Medical Imaging for the Audiologist: From Symptoms to Scans, Case Based Strategies for Imaging in Audio-vestibular Disorders

Kevin L. Berger, MD
CAQ Neuroradiology

ACR Appropriateness Criteria

- Developed by consensus from multidisciplinary physician panels
- Evidence based guidelines to help referring providers make appropriate imaging decisions
- https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria
- 3700+ Clinical Scenarios
- 1200+ Clinical Variants
- 257 Diagnostic Imaging Documents

Hearing Loss and/or Vertigo

- HEARING LOSS AND/OR VERTIGO Expert Panel on Neurologic Imaging: Edgardo J. Angtuaco, MD1; Franz J. Wippold II, MD2; Rebecca S. Cornelius, MD3; Ashley H. Aiken, MD4; Kevin L. Berger, MD5; Daniel F. Broderick, MD6; Douglas C. Brown, MD7; Julie Bykowski, MD8; Annette C. Douglas, MD9; Isabelle M. Germano, MD10; Bradley W. Kesser, MD11; Marcus M. Kessler, MD, Dr.med12; Charles T. McConnell Jr, MD13; Laszlo L. Mechtler, MD14; James G. Smirniotopoulos, MD15; Michael A. Vogelbaum, MD, PhD.16
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Hearing Loss and/or Vertigo

- Variant 1: Acquired conductive hearing loss in absence of clinically evidence mass in middle ear.
  - CT Temporal Bone: 1st line test (usually appropriate)
  - CT Head: Usually not appropriate.
  - CTA Head: Usually not appropriate
  - MRI Head/IAC: Insufficient bone detail.
    - No evidence to support as 1st line test (Usually not appropriate)
  - MRA: Usually not appropriate
  - MRV: Usually not appropriate

Imaging Modalities

- CT Temporal bone: Provides high resolution imaging of EAC, internal ossicles and boney labyrinth. These structues require high resolution , thin section images with bone algorithm reconstructions. Use of contrast is unhelpful in assessing these bone details.

Relative Radiation Level

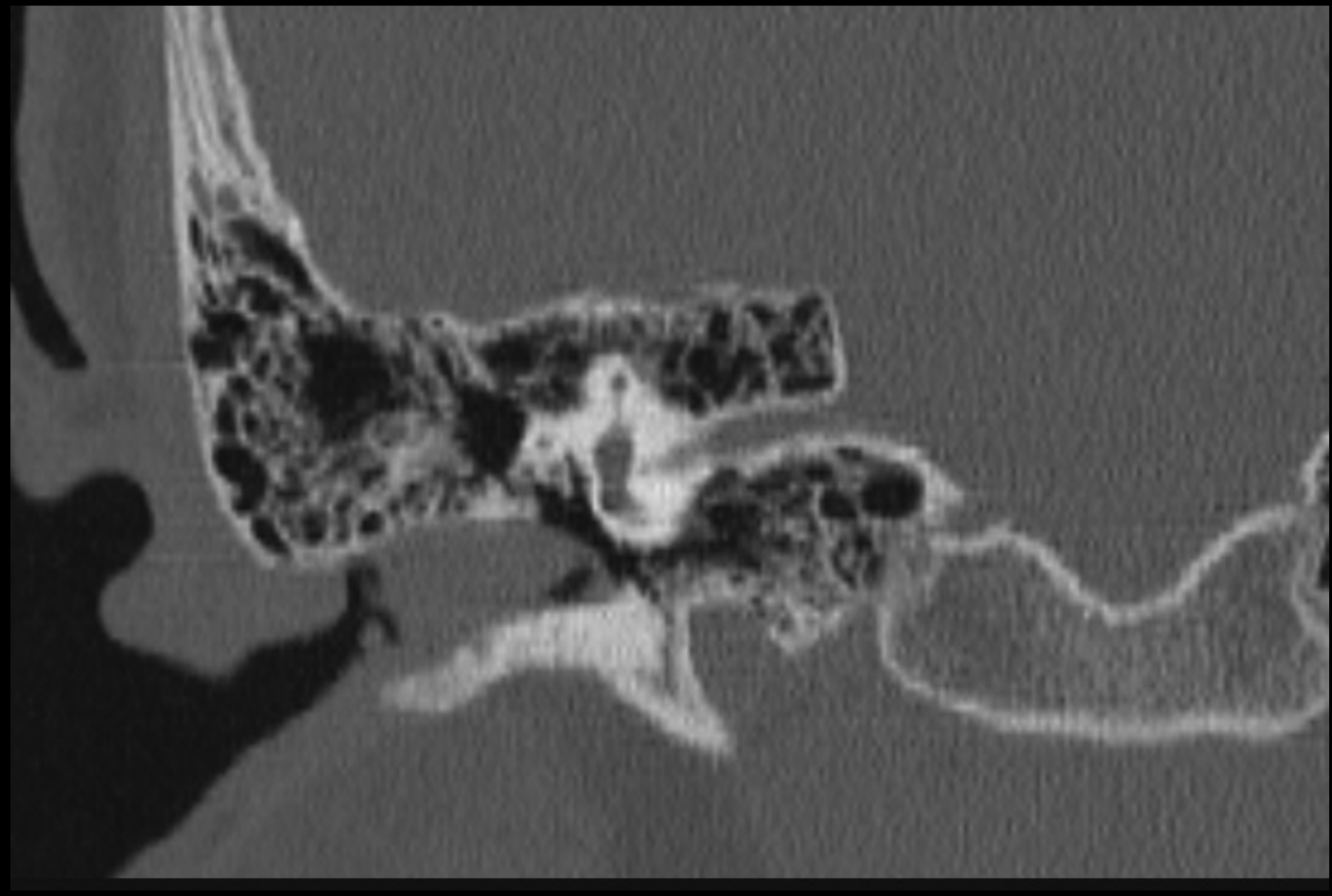
- CT Temporal Bone - ***
- CT Head- ***
- CTA Head- ***
- MRI Head/IAC -0
- MRA Head- 0
- MRV Head -0

* = < 0.1 mSv Adult effective dose estimate

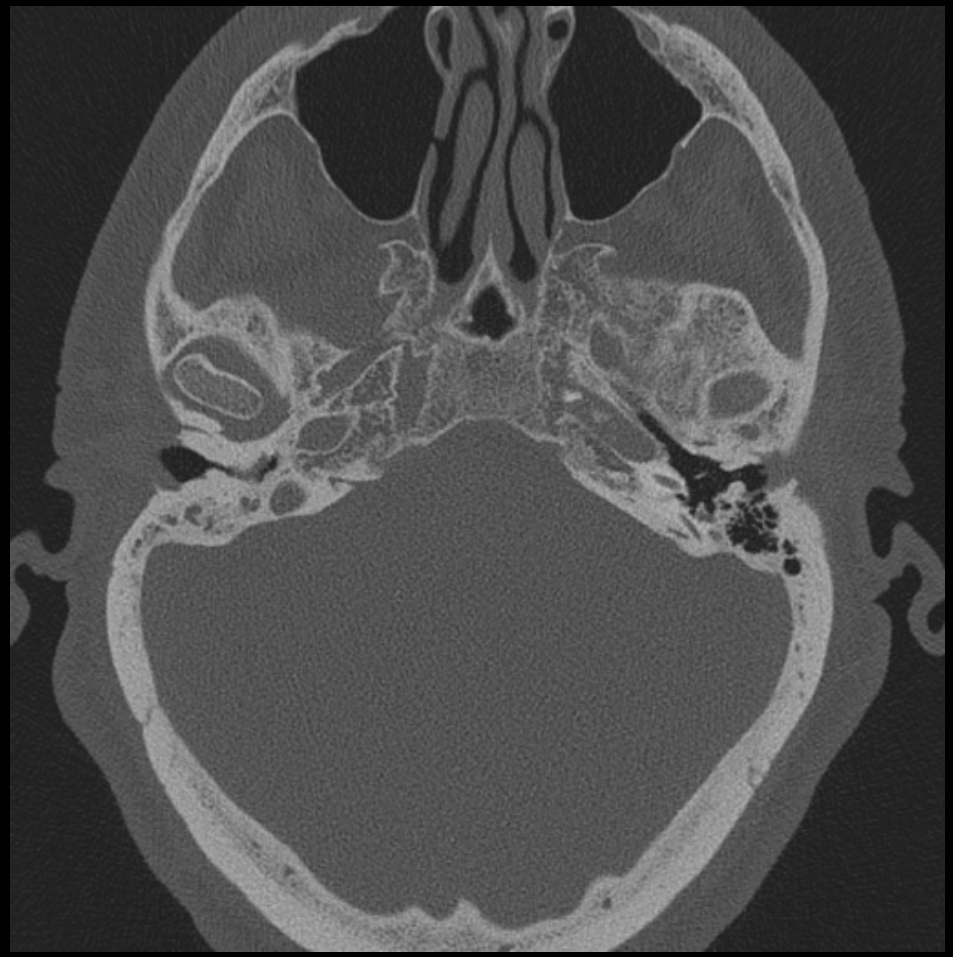
** = 0.1 – 1mSv Adult effective dose estimate range

*** = 1-10 mSv Adult effective dose estimate range

11 year old with right conductive hearing loss



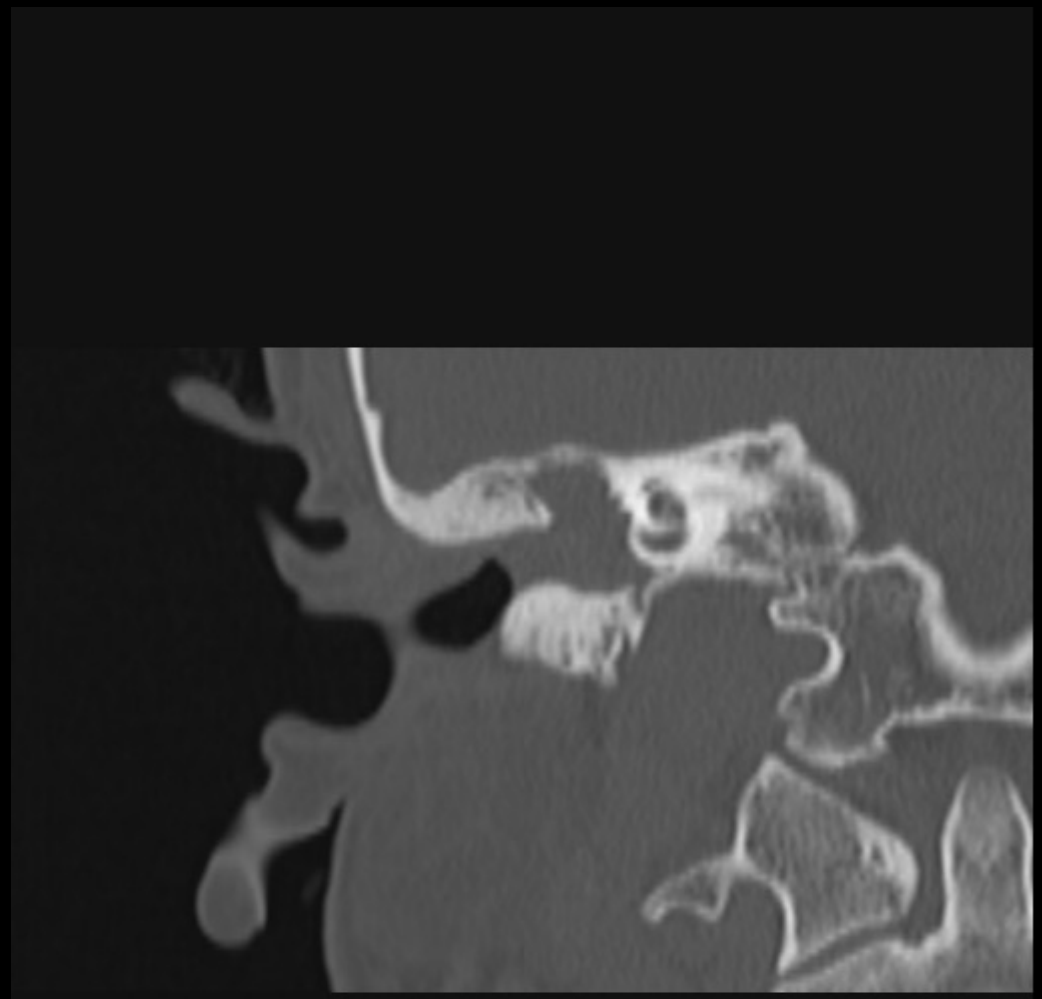
68 yo with history of multiple ear infections and unsuccessful otoscopic exam

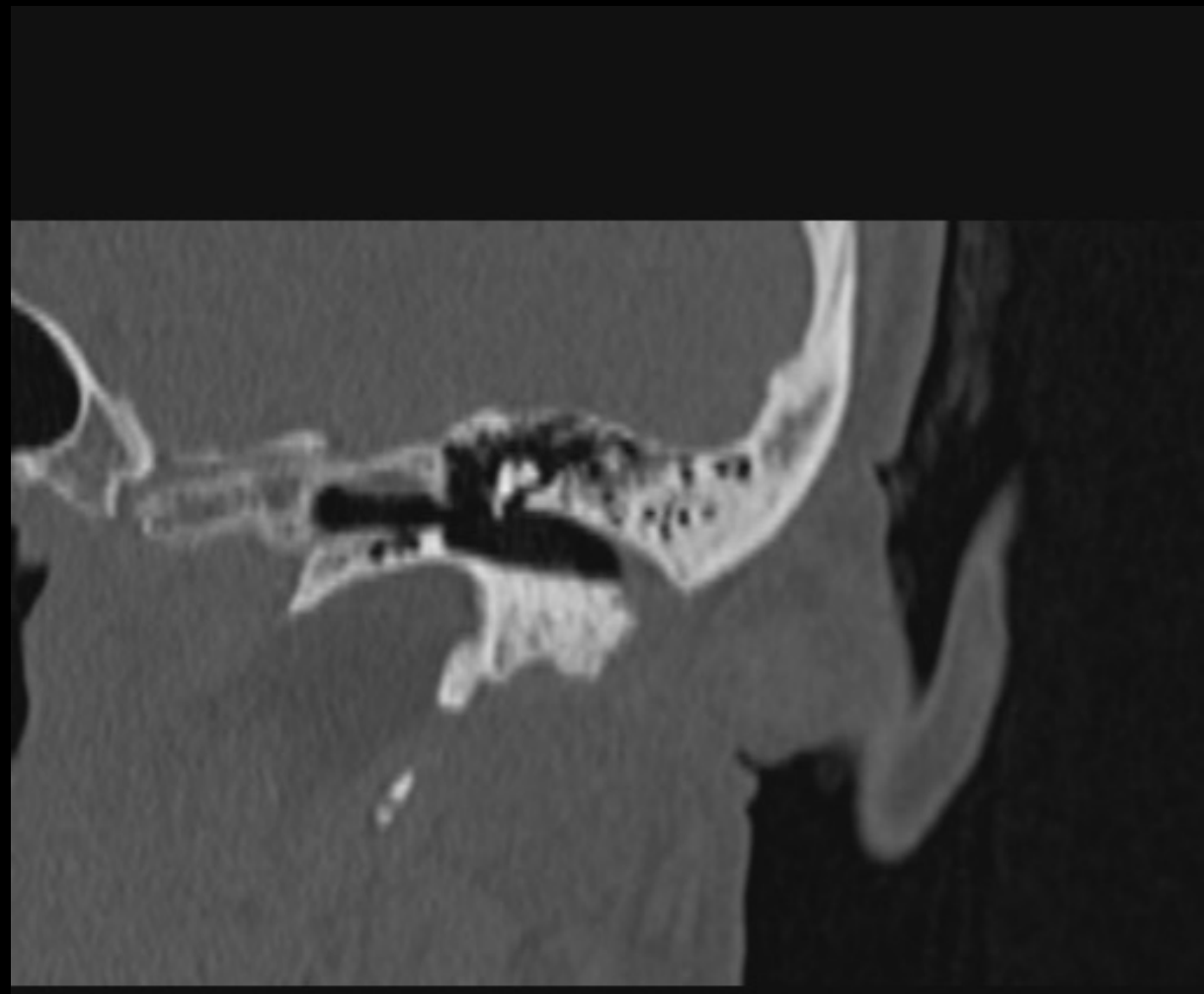


13 yo with left conductive hearing loss

23 yo female with right conductive hearing loss and chronic drainage

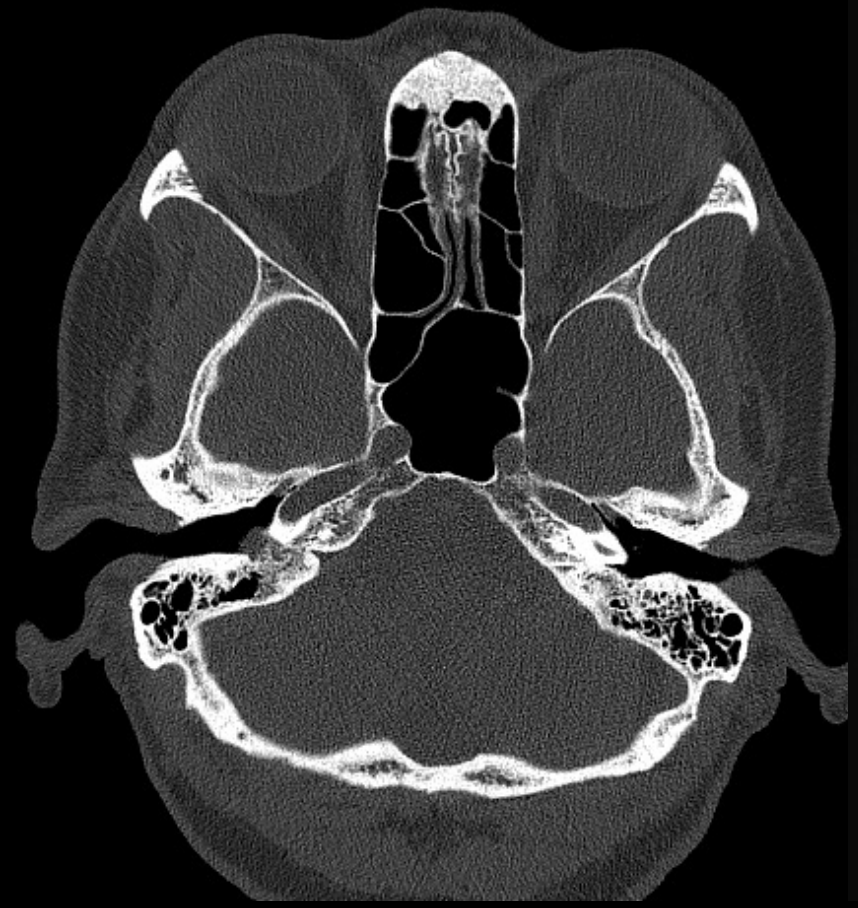
23 yo female with right conductive hearing loss and chronic drainage

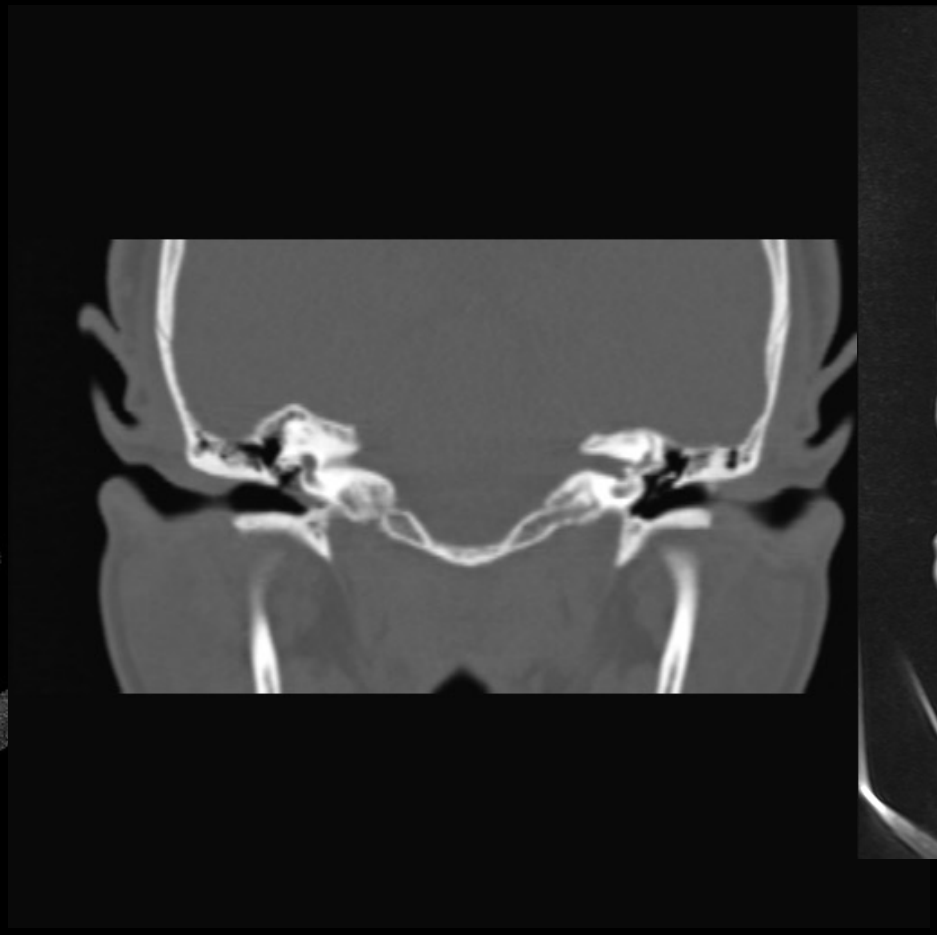


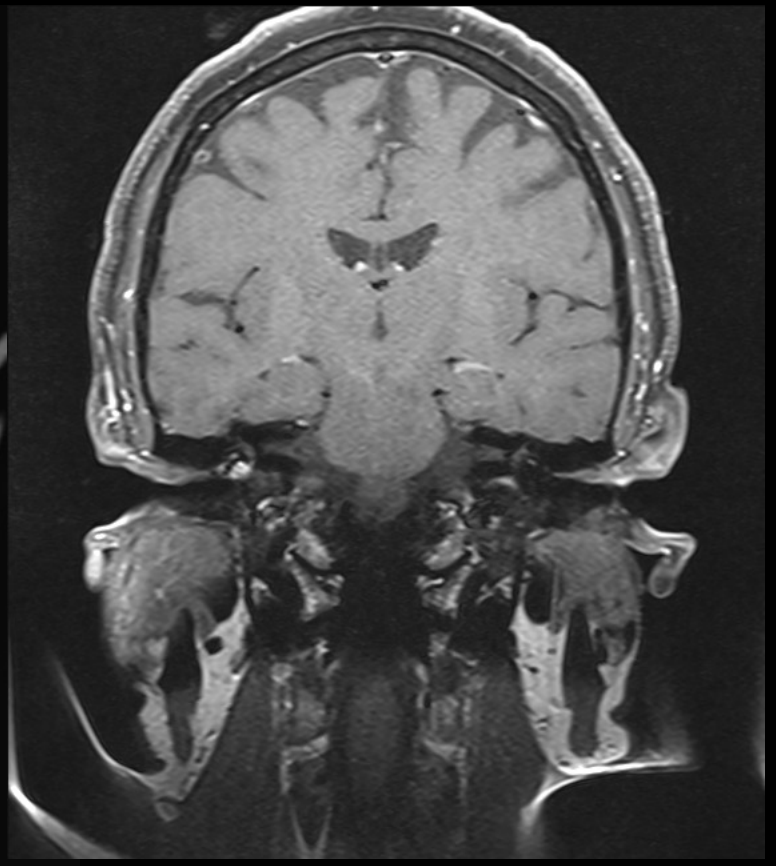


Fenestral Otosclerosis

Right sided hearing loss and abnormal otoscopic exam







Variant 3: Acquired sensorineural Hearing Loss. Initial Imaging

- CT Temporal Bone is a 6: Insensitive to soft tissue abnormalities that commonly cause sensorineural hearing loss. In post-traumatic hearing loss, can see fractures across the otic capsule.
- CT Head with contrast is a 3: Less sensitive than MRI. May be appropriate in specific circumstances
- CTA Head is a 1: Usually not appropriate.
- MRI Head/IAC is a 9: Modality of choice. Insufficient evidence to prove incremental benefit of contrast.
- MRA Head is a 1: Usually not appropriate.
- MRV is a 1: Usually not appropriate.

Appropriateness Category Names and Definitions

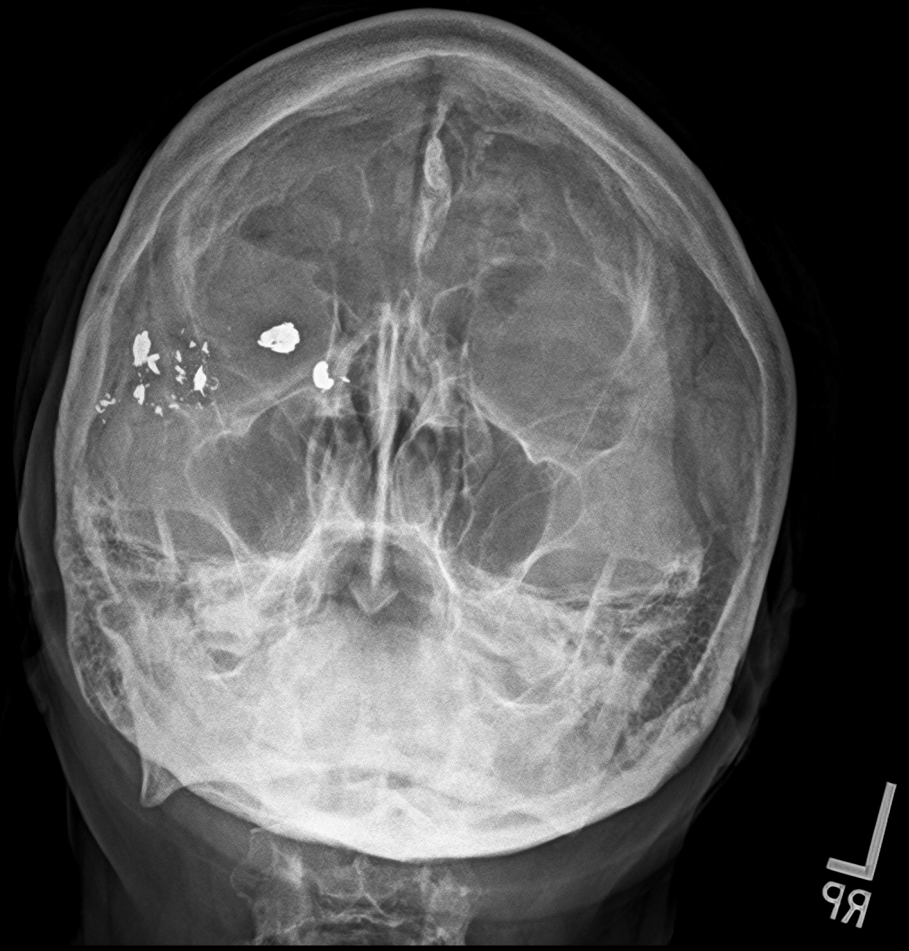
• Usually appropriate	7,8,9 Imaging procedure indicated with favorable risk benefit to patient
• May be appropriate	4,5,6 May be indicated in specific clinical scenarios or risk benefit ratio is equivocal
• Usually not appropriate	1,2,3 Unlikely to be indicated or unfavorable risk/benefit ratio

Contraindications to MRI

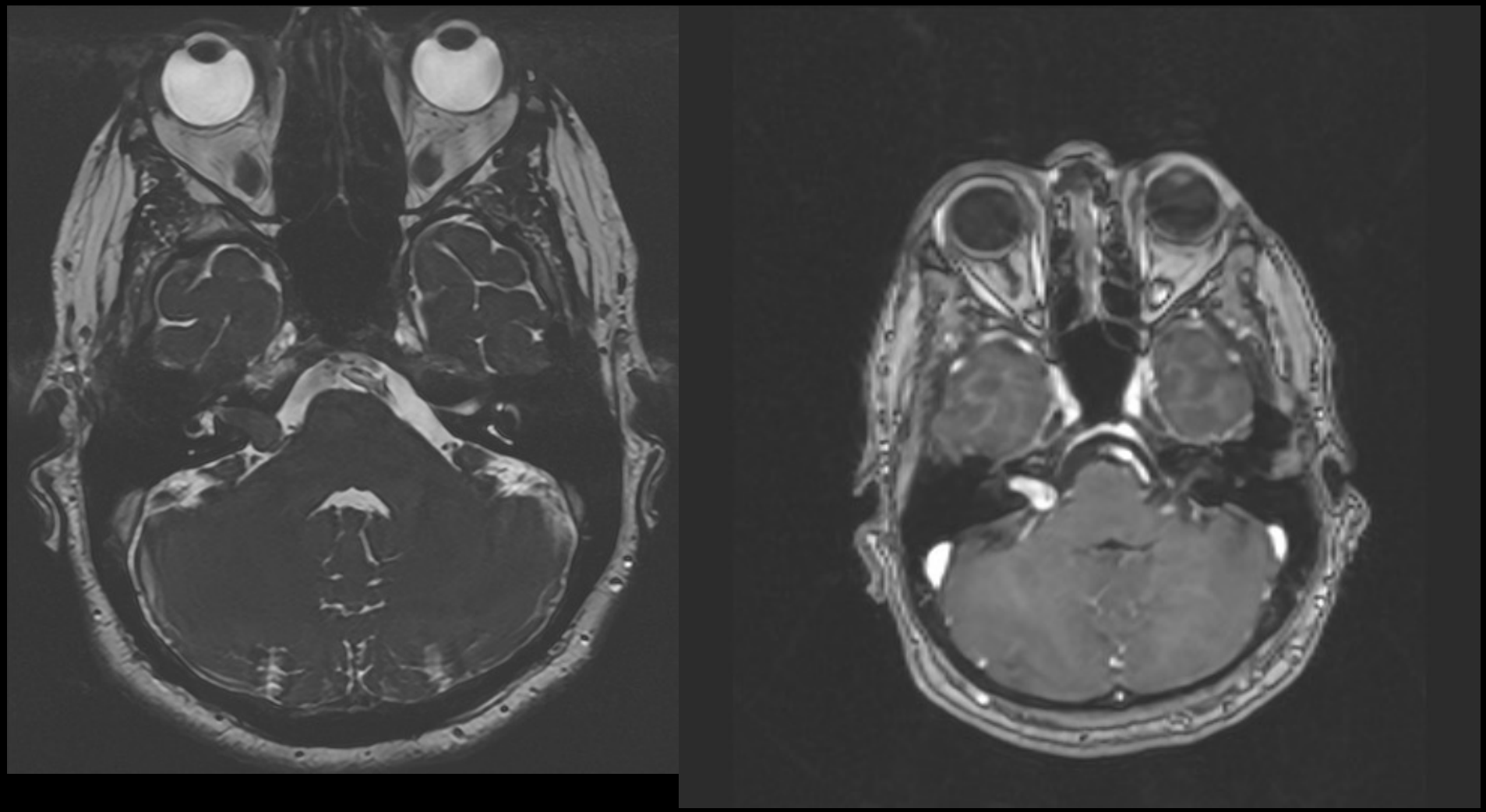
- Ferromagnetic Aneurysm clips
- Most pacemakers
- Some Cochlear implants
- Ventricular assist devices
- Intraocular metallic foreign bodies (screen welders with orbital radiograph)
- Insulin pumps
- Breast tissue expanders
- Implanted cardioverter-defibrillator
- Hearing aids
- Neurostimulators
- Some ventricular peritoneal shunts

- Tell patient to bring implant device card to MRI appointment

Waters Projection X-ray



66 yo female presents with asymmetric bilateral sensorineural hearing loss



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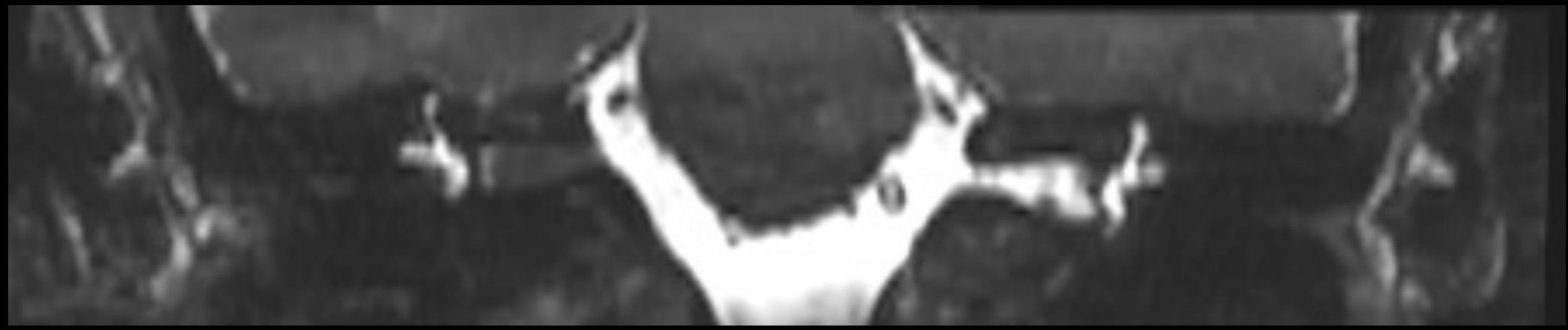
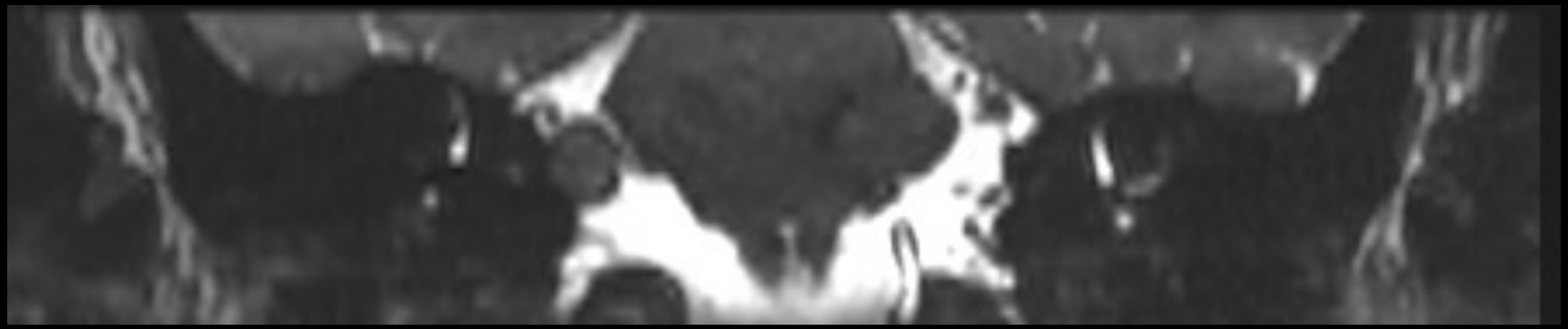
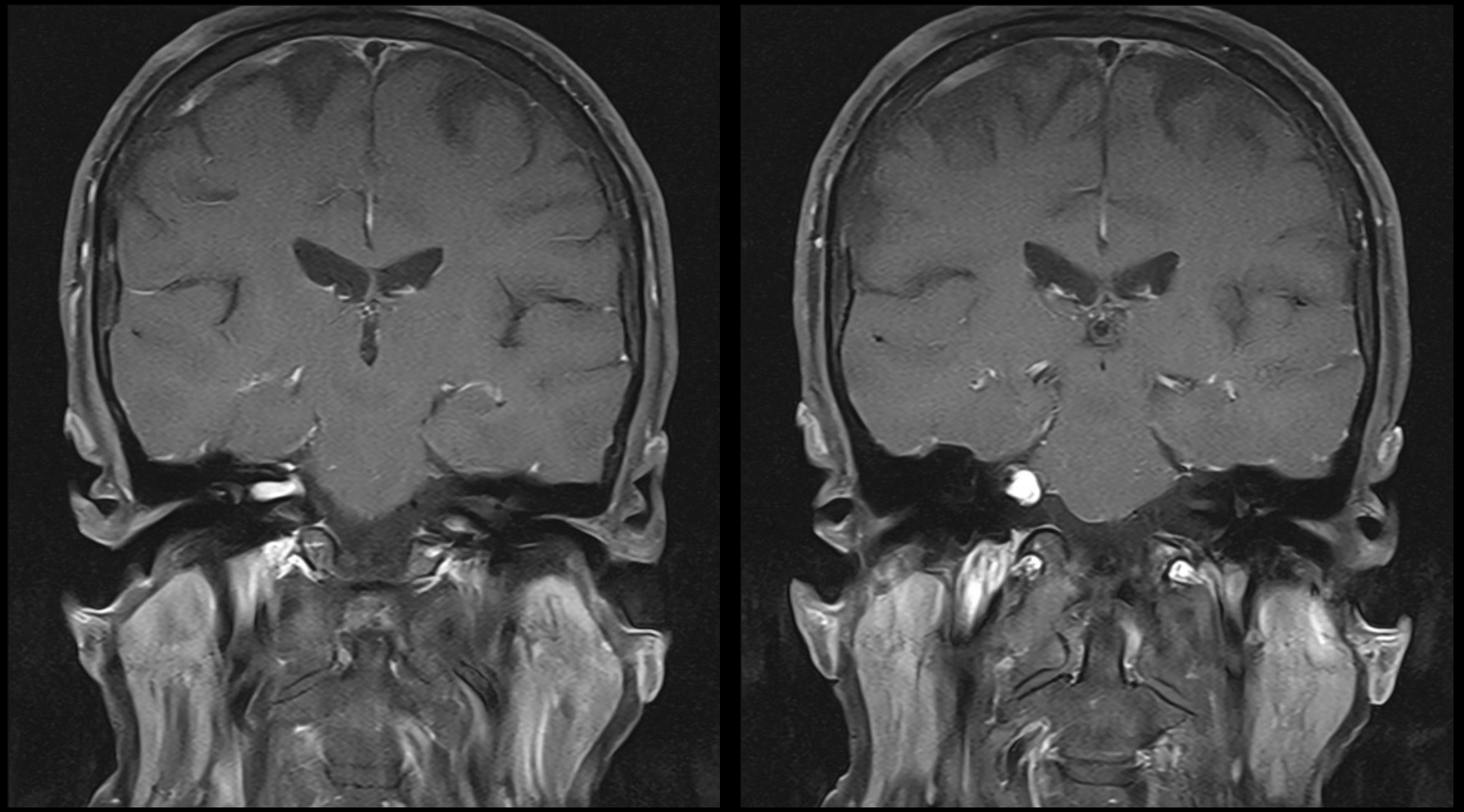
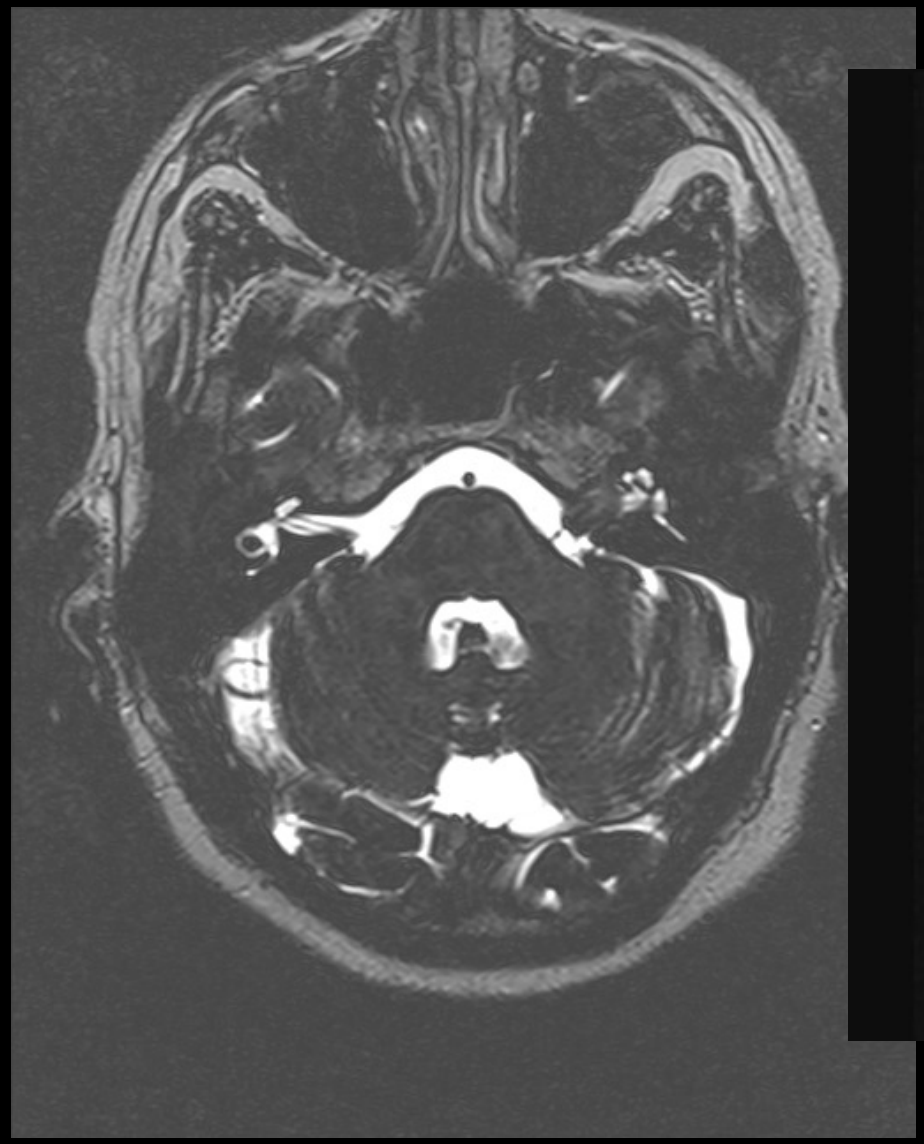


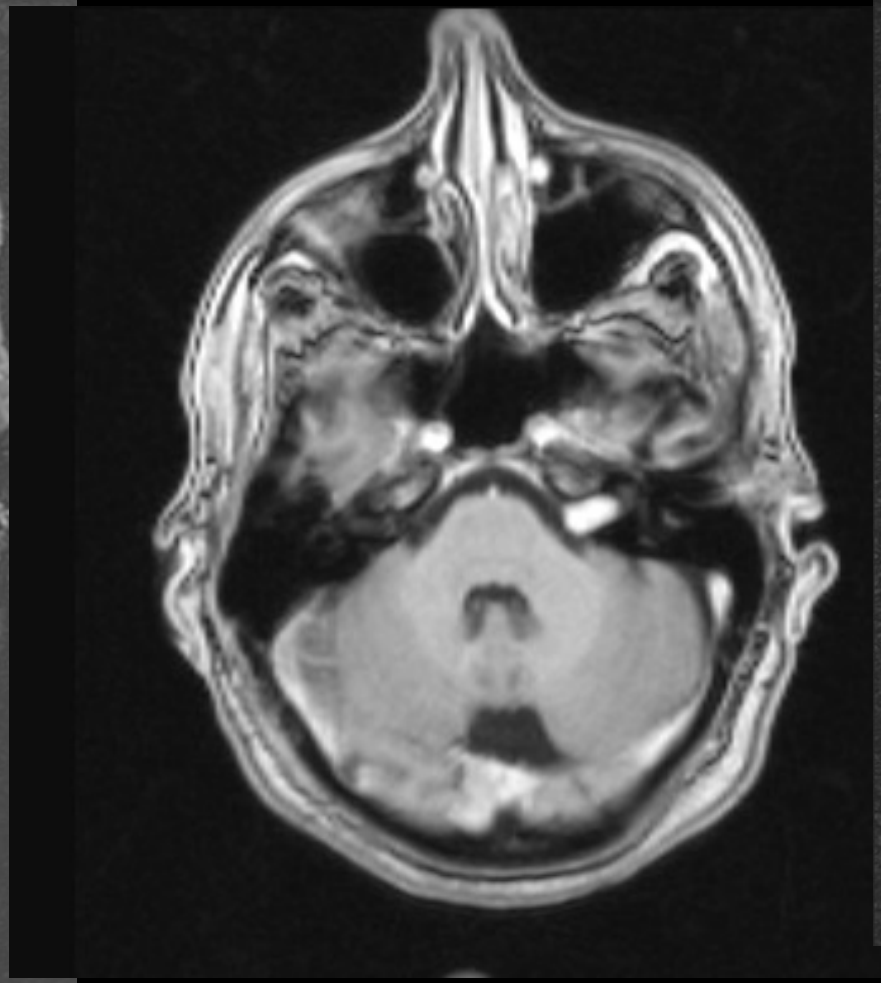


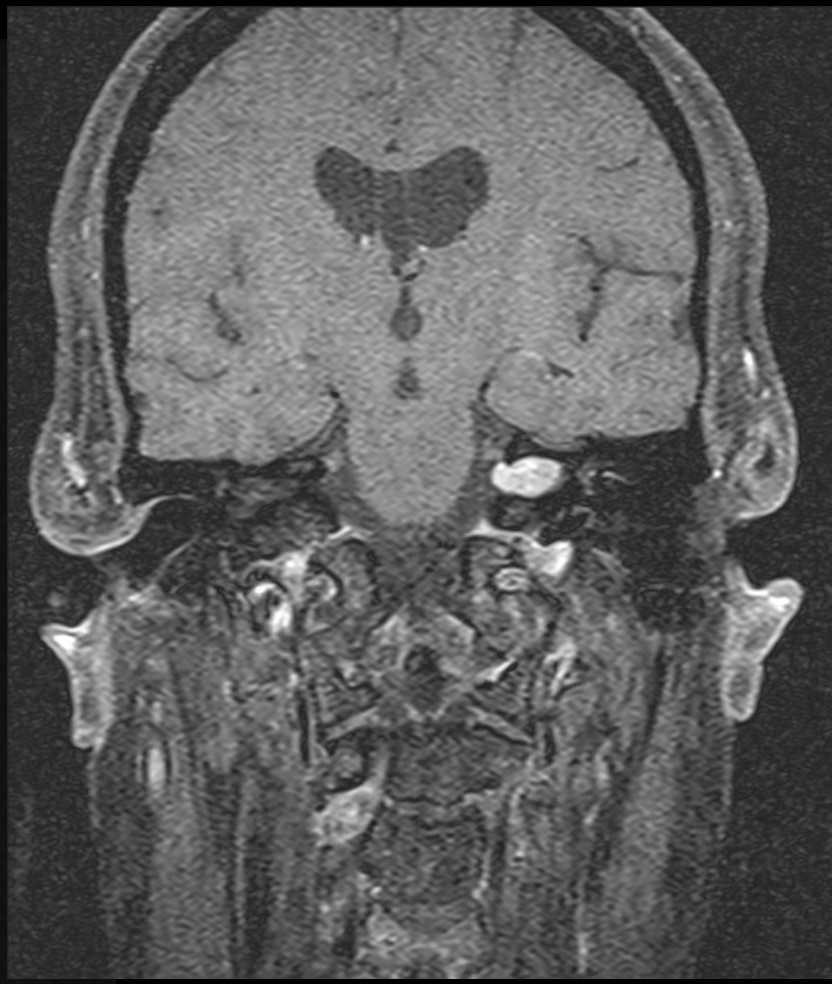
66 yo female presents with bilateral sensorineural hearing loss



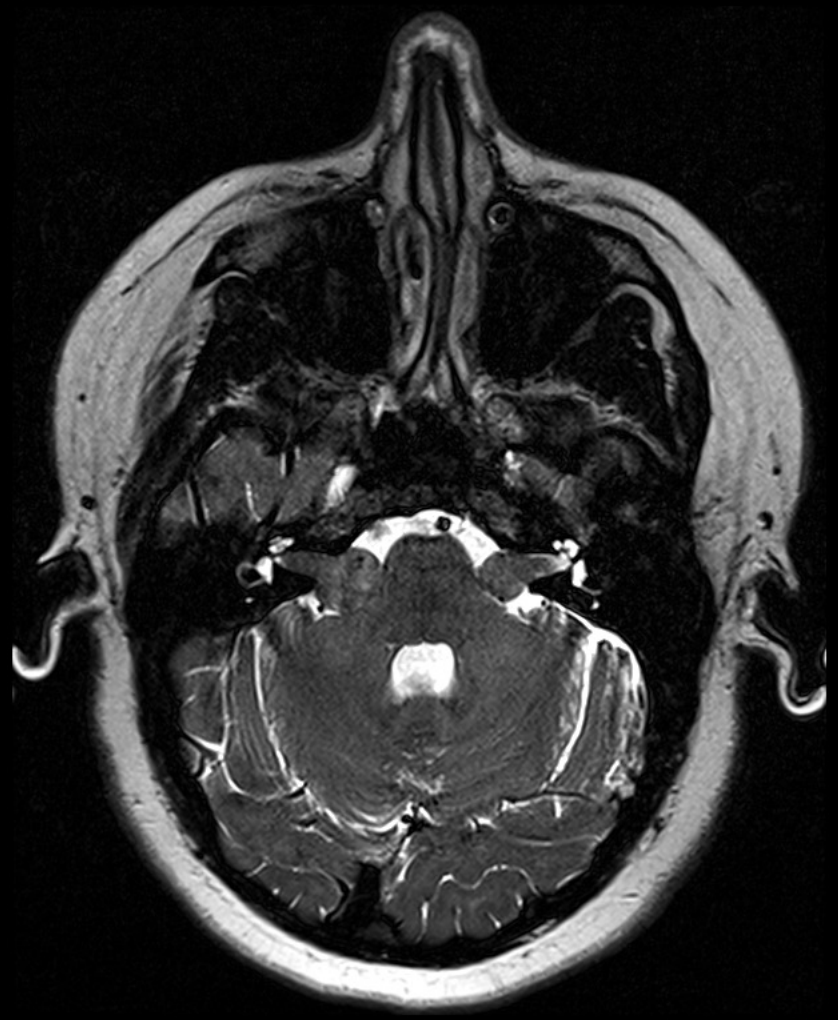
52 yo with left sensorineural hearing loss

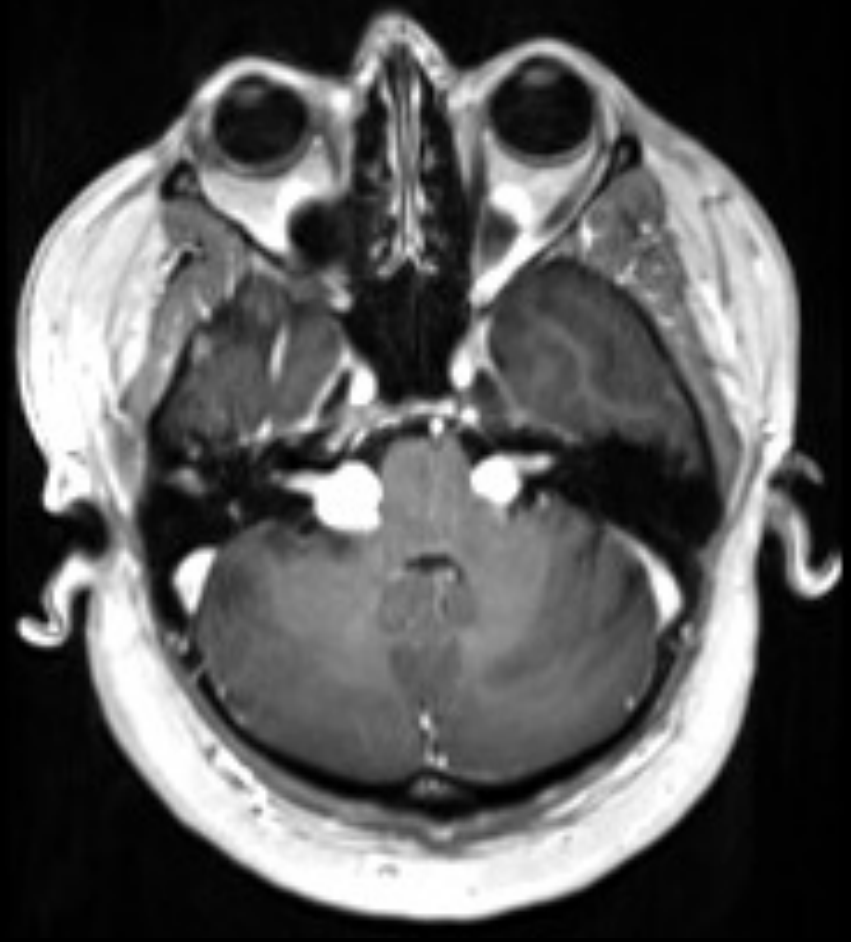




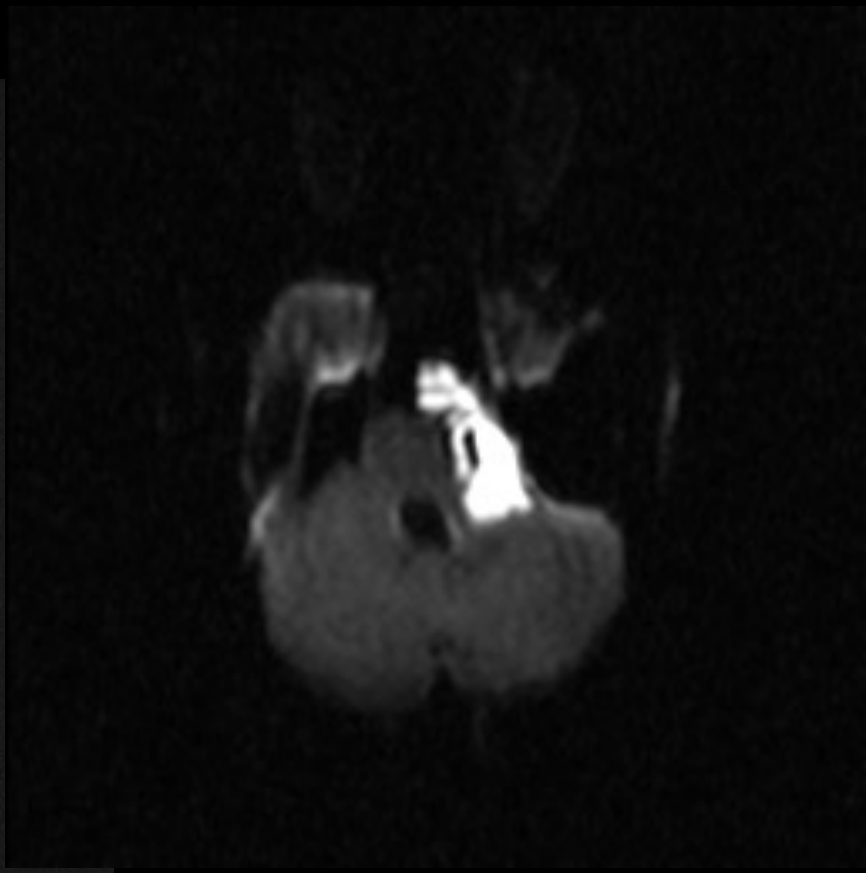


41 year old with Neurofibromatosis Type II

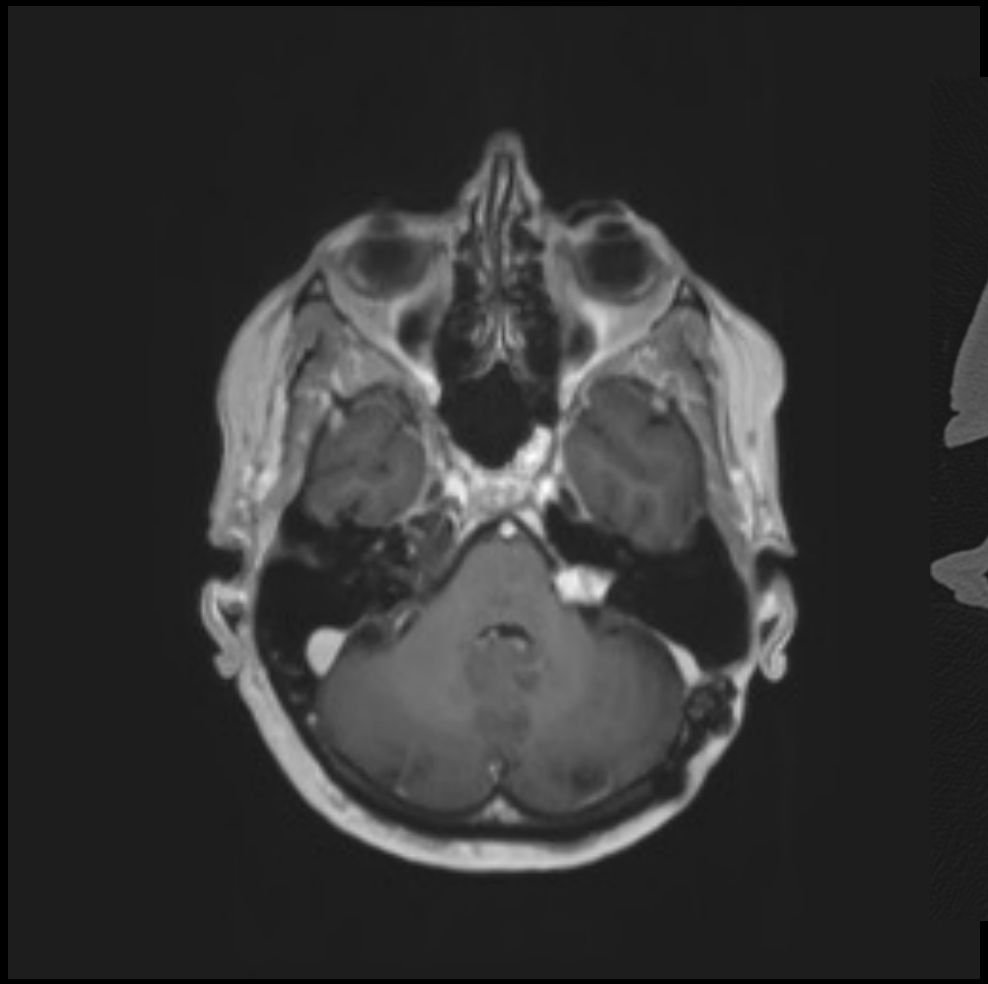


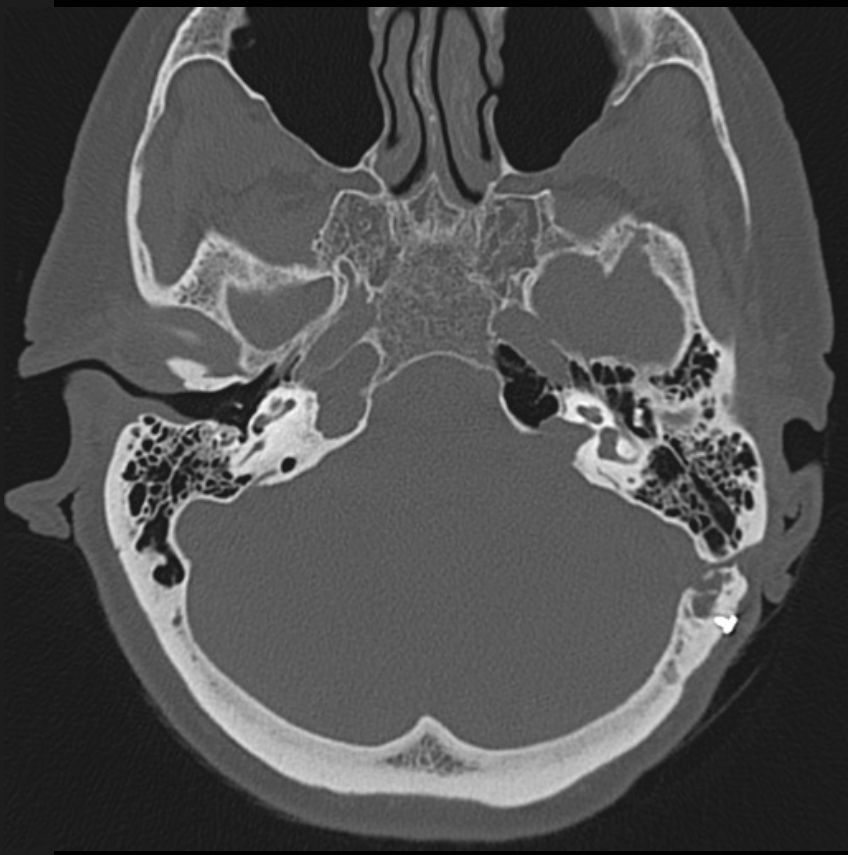


37 year old with cerebellopontine angle mass



77 yo female with known vestibulocochlear schwannoma status post left retromastoid craniotomy and cyberknife treatment





Variant 6: Episodic Vertigo with or without hearing loss or tinnitus or aural fullness

- MRI Head and IAC without and with contrast: 8
- MRI Head and IAC without contrast: 7
- CT Temporal Bone without contrast: 7
- CT Temporal Bone with contrast: 3
- CT Head without contrast: 3
- CTA Head: 1
- MRV Head: 1

ACR Contrast Guidelines

- Weigh risk of contrast versus benefits
- Risk of allergic reaction
- In iodinated contrast (CT contrast), we screen high risk patients for renal insufficiency (personal history of renal disease or history of diabetes (using metformin). In patients with an eGFR greater than 30, there is very little evidence for contrast induced acute kidney injury.
- In Gadolinium contrast (MRI Contrast), patients with end stage renal disease (requiring dialysis) were at risk for contrast induced nephrogenic system fibrosis (seen previously in patients with weak Gd binding agents)

ACR Contrast Guidelines

- Pregnant patients, contrast is Class C drug (informed consent)
- Breast feeding mothers given contrast
  - Less than 0.01% of iodinated dose would end up in breast milk.
  - Less than 0.0004% of gadolinium dose would end up in breast milk.
  - No discontinuation of breast feeding is recommended based on amount of iodine in breast milk
  - Breast feeding in concerned mothers could resume after 24 hours

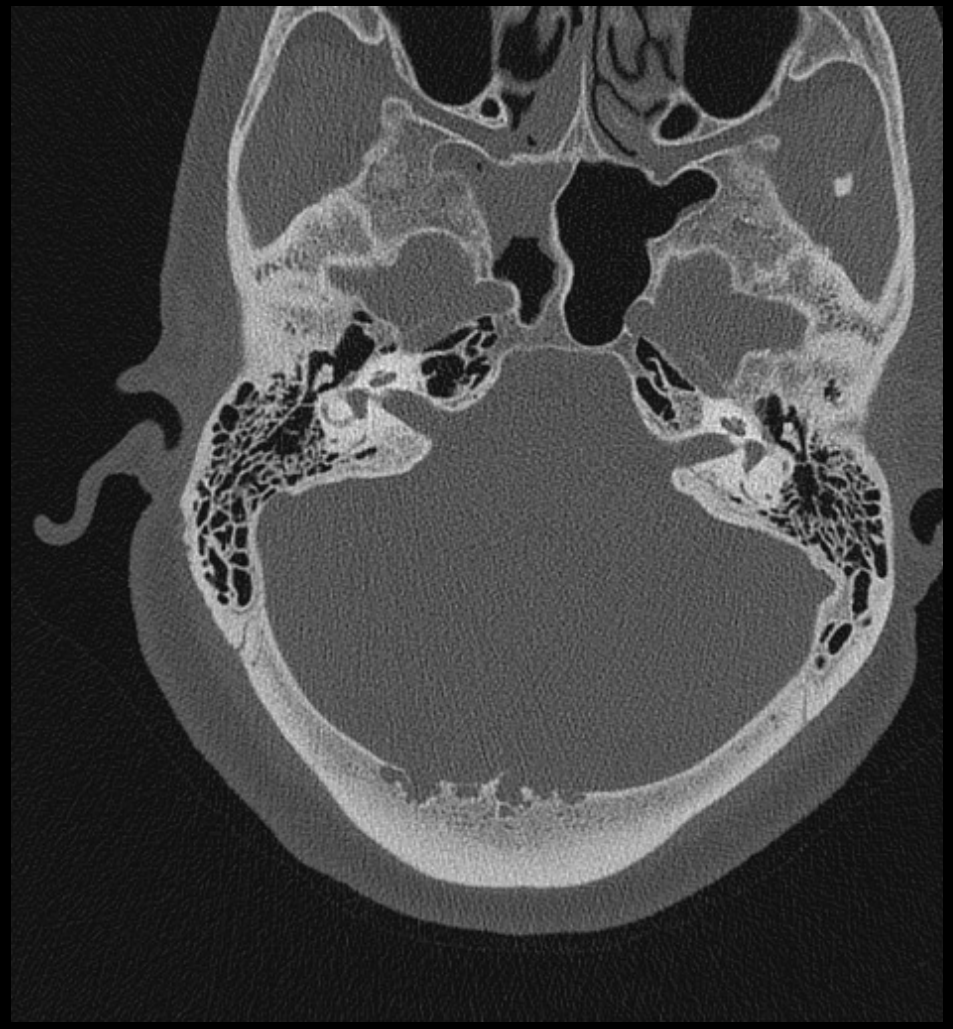
Contrast Reaction prophylaxis

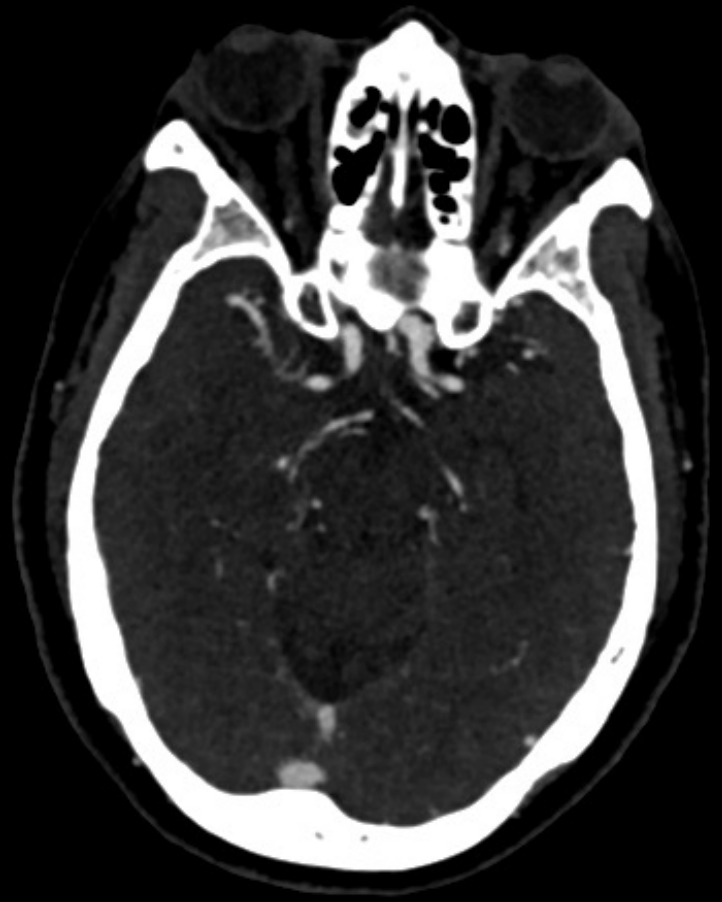
- In outpatients with history of prior allergic like contrast reaction, Consider switching type of contrast and/or steroid prophylaxis

- Prednisone 50 mg po at 13 hours, 7 hours and 1 hour before.
- Methylprednisolone 32 mg po at 12 hours and 2 hours before.

- Diphenhydramine 50 mg po (optional)

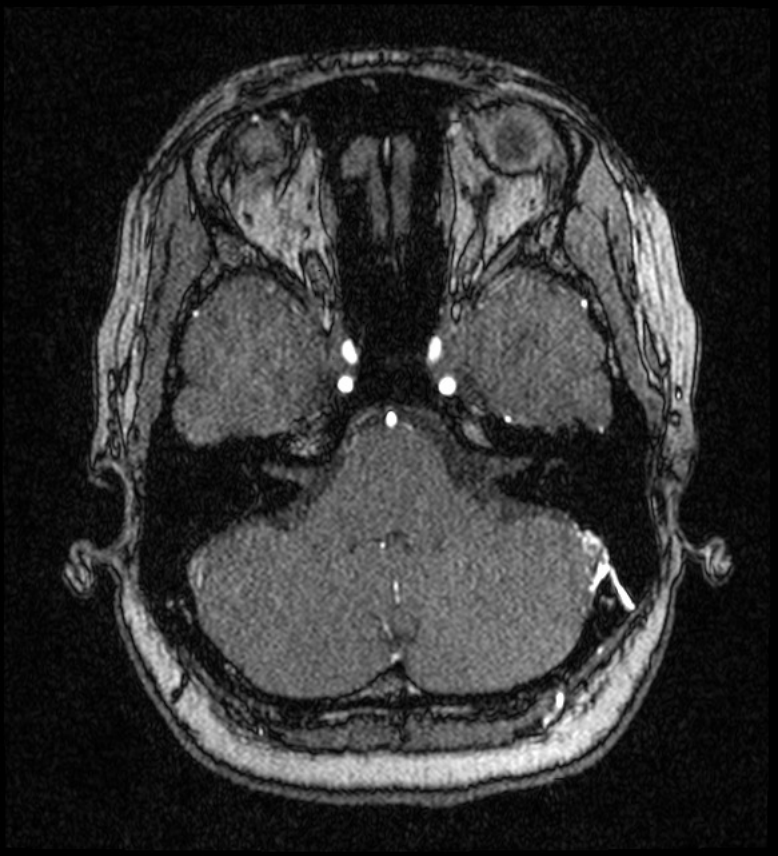
80 yo with right pulsatile tinnitus and hearing loss

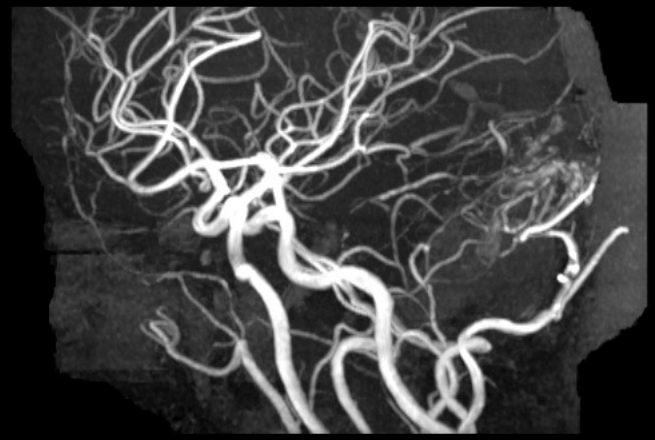




80 yo with right pulsatile tinnitus and hearing loss

40 yo female with left sided pulsatile tinnitus

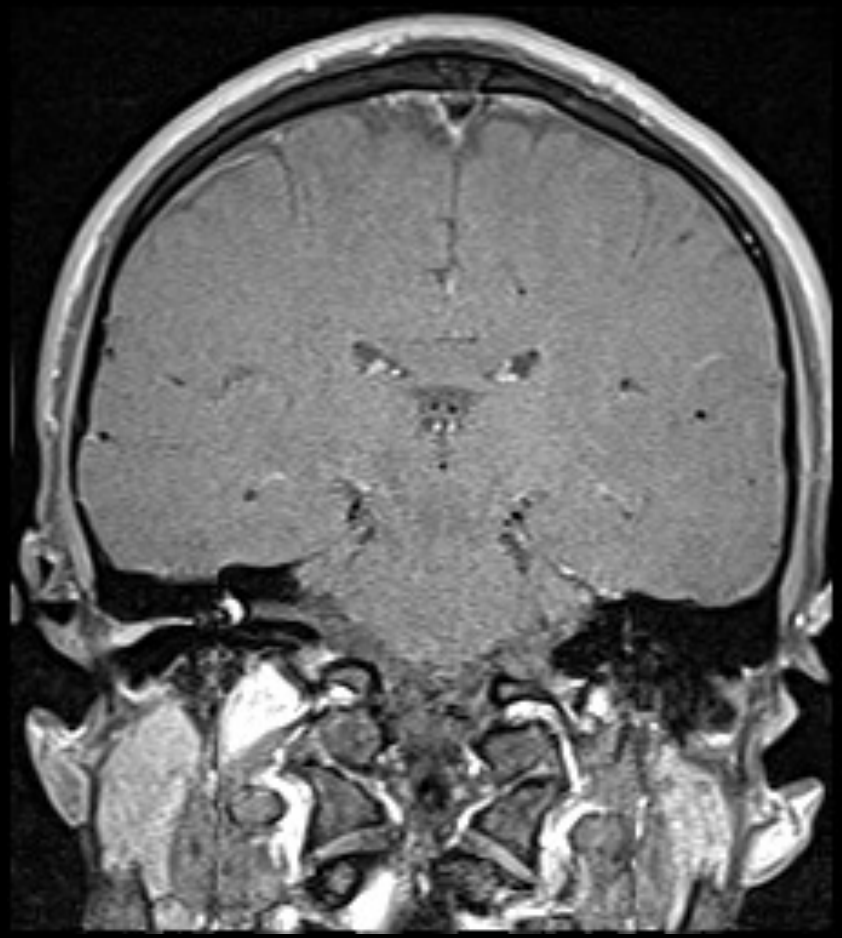


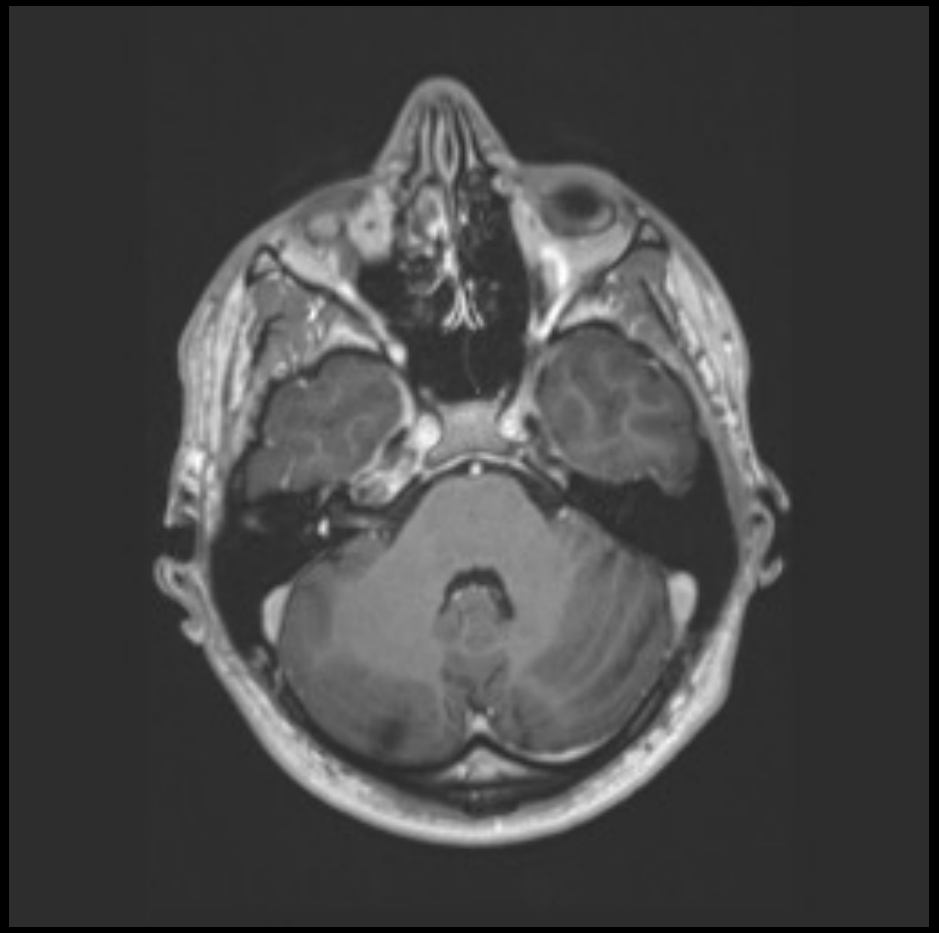


Variant 7: Evaluation of persistent vertigo with or without neurological symptoms

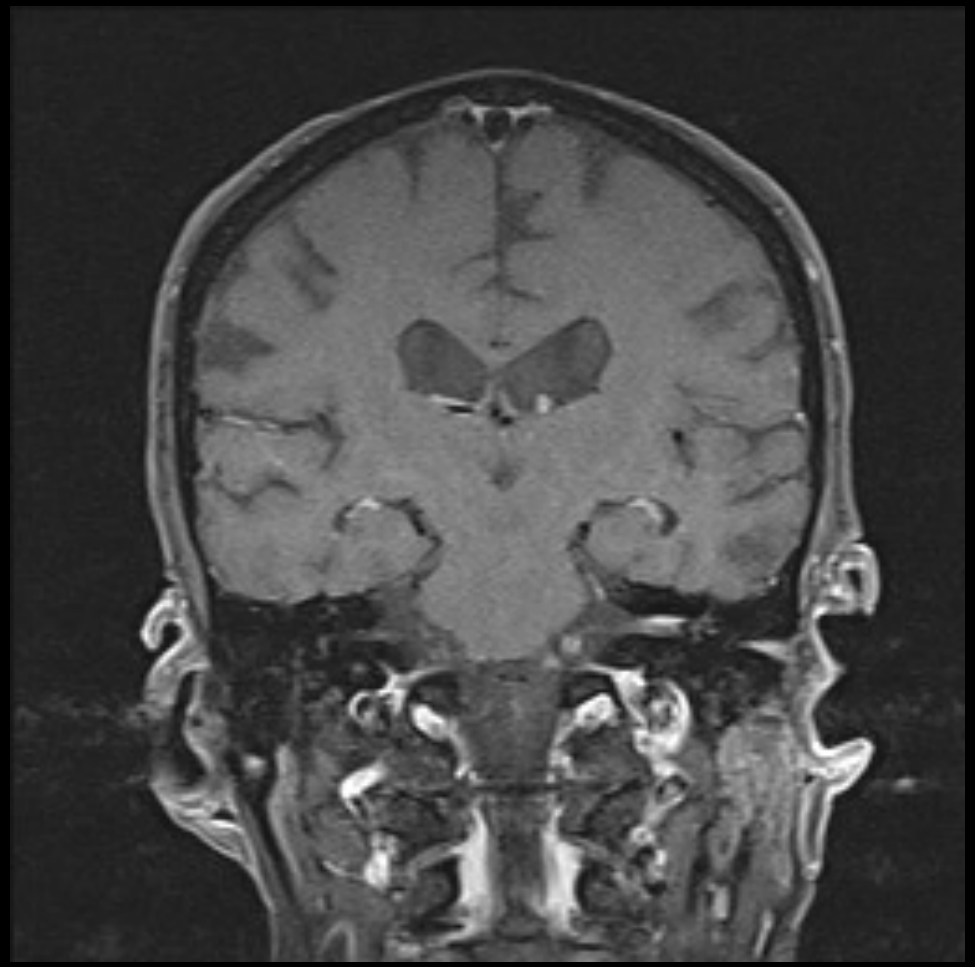
- MRI Head/IAC with and without contrast: Usually appropriate
- MRI Head/IAC without contrast: Usually appropriate
- CT Head without contrast: May be appropriate
- CTA Head and neck with IV contrast: May be appropriate
- MRA Head and neck without and with contrast: May be appropriate
- MRA head and neck without iv contrast: May be appropriate
- CT head with contrast: May be appropriate
- CT head without and with IV contrast: Usually not appropriate
- CT Temporal Bone: Usually not appropriate
- MRV Head: Usually not appropriate

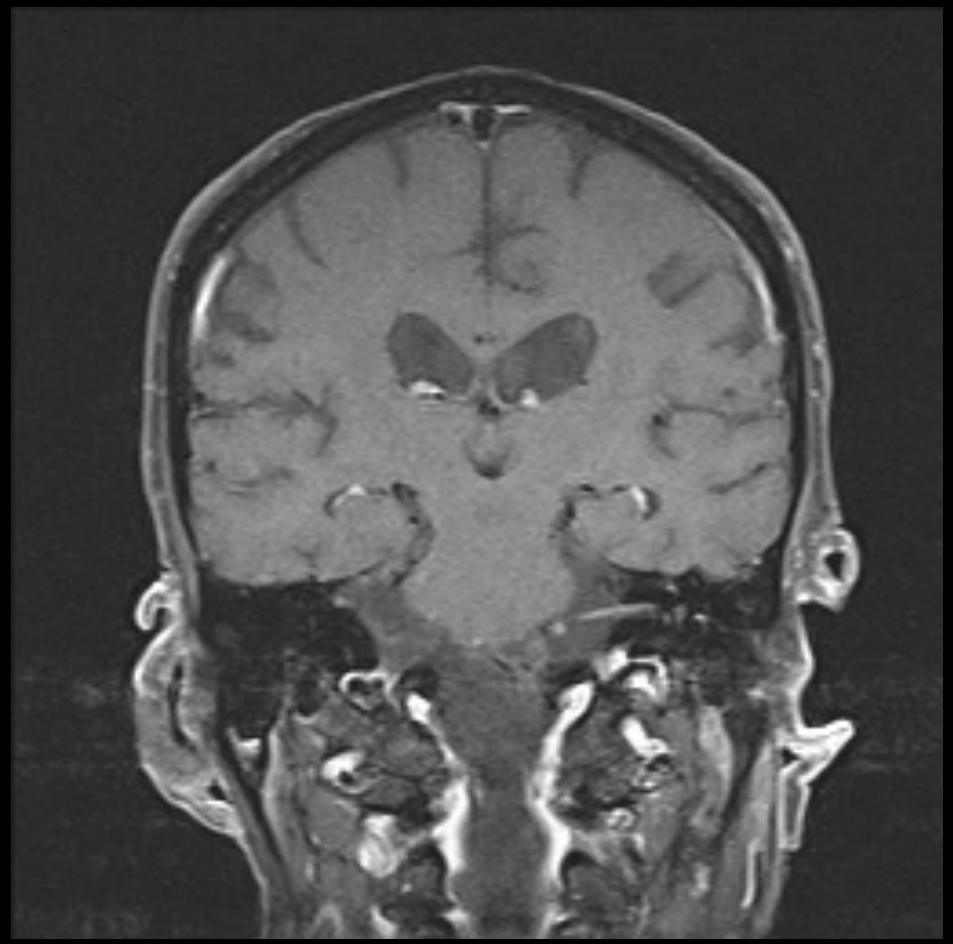
23 yo male with right hearing fullness and hearing loss





84 yo male presents with dizziness and vertigo but no hearing loss

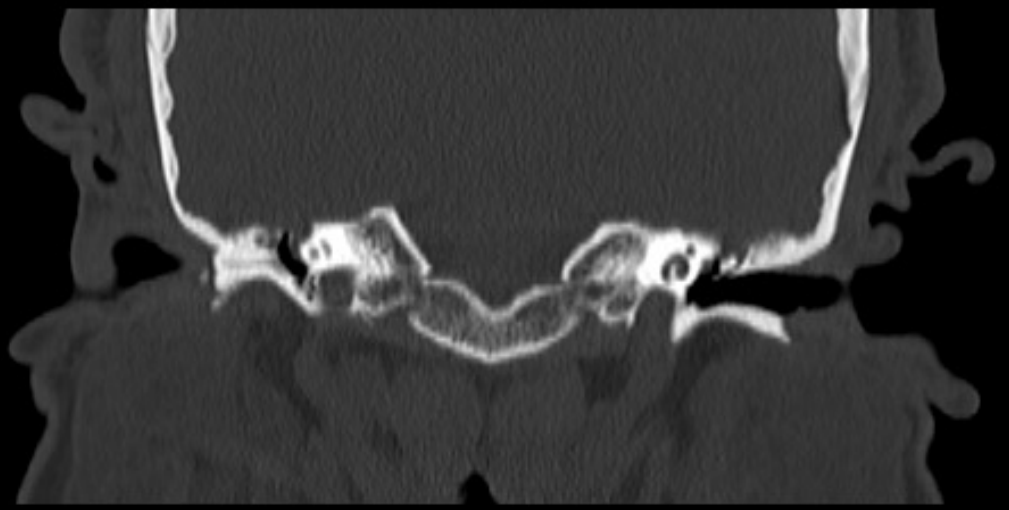




Variant 4: Mixed Conductive and Sensorineural Hearing Loss. Initial Imaging

- Temporal Bone CT: Usually appropriate
- MRI Head and IAC without contrast: Usually appropriate
- MRI Head and IAC without and with contrast: Usually appropriate

57 yo female with history of recurrent meningitis and bilateral otorrhea



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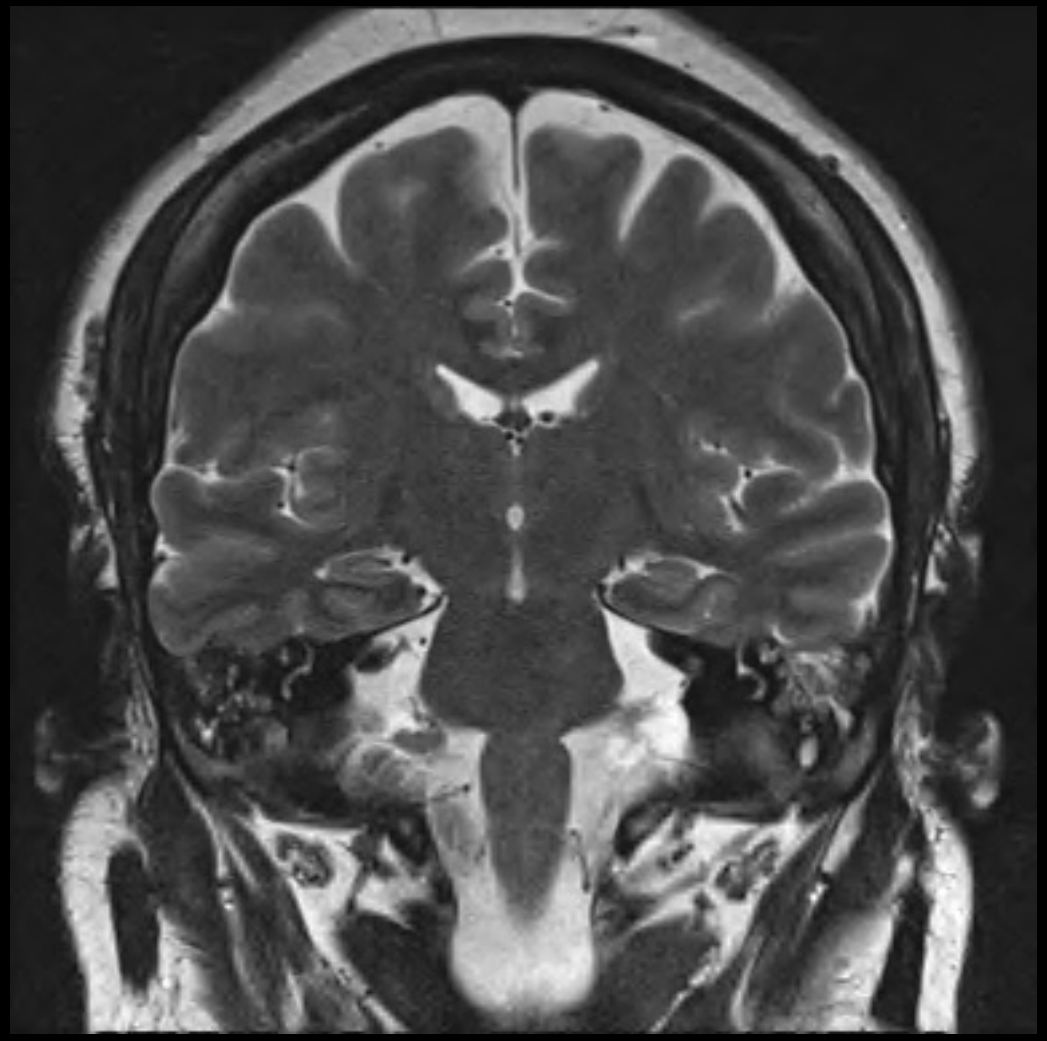
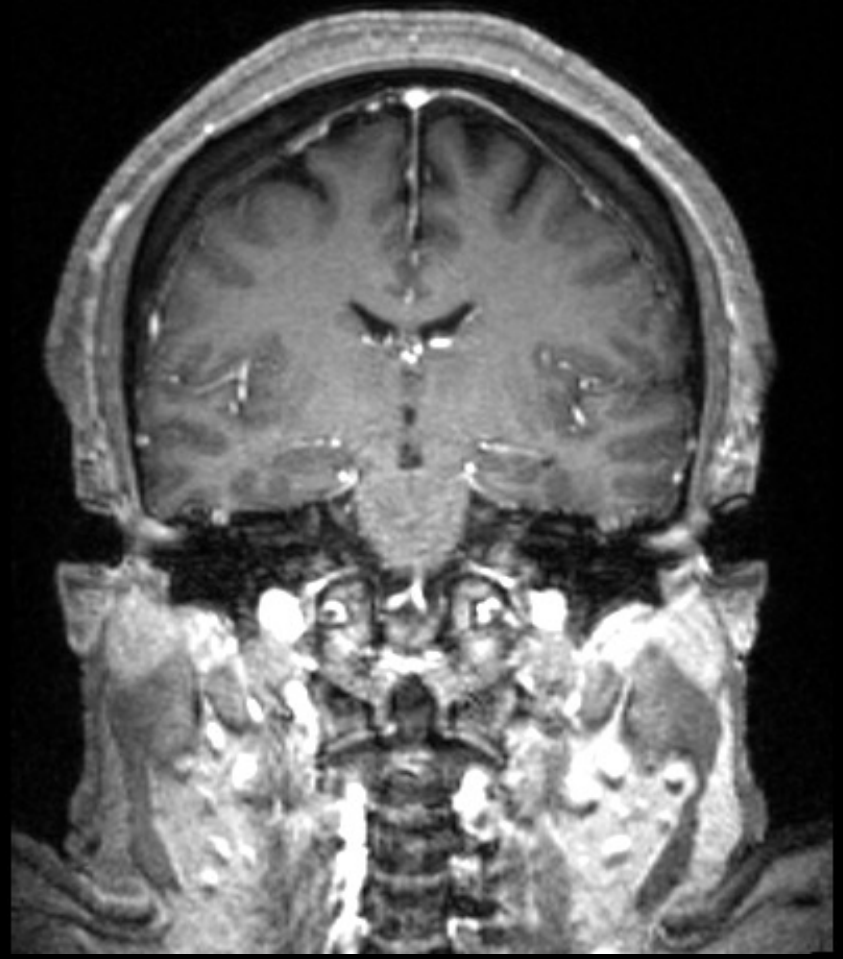
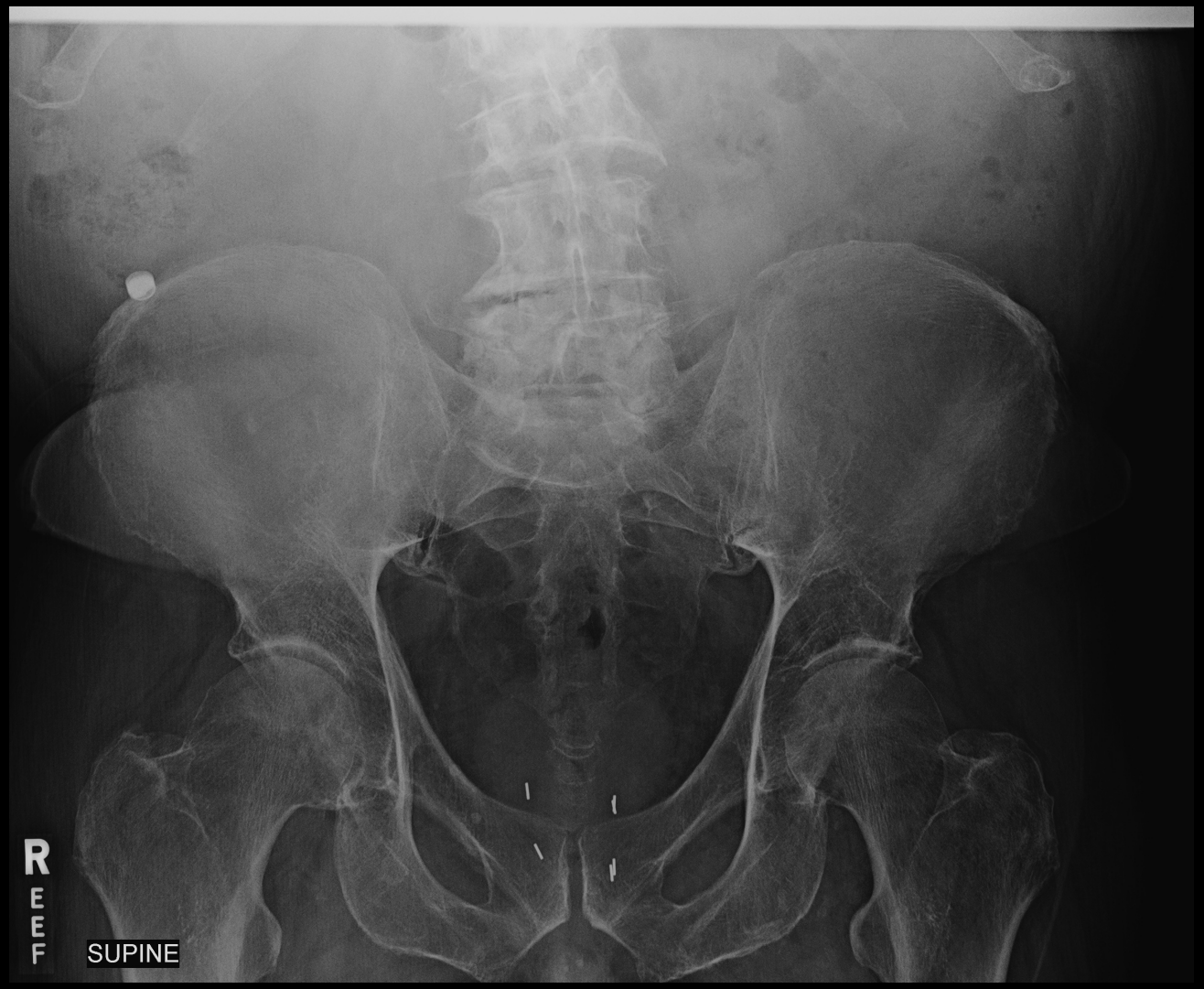




81 yo male who swallowed hearing aid battery



Imaging for Audiologists

- CT Temporal bone without contrast is the primary modality for use for conductive hearing loss
- MRI Brain/IAC primary modality for use for sensorineural hearing loss
- No evidence for US in patients with symptomatic disease and setting of hearing loss/vertigo
- Only role for plain radiographs in neuroimaging exams is to exclude radio-opaque foreign bodies
- ACR appropriateness criteria is an excellent guide for summarizing imaging options and justifying exam choices
- ACR appropriateness criteria tables summarizes radiation exposure risks
- ACR Contrast Manual provides guidelines for preventing contrast reactions and counseling patients on relative risks in setting of pregnancy and breastfeeding

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From Symptoms to Scans: Case-Based Strategies for Imaging in Audio-Vestibular Disorders

Melissa J. Segev, Au.D.
Alicia D.D. Spoor, Au.D.

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SEPTEMBER 25-28, 2025 • WASHINGTON HILTON HOTEL, WASHINGTON, DC

Disclosures- Melissa Segev, Au.D.

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  - Advocacy Chair, Academy of Doctors of Audiology (ADA)
  - ADA Representative, Audiology Quality Consortium (AQC)
  - Advisory Board, Earways Medical

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Learning Objectives

- **Differentiate** between MRI and MRA and identify appropriate clinical indications for each in the diagnosis of auditory and retrocochlear pathologies.
- **Describe** the role of ultrasound in evaluating vascular contributions to vestibular symptoms, including dizziness and imbalance.
- **Recognize** the limited but targeted diagnostic applications of plain film X-rays in otologic assessment.
- **Apply** case-based decision-making strategies to determine when imaging is warranted in audio-vestibular disorders.
- **Demonstrate** effective interdisciplinary communication techniques to enhance collaboration between audiologists and radiologists, improving diagnostic accuracy and patient outcomes.

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Why is this happening now?

- Maryland Statute update in 2024
  - Enacted on October 1, 2024
- Modernized and Harmonized the ‘Practice Audiology’ definition with other clinical doctors in Maryland (and nationwide)
- Statute reads:
  - Evaluate, Diagnose, Manage, and Treat Auditory or Vestibular Conditions in the Human Ear
  - “Practice Audiology” includes:
    - The Ordering of Radiographic Imaging as it Relates to the Auditory or Vestibular Conditions in the Human Ear.

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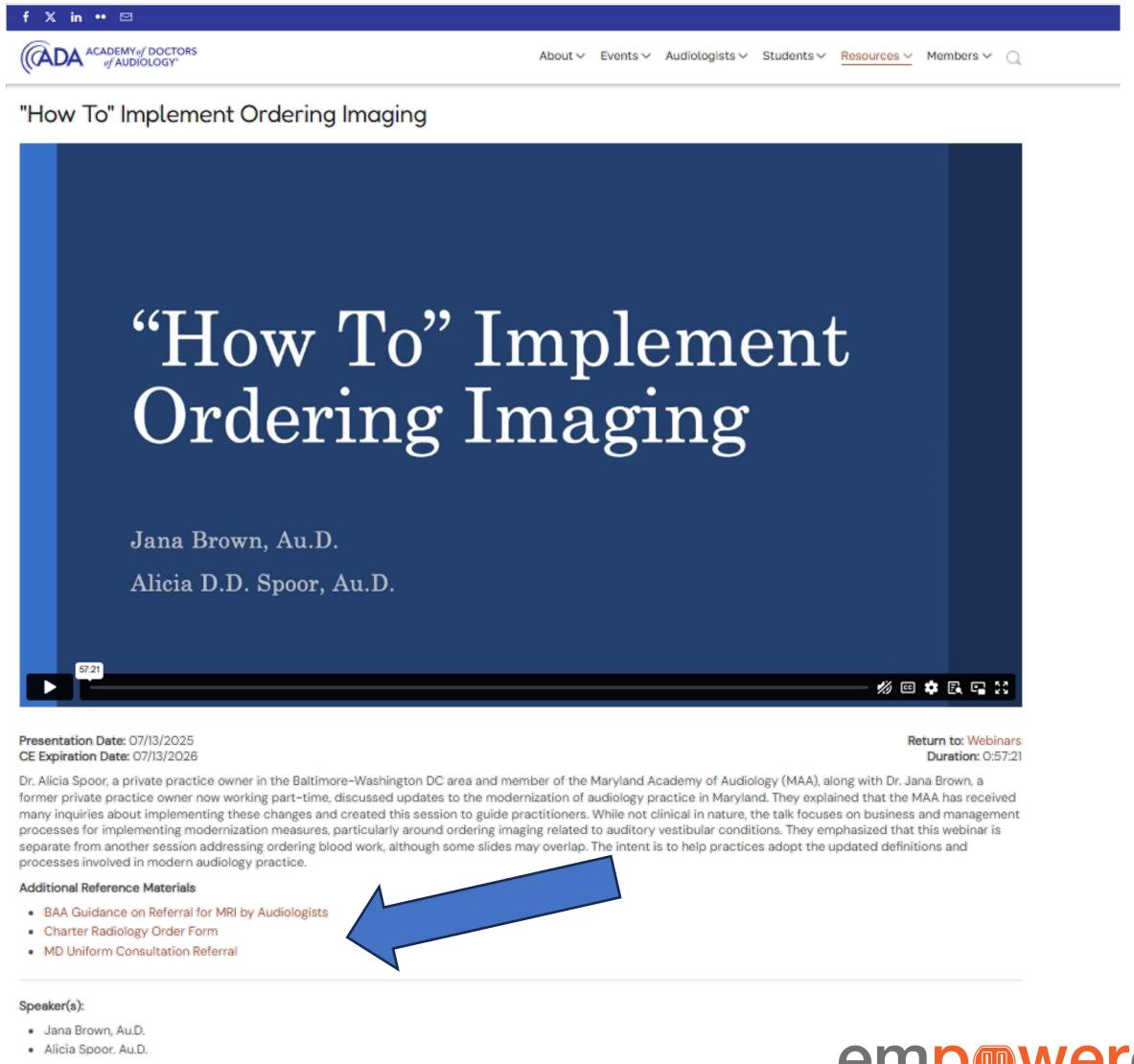
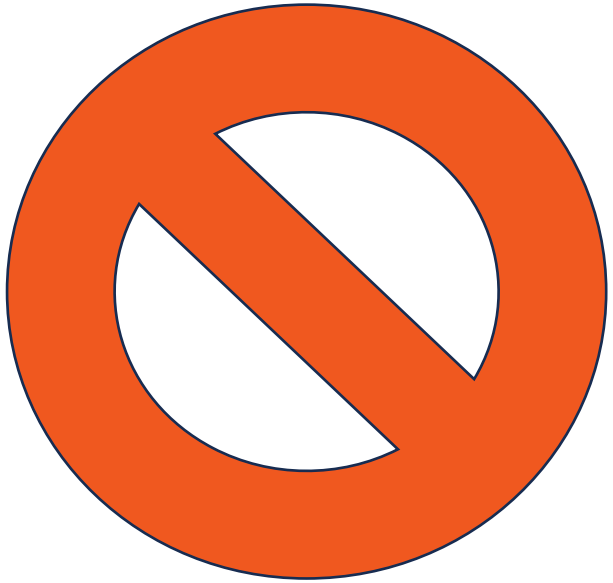
Ordering Protocols

- Protocols will need to be tailored to each practice and all team members trained
- Sample orders
  - Local imaging center's paper forms, online portals, or prescription pads
  - British Academy of Audiology
  - Combination from 3 audiology private practices in Maryland
  - Samples available on the ADA homepage
- Not sure?
  - Call the imaging site



A negative result? Whew!

- Forward the imaging report to the patient's PCP
  - Simple note to make sure they saw the unremarkable findings
    - Save phone calls for positive findings
- Call the patient and let them know the imaging results
- Have a plan for management/treatment:
  - Another provider to manage/treat
  - Audiologic management/treatment
  - Follow-up imaging



What happens with a positive result?

- In 2 of 3 cases, the radiologist called/texted the referring audiologist immediately
  - Determine urgency
- Wait for the professional report to be faxed
- Create a treatment/referral plan

- Call the primary doctor and explain the results
  - Offer to fax the report if they don't have access to the imaging site's portal or have not received a copy
  - Share your treatment/referral plan with the PCP
  - Get the consent to manage the patient, moving forward:
    - Explaining results to the patient
    - Provide referral information
    - Follow-up care from the PCP

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Managing the Patient

- Call the patient
  - Explain the findings
    - Slowly, with pauses
    - Laymen's terms
    - Prepare to answer questions to the best of your ability within scope
      - Cannot interpret imaging findings

Managing the Patient

- Inform them of the treatment/referral plan and that you have spoken to the PCP
  - Follow-up with written information via email, text, or portal
  - Document all contact with the patient

- Help schedule the next appointment
  - The patient may be seen sooner, if you/the provider, calls to schedule
  - There is liability on the audiologist to ensure they pursue treatment, or document why they chose not to do so

Outcomes of the Audiologist's Ordering

- Positive imaging results:
  - Significant reduction in the patient's treatment, with remarkable findings
    - Local general ENT wait times in Maryland can be up 5 weeks (or longer), then an imaging order, then follow-up
    - The (following) two patients waited less than 2-3 weeks from the time of audiologic evaluation to surgery consult
- Negative imaging results:
  - Less appointments to get results
  - Improved quality of life (less worry, stress)
  - Audiologic treatment can proceed

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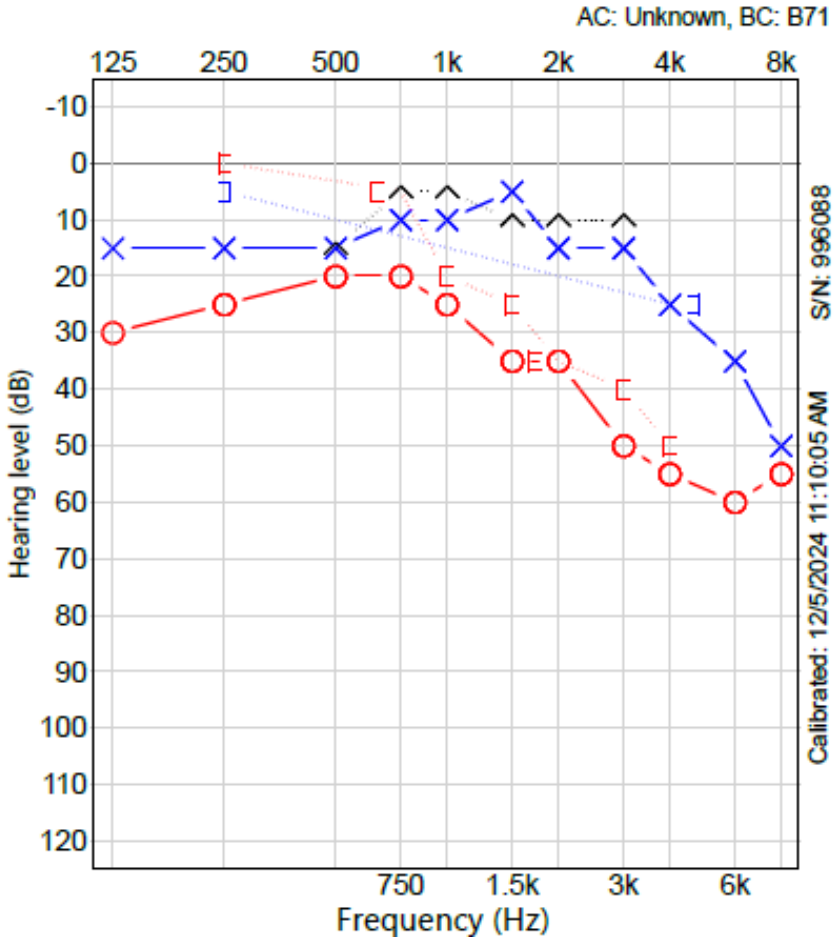
Case Study #1

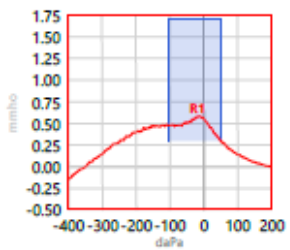
January 09, 2025

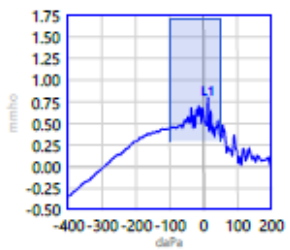
- 64 year old male seen for an audiologic evaluation
  - Chief complaint: gradual hearing loss for the past 9 months in the right ear.
  - HHI-S: 0
  - No other audiologic symptoms.
  - Medical history:
    - HTN treated with medication

Audiologic Results

- Right Ear- Mild-Moderately Severe Sensorineural Sloping Hearing Loss
- Left Ear- Normal-Moderate Sensorineural Sloping Hearing Loss
- Symmetrical WRS
- Immittance:
  - Type A tympanograms, bilaterally
  - Acoustic reflexes present in the ipsilateral condition, absent in the contralateral condition
  - Acoustic reflex decay negative in both ears





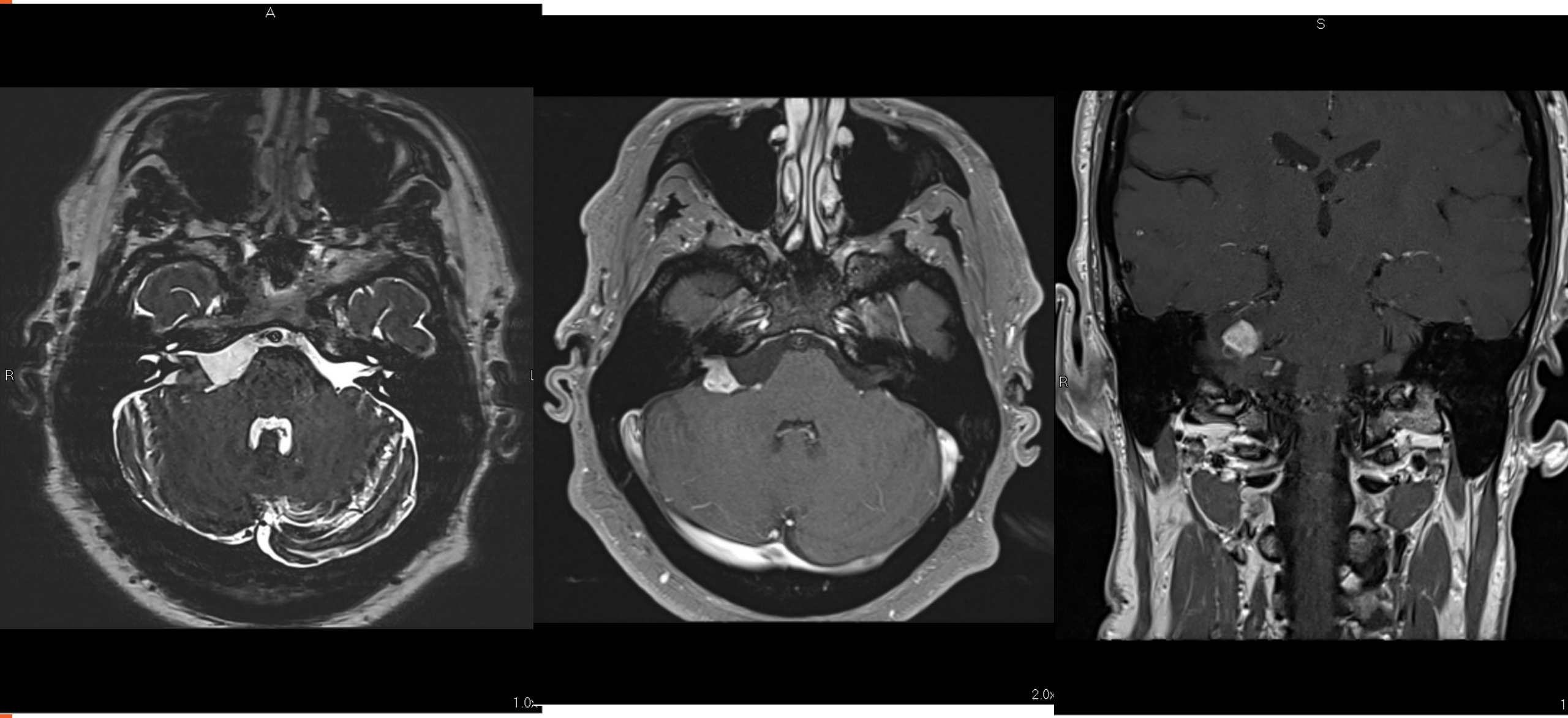


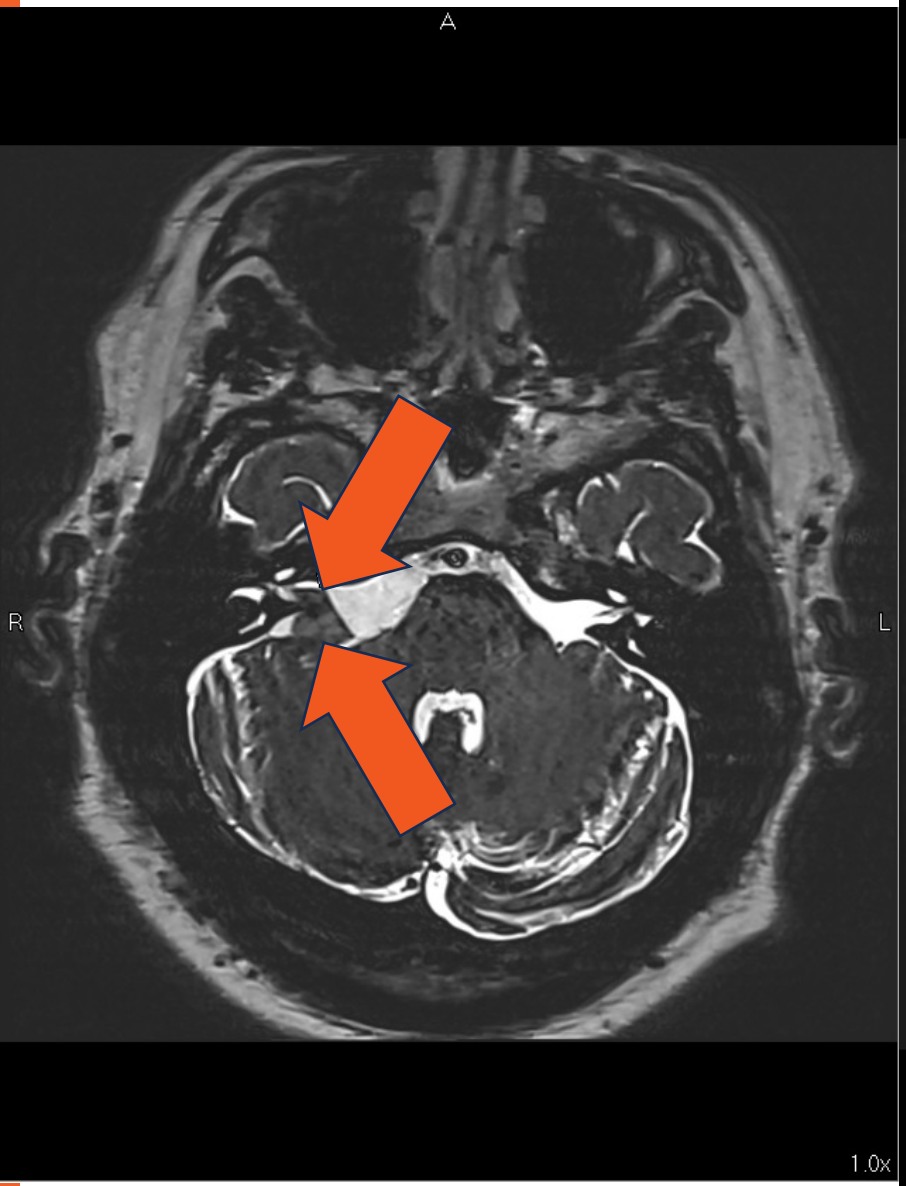
Tymp	Right
Tone	226 Hz
SC	0.6 ml
TPP	-7 daPa
ECV	2.1 ml
TW	304 daPa
Type	A

Tymp	Left
Tone	226 Hz
SC	0.7 ml
TPP	-1 daPa
ECV	2.4 ml
TW	247 daPa
Type	A

Reflex	Threshold (dB HL)					Decay (s)	
	500	1k	2k	4k	BBN	500	1k
R Ipsi	90	85	80	95			-
L Ipsi	95	90	85	90			-
R Contra	~~105~~	~~105~~	~~105~~	~~105~~			
L Contra	~~105~~	~~105~~	~~105~~	~~105~~			

Stimulus Ear Probe tone: 226 Hz


A
R
L
1.0x
2.0x
S
R
1


A
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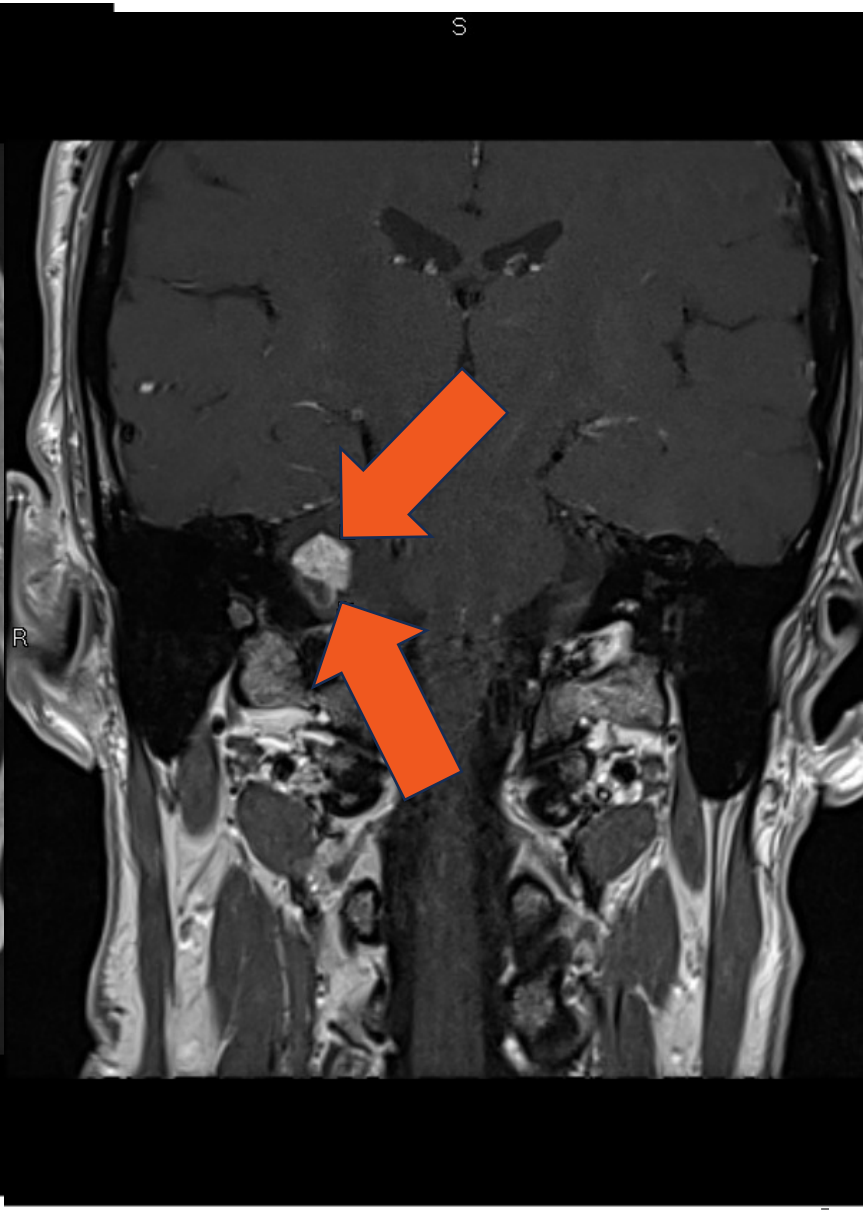
S
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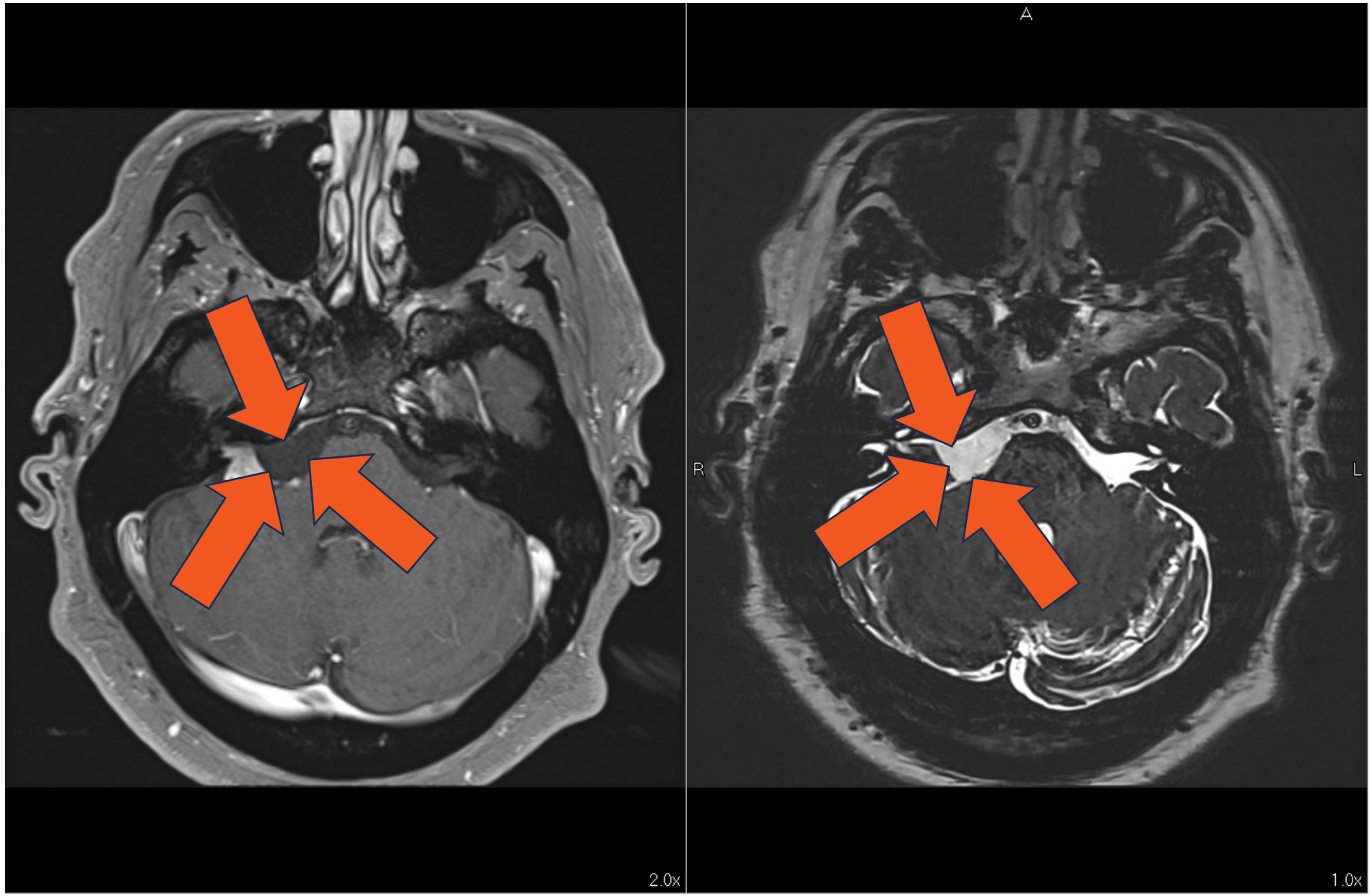
A
R
L
2.0x
1.0x

January 22, 2025

- MRI completed:
  - Right vestibular schwannoma
  - Possible arachnoid cyst
- Radiologist report:

1. Diffusely enhancing mass lesion located within the right internal auditory canal and extending into the adjacent right cerebellar pontine angle cistern measuring approximately 16 mm x 10 mm x 12 mm in size, most compatible with right vestibular schwannoma.

2. In addition, there is nonenhancing cystic mass lesion located anterior medial to the previously described enhancing mass lesion abutting the anterior margin of the vestibular schwannoma. Cystic lesion measures approximately 22 mm x 10 mm x 19 mm in size and is causing mass effect and flattening of the right lateral surface of the pons without associated vasogenic edema. This may likely represent arachnoid cyst. Alternatively, this may represent cystic component of the right vestibular schwannoma.

Patient Management

1. Phone call to the primary care physician (PCP). Left message for PCP regarding mutual patient and he returned the call. [Front office was told to interrupt me if I was with patients.]
    - Imaging report likely received by office but will resend to confirm.
    - Plan for patient: send to neuro-otologist at Johns Hopkins (JHU) for surgical consultation.
    - PCP was thankful for call and thought the management was great.
2. Phone call to patient.
    - Counseled that MRI report was received (he had not seen it). Reminder that the reason he was referred was to rule-out a benign tumor.
    - Informed of the results.
    - Mentioned the PCP call.
    - Referral to JHU. Patient provided his schedule.

Patient Management (cont).

3. Called Johns Hopkins Otolaryngology Department.
    - [Relationship in place] Requested surgical consult with specific neuro-otology surgeon.
    - Scheduled for February 7, 2025.
4. Repeat audiologic evaluation on August 21, 2025.
    - No significant changes in audiologic symptoms, audiologic results.
- 5. Re-visit ENT recommendations.
    - Patient stated in February, he was only to see the surgeon if he wanted surgery.
    - ENT wanted 6 month MRI.
        - Audiologist ordered MRI.
        - Will compare size of schwannoma and cyst from radiologist's report and patient will follow-up with ENT.

Timeline from audiology to treatment

- **13 days**
  - Audiologic diagnosis to MRI procedure/results
  - Typical 4-6 week wait to get into general ENT to obtain an order
    - **SAVED**: 2-4 weeks time, or longer

- **29 days**
  - Audiologic diagnosis to surgical consult with neuro-otologist
  - **SAVED** time: 4+ weeks, or longer

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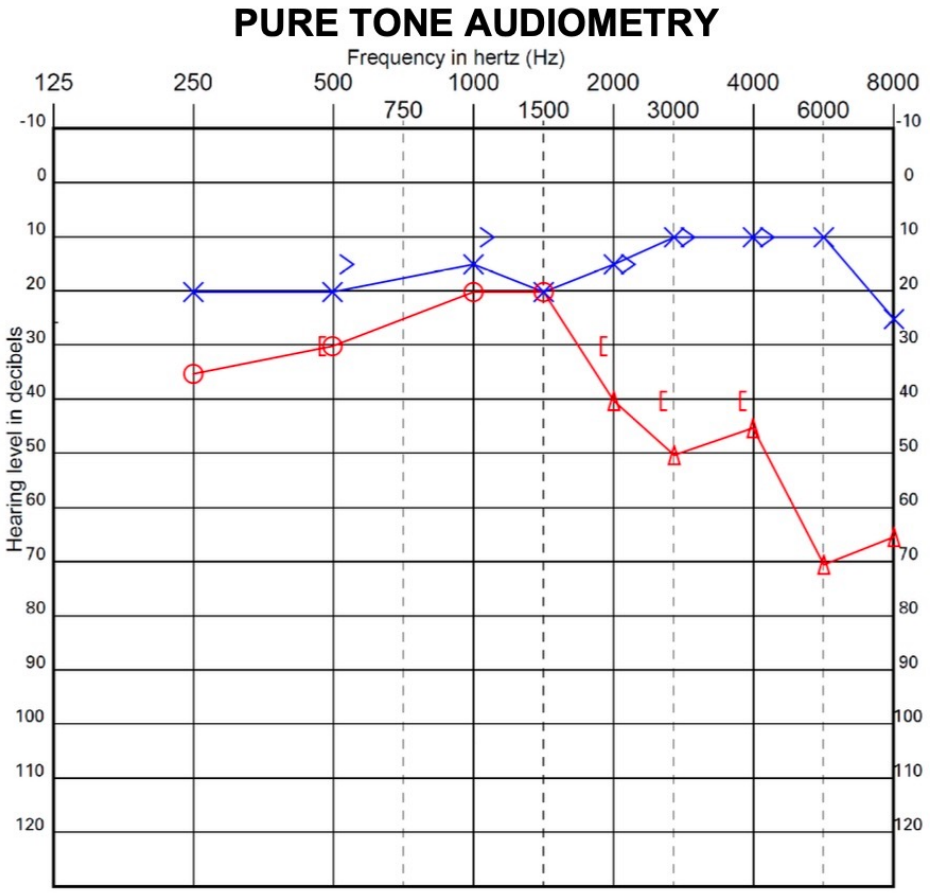
Case Study #2

Case Study

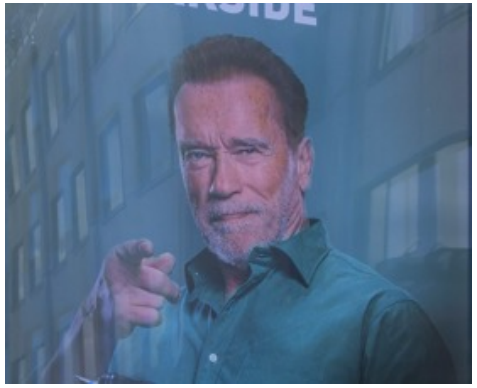
- 40 yr old male presents with difficulty hearing in the right ear for the past few years
- Awoke morning of exam with tinnitus right ear (never had before)
- Dizziness when turning head past few months (lightheaded)



Imaging Needed

- Referred patient to local radiology facility using the referral form posted on their website
  - Ordered a contrast MRI (faxed referral and emailed patient)
- The audiologic report was completed the same day and sent to his primary care doctor
- Counseled patient regarding imaging
  - If results were unremarkable, a brief review of treatment options was mentioned and more would be discussed
- PATIENT HAD TO SCHEDULE
  - Followed up 1 week later to ensure he scheduled the MRI

Radiology Report- It's a Tumah!



- BRAIN: There is an extra axial mass in the right cerebellopontine angle measuring 3.5 x 3.3 x 3.0 cm in size which extends into the right internal auditory canal. It compresses the brainstem and cerebellum to the left and the mass effect narrows the 4th ventricle which is shifted to the left 5 mm. There is no hydrocephalus. No focal brain parenchymal T2 signal abnormalities are identified.

- IMPRESSION: Large right cerebellopontine angle vestibular cochlear schwannoma with extension into the right internal auditory canal and significant mass effect on the adjacent brainstem and cerebellum. This compresses the 4th ventricle but there is no evidence of hydrocephalus.

ADA

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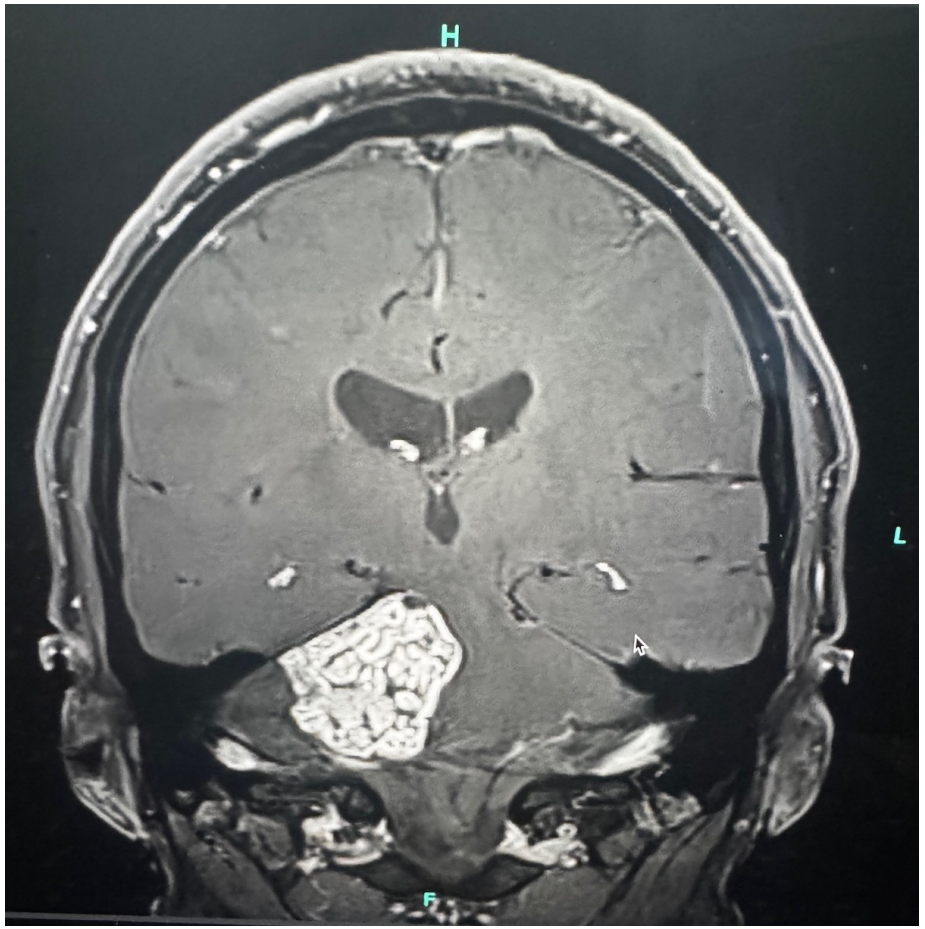
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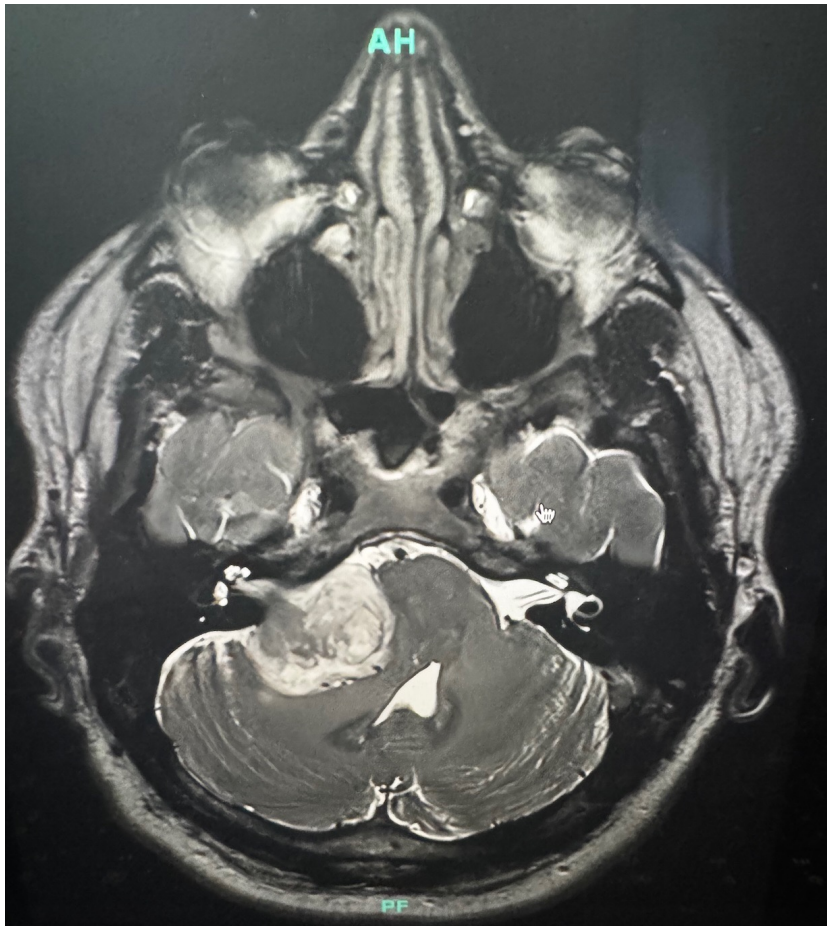
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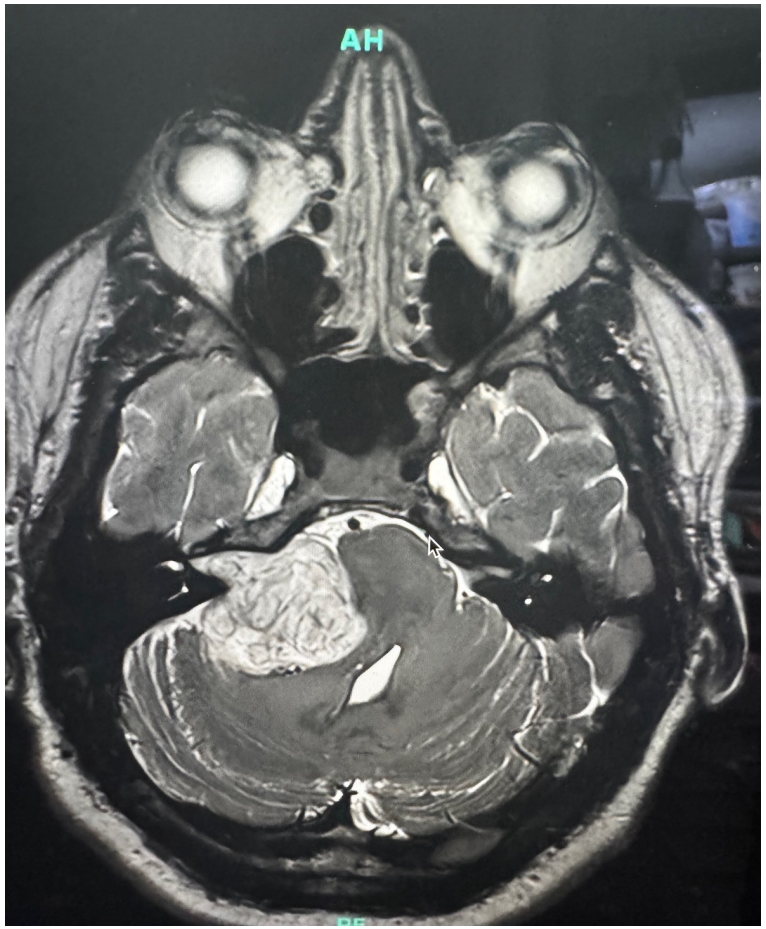

AH

Patient Management

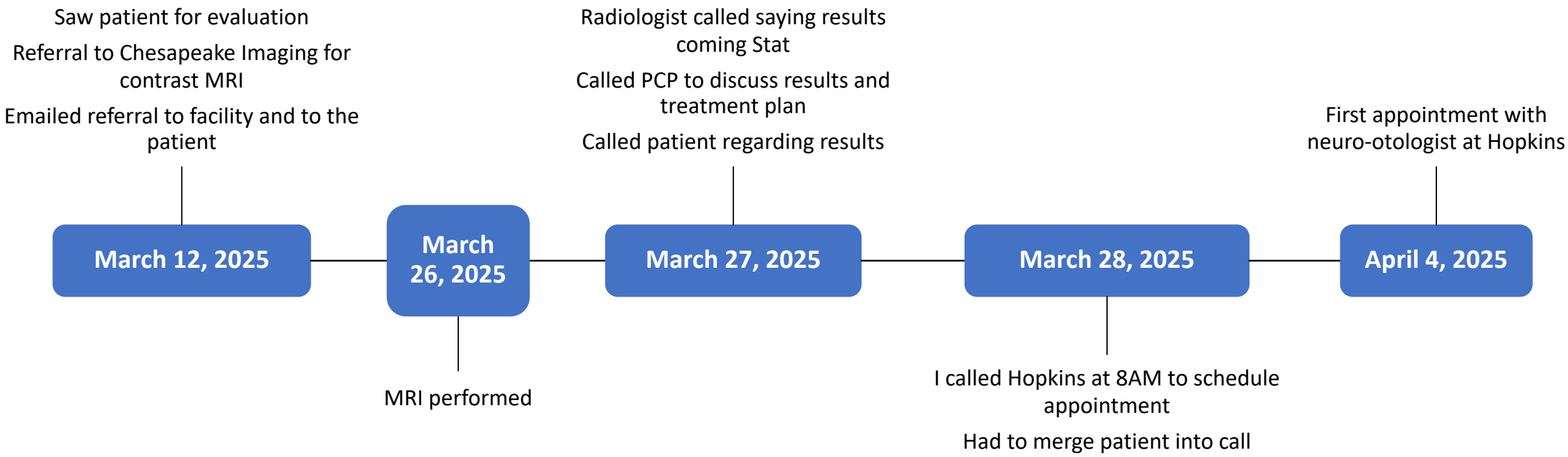
- Called primary care doctor with positive findings
- Reviewed treatment referral plant to confirm she was comfortable with audiologist's management of the patient
- Called the patient to discuss the MRI results
  - Ensure you have a treatment/referral plan
  - Don't give more information than what you know
  - Patients have access to online imaging portals

Timing is critical…

- MRI performed 2 weeks after audiologic evaluation
- Radiologist called immediately to alert the report was coming. He also called the follow day to confirm the patient was contacted.

- Have support ready in case you need guidance!
  - Radiologist
  - Colleague

Timeline


Saw patient for evaluation
Referral to Chesapeake Imaging for contrast MRI
Emailed referral to facility and to the patient
March 12, 2025
March 26, 2025
MRI performed
Radiologist called saying results coming Stat
Called PCP to discuss results and treatment plan
Called patient regarding results
March 27, 2025
March 28, 2025
I called Hopkins at 8AM to schedule appointment
Had to merge patient into call
First appointment with neuro-otologist at Hopkins
April 4, 2025

1 WEEK

MRI to surgical consultation

Neurotology Consultation

- He said “Wouldn’t wish this on my worst enemy”
- Major surgery, 12 hours in length
- 2 surgeons: brain, hearing
- 1-ish week in hospital post-operation
- 6-8 week recovery, to get back to “normal”
- No recovery of hearing, will be addressed in the future
- Facial nerve damage is a potential side effect
- Swallowing, speaking, tongue, eating, drinking, facial expression

Surgery

- May 14, 2025
  - 15 hours to complete
  - 9 days in hospital
  - Saved facial nerve
  - Severed audio-vestibular nerve

Show me the MONEY!!!

- Initial ENT or PCP visit was not necessary; audiologist referred directly
  - Savings: insurance visit cost, copay/co-insurance, time/travel to the patient
  - Savings to the patient: cost of copay (co-insurance) for specialists: $30-$50
  - Savings to insurance company: cost of a new patient ENT visit: $212

- Regardless of what path the patient takes to get to the imaging appointment; there may be a copay at the facility.

Take Home Message

- Patients are likely to receive the same care when audiologists order
  - Audiologic appointment
  - Imaging appointment
  - Surgical consult, with remarkable findings

- The time that it takes to receive this care is **SIGNIFICANTLY reduced:**
  - Resulting in **faster** access to care
  - **Reduced** cost to insurance payors and patients

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Questions?

Radiologist- Dr. Berger

Audiologists- Dr. Segev, Dr. Spoor

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Thank you!