine risk factors that are associated with the development of persistent headaches lasting more than three months after surgery.

***Desired Result:** Neurotologists and skull-base neurosurgeons will better understand the rate of post-craniotomy headaches after retrosigmoid resection of vestibular schwannomas and identify risk factors associated with headaches.

Level of Evidence – Level IV

Indicate IRB or IACUC : IRB approval was acquired before data collection (University of California San Diego IRB 180978XL, approved October 2018).

Healthcare Utilization following Different Modalities of Cholesteatoma Surgery United States 2003-2019

Z. Jason Qian, MD; Jennifer C. Alyono, MD; Alan G. Cheng, MD
Iram N. Ahmad, MD; Kay W. Chang, MD

Objective: To describe national trends in cholesteatoma management.

Study Design and Setting: Retrospective analysis Optum Clinformatics® Database from 2003-2019.

Patients: 16,179 unique patients who received cholesteatoma surgery.

Interventions and Main Outcome Measures: Patients were categorized into three groups by initial surgical modality: trans-tympanic (TT), canal wall up mastoidectomy (CWU), and canal wall down mastoidectomy (CWD). Four major comparisons between groups were performed: 1) temporal trends, 2) clinical and sociodemographic determinants, 3) total healthcare costs before and after, and 4) utilization of surveillance imaging and subsequent surgeries.

Results: Overall, 32.5% received initial TT surgery, 44.3% CWU, and 23.2% CWD. 1) The incidence of initial CWU surgery increased ($p<0.050$) while CWD decreased ($p<0.050$) and TT remained stable ($p=0.084$) over time. 2) Relative to CWU, age<18, prior complicated diagnoses, and non-white race were negatively predictive of TT ($p<0.050$ each), while annual household income >$100K was positively predictive of TT (aOR=22.90, 95%CI [2.74,43.06], $p=0.026$). Contrastingly, age>18 and non-white race were positively predictive of CWD compared to CWU ($p<0.050$ each) while income had no effect. 3) For preop costs, TT<CWU<CWD ($p<0.050$ each). While for postop costs, CWU=CWD ($p=0.852$), while TT was less than both ($p<0.050$ each). 4) In patients with at least six years of continuous enrollment, post-op imaging and/or subsequent surgery was performed in 41.62% of TT, 57.42% of CWU, and 45.48% of CWD patients.

Conclusions: Rates of postoperative imaging and second look surgery are less than expected for non-CWD surgery. Socioeconomic difference in care were observed.

***Define Professional Practice Gap & Educational Need:** Management of cholesteatoma remains controversial and assessment of national practice patterns is critical for defining areas for overall improvement.

***Learning Objective:** Utilization of imaging and operative surveillance after trans-tympanic and canal wall up cholesteatoma surgery is lower than is expected, while canal wall down surgery may not be as definitive as traditionally thought.

***Desired Result:** To provide awareness of national patterns in cholesteatoma management and help otologists be cognizant of factors associated with deviations from best practices.

Level of Evidence – Level V

IRB: Exempt

Analysis of the Characteristics and Co-Morbidities of Patients with Pseudohypoacusis

Benjamin D. Liba, MD; Paige M. Pastalove, AuD
Pamela C. Roehm, MD, PhD

Objective: Across the world the inability to hear affects millions of people and results from many causes, including, congenital disorders, acoustic trauma, infection, and aging. Pseudohypoacusis or non-organic hearing loss is an underdiagnosed disorder which can occur fairly frequently and which can lead to inappropriate medical and surgical therapy. Our study analyzed a series of patients with this issue to better identify the characteristics of these patients and to shed light on this understudied issue.

Study Design: Retrospective chart review

Setting: Otolaryngology Clinic of a Tertiary Referral Center

Patients: Patients with diagnoses of pseudohypoacusis, functional hearing loss, or non-organic hearing loss

Main Outcome Measures: Pure tone averages, speech reception thresholds, word recognition scores, auditory brainstem response waveforms.

Results: Our review yielded 28 patients with evidence of pseudohypoacusis. The majority of these patients were female (n= 21, 75%) and showed bilateral non-organic hearing loss (n=14, 50%). Many patients suffered from a coexisting psychiatric disorder (n=13, 46%) with depression and anxiety occurring most frequently. In those patients in which auditory brainstem responses (ABR) were obtained the average difference between pure tone average and ABR were statistically significant at an average of 44 dB ±27 (p=0.0002) for the left ear and 43 dB ±19 (p=0.0009) for the right ear

Conclusions: Pseudohypoacusis is an issue that is more common than might be realized and is often associated with co-morbid psychiatric issues. Recognizing these patients therefore carries increased importance to ensure they are receiving appropriate treatment for their disorder.

Define Professional Practice Gap & Educational Need: To better understand and identify those patients presenting with functional hearing loss.

Learning Objective:
To be able to diagnose patients with pseudohypoacusis
To understand the co-morbidities and that these patients typically exhibit

Desired Result:
Improved understanding of the diagnostic criteria and underlying comorbidities associated with pseudohypoacusis

Level of Evidence – Level IV

Indicate IRB or IACUC : Temple University Hospital IRB Protocol 26091

Resource Utilization and Outcomes in Mastoidectomies between 2007-2015 in Adult Patients

Rahul K. Sharma BS; Alexander Chern MD; Anil K. Lalwani MD

Objective: Over the past several decades, mastoid surgery has become a routine outpatient procedure, reducing hospital spending and increasing patient comfort during recovery; however, this has not always been the case. We aim to examine the effect of hospital volume on same-day discharge and readmission rates for mastoidectomies in New York State over time.

Study design: Longitudinal Cohort Study

Setting: New York State Insurance Claims Database

Patients: Patients receiving a Mastoidectomy between 2007-2015

Intervention: None

Main outcome measure(s): 30-day readmission rates, Same-day discharge

Results: 9,948 unique mastoidectomy claims were analyzed in the New York Statewide Planning and Research Cooperative System (SPARCS) database. High-volume centers were defined as >=75th percentile of procedures/year (78 procedures/year) and were compared to lower-volume centers (<75th percentile). The proportion of same-day discharges increased from 85% in 2007 to 93% in 2015 ($p < 0.01$). High-volume centers had increased odds of same-day discharge compared to the comparison group (OR 1.13, 95% 1.10-1.15, $p < 0.001$) on multivariable logistic regression models after controlling for covariates (complications, year of surgery, pathologies, age, sex, race and comorbidities). High-volume centers had a lower risk of 30-day readmissions (OR 0.56, 95% CI 0.32-0.97, $p=0.042$) after controlling for covariates.

Conclusions: Same-day discharge rates have increased in New York State between 2007-2015, with high volume centers more likely performing ambulatory surgery compared to lower volume centers. High volume centers have a lower likelihood of 30-day readmission rates despite higher rates of same-day discharges.

Define Professional Practice Gap & Educational Need: Mastoidectomy has largely become an outpatient procedure over the past several decades. Understanding the adoption of same-day discharge in New York State, and its effect on readmission rates, will help us define clinical guidelines.

Learning Objective: After this presentation, the learner will be able to describe the relationship high-volume centers, same-day discharge, and 30-day readmission rates for mastoidectomies in New York state

Desired Result: Otolaryngologists will better understand the effect of high-volume centers on resource utilization and outcomes in mastoid surgery.

Level of Evidence – Level III

Indicate IRB or IACUC: Approved IRB-AAAT2769

Tympanoplasty Healing Outcomes

Casey L. Kolb, Carolyn O. Dirain, PhD, Patrick J. Antonelli, MD

Objective: Tympanoplasty is usually successful for perforation closure, but postoperative healing may be suboptimal. The aim of this study is to quantify rates of normal and suboptimal healing outcomes with tympanoplasty.

Study Design: Retrospective chart review

Setting: Academic, tertiary hospital

Patients: 101 randomly selected patients that had tympanoplasty

Interventions: Observation only

Main Outcome Measures: Postoperative healing problems (eg, granulation tissue, perforation, myringitis, bone exposure, lateralization, medial canal fibrosis, and lateral canal stenosis) and hearing outcomes up to 2 years postoperatively.

Results: 78 patients had 1 to 2-year postoperative data. 52 subjects (67%) had no healing or postoperative issues, 19% had adverse healing outcomes (perforation 6.4%, granulation tissue 6.4%, medial fibrosis 3.8%, and myringitis, bone exposure, webbing, lateralization, and lateral stenosis (all 1.3%), and 14% have other post-op issues such as otorrhea (11.5%), otitis externa(9%), otitis media (1.3%), and atelectasis (2.6%). Air-bone gap at 1 to 2-years did not differ between these three groups (p=0.87).

Conclusions: Despite a high success rate of perforation closure with tympanoplasty, a considerable percentage of patients developed adverse healing events. Fortunately, these healing issues did not significantly compromise hearing 1 to 2-year post-op. Opportunity remains to improve wound healing with tympanoplasty.

Define Professional Practice Gap & Educational Need: Tympanoplasty is routinely performed to treat a variety of diseases and improve hearing. While success rates are high, healing can be complicated in a range of ways. All of tympanoplasty healing sequelae may cause poor hearing, persistent infection, and require additional surgery. Thus, it is important to assess the adverse healing outcomes with tympanoplasty to further improve outcomes.

Learning Objective: At the conclusion of this presentation, the attendees will learn that tympanoplasty is commonly associated with complicated healing.

Desired Result: Attendees may be able to apply this knowledge by considering the potential adverse impact of tympanoplasty on healing outcomes when performing tympanoplasty and thereby seek to refine techniques to improve these outcomes.

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

Indicate IRB or IACUC: This study has been approved by the University of Florida IRB #201901717

Bezold's Abscess with Lateral Skull Base Osteomyelitis, Lemierre's Syndrome and Dural Sinus Thrombosis

Mahnoor S. Khan, MD; Nicholas W. Pritchard, MD, MA; Kestutis P. Boyev, MD

Objective: We present a severe case of malignant otitis externa resulting in a Bezold's abscess (BA), dural venous sinus thrombosis and Lemierre's Syndrome in a patient with multiple contributing comorbidities.

Study Design: Case Report

Setting: Tertiary Referral Center

Patients: A 53-year-old female with a past medical history is notable for heavy tobacco use, previous right sided mastoidectomy due to recurrent ear infections, uncontrolled DM type 2, schizophrenia.

Interventions: Radical mastoidectomy with mastoid obliteration and a left neck exploration and wash out. Initiation of broad spectrum antibiotics, which were later tailored to intra operative cultures.

Main Outcome Measures: CT imaging with extensive osseous destruction throughout the left temporal bone, large abscess adjacent to the left sternocleidomastoid muscle, extensive dural venous thromboses throughout the left sigmoid and transverse sinuses, along with a venous thrombus of the left internal jugular vein.

Results: Patient was transferred from an outside hospital to be evaluated for left sided otalgia and otorrhea with concerns for lateral skull base osteomyelitis. The patient was initially found to have otorrhea and otalgia six weeks prior and was treated with a ten-day course of oral and otic antibiotics and was lost to follow up. She presented with anterior displacement of the left auricle due to swelling and erythema of the mastoid which tracked inferiorly along the sternocleidomastoid (SCM) muscle. She was noted to have a large area of firm induration superficial to the SCM with a diameter of four cm. CT showed extensive dural venous thromboses throughout the left sigmoid and transverse sinuses, along with a venous thrombus of the left internal jugular vein. Patient was discharged with IV Zosyn and PO doxycycline to an outside hospital one month post-operatively. Patient followed up one month after discharge with well healed incisions and reported antibiotic compliance.

Conclusions: Our report highlights the need for serious appraisal and timely management of common ear infections in immunocompromised psychiatric patients.

***Define Professional Practice Gap & Educational Need:** BA is an extremely rare complication of otitis media and mastoiditis with only 41 cases recorded in the literature between 1975-2014. However, the pathology of mastoiditis can occur by other infectious processes such as malignant otitis externa (MOE). Those in immunocompromised states may have an unusual and severe presentation with atypical organisms as the culprit of their disease. This case reports is only the second case of MOE induced BA and the first complicated by dural venous sinus thrombosis and Lemierre's Syndrome.

***Learning Objective:** To elucidate that BA can occur as a result of otitis externa with serious complications resulting from patient comorbidities.

***Desired Result:** An elevated level of suspicion is needed for smokers, diabetics, the elderly and those with psychiatric illness.

Level of Evidence - Level V

Indicate IRB or IACUC : Case report/did not require

Susceptibility to Cisplatin-Induced Hearing Loss in Mice within the Hybrid Mouse Diversity Panel

Tammy B. Pham, BA; Danielle M. Gillard, MD; Ely Cheikh Boussaty, PhD
M. Eileen Dolan, PhD; Rick A. Friedman, MD, PhD

Objective: To use the Hybrid Mouse Diversity Panel (HMDP) to study the phenotypic variation and genetic susceptibility of cisplatin-induced hearing loss (CIHL).

Background: Cisplatin-based chemotherapy for solid tumors is associated with permanent bilateral hearing loss. The mouse is an excellent animal model for the study of human deafness because the mouse cochlea is anatomically similar to that of humans, and the genes related to hearing loss are highly conserved. Inbred mouse genome wide association studies (GWAS) can be used as a model for the study of CIHL.

Methods: Thirty-one HMDP strains underwent Auditory Brainstem Response testing at baseline and seven days after administration of 15mg/kg intraperitoneal cisplatin. Hearing threshold shifts were determined at 4, 8, 12, 16, 24 and 32 kHz. Efficient Mixed-Model Association algorithm was applied to phenotypes at 12, 16, and 24 kHz separately to identify genetic associations for each frequency.

Results: We observed variation in CIHL susceptibility at each tested frequency. We identified one significant genome-wide association on chromosome 7, where the single nucleotide polymorphism (SNP) rs48373903 was significant at more than one frequency. Regional mapping reveals several genes associated with membrane transport and oxidation reduction reactions associated with this SNP.

Conclusions: Our results provide the first large scale phenotypic data on cisplatin-sensitivity in mice. We demonstrate clear strain variation in sensitivity and highlight the genetic component of CIHL using HMDP mouse GWAS. The methods used in this study provide a potential resource for the study of specific genes that may be associated with CIHL.

Professional Practice Gap & Educational Need: There remains no FDA-approved agent to reduce CIHL for patients who receive cisplatin. A greater understanding of the genetics of CIHL will facilitate the development of potential otoprotective agents as well as allow *a priori* identification of those of individuals who are at a greater risk of CIHL who might be offered reduced dose regimens or alternative therapies when possible.

Learning Objectives: To appreciate the large variation in susceptibility to CIHL across strains in the HMDP. To understand the promising utility of HMDP mouse GWAS in guiding candidate gene selection for the study of CIHL susceptibility.

Desired Result: To encourage use of HMDP mouse GWAS to guide candidate gene selection for the study of CIHL susceptibility.

Level of Evidence - Level III

Indicate IRB or IACUC: The Institutional Care and Use Committee (IACUC) at the University of California, San Diego, approved the animal protocol for the HMDP strains (Protocol #S17178).

Primary non-Hodgkin Lymphoma of the External Auditory Canal: Case Report

Sarah A. Schmoker, MD; Steven D. Curry, MD, MPH; Jonathan L. Hatch, MD

Objective: To describe a rare presentation of non-Hodgkin lymphoma (NHL) isolated to the external auditory canal (EAC) and mastoid.

Study Design: Case report and review of the literature.

Setting: Tertiary care academic medical center.

Patient: A 62-year-old female.

Main Outcome Measures: Imaging studies, biopsy for analysis of histopathology and tumor markers.

Case Report: A 62-year-old woman was referred to the otolaryngology clinic for right EAC mass. She presented with right aural fullness, hearing loss, and otalgia without otorrhea for 8 months. Exam revealed a mass obstructing the canal and impeding a view of the tympanic membrane (TM). Pure tone audiometry in the right ear showed mild sloping to profound mixed hearing loss. Temporal bone CT demonstrated a 2 cm solid mass in EAC with erosion of the mastoid air cells, posterior EAC and of the sigmoid plate. Incisional biopsy of the mass was performed. Histopathology exam was consistent with diffuse large B-cell non-Hodgkin lymphoma (DLBCL). FISH cytogenetics were negative for BCL2, BCL6, and C-MYC. Clinical staging PET/CT and bone marrow biopsy showed no evidence of malignancy outside of the EAC and temporal bone. She was referred to the hematology-oncology service and LP was negative for CNS involvement. She is undergoing treatment with R-CHOP regimen.

Discussion: Although primary tumors of the EAC are rare, hematologic malignancy should be considered in the differential diagnosis of an EAC mass lesion. NHL makes up 10% of head and neck cancers and presents with extranodal involvement in up to 40% of cases. DLBCL is the most common subtype of NHL and is characterized by aggressive tumor growth. Nonspecific symptoms of aural fullness, otalgia, and hearing loss make early diagnosis challenging, but diagnostic workup supplemented by imaging and biopsy can guide the correct diagnosis for this rare malignancy.

Define Professional Practice Gap & Educational Need: Common causes of EAC obstruction and associated conductive hearing loss such as cerumen impaction are frequently seen in the otolaryngology clinic, but other less common etiologies such as hematologic malignancy are possible, even in the absence of signs and symptoms beyond the ear or previously identified malignancy.

Learning Objective: Understand that hematologic malignancies, such as non-Hodgkin lymphoma, can present as isolated masses of the external ear canal.

Desired Result: At the conclusion of this presentation, the participants should be able to recognize the presentation of hematologic malignancies of the ear and temporal bone, and understand the appropriate diagnostic workup required.

Level of Evidence - Level V

Indicate IRB or IACUC: Exempt

Image Analysis of Otosclerosis Using Artificial Intelligence

Susanna Betti, BS; Ron DeSpain, BS; Kirolos Georges, BA; Aatin Dhanda, BA
Mary George, BA; Alicia Quesnel, MD; Robert W. Jyung, MD

Objective: Image analysis using artificial intelligence (AI) has great potential to classify temporal bone histopathology. Human input for such tasks is prone to subjectivity. We assessed the capability of AI to detect regional differences within otosclerotic lesions corresponding to accepted criteria that differentiate active and inactive regions.

Study Design: ImageJ/Trainable Weka Segmentation (TWS) were used to create models to analyze photomicrographs of otosclerotic lesions (n=7). These models were designed to distinguish otosclerotic bone of pink (eosinophilic) or purple (basophilic) hue imparted by H&E staining. To validate this method of separation, we quantified microvessel density (MVD) and percentage occupancy of pseudovascular spaces. Manual vessel counts were divided by surface area to generate MVD.

Patients: Temporal bone cases had been obtained from the Massachusetts Eye and Ear Infirmary and the House Ear Clinic according to protocol. Specimens were processed with conventional H&E staining for light microscopy and anonymized for analysis.

Results: TWS was able to delineate otosclerotic regions from surrounding normal bone matrix as well as pseudovascular spaces from otosclerotic bone. TWS reliably differentiated eosinophilic and basophilic regions within otosclerotic foci, allowing comparative analysis. With H&E criteria alone, we found no significant differences in terms of total pseudovascular space area or percent occupancy of pseudovascular space between eosinophilic and basophilic regions. We did discover significantly higher MVD in basophilic regions.

Conclusions: TWS is a powerful tool for analysis of otosclerotic lesions and can provide a more quantitative evaluation of pathologic features of disease activity, such as pseudovascular spaces. Further refinement is required.

Define Professional Practice Gap & Educational Need: To determine if automated segmentation/AI can reliably differentiate active from inactive otosclerosis.

Learning Objective: To educate the learner on the value of AI for analysis of temporal bone pathology.

Desired Result: Increased understanding and acceptance of AI driven technology to assist in analysis of temporal bone pathology.

Level of Evidence: Level V

Indicate IRB or IACUC: Exempt

Classification of Advanced Otosclerosis and Bone Conduction Outcomes of Stapedotomy

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

Objective: To examine the degree of advanced otosclerosis on outcomes of bone conduction (BC) thresholds

Study Design: Retrospective chart review

Setting: Single tertiary care center

Patients: Adult patients undergoing primary stapedotomy with advanced otosclerosis

Interventions: Stapedotomy

Main Outcome Measures: Pre- and postoperative bone conduction threshold means based on frequencies of 500, 1000, 2000, and 4000 hertz (Hz) compared between different classification methods. Methods of classification for advanced otosclerosis were based on mean BC thresholds (>50 dB HL and > 60 dB HL), speech discrimination (<70%), and pure tone average (PTA) (>85 dB HL).

Results: For the >50 dB HL (36 patients) and >60 dB HL (15 patients) mean BC threshold classifications there was a statistically significant improvement in mean BC thresholds from 58.46 to 53.75 dB HL and 66.5 to 60.25 dB HL, respectively ($p<.001$, $p<.001$). Bone conduction thresholds improved for classifications based on speech discrimination (13 patients) and PTA (24 patients), however, this was not statistically significant.

Conclusions: When the classification of advanced otosclerosis is based on bone conduction threshold, there is a statistically significant improvement of mean bone conduction thresholds compared to classification based on speech discrimination or PTA.

***Define Professional Practice Gap & Educational Need:** Expands audiologic outcomes of stapedotomy in advanced otosclerosis patients, specifically looking at different potential classifications of advanced otosclerosis.

***Learning Objective:** Identify which advanced otosclerosis patients may have improved bone conduction thresholds after stapedotomy

***Desired Result:** Provide evidence to help identify advanced otosclerosis patients whom may improve with stapedotomy and hearing aid usage

Level of Evidence - IV

Indicate IRB or IACUC : 1130957-4

Volumetric Accuracy Analysis of Virtual Safety Barriers for Cooperative Control Robotic Mastoidectomy

Andy S. Ding, BA; Sarah Capostagno, PhD; Christopher R. Razavi, MD
Russell H. Taylor, PhD; John P. Carey, MD; Francis X. Creighton, MD

Background and Objectives: Cooperative control robots (CCRs) allow for a surgeon and robot to hold and manipulate an instrument simultaneously, allowing robotic precision while still capitalizing on surgeon motor skills and haptic feedback. CCRs can implement virtual safety barriers to prevent surgeon motion into undesired locations. This study assesses the accuracy of CCR-imposed safety barriers in a cortical mastoidectomy.

Methods: Temporal bone phantoms were registered to a CCR using preoperative CT imaging. Virtual safety barriers were created using 3D Slicer, with 2D planes placed along the external auditory canal, tegmen, and sigmoid, converging on the antrum. Five mastoidectomies were performed by novice surgeons, moving the drill to the limit of the safety barriers. Postoperative CT scans were obtained, and Dice coefficients and Hausdorff distances were calculated between preoperative and postoperative drilled volumes.

Results: Procedural success rate was 100% (5/5) with a mean time to completion of 221 ± 35 seconds. Hausdorff distances between drilled bone and the preplanned volume resulted in an average point-to-point distance of 0.351 mm. Compared to the preplanned volume of 0.947 cm^3, the mean volume of bone removed was 1.045 cm^3 (difference of 0.0982 cm^3 or 10.36%). Dice coefficient calculations yielded an average of 0.741.

Conclusions: This study shows feasibility for the use of virtual safety barriers in CCRs for otologic surgery. Future studies will focus on developing 3D virtual safety barriers placed around relevant surgical anatomy rather than 2D planes.

***Define Professional Practice Gap & Educational Need:** Although there are previous studies describing the use of robotic guidance in performing mastoidectomy, prior work has focused on autonomous designs. Our work in developing a CCR for surgery, in which the surgeon and robot work together to manipulate the surgical instrument, is a semi-autonomous method which allows the system to benefit from the surgeon's inherent skill and knowledge, while providing increased safety. To our knowledge, this is the first assessment of the accuracy of CCR-enforced virtual barriers for otologic surgery.

***Learning Objective:** The learning objectives were to examine the efficacy of using a cooperatively controlled robotic system to perform a cortical mastoidectomy and to determine the accuracy of robot-enforced virtual safety barriers in this system.

***Desired Result:** We hope our study will highlight the role of robotics in otology and will spark discussion of methods to improve this technology in the future.

Level of Evidence – NA – This is a feasibility study of a robotic system using temporal bone phantoms.

Indicate IRB or IACUC: Exempt.

Otopathological Findings following Mild Traumatic Brain Injury in a Porcine Model

Renata M. Knoll, MD; Matthew J. Wu, BS; David H. Jung, MD, PhD
Aaron K. Remenschneider, MD; Randel Swanson, DO, PhD
Douglas Smith, MD, Elliott D. Kozin, MD

Hypothesis: We hypothesize that discrete changes occur to the inner ear after mild traumatic brain injury (mTBI) in a validated porcine model.

Background: Labyrinthine concussion has long been recognized as a possible consequence of head injury. While audiovestibular dysfunction following head trauma with concurrent temporal bone (TB) fracture is generally well described, little is known about the pathophysiology of head injury without TB fracture (i.e. mTBI).

Methods: Swine were subjected to sham conditions (n=1) or head rotational acceleration using a HYGE pneumatic actuator (n=3) and euthanized 2 weeks post-injury. TBs were harvested and processed for histological evaluation under light microscopy. Degenerative changes in the cochleovestibular membranous labyrinth and presence of endolymphatic hydrops (EH) were assessed.

Results: All mTBI and sham TBs presented normal stria vascularis and spiral ligaments, in addition to scattered areas of outer hair cell (HC) degeneration in the apical turns. However, one mTBI TB showed outer HC degeneration in the middle and basal turns. Cellular debris and basophilic precipitate were found within the scala media in 3 mTBI TBs, whereas sham TBs were unremarkable. Mild cochlear EH was found in 4/6 mTBI TBs. Although HC and dendrites of vestibular-end organs were normal in all TBs, collapse of the membranous labyrinth (n=4 TBs) and otoconia debris in the semicircular canals (n=5 TBs) were found only in mTBI TBs.

Conclusions: This is the first study to investigate the inner ear following mTBI using a validated large animal model. Larger studies are needed to elucidate whether or not our findings are directly attributable to trauma.

***Define Professional Practice Gap & Educational Need:** TBI is a major public health issue and contributes to injury-related morbidity and mortality worldwide. While auditory and vestibular dysfunction secondary to TBI is a recognized clinical phenomenon, the precise mechanism remains poorly described. Highly controlled and validated animal models of mTBI are necessary to correlate mechanisms of audiovestibular injury with pathologic findings in the acute and, eventually, chronic settings.

***Learning Objective:** Expand our understanding of the pathophysiology of auditory and vestibular dysfunction after mTBI.

***Desired Result:** Our evolving understanding of changes that occur in the auditory and vestibular peripheral systems may provide a new paradigm to study audiovestibular dysfunction following mTBI.

Level of Evidence - Does not apply

Indicate IRB or IACUC: Exempt

Cochlear Implant Hearing Outcomes Are Not Affected by Hearing Status in Non-Implanted Ear

Carly Misztal, BS; Stefanie Peña, MS; Diane Martinez, AuD
Sandra Velandia, AuD; Christine T. Dinh, MD

Objective: The Food and Drug Administration recently expanded cochlear implant (CI) indications to include asymmetric hearing loss and single-sided deafness. In this study, we determine whether higher word discrimination scores (WDS) in non-implanted ears hinders hearing outcomes in implanted ears.

Study Design: Retrospective cohort study

Setting: Tertiary care hospital

Patients: Adult patients with unilateral CIs (N=71), implanted between 2014-2018, were stratified by preoperative WDS in non-implanted ears (Groups 1-5: 0-20%, 21-40%, 41-60%, 61-80%, 81-100%, respectively)

Interventions: CI surgery in the poorer performing ear

Main Outcome Measures: Word and sentence test scores pre- and post-operatively

Results: The mean age for each group ranged from 66.2-71.9 years. Overall, 63.4% were female, 71.8% reported English as their primary language, and 66.2% had hearing loss for <10 years. In English-speakers, CNC and AzBio scores in quiet were significantly higher at 12 months in implanted ears compared to pre-operative scores ($p<0.05$); mean improvements were 44.3% and 52.8%, respectively. In Spanish-speakers, significant improvements in Bisyllables and HINT (Spanish) scores in quiet were also observed post-operatively ($p<0.05$). However, when stratified by groups, there were no significant differences in CNC, AzBio, Bisyllables (Spanish), and HINT (Spanish) scores in the implanted ear. In addition, there were no correlations between preoperative WDS in the non-implanted ear and post-operative hearing outcomes in the implanted ear ($p>0.05$).

Conclusions: CI patients with higher pre-operative WDS in non-implanted ears performed similarly to traditional CI patients on aided word and sentence tests in the implanted ear. These findings support the recent expansion of CI candidacy to incorporate patients with serviceable hearing in the non-implanted ear.

Define Professional Practice Gap & Educational Need: It is thought that cochlear implant patients with good hearing on one side may not achieve maximum benefit from cochlear implants due to comfort and preference for acoustic hearing. A better understanding of cochlear implant outcomes in patients with asymmetric and single-sided deafness, as it compares to traditional cochlear implant patients, is needed.

Learning Objective: Recognize that cochlear implant patients with serviceable hearing in the non-implanted ear obtain comparable hearing outcomes to traditional cochlear implant patients in the implanted ear.

Desired Result: Physicians will gain knowledge about the benefits of cochlear implant surgery in patients with asymmetric hearing loss and single-sided deafness and take these outcomes into consideration when counseling patients.

Level of Evidence – Level IV

Indicate IRB or IACUC : University of Miami IRB # 20181028, approved 03/04/2019

AMERICAN OTOLOGICAL SOCIETY RESEARCH FUND
RESEARCH GRANT AWARDS & TRAINING FELLOWSHIPS

The purpose of the American Otological Society (AOS) Research Grant is to encourage and support academic research in sciences related to the ear. 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.

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. **www.americanotologicalsociety.org**

SAVE THE DATE 2021

A letter of intent must be submitted by November 1st of the year *prior* to funding (funding begins July 1, 2022). The letter must state the grant mechanism for the proposal, the Principal Investigator and Institution(s) for the work, the PI biosketch, and provide a working title, and abstract. The abstract should contain the Specific Aims and summarize the proposal in no more than 2 pages. (page limit does not include the other required documents).

Complete applications will be invited from selected applicants based on our review of the letters of intent. Applicants will be notified whether they are invited to submit a full application by December 1st. 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:

Kristen Bordignon, Assistant to
Andrea Vambutas, MD
Executive Secretary, Research Fund of the American Otological Society, Inc.
Email: **avambuta@northwell.edu**

Kristen Bordignon PH: 217-638-0801
E-mail: **administrator@americanotologicalsociety.org**

American Otological Society Research Grant
Progress report: 7/1/2020 – 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 note:

Introduction:

There are 28 million individuals with hearing loss in the United States. Individuals with even mild hearing loss have decreased speech perception in environments with background noise. Furthermore, even individuals with normal hearing on standard audiometric evaluation have decreased ability to comprehend speech in noisy environments with increasing age. Hearing loss is a very common disability that has negative effects on quality of life and is associated with myriad negative consequences including decreased social connectivity, decreased work productivity and increased prevalence of adverse health outcomes, including dementia.[1-4] Traditional hearing aids (HA) and cochlear implants (CI) have been shown to improve hearing-related quality of life, general health-related quality of life and listening ability for those with hearing loss.[5] However, even with directional microphone and noise reduction technology, HA and CI have limited efficacy in improving speech perception in background noise.[6]

Both normal hearing individuals and those with hearing loss naturally rely on speechreading, that is the perception of speech through both the auditory signal (hearing the speaker) and the visual signal (seeing the speaker's face), to better comprehend speech in background noise. Speechreading offers significant benefit to speech perception alone or in combination with HA or CI.[7 8] Unlike individuals who naturally combine auditory and visual speech signal to comprehend speech, current HA and CI technology utilizes auditory input alone. Given the limited efficacy of hearing devices in background noise, there is substantial potential to increase communication efficacy through an assistive communication device that combines the auditory signal via microphone as well as the visual signal via video camera (from a smartphone camera or camera embedded in glasses). We propose evaluating whether audiovisual based communication devices can improve speech perception in real-world listening situations through the following aims:

Aim 1: To develop an automated speech recognition (ASR) program that integrates visual cues (via video camera) and auditory cues (via microphone) and supplies a real-time estimation of the current signal (phonetic message). *We will test the hypothesis that individuals with either normal hearing or hearing loss will achieve better speech perception in noise with ASR compared to their best aided condition.*

Progress:
We have implemented an automated speech recognition (ASR) program through dimension reduction transformations of the raw auditory and visual signal followed by input of this data into a connectionist temporal classification scoring algorithm with an associated Long Short-Term Memory language model in order to achieve speech text as an output. The algorithm was trained on the Oxford-British Broadcasting Corporation (BBC) Lip Reading Sentences 2 (LRS2) dataset, which consists of 96318 video excerpts of spoken sentences from BBC television. A test set from the LRS2 dataset of 1243 audio-visual speech excerpts, which was not part of the training set for the ASR, were modified with the addition of multi-talker babble noise at defined signal-to-noise ratios (SNR) of +20, +10, +5, and 0 decibels (dB). We then compared the ASR to a commercially available auditory only speech recognition program (Google Speech-to-Text) in background noise. In the lowest noise condition (SNR: +20 dB), the commercial system achieved an accuracy of 93.9%, while the ASR achieved an accuracy of 93.2% ($p = 0.46$). At an SNR of +10 dB, the commercial system achieved an accuracy of 75.5% while the ASR achieved an accuracy of 90.4% ($p < 0.001$). At an SNR of +5 dB, the commercial system achieved an accuracy of 15.4% while the ASR achieved an accuracy of 84.2% ($p < 0.001$). At an SNR of 0 dB, the commercial system achieved an accuracy of 4.4% while the ASR achieved an accuracy of 62.9% ($p < 0.001$). Across all noise conditions, the commercial speech recognition program achieved an average accuracy of 48.3% and the ASR achieved an accuracy of 86.6% ($p < 0.001$).

We are currently implementing the ASR through a smartphone video camera and microphone with the output speech text displayed on the smartphone screen as well as through augmented reality glasses with an embedded

camera and results projected onto the augmented reality glasses heads up display. We plan to perform human subjects testing to test the hypothesis that ASR will improve speech perception in noise for normal hearing individuals and individuals with hearing loss. In person human subject testing had been on hold at our institution because of COVID-19 pandemic. In January 2021, we were able obtain IRB, departmental and university approval to start in person human subject testing

Aim 2: To develop an algorithm that combines the auditory signal and visual signal of a target speaker in order to perform speech enhancement (SE) of the speaker's auditory signal in background noise. *We will test the hypothesis that individuals with either normal hearing or hearing loss will achieve better speech perception in noise with SE compared to their best aided condition.* The Kalman Filter (KF) is commonly used in auditory based SE. Visual signal of facial articulatory motion of the target speaker, which can be captured by video camera, carries a significant amount of speech signal. We plan to implement an audiovisual SE algorithm by applying KF on the visual signal from the target speaker in order to reduce noise signal in the auditory stream. Unlike computationally complex deep learning based audiovisual SE algorithms that do not function in real-time, a KF based audiovisual SE algorithm has the potential to have a much lower computational complexity so as to function in real-time.

Progress:
KF relies on measured noise covariance, R, and process noise covariance, Q. In speech enhancement (SE) algorithms that utilize KF, estimating R and Q is challenging and is likely suboptimal. We are attempting to use video of facial articulatory motion to improve the estimates of R and Q which we hope will significantly improve the effectiveness of the SE algorithm. We will evaluate a standard auditory only implementation of SE with KF compared to our audiovisual implementation with improved estimates of R and Q on normal hearing and hearing loss subjects.

Aim 3: To evaluate various human-computer interfaces for improving communication efficacy in background noise with audiovisual communication devices. *We will test the hypothesis that both characteristics of the hearing device and the extent of hearing loss will be determinants for the most beneficial interface for a particular person.* The ASR of aim 1 would lead to presentation of speech in a visual manner (speech- to-text presented on a screen) while the SE of aim 2 would lead to presentation of augmented speech signal via auditory signal alone (through earphones, HA or CI). I plan to evaluate both types of presentation output on human subjects with varying levels of hearing loss while also probing the effects of computing latency and program error rate on subject performance. Specifically, we will evaluate speech perception, listening comfort and cognitive load of the subjects. Experiments will be performed with simulated output, so that aim 3 can be performed in parallel to aims 1 and 2 as well as with actual ASR and SE output once functional prototypes are implemented.

Progress:
In person human subject testing had been on hold at our institution because of COVID-19 pandemic. In January 2021, I was able to obtain IRB, departmental and institutional approval to start in person human subject testing, and therefore anticipate being able to now generate data needed to evaluate this aim.

References:

1. Brodie A, Smith B, Ray J. The impact of rehabilitation on quality of life after hearing loss: a systematic review. *Eur Arch Otorhinolaryngol.* 2018;275(10):2435-2440.
2. Punch JL, Hitt R, Smith SW. Hearing loss and quality of life. *J Commun Disord.* 2019;78:33-45.
3. Gurgel RK, Ward PD, Schwartz S, Norton MC, Foster NL, Tschanz JT. Relationship of hearing loss and dementia: a prospective, population-based study. *Otol Neurotol.* 2014;35(5):775-781.
4. Lin FR, Yaffe K, Xia J, et al. Hearing loss and cognitive decline in older adults. *JAMA Intern Med.* 2013;173(4):293-299.
5. Brennan-Jones CG, Weeda E, Ferguson M. Cochrane corner: hearing aids for mild to moderate hearing loss in adults. *Int J Audiol.* 2018;57(7):479-482.
6. Wu YH, Stangl E, Chipara O, Hasan SS, DeVries S, Oleson J. Efficacy and Effectiveness of Advanced Hearing Aid Directional and Noise Reduction Technologies for Older Adults With Mild to Moderate Hearing Loss. *Ear Hear.* 2019;40(4):805-822.

7. Tye-Murray N, Sommers MS, Spehar B. Audiovisual integration and lipreading abilities of older adults with normal and impaired hearing. *Ear Hear.* 2007;28(5):656-668.
8. Walden BE, Grant KW, Cord MT. Effects of amplification and speechreading on consonant recognition by persons with impaired hearing. *Ear Hear.* 2001;22(4):333-341.

American Otological Society

Fellowship Grant Funding Period: 7/1/2020-6/30/2021

Progress Report Date: 2/9/2021

Principal Investigator: Sumana Ghosh

Project Title: Novel Role of *Six2* in Vestibular Planar Cell Polarity (PCP).

Background*: Sine Oculis Homeobox Homolog (Six)2* is an evolutionarily conserved transcription factor which has been shown to be critical for the development and patterning of a number of tissues and organs including eyes, kidneys, heart and limb buds. Furthermore, a loss-of function mutation study of *Six2* ancestral homologous gene *sine oculis (so)* in *Drosophila* showed that loss of *so* led to disruption of planar cell polarity (PCP) and severe disorganization of f-actin-based ommatidial bristles. Therefore, in the current study we hypothesized that *Six2* plays a similar role in the development of sensory cells in the inner ear (IE). Transcriptome analysis by RNA-Seq revealed the expression of *Six2* gene in the developing IE. However very little is known about the role of this transcription factor in the development or patterning of the auditory or vestibular sensory epithelia. Here we utilize a germline deletion *Six2* knockout (S2KO) model to study the function of *Six2* during development. We hypothesize that loss of *Six2* will result in PCP disruption which can be assayed via disorganization or misorientation of actin-rich stereocilia and PCP-related proteins in vestibular hair cells

Aim1: To test the hypothesis that *Six2* is expressed in the developing IE when PCP is being established. The overarching goal of this aim is to map *Six2* expression at various stages of cochlear and vestibular epithelia development from otic vesicles starting as early as embryonic day (E11.5) when hair cells start forming, to as late as postnatal day(P)30 when vestibular organs are completely developed and fully functional.

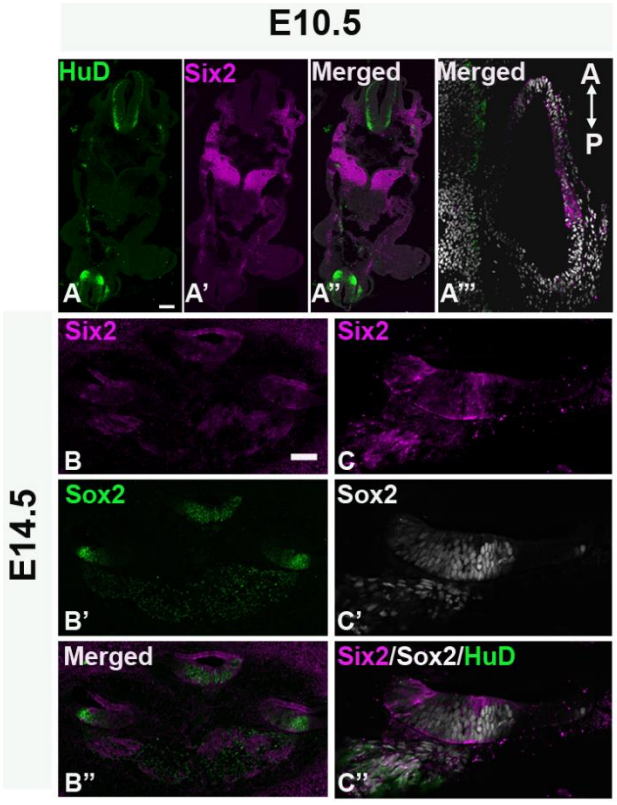


Figure1: Six2 expression in otic vesicle of CD1 mice at E10.5 (A-A''') and E14.5. RNAScope in-situ hybridization of *Six2* probe with co-immunolabelling of neuronal marker HuD and Sox2 in coronal sections of E10.5 and sagittal sections of E14.5 embryos show *Six2* expression in the otic vesicle.

Progress: We performed timed matings of CD1 mice and collected embryos at E10.5, E12.5, E14.5, E16.5, P0 and P30 and studied *Six2* expression by RNAScope *in situ* hybridization in either cryosections or wholemount preparations. The sections from early stages of development (E10.5- E14.5) were also co-immunolabelled with SRY (sex determining region Y)-box 2 (Sox2) to identify pro-sensory domain and either HuD to label delaminating neuroblasts and neurons or neurofilament heavy chain (NF-H) to label differentiated neurons. The late embryonic and postnatal samples were co-labeled with hair cell marker Myo7A and NF-H. Our preliminary data suggests that *Six2* is expressed as early as E10.5 (n=3), earlier than hair cell differentiation. *Six2* continues to be expressed in the otic vesicle both in and around the pro-sensory domain at E12.5 (n=1) and E14.5 (n=3). It is also present in a number of areas including utricular hair cells at E16.5 (n=1) and P0 (n=2). We continue to collect embryonic and postnatal samples and will increase the number of replicates to successfully map *Six2* expression during development and postnatal maturation. Additionally, since *Six2* appears to be expressed at least as early as E10.5, we will add E8.5 and E9.5 timepoints to try and determine the earliest point at which *Six2* begins to be expressed in the developing otic vesicle. Thus, the data we

have generated so far demonstrates that *Six2* is expressed throughout HC development, consistent with the hypothesis that it may influence the establishment or maintenance of PCP. The data also suggest that *Six2* may be present much earlier than originally hypothesized, which suggests that *Six2* may have other roles in inner ear development.

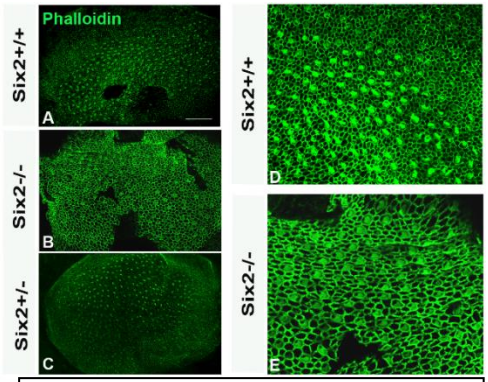


Figure 2: Misorientation of hair cells in knockout (Six2-/-) mice compared to wild type (Six2+/+) and heterozygous (Six2+/-) littermate. Phalloidin (green) labelling of E17.5 utricles shows severe misorientation of hair cells in Six2-/- (B and E) mice compared to Six2+/+ (A and D) and Six2+/- littermates. (C).

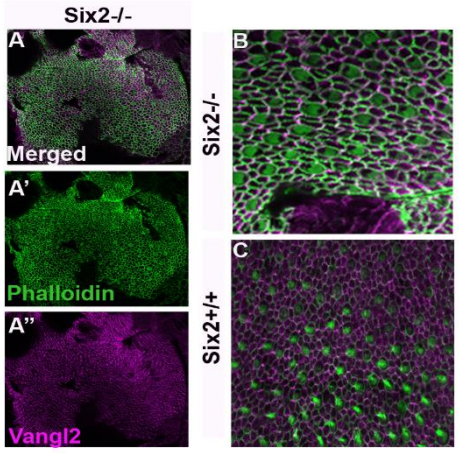


Figure 3: Comparison of VANGL2 expression in Six2-/- mice (A-A'') with Six2+/+ (C)littermate. E17.5 utricles were immunolabelled with VANGL2(magenta) and phalloidin (green). Six2+/- littermates (C).

Aim2: <u>To test whether *Six2* is necessary for the establishment of PCP in vestibular sensory epithelia.</u>

To test this hypothesis, we collected E17.5 embryos from S2KO mice and compared the hair bundle orientation of the homozygous *Six2(-/-)* samples with the wild type *Six2(+/+)* and heterozygous *Six2(+/-)* littermates by staining with fluorescently labeled phalloidin. Our data suggests that there is disruption of the line of polarity reversal and misorientation of many of the utricular hair cells in the knockouts (figure 2) compared to the WT samples (n=3). High resolution images were collected at higher magnification and used for data analysis.

Similarly, data is also being collected from saccule and cristae, to investigate if there is any PCP phenotype in those epithelia. Furthermore, we extended our study in the cochlear epithelium as well. Additional samples will be collected to investigate the bundle morphology of both cochlear and vestibular epithelium by scanning electron microscopy.

Aim3: To test the hypothesis that embryonic KO of *Six2* will increase *Fgf8* expression in the vestibular sensory epithelia. Downregulation of *Six2* in progenitor nephron cells causes increased transcription of *Fgf8* and higher levels of *Fgf8* have been shown to alter the PCP of limb bud epithelia via reorientation of VANGL2. Thus, we hypothesize that *Six2* deletion upregulates *Fgf8* which could be a potential mediator of PCP disruption. **Aim3a: To determine whether VANGL2 expression changes with embryonic deletion of Six2.** Currently we started collecting S2KO samples at E17.5 and immunolabeled the samples with anti-VANGL2 antibody along with phalloidin to compare the distribution of VANGL2 between Six2(+/+) and Six2(-/-) samples (figure 3). We will continue collecting samples and perform statistical analysis. **Aim3b: To test the hypothesis that *Fgf8* expression is increased with Six2 deletion.** We started verifying expression of *Fgf8* by RNAScope at E17.5 in Six2(+/+) and Six2(+/-) samples. Furthermore, we will overexpress Fgf8 in E17.5 utricle in-vitro in organotypic culture and investigate whether overexpression of Fgf8 leads to misorientation of hair bundles by misorientation of VANGL2. **Training progress:** Last year I published a first-author paper (**Ghosh S**, Lewis MB, Walters BJ. **Comparison of ethylenediaminetetraacetic acid and rapid decalcificier solution for studying human temporal bones by immunofluorescence.** *Laryngoscope Investig Otolaryngol*. 2020 Aug 26;5(5):919-927) from my postdoctoral work and submitted a manuscript for a book chapter in Springer's Neuromethods series. Additionally, I am finalizing another original research manuscript to be submitted this month, and I am generating preliminary data to apply for a K99-R00 grant this Fall. So far, I have gained proficiency in animal husbandry, mouse genetics and genotyping, mouse embryonic development with particular focus on the inner ear, and RNAscope *in situ* hybridization and confocal microscopy. I have also acquired training in scanning electron microscopy. During the award period, I have also had opportunities to train students and technicians in the lab, and have undertaken several leadership

roles in the UMMC postdoctoral association and in the student and postdoc Association for Research in Otolaryngology (spARO).

American Otological Society
Fellowship Grant Funding Period: 07/01/2020 – 06/30/2021
Progress Report Date: 02/17/2021

Principal Investigator: Gabriel Sobczak
Mentors: Xin Zhou, PhD; Ruth Litovsky, PhD
Project Title: Cortical Mechanisms of Binaural Integration Investigated Using Functional Near-Infrared Spectroscopy (fNIRS)

Background

Binaural hearing depends on integration of inputs from both ears by the auditory system and facilitates perception of multiple sound sources. To date the binaural hearing deficits of single-sided deaf cochlear implant (SSD-CI) and bilateral CI (BiCI) listeners have not been studied on a neural level. We aim to assess neural mechanisms of binaural integration by measuring cortical activity using functional near-infrared spectroscopy (fNIRS).

Functional near-infrared spectroscopy (fNIRS) is a novel neuroimaging technique that uses near-infrared light to measure cortical brain activity. By employing optical probes, fNIRS is not impeded by ferromagnetic and electrical components of CIs, making it an ideal modality to examine cortical mechanisms of binaural hearing deficits in CI users. To examine binaural integration, we utilize a paradigm in which sequential sentence segments alternate between ears. Based on previous studies, listeners are posited to use different listening strategies depending on the rate of switching. Using switching speech and fNIRS, this study assesses cortical activity in the left auditory cortex (LAC) and in the left inferior frontal gyri (LIFG). We simulated SSD-CI (right ear vocoded) and BiCI (both ears vocoded) conditions; non-degraded speech was presented in a third speech condition (NH). Speech was presented 2, 4, 8, and 32 Hz switching rate, for a total of 12 listening conditions.

Speech intelligibility directly correlates with auditory cortical responses; therefore, we hypothesize that if conditions with degraded speech and certain switching rates decrease speech intelligibility, we will see lower fNIRS responses in the LAC in less intelligible listening conditions. Also, listening conditions that require increased listening effort to understand speech are associated with higher LIFG activity. Therefore, if the switching rates differ in task demands based on posited listening strategies, then we will observe higher fNIRS responses in left IFG in more demanding listening conditions. Correspondingly, if conditions with degraded speech increase task demands compared to the non-degraded speech conditions, then we will observe higher fNIRS responses in left IFG in degraded speech conditions. Finally, if the above cortical activity patterns are observed, then increased left AC activity coupled with decreased left IFG activity between listening conditions may indicate cortical integration of binaural inputs.

COVID-19 Update

The original study population included normal-hearing listeners and those with single-sided deafness and cochlear implant (SSD-CI). However, research participant travel was restricted due to COVID-19, so I was unable to recruit the necessary sample size of cochlear implant listeners. I pivoted my initial study to focus on cortical integration of binaural stimuli in young, normal-hearing listeners with simulated SSD-CI and BiCI speech conditions. The goal is to apply the findings of this study to future fNIRS studies in listeners with cochlear implants to understand potential neural underpinnings of binaural hearing deficits in BiCI and SSD-CI listeners.

Aim 1: *Using a switching speech paradigm, we propose to assess the cortical neural signatures of effortful auditory processing and speech perception related to changes in speech intelligibility across switching rates.* In this aim, we recorded fNIRS activity in the left auditory cortex (LAC) and left inferior frontal gyrus (LIFG) while

participants listened to sentences presented at four different switching rates (2, 4, 8, and 32 Hz). In a separate experiment with the same subjects, we recorded speech intelligibility scores for sentences presented at the 12 different listening conditions.

Progress: We have shown that the LAC and LIFG exhibit differing patterns of activation in response to speech stimuli switching between ears at different rates. Importantly, cortical activity in these regions of interest (ROIs) reflected differential processing of speech at varying rates even if speech intelligibility scores were at or near ceiling, as in the case of NH and SSD-CI speech conditions (Fig. 1). LAC activity suggested different degrees of intelligibility depending on switching rate, and LIFG activity suggested different degrees of effort depending on switching rate, providing support for different listening strategies to extract speech information across the four switching rates (Fig. 2).

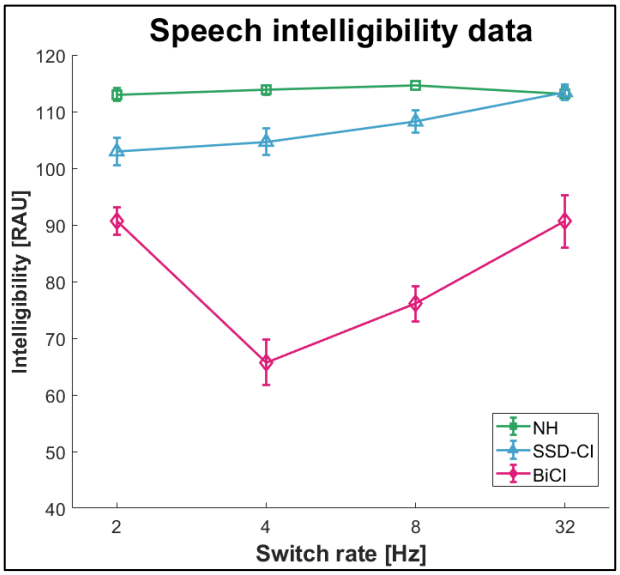


Figure 1. Mean speech intelligibility data for each of the 3 speech conditions across all 4 switching rates. Error bars plot ± 1 SEM. RAU = rationalized arcsine units.

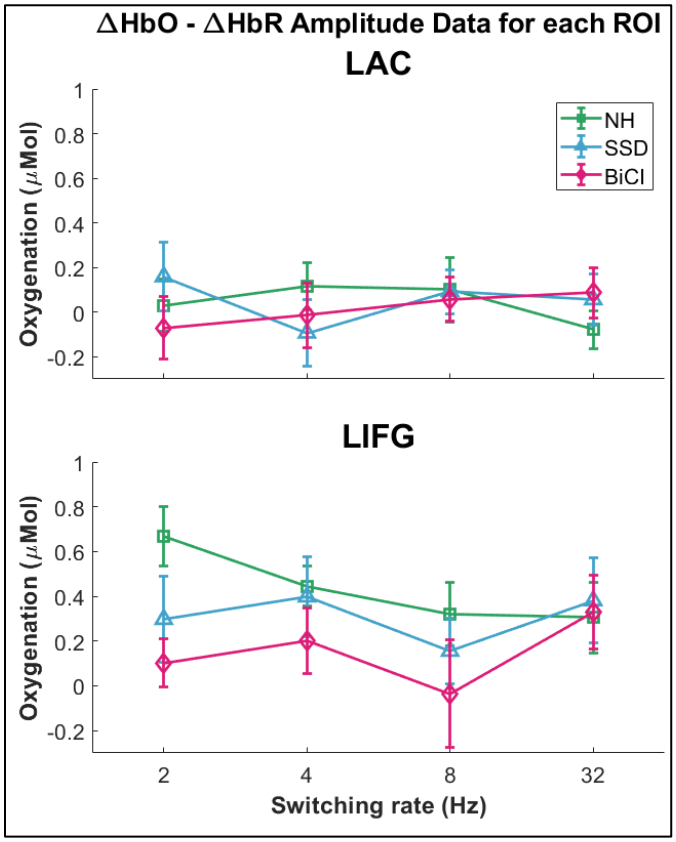


Figure 2. Group-averaged fNIRS oxygenation (ΔHbO minus ΔHbR) amplitude data for each speech condition at all 4 switching rates, grouped by cortical region of interest. Oxygenation has been demonstrated to reveal changes in mental effort. Error bars plot ± 1 SEM. ROI = region of interest; LAC = left auditory cortex; LIFG = left inferior frontal gyrus.

Aim 2: *Understand how the patterns of cortical activity assessed in Aim 1 vary between normal-hearing speech conditions and simulated single-sided deaf and bilateral cochlear implant (CI) use.* Extending from the methods in Aim 1, we analyzed how addition of one or two degraded inputs in the SSD-CI and BiCI speech conditions, respectively, impacted cortical across switching rates compared to the NH speech condition.

Progress: Addition of degraded speech in one or two ears altered patterns of LAC and LIFG activity across switching rates compared to the non-degraded speech condition. In the LAC, fNIRS responses were at a minimum for SSD-CI condition but not the BiCI condition at 4 Hz; which was unexpected. Interestingly, the pattern of LAC activity for NH speech was opposite to SSD-CI, which was also an unexpected result. In the LIFG a pattern emerged in SSD-CI speech condition data suggesting input of effortful auditory processing at 4 Hz. Decreased LIFG activity at 8 Hz with increased LAC activity at the same rate supports the hypothesis about cortical signatures for integration of binaural stimuli. LIFG activity for the BiCI speech condition mirrored that of the SSD-CI condition, which was expected. The monotonic decrease in LIFG responses for the NH speech condition was unexpected. Overall, these findings suggest that degraded speech inputs in one or two ears impacts cortical integration of binaural speech stimuli in ways that cannot be revealed by behavioral data alone.

Currently, we have carried out data collection for both aims in 13 young, normal-hearing participants, and plan to finish in March 2021 with a sample size of 20 subjects. We hope to submit a manuscript in preparation shortly afterwards, in April or May of 2021.

Presentations

Sobczak, G., Zhou, X., Moore, L., Litovsky, R.Y. Cortical Mechanisms of Binaural Integration Investigated Using Functional Near-Infrared Spectroscopy (fNIRS). Poster presented at Association for Research in Otolaryngology 44th Annual Midwinter Conference. 2021 February 24.

Sobczak, G. “Optical Imaging with fNIRS: Investigating Cortical Integration of Binaural Stimuli in the Auditory Cortex and Inferior Frontal Gyrus.” Hearing and Donuts Seminar. Waisman Center, University of Wisconsin – Madison. 2021 February 12. Madison, WI.

American Otological Society Fellowship Grant – 6 Month Progress Report

PI: Christopher Nielson, University of Utah School of Medicine

Mentors: Albert Park, Matthew Firpo

Project Title: Determining the Role of Macrophages in the Pathogenesis of Cytomegalovirus-Induced Sensorineural Hearing Loss

Introduction. Progressive sensorineural hearing loss (SNHL) is an important characteristic of congenital cytomegalovirus (CMV)-induced hearing loss. We have observed that progressive SNHL occurs weeks after the virus has entered latency in our murine CMV (mCMV) model. Our research aims to investigate whether macrophages play a role in immune-mediated pathology as a potential explanation for the development of progressive SNHL in the setting of latent CMV infection.

Aim 1. Establish the relative contribution of infiltrating and resident macrophages to mCMV mediated SNHL through targeted depletion studies.

Progress. We performed auditory brainstem response (ABR) and distortion product otoacoustic emission (DPOAE) testing at 4, 6, and 8 weeks of age in CCR2$^{-/-}$ and clodronate-treated mice infected with mCMV. The CCR2 chemokine receptor is necessary for migration of **infiltrating** macrophages. Clodronate liposomes are engulfed by phagocytes and cause systemic depletion of **infiltrating** and **resident** macrophages. Mice received clodronate treatment from postnatal day 8 to postnatal day 20. Clodronate-treated mice infected with mCMV had worse hearing outcomes compared to untreated mice infected with mCMV at 4-weeks of age but had no difference in hearing outcomes at 6- and 8 weeks of age. CCR2$^{-/-}$ mice had worse DPOAE thresholds across all timepoints, but only worse ABR thresholds at 6- and 8-week testing. These results indicate that both **resident** and **infiltrating** macrophages play an otoprotective role in CMV infection.

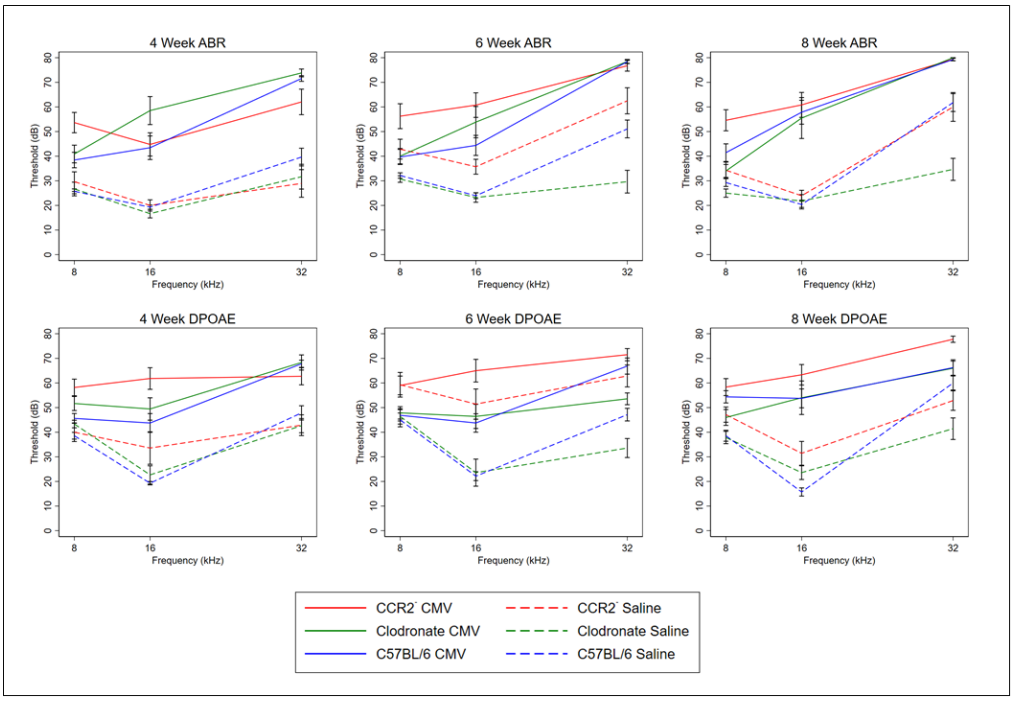


Figure 1. Hearing outcomes in mCMV-infected CCR2$^{-/-}$, Clodronate-treated, and wild-type mice

We also wanted to understand whether macrophages play a role in controlling viral replication in the inner ear. In additional experiments, we quantified viral titer in the temporal bones of CCR2$^{-/-}$ and parental strain pups on postnatal day 8 (peak viral load) using quantitative PCR. We found that knockout of the CCR2 gene did **not** result in increased viral load in temporal bones of infected mice compared to wild-type mice.

Aim 2. Characterize the macrophage response as pro- or anti-inflammatory over time.

Progress. We treated mCMV-infected mice with D-methionine during the first two weeks of life and measured their hearing outcomes at 4 weeks of age. Following hearing testing at 4 weeks of age, individual temporal bones were harvested from these mice and prepared for flow cytometric analysis. Peripheral blood was also taken to observe the systemic immune response to CMV infection. We have previously shown that D-methionine treatment improves hearing outcomes in mCMV-infected mice by decreasing reactive oxygen species production in the inner ear. D-methionine is also known to have anti-inflammatory properties, so we chose to investigate which myeloid-derived populations are affected by D-methionine treatment as a first step to characterize the macrophage response to CMV infection. We confirmed our previous findings that D-methionine treatment improves hearing outcomes in mCMV-infected mice. We also found that heterogenous populations of activated myeloid-derived cells persist in the inner ear well after the virus has entered latency. Non-classical monocytes were decreased by D-methionine treatment **(Figure 2)**. However, these populations do not remain elevated in peripheral blood and were not changed by D-methionine treatment. These experiments are currently ongoing and more complete interpretation of our results will be forthcoming. Our results also represent work over the past several months optimizing a protocol for flow cytometric analysis of individual temporal bones.

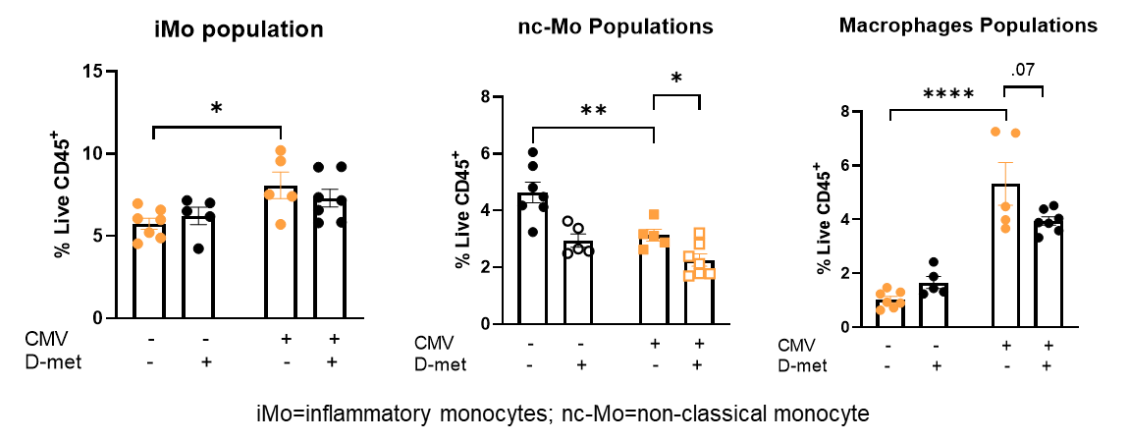


Figure 2. Changes in cochlear myeloid populations following D-methionine treatment. Points represent values from individual cochleae harvested at P28 from C57BL/6 mice.

Future Direction.

- **Aim 1:** Our clodronate depletion studies were performed in early phases of mCMV infection. We plan to deplete macrophages at later time points to observe the contribution of macrophages in later stages of SNHL development. Additionally, we harvested and preserved temporal bones from the mice used in our completed macrophage depletion studies for histologic analysis. We will use these specimens to determine spiral ganglion and outer hair cell densities to describe the development of SNHL in macrophage-depleted mice more completely. Upon completion of these two steps (histologic analysis and late-phase macrophage depletion) we will have achieved all milestones in our original grant proposal for Aim 1.
- **Aim 2:** The results of our ongoing D-methionine flow cytometry experiments will direct our approach to further characterize the myeloid cytokine response to mCMV infection in the inner ear. Additional litters are currently being prepared for flow cytometric analysis at postnatal day 8 (acute phase of infection). Based on the results of these experiments, we will perform cytokine analyses on select immune populations to characterize their signaling during acute and latent phases of infection to complete our originally proposed experiments.

Professional Development. I am early in my career path and chose to take a research year between my second and third years of medical school to begin shaping my career interests. This year has deepened my commitment to making research an emphasis in my future career and crystalized my intent to apply for otolaryngology residency. I have also learned a tremendous amount this year. In addition to learning practical lab techniques, I am enrolled in the Master of Science in Clinical Investigation (MSCI) and will complete the degree over the coming year. Funds from the AOS Fellowship Grant have been critical in supporting my research and learning.

AOS FELLOWSHIP GRANT: PROGRESS REPORT

BACKGROUND

Since its initial implementation, cochlear implantation has achieved widespread success in providing access to auditory communication for individuals with severe hearing loss. Preserving functional residual hearing after CI has gained importance as simultaneous electric-acoustic stimulation allows for additional improvement in hearing outcomes; however, residual hearing is lost in a subset of patients and the exact mechanism of this post-operative loss remains largely unknown. With increasing focus on hearing preservation during cochlear implant surgery, atraumatic electrode insertion is of the utmost importance. It has been established previously that large pressure spikes can be generated in the cochlea during the electrode insertion[1-3]. Estimates of equivalent ear canal pressure suggest these peak pressures may be of sufficient intensity to cause trauma similar to that of an acoustic blast injury[1] and may be one source for postoperative loss of residual hearing. **Here, we propose a study to investigate insertion trauma as a mechanism for postoperative loss of residual hearing**. The overall objective of this proposal is to characterize changes in the intracochlear environment resulting from implant insertion in order to better understand the mechanism of loss of residual hearing. To accomplish this objective, we will first characterize changes in intracochlear pressures during cochlear implant insertions in a cadaveric model (**Aim 1**). Simultaneous fluoroscopy measurements will be made in order to correlate the location of the electrode with measured pressure changes (**Aim 2**). Following placement of CI electrodes, cadaveric specimen will undergo high-resolution computerized tomography (CT) scanning to evaluate for post-procedural anatomic changes and structural damage. Correlations will be made between specimens with evidence of structural damage on imaging and magnitude of pressure spikes recorded during electrode insertions (**Aim 3**).

The purpose of this study is to use data to implement evidence-based changes in clinical practice and improve preservation of postoperative residual hearing. The long-term goal of our lab is to implement these surgical techniques in practice, allowing patients to *capitalize on optimal bimodal cochlear stimulation* following surgery and *realize the best possible hearing outcomes from implantation*.

(a) AIM 1. Characterize changes in intracochlear pressures during electrode insertion in cadaveric specimen. Microscale pressure probes placed into cochlear scalae in cadaveric specimen will measure real-time changes in pressures during the insertion of eight different models of CI electrodes

Progress: We have completed analysis on a large set (n=534) insertions. Styleted and sheathed electrodes generated significantly larger electrode spikes during insertion (see Figure 1A,B). There was no correlation between electrode length,

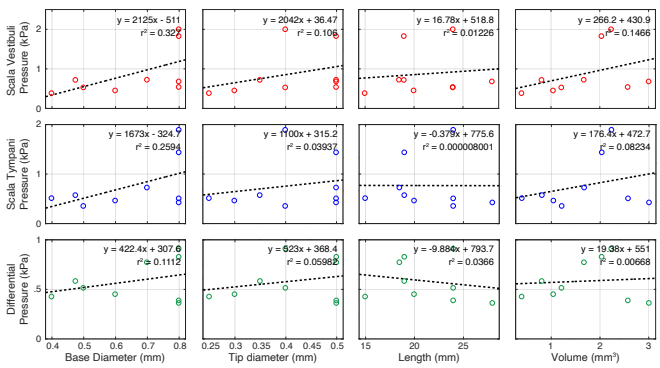


Figure 2. Pearson correlations for average peak pressure levels observed in all specimens during all electrode insertions as a function of electrode dimensions (base diameter, tip diameter, length, and volume). Significant correlations were not noted for any dimension across recording site for either raw pressures or estimated equivalent pressures; no trends toward higher peak intracochlear pressure levels could be identified for larger or bulkier electrodes.

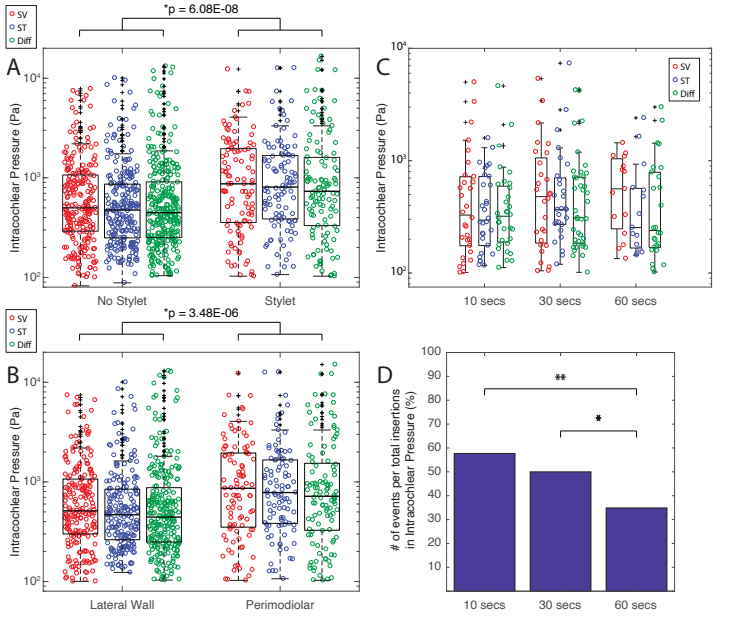


Figure 1. Peak pressure levels observed by electrode characteristics and analyses of insertion duration. Unfiltered peak intracochlear pressure measurements are shown by electrode characteristics (straight or precurved in Panel A, styleted or non-styleted in Panel B). Panel C shows a summary of peak pressure levels observed in all specimens during all electrode insertions by insertion duration. Panel D shows the percent of insertions with a significant pressure event by insertion duration. Chi-squared analysis with Bonferroni correction revealed a significant pattern of fewer exposures with longer insertions. Significant differences between groups are indicated with asterisks (* p<0.05, ** p<0.01).

diameter, or volume and transient intracochlear pressure amplitudes (see Figure 2). Electrodes that were inserted more quickly were more likely to generate pressure spikes (see Figure 1C,D). Other post-insertional manipulations generated higher peak pressures than those seen with insertion (see Figure 3). A manuscript detailing the results of the analysis for AIM 1 has been written and is currently submitted under review.

(b) AIM 2. Correlate real-time electrode intracochlear position with generation of pressure spikes during electrode insertion in cadaveric specimen. Simultaneous fluoroscopy and intracochlear pressure measurements will be analyzed for differences based on electrode style and size.

Progress: Additional data collection on this Specific Aim has been delayed due to COVID-related restrictions and personnel limitations in campus research facilities. Data collection requires the presence of a fluoroscopy technician and will resume once COVID restrictions in the research facilities permit.

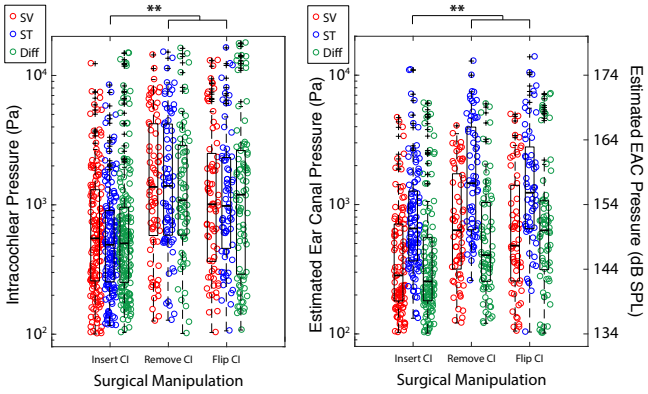


Figure 3. Summary of peak pressure levels observed in all specimens during all electrode insertions and manipulations by type of surgical manipulation. Unfiltered peak intracochlear pressure measurements (upper panel) and estimated EAC pressures (lower panel) are shown for each pressure recording as a function of recording site. Box plots represent the median +/-25% of the range of pressures observed, whiskers show the full range of the estimated distribution, and +'s mark outliers. Significant differences between groups are indicated with asterisks (** p<0.01).

(c) AIM 3. Examine and quantify location and type of mechanical damage in cadaveric specimen after CI electrode insertion on post-experimental imaging. MicroCT scans will be obtained on specimen following placement of CI electrodes to evaluate electrode position, specifically looking for evidence of trauma or suboptimal positioning, such as tip-fold-over, basilar membrane translocation, and scala vestibuli insertion.

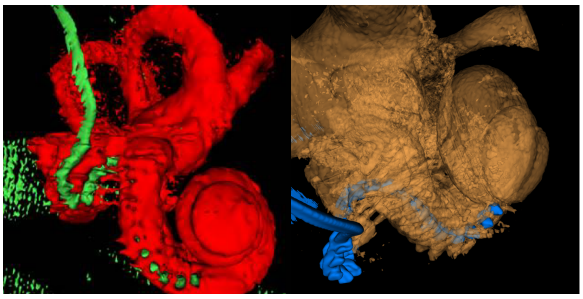


Figure 7. 3-D reconstruction of micro-CT with 40-µm resolution. A CI electrode is coiled in the vestibule of a cadaveric cochlea.

Progress: Images have been collected for preliminary specimen and confirm feasibility of the technique. Additional data collection on this Specific Aim has been delayed due to COVID-related restrictions and in campus research facilities. Data collection will resume once we are able to confirm suboptimal positioning with simultaneous fluoroscopy measurements.

PI: Douglas E. Vetter
Project title: Defining novel cochlear signaling systems that determine ABR wave I threshold shifts following noise
Grant funding period: 7/1/2020 – 6/30/2021

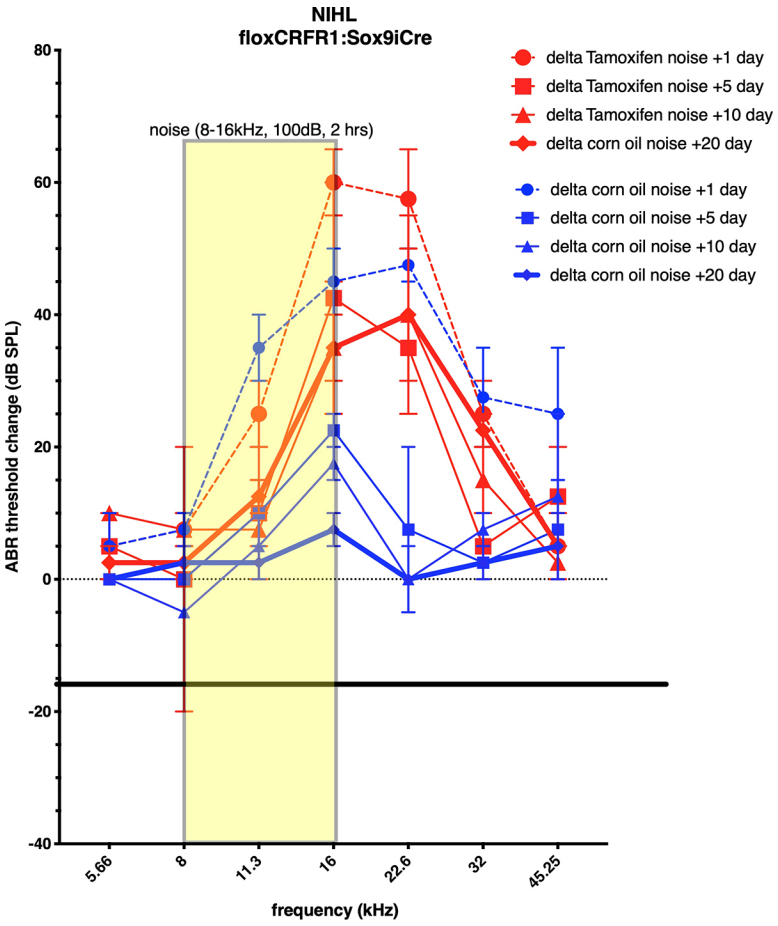
Brief background- Following systemic stressors, the body mounts a stress-response that includes release of steroid hormones such as cortisol (in humans, corticosterone in rodents used in lab experimentation) and other processes indicative of inflammation such as activation of resident immune cells and infiltration of various families of granular and agranular leukocytes. However, this is an inherently slow process that can take an hour or more to reach peak plasma cortisol/corticosterone levels and up to a week to produce the highest immune cell infiltration into the local environment impacted by the original stressor. While these time frames are still viable response times from the point of view of the entire organism, at the local level the effects following a stressor challenge can be run unimpeded due to this considerable time delay in response. Fortunately, a number of organs, including skin and retina, contain their own local stress-response system. We previously discovered a cell signaling pathway in the cochlea that suggested the presence of a local stress-response system wholly expressed within the cells of the cochlea. Briefly, we found corticotropin-releasing factor (CRF), the hypothalamic initiation signal of the hypothalamic-pituitary-adrenal (HPA) axis, and its receptors CRFR1 and CRFR2 and POMC/ACTH, the systemic endocrine mediator signals from the pituitary responsible for inducing corticosterone release from the adrenal glands, are all expressed in support cells of the cochlea (Graham et al., 2011; Graham and Vetter, 2011). Our most recent work demonstrates that the cochlea also expresses all of the steroidogenic enzymes required to synthesize corticosterone and aldosterone and releases both corticosterone and aldosterone in response to noise exposures (paper in preparation). Together these data demonstrate that the cochlea functions independent of the classic (systemic) HPA axis as an extra-adrenal steroidogenic organ. We also have published data showing that CRFR1 activation protects against noise-induced ABR threshold elevation.

In our original application, we described *our long-term objective as revealing the mechanisms by which the mammalian cochlea maintains* ***homeostatic equilibrium*** *and protects against acoustic injury.* As we delve more deeply into understanding the cellular signaling systems that may play significant roles in cochlear homeostasis, we suggested in our original plan that we would further examine the roles of CRFR1 in these processes. As we have carried out our work, we took advantage of the chance to expand our work beyond simple effects of challenging the cochlea with standard noise exposure paradigms. The reasoning behind expanding our challenges is that if our ideas are correct and signaling via the local CRF signaling system is involved in homeostatic maintenance, then degrading this signaling system such as we do via gene manipulation, should prove deleterious to hearing following more than just noise insults. We have thus added mild traumatic brain injury (mTBI), also commonly referred to as concussion to our challenge paradigms.

Briefly, we have used a mouse carrying a floxed CRFR1 gene and a Tamoxifen activatable Cre recombinase whose expression is driven by Sox9 regulatory sequences to produce mice that, following Tamoxifen injections) undergo gene recombination and CRFR1 gene ablation in cochlear support cells. These conditional CRFR1 nulls and corn oil (vehicle control for Tamoxifen) are used in all of our studies.

Progress-

Experiment 1- Noise exposure: Conditional CRFR1 null mice exposed to a noise intensity (Specific Aim 1) that typically produces a temporary threshold shift experience a greater threshold shift that is also longer lasting (perhaps permanent) compared to controls. In the figure below, the blue lines and symbols are data from the control (corn oil injected) mice and the red lines and symbols are from the Tamoxifen injected (conditional null) mice. Tamoxifen injections started at approximately 2 months of age. Thus, the cochlea has developed and matured normally prior to the CRFR1 gene ablation. No congenital defects such as could occur with standard constitutive gene ablation procedures can be ascribed to explain the data. The dotted lines indicate the effects of noise one day following noise exposure and the bold lines indicate the last day of the experiment, 20 days following noise exposure. Data sets are mean and SEM of an n=5 mice per condition (Tamoxifen/corn oil). Work is underway to increase the number of mice used to have a final group size of 8 per condition. Apparent decreased effects at higher frequencies are actually caused by the slowly rising thresholds at these frequencies and the concomitant ceiling effect for threshold elevation at these frequencies. For example, if at 32 kHz the ABR threshold is 50 or 60 dB SPL, there is less room to the ceiling of our testing (80dB SPL) than is available at a frequency with a much lower threshold and greater room to rise to 80db SPL.



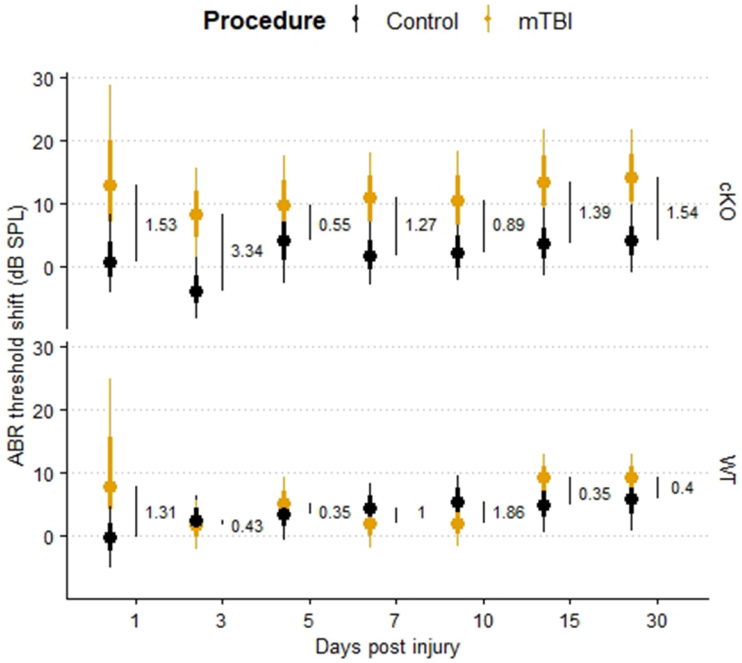
Preliminary interpretation- Loss of CRFR1 signaling from support cells of the cochlea results in greater threshold shifts following noise exposure.

Experiment 2- mTBI: The demographics of individuals at-risk for mTBIs include large numbers of under-represented individuals in medical research. This includes young children. Approximately 2.8 million children aged 5-14 play organized Pop Warner *(tackle) football* and it is estimated that 5% will experience a concussion/mTBI *each season* (Chrisman et al., 2019). Many more individuals are involved in other activities that also carry a significant risk of head injury. The danger these activities pose to the brain is garnering more attention, but *the effects of mTBI on hearing remain largely undiagnosed and unknown*. Current knowledge of the disproportionately greater impact noise exposures have at young ages (Kujawa and Liberman, 2006) may indicate a similarly higher risk of mTBI-associated long-term hearing loss in young participants.

While individuals experiencing military service-related training and hostile combatant encounters, sports-related injuries and motor vehicle accidents represent the most visible at-risk population for mTBI, physical abuse toward women at the hands of their partner/spouse, a component of

intimate partner violence (IPV), dwarfs all these more visible mTBI cohorts *combined* (Valera and Kucyi, 2017; Valera et al., 2019). In the US, it is estimated that *4.4 million females are victims of IPV each year, and 22 million will experience IPV in their lifetime (Tjaden and Thoennes, 2000).* Of these, an *estimated 1.6 million* suffer *multiple* TBIs each year (Valera and Berenbaum, 2003; Valera et al., 2019). A better understanding of sensory dysfunction that includes possible sex-based differences in impacts of mTBI on hearing and balance is critical for providing the care these individuals require. Due to the dogma that mTBIs resolve over time, limited examination following mTBIs by medical professionals *very likely results in the* under-diagnosis of *inner ear* effects from *mTBI. Novel, dedicated research is required in order to better understand the full medical and societal significance of the effect of mTBI on hearing*.

Using the same procedures followed for Experiment 1, we produced conditional CRFR1 null mice. In experiment 2, we used a system to induce a mTBI in the mice and then examined the ABR thresholds. The mTBI produced a more variable response measured by ABR threshold shifts. Anecdotally, this seems to reflect the human clinical manifestations of mTBI, with some people reporting significant tinnitus and mild/moderate temporary hearing "loss" (typically interpreted as higher thresholds) while others report purely vestibular deficits (vertigo) or no inner ear-related symptoms at all. While trends in our data are unmistakable, standard frequentist statistical investigation of the data rarely reached significance at the $p<0.05$ level (data not shown here). Simple visual inspection of the data clearly indicate the "problem" is the variability in the data. While more mice have been added to the pool, the variability persists. We have therefore also incorporated a Bayesian analysis of our data, demonstrated in the above graphic. Here, ABR threshold shifts from the conditional CRFR1 null mice and wild type mice (gold symbols) and their corn oil injected controls (black symbols) are plotted by days post mTBI challenge. While on day one, both the conditional null and wild type mice suffer an ABR threshold shift, the shift resolves by day 3 in wild type mice but persists the entire time of the experiment (20 days) when CRFR1 gene expression is lost in the cochlear support cells. Numbers next to the plots are Bayes Factor (BF_{10}) metrics and can simply be considered to indicate the probability that the hypothesis is different from the null hypothesis and is driven by the manipulation (conditional null of CRFR1). For example, on day 3, the BF_{10} indicates roughly a 3.34x greater probability that the data are explained by the loss of CRFR1 gene expression. While Bayesian probability analysis is not common in our field, its power is well understood in other fields of science. One of the main strengths of this approach is that Bayesian analysis can also produce actual tests of the null hypothesis that is not available in standard frequentists approaches.



Preliminary interpretation: Further work and analysis continues, but our data to date indicate that loss of CRFR1 results in elevated ABR thresholds that do not appreciably recover following mTBI (compare cKO and WT plots). Coupled with data from Experiment 1, these data begin to lend

support to the idea that the local response in the cochlea to homeostatic challenges (here, induced by noise and by mTBI/concussion) *require CRFR1 signaling from support cells to mount a cellular response to injury important for recovery from injury.* Further analysis may also help reveal how these injuries are similar in some ways and perhaps different in other ways. This kind of comparison between injury models has not been carried out to our knowledge and may be clinically useful in the future.

Experiment 3: We have also begun our work to both visualize and quantify the local immune/inflammatory response of the cochlea in response to noise (Specific Aim 2). We have obtained hCD68-GFP mice from JAX Labs, have bred the mice to obtain offspring for use in experiments, and have recently sound exposed the first cohorts. CD68-GFP mice express green fluorescent protein in monocytes. The GFP marker is maintained as these cells mature into macrophages, one of the most numerous immune cells infiltrating the cochlea following injury. Mice have been noise exposed and perfused to anatomical analysis. The recent winter storm hitting the South (it is current 18F in Jackson MS at the time of this writing) has hindered the first microscopic examination of the results, but these should be available very soon. The first cohort of mice noise exposed will be used to establish a baseline of CD68+ infiltrates in the cochlea. Once this baseline is established, work will proceed in which both pharmacological and gene null manipulations will be used to assess whether CRFR1 plays a role in the immune response of the cochlea to noise. We anticipate this Aim to be completed by the end of April at the latest.

Summary: Despite COVID-19 disruptions, work has proceeded well. We are on track to finishing the first two Aims by the end of the Spring semester even with expanding our Aim 1 insults to include the mTBI procedures. The no-cost extension will be critical for us to continue making progress on the grant, especially with respect to the last Aim described in the original proposal.

PAST PRESIDENTS OF THE AMERICAN OTOLOGICAL SOCIETY

1868 - 69 Elkanah G. Williams, MD

1870 - 73 Henry D. Noyes, MD

1874 - 76 Daniel Bennett St. John Roosa, MD

1877 - 78 Clarence J. Blake, MD

1879 - 80 Albert H. Buck, MD

1881 - 83 John O. Green, MD

1884 - 85 Charles H. Burnett, MD

1886 - 89 J.S. Prout, MD

1890 Oren D. Pomeroy, MD

1891 - 94 Gorham Bacon, MD

1895 - 99 Arthur Mathewson, MD

1900 - 02 Horace.G. Miller, MD

1903 - 05 B. Alex Randall, MD

1906 - 07 Emil Gruening, MD

1908 – Charles .J. Kipp, MD

1909 - 10 Frederick L. Jack, MD

1911 - 12 Edward B. Dench, MD

1913 - 14 James .F. McKernon, MD

1915 - 16 Charles .W. Richardson, MD

1917 - Christen R. Holmes, MD

1918 Norval H. Pierce, MD

1919 Ewing W. Day, MD

1920 Robert Lewis, MD

1921 Wells P. Eagleton, MD

1922 Herbert S. Birket, MD

1923 George E. Shambaugh, Sr., MD

1924 John B. Rae, MD

1925 Eugene A. Crockett, MD

1926 Thomas J. Harris, MD

1927 Arthur B. Duel, MD

1928 Max A. Goldstein, MD

1929 John G. Wilson, MD

1930 S. MacCuen Smith, MD

1931 D. Harold Walker, MD

1932 Lee W. Dean, MD

1933 George I. Tobey, Jr., MD

1934 John R. Page, MD

1935 Samuel J. Crowe, MD

1936 Francis R. Packard, MD

1937 Edmund P. Fowler, MD

1938 Harris P. Mosher, MD

1939 Isidore Friesner, MD

1940 Horace Newhart, MD

1941 George M. Coates, MD

1942 Ernest M. Seydell, MD

1943 - 44 Wesley C. Bowers, MD

1945 - 46 Gordon Berry, MD

1947 William E. Grove, MD

1948 Bernard J. McMahon, MD

1949 Marvin F. Jones, MD

1950 Philip E. Meltzer, MD

1951 Kenneth M. Day, MD

1952 Gordon D. Hoople, MD

1953 Albert C. Furstenberg, MD

1954 Frederick T. Hill, MD

1955 D.E. Staunton Wishart, MD

1956 William. J McNally, MD

1957 John R. Lindsay, MD

1958 Dean M. Lierle, MD

1959 Moses H. Lurie, MD

1960 Robert C. Martin, MD

1961 Henry L. Williams, MD

1962 Lawrence R. Boies, MD

1963 Joseph A. Sullivan, MD

1964 Theodore E. Walsh, MD

1965 Harry Rosenwasser, MD

1966 Howard P. House, MD

1967 James A. Moore, MD

1968 George E. Shambaugh, Jr., MD

1969 Frank D. Lathrop, MD

1970 Francis L. Lederer, MD

1971 John E. Bordley, MD

1972 Walter P. Work, MD

1973 Ben H. Senturia, MD

1974 Wesley H. Bradley, MD

1975 Lester A. Brown, MD

1976 Victor Goodhill, MD

1977 Harold Schuknecht, MD

1978 Clair M. Kos, MD

1979 G. Dekle Taylor, MD

1980 Eugene Derlacki, MD

1981 Richard J. Bellucci, MD

1982 J. Brown Farrior, MD

1983 Jack V. Hough, MD

1984 Cary N. Moon, Jr., MD

1985 Francis A. Sooy, MD

1986 Brian F. McCabe, MD

1987 Harold G. Tabb, MD

1988 Richard R. Gacek, MD

1989 D. Thane Cody, MD

1990 H.A. Ted Bailey, Jr., MD

1991 William F. House, MD

1992 Michael Glasscock, III, MD

1993 Mansfield F.W. Smith, MD

1994 Robert I. Kohut, MD

1995 Robert A. Jahrsdoerfer, MD

1996 Derald E. Brackmann, MD

1997 Joseph C. Farmer, Jr., MD

1998 Charles M. Luetje, MD

1999 Gregory J. Matz, MD

2000 C. Gary Jackson, MD

2001 A. Julianna Gulya, MD

2002 Richard A. Chole, MD PhD

2003 Horst R. Konrad, MD

2004 Jeffrey P. Harris, MD, PhD

2005 Sam E. Kinney, MD

2006 John K. Niparko, MD

2007 Antonio De La Cruz, MD

2008 Clough Shelton, MD

2009 Joseph B. Nadol, Jr., MD

2010 Bruce J. Gantz, MD

2011 C. Phillip Daspit, MD

2012 Herman A. Jenkins, MD

2013 Paul R. Lambert, MD

2014 John W. House, MD

2015 D. Bradley Welling, MD, PhD

2016 Debara L. Tucci, MD, MS, MBA

2017 Samuel H. Selesnick, MD

2018 Roberto A. Cueva, MD

2019 Carol A. Bauer, MD

2020 John P. Carey, MD

PAST SECRETARY - TREASURERS OF THE AMERICAN OTOLOGICAL SOCIETY

1868 - 1870	C. E. Ryder, MD
1870 - 1879	J. O. Green, MD
1879 - 1898	J. J. B. Vermyne, MD
1898 - 1907	Frederick L. Jack, MD
1907 - 1912	James F. McKernon, MD
1912 - 1917	John B. Rae, MD
1917 - 1919	George E. Shambaugh, MD
1919 - 1925	Thomas J. Harris, MD
1925 - 1927	D. Harold Walker, MD
1927 - 1940	Thomas J. Harris, MD
1940 - 1945	Isidore S. Friesner, MD
1945 - 1950	Gordon D. Hoople, MD
1950 - 1955	John R. Lindsay, MD
1955 - 1960	Lawrence R. Boies, MD
1960 - 1965	James A. Moore, MD
1965 - 1972	Wesley H. Bradley, MD
1972 - 1977	G. Dekle Taylor, MD
1977 - 1982	Cary N. Moon, Jr., MD
1982 - 1987	D. Thane Cody, MD
1987 - 1992	Robert I. Kohut, MD
1992 - 1997	Gregory J. Matz, MD
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

AWARD OF MERIT RECIPIENTS (1949 - 2019)

1949	George M. Coates, MD
1951	Barry J. Anson, PhD
	Theodore H. Bast, PhD
1952	Edmund P. Fowler, Sr., MD
1953	Julius Lempert, MD
1954	Stacy Guild, PhD
1957	Georg von Bekesy, PhD
1959	Ernest Glen Wever, PhD
1960	Hallowell Davis, MD
1961	John R. Lindsay, MD
1962	William J. McNally, MD
1965	Anderson C. Hilding, MD
1966	Gordon D. Hoople, MD
1967	Merle Lawrence, PhD
1968	Lawrence R. Boles, MD
1969	Sir Terence Cawthorne
1970	Senator Joseph A. Sullivan, MB
1971	Samuel Rosen, MD
1972	Howard P. House, MD
1973	Moses H. Lurie, MD
1974	George E. Shambaugh, Jr., MD
1975	Catherine A. Smith, PhD
1976	Harry Rosenwasser, MD
1977	Frank Lathrop, MD
1978	Juergen Tonndorf, MD
1979	John Bordley, MD
1980	Ben H. Senturia, MD
1981	J. Brown Farrior, MD
1982	William F. House, MD
1983	Victor Goodhill, MD
1984	Harold F. Schuknecht, MD
1985	Wesley H. Bradley, MD
1986	John J. Shea, Jr., MD
1987	Jack V. Hough, MD
1988	George D. Nager, MD
1989	Brian F. McCabe, MD
1990	Eugene L. Derlacki, MD
1991	Richard R. Gacek, MD
1992	James L. Sheehy, MD
1993	James A. Donaldson, MD
1994	Fred H. Linthicum, Jr., MD
1995	D. Thane Cody, MD
1996	F. Blair Simmons, MD
1997	Michael E. Glasscock, III, MD
1998	Michael M. Paparella, MD
1999	Mansfield F. W. Smith, MD
2000	Robert A. Jahrsdoerfer, MD
2001	Derald E. Brackmann, MD
2002	Gregory J. Matz, MD
2003	James B. Snow, Jr., MD
2004	Robert J. Ruben, MD
2005	David J. Lim, MD
2006	Herbert Silverstein, MD
2007	Richard A. Chole, MD, PhD
2008	Malcolm D. Graham, MD
2009	William H. Lippy, MD
2010	George Gates, MD
2011	Sam E. Kinney, MD
2012	Joseph B. Nadol, Jr., MD
2013	Bruce J. Gantz, MD

2014 Richard T. Miyamoto, MD

2015 Jeffrey P. Harris, MD, PhD

2016 Charles M. Luetje, MD

2017 Clough Shelton, MD

2018 Paul R. Lambert, MD

2019 John W. House, MD

2020 TBA

2021 TBA

ANNOUNCEMENT!!

The recipients of the 2020 Award of Merit and the 2021 Award of Merit will be announced on Sunday, April 11 at 5:30 P.M., Central Time at the close of the 154th Annual AOS meeting!

GUESTS OF HONOR (1974 - 2020)

1974	Harry Rosenwasser, MD
1975	John E. Bordley, MD
1976	Ben H. Senturia, MD
1977	Henry B. Perlman, MD
1978	Howard P. House, MD
1979	Hallowell Davis, MD
1980	Victor Goodhill, MD
1981	Harold Schuknecht, MD
1982	George E. Shambaugh, Jr., MD
1983	Wesley H. Bradley, MD
1984	Brown Farrior, MD
1985	Bruce Proctor, MD
1986	Merle Lawrence, PhD
1987	Robert M. Seyfarth, PhD
1988	G. Dekle Taylor, MD
1989	Eugene L. Derlacki, MD
1990	William F. House, MD
1991	Michael E. Glasscock III, MD
1992	William E. Hitselberger, MD
1992	D. Thane R. Cody, MD
1994	Cesar Fernandez, MD
1995	Richard R. Gacek, MD
1996	James L. Sheehy, MD
1997	Mansfield F.W. Smith, MD
1998	Robert A. Jahrsdoerfer, MD
1999	Barbara A. Bohne, Ph.D.
2000	Derald E. Brackmann, MD
2001	James B. Snow, Jr., MD
2002	David J. Lim, MD
2003	James F. Battey, Jr., MD, PhD
2004	Ugo Fisch, MD
2005	George A. Gates, MD
2006	Richard A. Chole, MD, PhD
2007	Fred H. Linthicum, Jr., MD
2008	H. Ric Harnsberger, MD
2009	Robert J. Ruben, MD
2010	Edwin Rubel, PhD
2011	Richard T. Miyamoto, MD
2012	Vicente Honrubia, MD
2013	Bruce J. Gantz, MD
2014	David A. Moffat, PhD
2015	Joseph B. Nadol Jr., MD
2016	Blake Wilson, PhD, DSc, DEng, Dr.med.hc
2017	John W. House, MD
2018	Konstantina M. Stankovic, MD, PhD
2019	Judy R. Dubno, PhD
2020	Meeting canceled/COVID-19

AMERICAN OTOLOGICAL SOCIETY 2020-2021 ROSTER

(Includes the 2021 Candidates inducted at the AOS 2021 Spring Meeting)

Kedar Adour, MD
San Francisco, California
1988 Emeritus

Oliver F Adunka, MD
Columbus, Ohio
2016 Active

Yuri Agrawal, MD
Lutherville, Maryland
2021 Active

Pedro Albernaz
Sao Paulo, Brazil
1993 Honorary

P. W. Alberti, MD
Toronto, Ontario, Canada
1982 Emeritus

Sean R Althaus, MD
Georgetown, Texas
1987 Emeritus

Ronald G Amedee, MD
New Orleans, Louisiana
1995 Active

Simon I Angeli, MD
Miami, Florida
2009 Active

Patrick J Antonelli, MD
Gainesville, Florida
2001 Active

Edward Applebaum, MD
Chicago, Illinois
1985 Emeritus

Moises A Arriaga, MD
Metairie, Louisiana
2002 Active

H. Alexander Arts, MD
Ann Arbor, Michigan
2001 Active

Marcus D Atlas, MBBS, FRACS
Subiaco, Australia
2005 Corresponding

Douglas D Backous, MD
Edmonds, Washington
2006 Active

Thomas J Balkany, MD
Dillon, Colorado
1991 Senior

Manohar Bance, MD
Cambridge, United Kingdom
2013 Active

David M Barrs, MD
Phoenix, Arizona
1997 Senior

Loren J Bartels, MD
Tampa, Florida
1992 Senior

Carol A Bauer, MD
Springfield, Illinois
2006 Active

Charles W Beatty, MD
Rochester, Minnesota
1995 Emeritus

James E Benecke, MD
Scottsdale, Arizona
2006 Senior

Marc L Bennett, MD
Nashville, Tennessee
2019 Active

Ricardo F Bento, MD, PhD
Sao Paulo,
2001 Associate

Brian Blakley, MD
Winnipeg, Canada
1996 Senior

Nikolas H Blevins, MD
Stanford, California
2009 Active

Charles D Bluestone, MD
Pittsburgh, Pennsylvania
1977 Emeritus

Derald E Brackmann, MD
Los Angeles, California
1979 Senior

B. Hill Britton, MD
San Antonio, Texas
1978 Emeritus

Hilary A Brodie, MD, PhD
Sacramento, California
2001 Active

Craig A Buchman, MD
St. Louis, Missouri
2005 Active

Matthew L Bush, MD, PhD
Lexington, Kentucky
2020 Active

Rinaldo F Canalis, MD
Santa Monica, California
1991 Emeritus

Robert W Cantrell, MD
Charlottesville, Virginia
1979 Emeritus

John P Carey, MD
Baltimore, Maryland
2006 Active

Stephen P Cass, MD
Aurora, Colorado
2000 Active

Margaretha L Casselbrant, MD, PhD
Pittsburgh, Pennsylvania
2001 Senior

Sujana S Chandrasekhar, MD
New York, New York
2004 Active

Kay W Chang, MD
Stanford, California
2014 Active

Douglas A Chen, MD
Pittsburgh, Pennsylvania
2008 Active

Steven Wan W Cheung, MD
San Francisco, California
2006 Active

Wade W Chien, MD
Potomac, Maryland
2020 Active

Edgar L Chiossone, MD
Miami, Florida
1993 Honorary

Richard A Chole, MD, PhD
St. Louis, Missouri
1984 Emeritus

Daniel Choo, MD
Cincinnati, Ohio
2008 Active

Graeme M Clark, PhD
Eltham, Victoria, Australia
2002 Honorary

Jack D Clemis, MD
Wilmette, Illinois
1976 Emeritus

Daniel H Coelho, MD
Richmond, Virginia
2018 Active

Newton J Coker, MD
Santa Fe, New Mexico
1991 Emeritus

Benjamin T Crane, MD, PhD
Pittsford, New York
2021 Active

Roberto A Cueva, MD
San Diego, California
2005 Active

Charles Phillip Daspit, MD
Paradise Valley, Arizona
1995 Emeritus

Charles C Della Santina, MD, PhD
Parkville, Maryland
2009 Active

M. Jennifer Derebery, MD
Los Angeles, California
2002 Active

Sandra G Desa Souza, MBMS
Chowpatty, Mumbai, India
2003 Corresponding

Vicente G Diamante, MD
Buenos Aires, Argentina
2000 Corresponding

Joseph R DiBartolomeo, MD
Santa Barbara, California
2015 Senior

John R Dickins, MD
Little Rock, Arkansas
1991 Emeritus

Hamid R Djalilian, MD
Orange, California
2015 Active

Joni K Doherty, MD, PhD
Los Angeles, California
2015 Active

Katsumi Doi, MD, PhD
Osaka-Sayama, Japan
2020 Corresponding

John L Dornhoffer, MD
Little Rock, Arkansas
2004 Active

Karen J Doyle-Enright, MD, PhD
Fenton, Michigan
2002 Active

Colin L Driscoll, MD
Rochester, Minnesota
2012 Active

Judy R Dubno, PhD
Charleston, South Carolina
2014 Associate

Larry G Duckert, MD
Seattle, Washington
1988 Emeritus

Arndt J Duvall III, MD
Minneapolis, Minnesota
1971 Emeritus

Thomas L Eby, MD
Jackson, Mississippi
1995 Active

David J. Eisenman, MD
Baltimore, Maryland
2019 Active

Hussam K El-Kashlan, MD
Ann Arbor, Michigan
2006 Active

John R Emmett, MD
Memphis, Tennessee
1990 Senior

Adrien A Eshraghi, MD
Weston, Florida
2013 Active

Abraham Eviatar, MD
Scarsdale, New York
1981 Emeritus

George W Facer, MD
Bonita Springs, Florida
1994 Senior

Jay B Farrior, III, MD
Tampa, Florida
1990 Senior

Jose N Fayad, MD
Dhahran, Saudi Arabia
2007 Active

Joseph G Feghali, MD
Bronx, New York
2002 Active

Howard W Francis, MD
Durham, North Carolina
2003 Active

Bernard Gil Fraysse, MD
Toulouse, France
1999 Corresponding

David R Friedland, MD, PhD
Milwaukee, Wisconsin
2011 Active

Rick Friedman, MD, PhD
La Jolla, California
2001 Active

Michael H Fritsch, MD
Indianapolis, Indiana
2003 Active

Richard R Gacek, MD
Worcester, Massachusetts
1969 Emeritus

Bruce J Gantz, MD
Iowa City, Iowa
1987 Active

L. Gale Gardner, Jr., MD
Shreveport, Louisiana
1983 Senior

George A Gates, MD
Boerne, Texas
1987 Emeritus

Soha N Ghossaini, MD
Astoria, New York
2019 Active

Gerard J Gianoli, MD
Covington, Louisiana
2007 Active

Paul W Gidley, MD
Houston, Texas
2015 Active

Joel A Goebel, MD
St. Louis, Missouri
1995 Emeritus

Robert A Goldenberg, MD
Dayton, Ohio
1989 Senior

Jerome C Goldstein, MD
Lake Worth, Florida
Honorary

Malcolm D Graham, MD
Atlanta, Georgia
1979 Emeritus

J. Douglas Green Jr., MD
Jacksonville, Florida
2008 Active

John H Greinwald Jr., MD
Cincinnati, Ohio
2013 Active

Andrew J Griffith, MD, PhD
Bethesda, Maryland
2015 Associate

Samuel P Gubbels, MD
Aurora, Colorado
2017 Active

A. Julianna Gulya, MD
Locust Grove, Virginia
1991 Emeritus

Thomas J Haberkamp, MD
Cleveland, Ohio
1997 Senior

Paul E Hammerschlag, MD
New York, New York
2001 Senior

Marlan R Hansen, MD
Iowa City, Iowa
2009 Active

Lee A Harker, MD
Omaha, Nebraska
1987 Emeritus

Jeffrey P Harris, MD, PhD
San Diego, California
1988 Senior

Cecil W Hart, MD
Palm Springs, California
1992 Emeritus

George T Hashisaki, MD
Charlottesville, Virginia
2015 Active

David S Haynes, MD
Nashville, Tennessee
2009 Active

Ronna Hertzano, MD, PhD
Baltimore, Maryland
2021 Active

Keiko Hirose, MD
St. Louis, Missouri
2010 Active

Barry E Hirsch, MD
Pittsburgh, Pennsylvania
1996 Senior

Michael Hoa, MD
Washington, DC
2021 Active

Michael E Hoffer, MD
Miami, Florida
2003 Active

Ronald A Hoffman, MD
New York, New York
1992 Senior

James J Holt, MD, MS
Marshfield, Wisconsin
2009 Emeritus

Karl L Horn, MD
Santa Fe, New Mexico
2001 Senior

John W House, MD
Los Angeles, California
1984 Senior

Timothy E Hullar, MD
Portland, Oregon
2013 Active

Makoto Igarashi, MD
Tokyo, Japan
1973 Senior Associate

S. Armagan Incesulu, MD
Eskisehir, Turkey
2012 Corresponding

Brandon Isaacson, MD
Dallas, Texas
2019 Active

Akira Ishiyama, MD
Los Angeles, California
2009 Active

Juichi Ito, MD, PhD
Shiga, Japan
2007 Corresponding

Salvatore J Iurato, MD
Bari, Italy
1994 Senior Associate

Robert K Jackler, MD
Stanford, California
1992 Active

Carol A Jackson, MD
Newport Beach, California
1994 Active

Abraham Jacob, MD
Tucson, Arizona
2014 Active

Adrian James, MD
Toronto, Canada
2011 Active

Herman A Jenkins, MD
Aurora, Colorado
1987 Active

Lars-Goran Johnsson, MD
1979 Senior Associate

Raleigh O Jones Jr., MD
Lexington, Kentucky
2017 Active

Steven K Juhn, MD
Minneapolis, Minnesota
1980 Senior Associate

Timothy T K Jung, MD, PhD
Riverside, California
1990 Active

Donald B Kamerer, MD
Pittsburgh, Pennsylvania
1988 Emeritus

David M Kaylie, MD
Durham, North Carolina
2014 Active

Bradley W Kesser, MD
Charlottesville, Virginia
2008 Active

Nelson Y Kiang, PhD
Boston, Massachusetts
1969 Emeritus

Paul R Kileny, PhD
Ann Arbor, Michigan
1979 Senior Associate

Ana H Kim, MD
New York, New York
2016 Active

Harold H Kim, MD
Portland, Oregon
2010 Active

Hung Jeffrey Kim, MD
Washington, District of Columbia
2014 Active

Sam E Kinney, MD
Moreland Hills, Ohio
1981 Senior

Horst R Konrad, MD
Naples, Florida
1991 Senior

Richard D Kopke, MD
Oklahoma City, Oklahoma
2005 Active

Arvind Kumar, MD
Hinsdale, Illinois
1993 Emeritus

J. Walter Kutz, MD
Dallas, Texas
2019 Active

Robert F Labadie, MD, PhD
Nashville, Tennessee
2009 Active

Anil K Lalwani, MD
New York, New York
1999 Active

Paul R Lambert, MD
Charleston, South Carolina
1995 Active

Daniel J Lee, MD
Boston, Massachusetts
2016 Active

K. J. Lee, MD
Guilford, Connecticut 1997
1997 Emeritus

Kenneth H Lee, MD, PhD
Plano, Texas
2017 Active

John P Leonetti, MD
Maywood, Illinois
1995 Active

S. George Lesinski, MD
Cincinnati, Ohio
1993 Emeritus

Samuel C Levine, MD *Eden Prairie, Minnesota* 1999
Senior

Charles J Limb, MD
San Francisco, California
2018 Active

Vincent Y W Lin, MD
Toronto, Canada
2018 Active

Roger C Lindeman, MD
Mercer Island, Washington
1987 Emeritus

Thomas E Linder, MD
Luzern, Switzerland
2001 Corresponding

William H Lippy, MD
Warren, Ohio
1988 Emeritus

Philip D Littlefield, MD
San Diego, California
2013 Active

Ward B Litton, MD
Bonita Springs, Florida
1969 Emeritus

Brenda Lee Lonsbury-Martin, PhD
Loma Linda, California
1978 Senior Associate

Charles M Luetje, MD
Olathe, Kansas
1991 Senior

Larry B Lundy, MD
Ponte Vedra Beach, Florida
2011 Active

Lawrence R Lustig, MD
New York, New York
2006 Active

John D Macias, MD
Phoenix, Arizona
2015 Active

Charles A Mangham Jr., MD
Hailey, Idaho
1987 Emeritus

Wolf J Mann, MD
Mainz, Germany
1996 Emeritus

Sam J Marzo, MD
Maywood, Illinois
2011 Active

Douglas E Mattox, MD
Atlanta, Georgia
1992 Active

Jennifer L Maw, MD
San Jose, California
2020 Active

John T McElveen Jr., MD
Raleigh, North Carolina
1997 Active

Michael J McKenna, MD
Boston, Massachusetts
1999 Active

Brian J McKinnon, MD, MBA
Galveston, Texas
2015 Active

Sean O McMenomey, MD
Seattle, Washington
2009 Active

Cliff A Megerian, MD
Cleveland, Ohio
2006 Active

Michael Merzenich, PhD
San Francisco, California
1986 Senior Associate

William L Meyerhoff, MD
Dallas, Texas
1981 Emeritus

Alan G Micco, MD
Chicago, Illinois
2007 Active

Mia E Miller, MD
Los Angeles, California
2021 Active

Josef M Miller, PhD
Ann Arbor, Michigan
1979 Senior Associate

Lloyd B Minor, MD
Stanford, California
2001 Active

Richard T Miyamoto, MD
Indianapolis, Indiana
1987 Senior

Edwin M Monsell, MD, PhD
Rochester Hills, Michigan
1995 Senior

Gary F Moore, MD
Omaha, Nebraska
2003 Active

William H Moretz Jr., MD
Augusta, Georgia
1999 Senior

Tetsuo Morizono, MD, DMS
Nishi-Ku, Fukuoka City, Japan
1985 Senior Associate

Terrence P Murphy, MD
Atlanta, Georgia
2002 Active

Eugene N Myers, MD
Pittsburgh, Pennsylvania
1974 Emeritus

Joseph B Nadol Jr., MD
Boston, Massachusetts
1988 Emeritus

Hideko H Nakajima, MD, PhD
Boston, Massachusetts
2017 Associate

Julian M Nedzelski, MD
Toronto, Ontario, Canada
1987 Emeritus

Brian A Neff, MD
Rochester, Minnesota
2014 Active

Erik G Nelson, MD
Lake Forest, Illinois
2011 Active

Ralph A Nelson, MD
Manchester, Washington
1995 Emeritus

John S Oghalai, MD
Los Angeles, California
2009 Active

Michael M Paparella, MD
Minneapolis, Minnesota
1968 Senior

James J Pappas, MD
Little Rock, Arkansas
1983 Emeritus

Dennis Pappas, MD
Birmingham, Alabama
1985 Emeritus

Dennis G Pappas Jr., MD
Birmingham, Alabama
2004 Active

Blake C Papsin, MD
Toronto, Ontario, Canada
2005 Active

Simon C Parisier, MD
New York, New York
1982 Senior

James L Parkin, MD
Salt Lake City, Utah
1986 Emeritus

Steven M Parnes, MD
Albany, New York
2002 Active

Lorne S Parnes, MD
London, Ontario, Canada
2000 Active

Myles L Pensak, MD
Cincinnati, Ohio
1992 Active

Rodney Perkins, MD
Woodside, California
2013 Senior Associate

Brian P Perry, MD
San Antonio, Texas
2015 Active

Harold C Pillsbury, MD
Chapel Hill, North Carolina
1988 Senior

Dennis S Poe, MD
Boston, Massachusetts
1995 Active

Leonard R Proctor, MD
Bel Aire, Maryland
1989 Emeritus

G. Mark Pyle, MD
Madison, Wisconsin
2003 Senior

Steven D Rauch, MD
Watertown, Massachusetts
2004 Active

Miriam I Redleaf, MD
Albuquerque, New Mexico
2013 Active

Jose A Rivas, MD
Bogota, Colombia
2009 Emeritus

Robert C. O'Reilly, MD
Philadelphia, Pennsylvania
2009 Active

Pamela C Roehm, MD, PhD
Jenkintown, Pennsylvania
2020 Active

Peter S Roland, MD
Eden, Utah
1992 Senior

John T Roland Jr., MD
New York, New York
2005 Active

Max L Ronis, MD
Philadelphia, Pennsylvania
1972 Emeritus

Seth Rosenberg, MD
Sarasota, Florida
2001 Active

John J Rosowski, PhD
Boston, Massachusetts
1989 Senior Associate

Edwin W Rubel, PhD
Seattle, Washington
1986 Senior Associate

Robert J Ruben, MD
New York, New York
1974 Senior

Allan M Rubin, MD, PhD
Perrysburg, Ohio
1997 Senior

Jay T Rubinstein, MD, PhD
Seattle, Washington
2002 Active

Michael J Ruckenstein, MD
Philadelphia, Pennsylvania
2003 Active

Christina L Runge, PhD
Milwaukee, Wisconsin
2019 Associate

Leonard P Rybak, MD, PhD
Springfield, Illinois
1989 Emeritus

Masafumi Sakagami, MD, PhD
Hyogo, Japan
2006 Corresponding

Alec N Salt, PhD
St. Louis, Missouri
2006 Associate

Ravi N Samy, MD
Cincinnati, Ohio
2020 Active

Clarence T Sasaki, MD
New Haven, Connecticut
1992 Senior

Robert T Sataloff, MD
Philadelphia, Pennsylvania
1990 Active

James E Saunders, MD
Lebanon, New Hampshire
2008 Active

Jochen Schacht, PhD
Ann Arbor, Michigan
1992 Senior Associate

Arnold G Schuring, MD
Warren, Ohio
1990 Emeritus

Mitchell K Schwaber, MD
Nashville, Tennessee
1993 Senior

Michael D Seidman, MD
Celebration, Florida
2001 Active

Samuel H Selesnick, MD
New York, New York
1999 Active

Clough Shelton, MD
Salt Lake City, Utah
1995 Senior

Neil T Shepard, PhD
Missoula, Montana
1973 Senior Associate

Jack A Shohet, MD
Newport Beach, California
2018 Active

Herbert Silverstein, MD
Sarasota, Florida
1973 Senior

George T Singleton, MD
Gainesville, Florida
1972 Emeritus

Aristides Sismanis, MD
Richmond, Virginia
1993 Senior

Henryk Skarzynski, MD, PhD
Warsaw, Poland
2012 Corresponding

William H Slattery III, MD
Los Angeles, California
2014 Active

Richard J Smith, MD
Iowa City, Iowa
2012 Honorary

Eric E Smouha, MD
New York, New York
2004 Active

James B Snow Jr., MD
West Grove, Pennsylvania
1973 Emeritus

Gershon J Spector, MD
St. Louis, Missouri
1979 Emeritus

Hinrich Staecker, MD, PhD
Kansas City, Kansas
2013 Active

Konstantina M Stankovic, MD, PhD
Boston, Massachusetts
2015 Active

Ronald Steenerson, MD
Atlanta, Georgia
2020 Associate

Olivier Sterkers, MD, PhD
Paris, France
2003 Corresponding

Steven A Telian, MD
Ann Arbor, Michigan
1997 Senior

Fred F Telischi, MD
Miami, Florida
2002 Active

Norman Wendell W Todd Jr., MD
Madison, Mississippi
1996 Senior

Daniel J Tollin, PhD
Aurora, Colorado
2016 Associate

Debara L Tucci, MD, MS
Durham, North Carolina
2000 Active

Andrea Vambutas, MD
New Hyde Park, New York
2019 Active

Jeffrey T Vrabec, MD
Houston, Texas
2004 Active

P. Ashley Wackym, MD
New Brunswick, New Jersey
1997 Active

George B Wanna, MD
New York, New York
2015 Active

Jack J Wazen, MD
Sarasota, Florida
1993 Senior

Peter C Weber, MD, MBA
Boston, Massachusetts
2002 Active

Roger E Wehrs, MD
Tulsa, Oklahoma
1975 Emeritus

D. Bradley Welling, MD, PhD
Boston, Massachusetts
1998 Active

Stephen J Wetmore, MD
Morgantown, West Virginia
2001 Emeritus

Richard J Wiet, MD
Sawyer, Michigan
1987 Emeritus

Eric P Wilkinson, MD
Boise, Idaho
2014 Active

Sabina R Wullstein, MD
Wurzburg,
1999 Senior Associate

Thomas P Wustrow, MD
Munchen, Germany
2000 Corresponding

Naoaki Yanagihara, MD
Matsyama, Japan
2008 Honorary

Eiji Yanagisawa, MD
New Haven, Connecticut
1996 Emeritus

Nancy M Young, MD
Chicago, Illinois
2007 Active

in Memoriam

(in alphabetical order)

The AOS Administrative office was notified of the following members death since our last Spring meeting in 2019.

Please take a moment of silence to remember these outstanding colleagues & friends

Prof Ugo Fisch, MD

Fred H. Linthicum Jr., MD

David A. Moffat, MD, PhD

Although the Administrative Office did not receive notification of the death of the following members, we confirmed they are no longer with us. Please include them in your thoughts and prayers.

J. H. Thomas Rambo, MD (Passed April 2016)
Dr. Rambo died in New York City at his home on his 101st birthday.

Jozef J. Zwislocki, MD, MSc (Passed May 14, 2018)

H.A. Ted Bailey, Jr., MD (Passed January 21, 2019)

Robert J. Wolfson, MD (Passed November 8, 2019)