

Seminar Summary Report: “Investigational Imaging Techniques of Inner Ear Seminar”

Date: Saturday, May 2, 2026
Time: 07:00–9:00 Pacific Time

Overview

The Investigational Imaging Techniques of Inner Ear Seminar, hosted by Dr. Willaim Slattery from the House Institute Foundation, highlighted multidisciplinary progress in non-invasive and functional imaging of the inner ear. Speakers covered contrast-enhanced MRI, ultra-high-resolution T2 MRI, delayed 3D FLAIR, terahertz imaging, functional tracer imaging with SPECT and sodium MRI, and intraoperative OCT, with a strong emphasis on clinical translation and the technical limits that still need to be overcome.

Introduction: HSA and SSNHL

The House Institute Foundation Hearing Science Accelerator (HSA) is a strategic initiative designed to advance biomedical research in hearing disorders that have historically lacked effective treatment options. By bringing together leading experts in hearing science and thought leaders from other disciplines to an in-person workshop, the HSA fosters innovative, cross-disciplinary collaboration. For each targeted disorder, the HSA identifies critical research questions with the aim of shifting from progress to transformative innovation.

Sudden Sensorineural Hearing Loss was defined during the seminar as a rapid loss of hearing, typically in one ear, amounting to more than 30 decibels over at least three consecutive frequencies and occurring within a 72-hour window, often instantaneously. Despite decades of investigation, its etiology remains unclear. Experts discussed various theories, including vascular, viral, autoimmune, and inflammatory causes, but no definitive conclusion has been reached. Dr. Slattery emphasized that much of the existing research remains stagnant and lacks translational impact, urging for more purposeful collaboration and innovation, which is a goal of the Hearing Science Accelerator initiative.

Critical research questions on imaging from SSNHL HSA:

Q2: Can acute MRI predict response to treatment?

- a. Is the MRI noise safe in the setting of acute inner ear hearing loss?
- b. Is it possible to get a quiet inner-ear protocol?
- c. Can early MRI help us determine etiology of SSNHL? Diagnostic tests protocols for intralabyrinthine, inflammation, infection, ischemia, hydrops, bleeding or schwannoma would be required.
- d. Can MRI determine the role of cochlear hydrops in SSNHL?

Q3: How can we use functional and imaging studies to identify the site of lesion, better predict prognosis or treatment protocol?

- a. Would earlier testing within (72 hours of onset) help?
- b. Would a natural history study of SSNHL help?
- c. Does the pattern of SSNHL on audiometric testing predict treatment response?
- d. A standardized testing protocol would allow comparison of standard data and potential a central registry for SSNHL. The following test should be included in such a testing protocol.
 1. Behavioral audiogram: pure tones averages (PTA) 250 Hz to 8 kHz, air and bone conduction, word recognition scores, tympanometry, acoustic reflexes
 2. Extended high-frequency audiogram if possible – up to 18 kHz
 3. Distortion product otoacoustic emissions (DPOAE)
 4. Electrocochleography (ECoG)
 5. Vestibular evoked myogenic potentials (VEMPs) at 250 and 500 Hz

Speaker Presentations

Bryan Ward, MD: Dynamic contrast MRI of the blood-labyrinth barrier

Dr. Ward presented a pilot study from Johns Hopkins examining blood-labyrinth barrier permeability using a dynamic contrast MRI method. The study included 7 patients with Meniere's disease and 10 healthy controls scanned on a 3T Philips system using IV ProHance and a CDSC-type sequence that captured whole-brain fluid volumes every 9 seconds over roughly 21 minutes.

His main point was that gadolinium enters the inner ear within seconds in all adults, but appears to enter faster in diseased ears. In this small cohort, the strongest differences were seen in the saccule and internal auditory canal in Meniere's disease, while the cochlea and utricle did not show statistically significant group differences. He emphasized that the method may eventually help study sudden sensorineural hearing loss, Meniere's disease, and other disorders involving vascular permeability, although interpretation still needs caution because faster enhancement may reflect permeability, volume changes, or perfusion effects.

Michael Eliezer, MD: Ultra-high-resolution T2 and delayed 3D FLAIR

Dr. Eliezer described how his group in Paris is using ultra-high-resolution T2 imaging and delayed 3D FLAIR in routine clinical inner ear MRI. He noted that their center performs around 400 delayed inner ear MRI protocols and that deep-learning reconstruction has made it possible to reach about 0.2 mm isotropic resolution with clinically practical acquisition times.

He explained that these techniques improve visualization of the membranous labyrinth, including the utricular and saccular maculae, and can support cochlear implant planning by helping segment the scala tympani and related structures. He also showed that delayed FLAIR can reveal patterns of blood-labyrinth barrier impairment in different vascular territories, including whole-cochlea enhancement, apical cochlear enhancement, and posterior semicircular canal involvement. He stressed that imaging findings must still be interpreted carefully, especially because false positives and false negatives can occur.

Takeshi Fujita, MD, PhD and Kazunori Serita, PhD: Terahertz imaging of the cochlea

Dr. Fujita and Dr. Serita introduced terahertz imaging as a new, complementary approach for cochlear microstructure visualization. They explained that terahertz waves sit between optical and radio frequencies, are non-ionizing, and may be able to image through bone while offering higher structural detail than MRI, though with less penetration than optical methods.

Their current work is based on ex vivo mouse cochleae using near-field terahertz systems. They showed that they can reconstruct both 2D and 3D cochlear images and estimate internal structures such as the cochlear duct and modiolus, with histology used for validation. They acknowledged major limitations, especially strong water absorption and the technical difficulty of generating and detecting sufficiently sensitive signals for in vivo work. Their view was that terahertz imaging is promising as a future complementary modality, but not yet ready for clinical use.

Parveen Bazard, PhD and Akil Turner, MS: Functional tracer imaging and sodium MRI

Dr. Bazard and Akil Turner (PhD student) presented a project aimed at measuring ionic composition and endocochlear potential in the inner ear. They first discussed thallium-201 SPECT as a potassium surrogate, showing that Tl-201 can reach the mouse cochlea rapidly after IV administration and can be detected in vivo with clear SPECT signal. Their phantom and animal experiments supported the basic feasibility of the approach.

They then explained that this line of work had to shift because Tl-201 became unavailable in North America. As a result, they moved toward sodium MRI using custom 9.4T hardware and a surface coil designed for mouse cochlear imaging. Their early results showed measurable sodium signal in the cochlea, with better signal than surrounding brain tissue in their pilot data. They are now working toward a combined proton/sodium coil, bilateral coverage, and higher-field imaging at 15.2T, with the long-term goal of linking imaging signal to ionic concentrations and eventually extending the method to potassium.

John Oghalai, MD and Brian Applegate, PhD: OCT imaging of the inner ear

Dr. Oghalai and Dr. Applegate presented OCT as an optical method that can image both structure and vibration in the inner ear. They described OCT as an ultrasound-like technique using light, with high axial resolution and the ability to measure extremely small vibrations, including picometer-scale motion.

They first showed cadaver temporal bone experiments comparing 1.3 μm and 1.7 μm OCT. Both wavelengths could visualize intracochlear soft tissues when the otic capsule was thin enough, although 1.7 μm offered only modest improvement and was technically harder to implement. The more clinically important part of their talk focused on intraoperative OCT mounted to an operating microscope. In patients undergoing mastoid or translabyrinthine surgery, they were able to image semicircular canals, visualize membranous labyrinth structures, and quantify endolymph-to-perilymph area ratios. Their data suggested that OCT can detect hydrops in humans and may be useful for intraoperative assessment.

Conclusions

Overall, the seminar showed that inner ear imaging is moving beyond exclusion of retrocochlear disease toward direct structural and physiologic characterization. MRI, OCT, terahertz imaging, and functional tracer methods each address different parts of the problem, and the consensus was that the field will likely advance through multimodal, highly collaborative work rather than any single technique alone.