# Audiological and Medical Considerations for SSD

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# Disclosures

Rachel Fryatt, AuD: receives a salary through Michigan Medicine

Emily Stucken, MD: receives a salary through Michigan Medicine, receives grant funding for research through the National Institutes of Health

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# Learning objectives

- Identify causes for single-sided deafness
- Describe devices currently available for patients with SSD
- Explain pre-operative testing to determine best audiological recommendations

# What is SSD?

“A type of unilateral hearing loss where the reduction in hearing is so severe that your ear is considered to be non-functional or deaf.”

*Clevelandclinic.org*

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# Causes for SSD

- Etiology
- Duration

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# Causes for SSD – does it matter?

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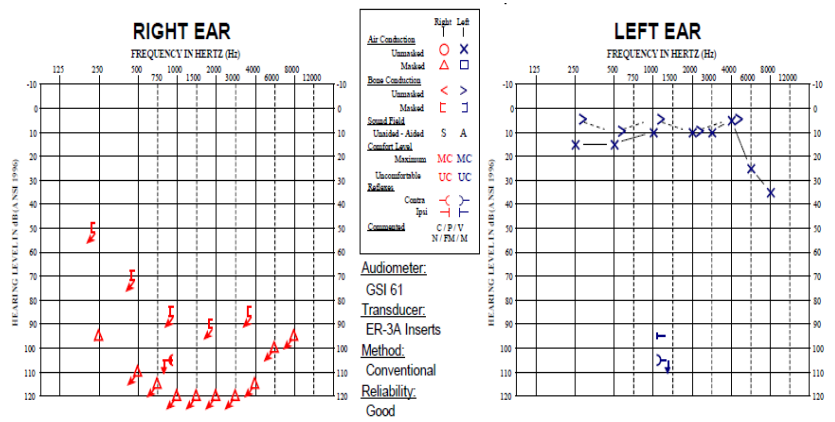


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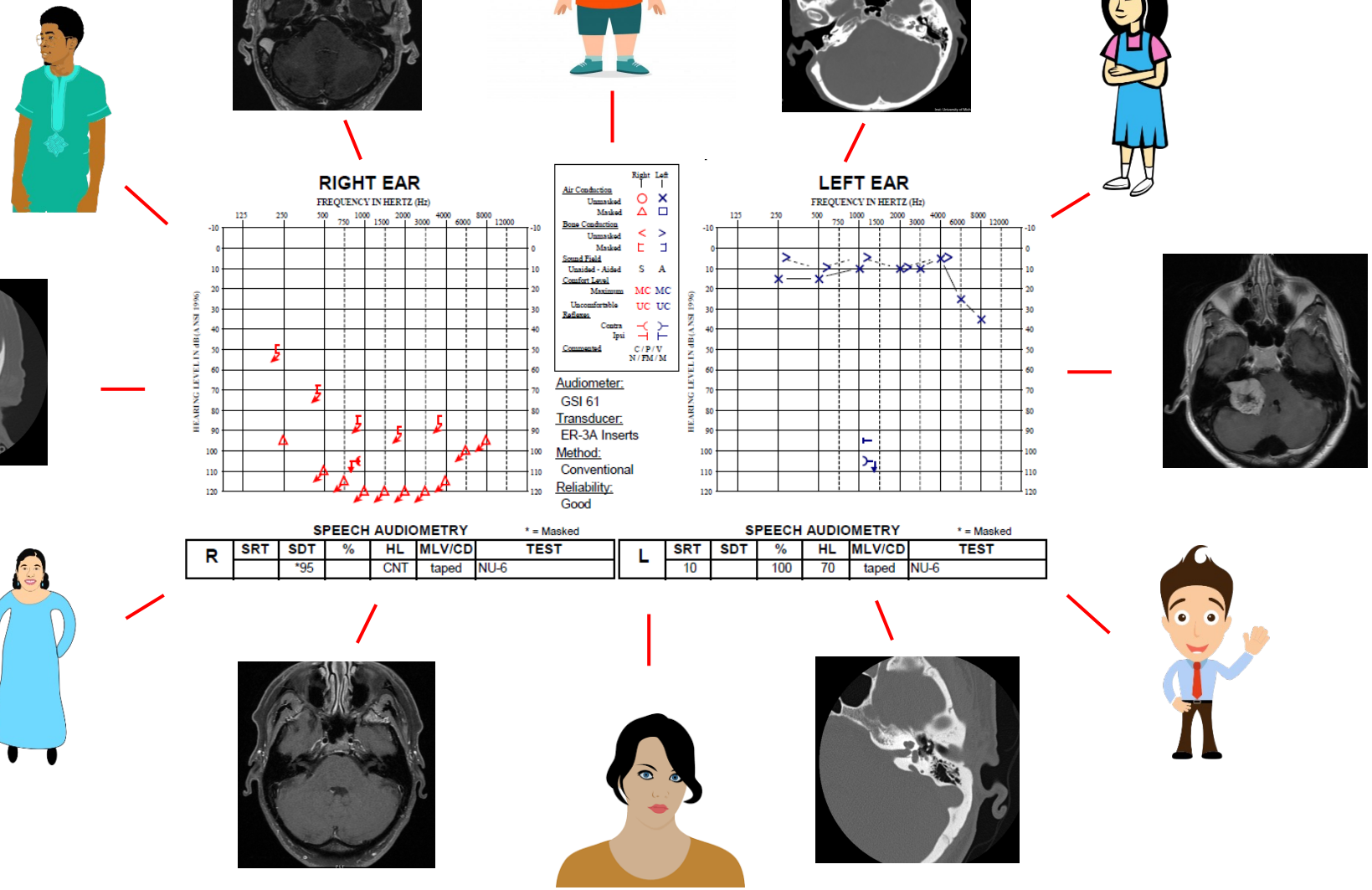
# Causes for SSD



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# Causes for SSD

- Congenital
- Infectious/inflammatory
- Ototoxicity
- Trauma
- Neoplastic
- Autoimmune
- Idiopathic

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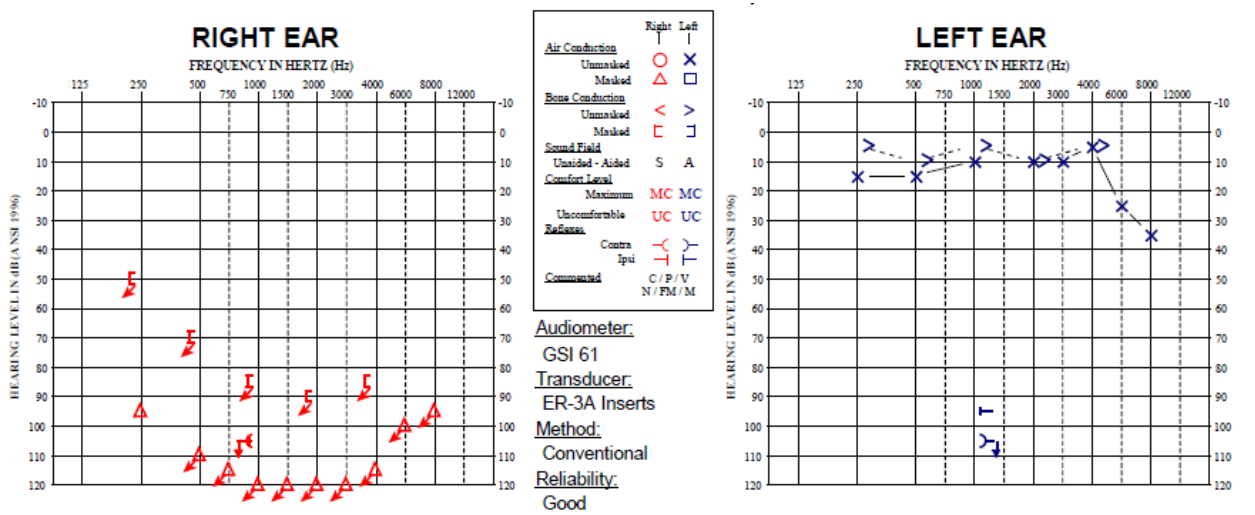
# Causes for SSD

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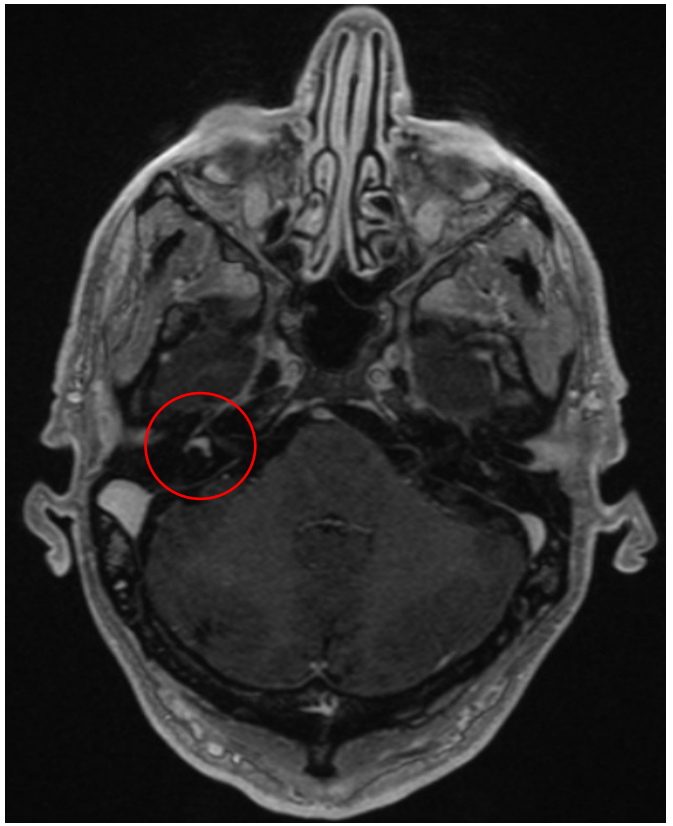

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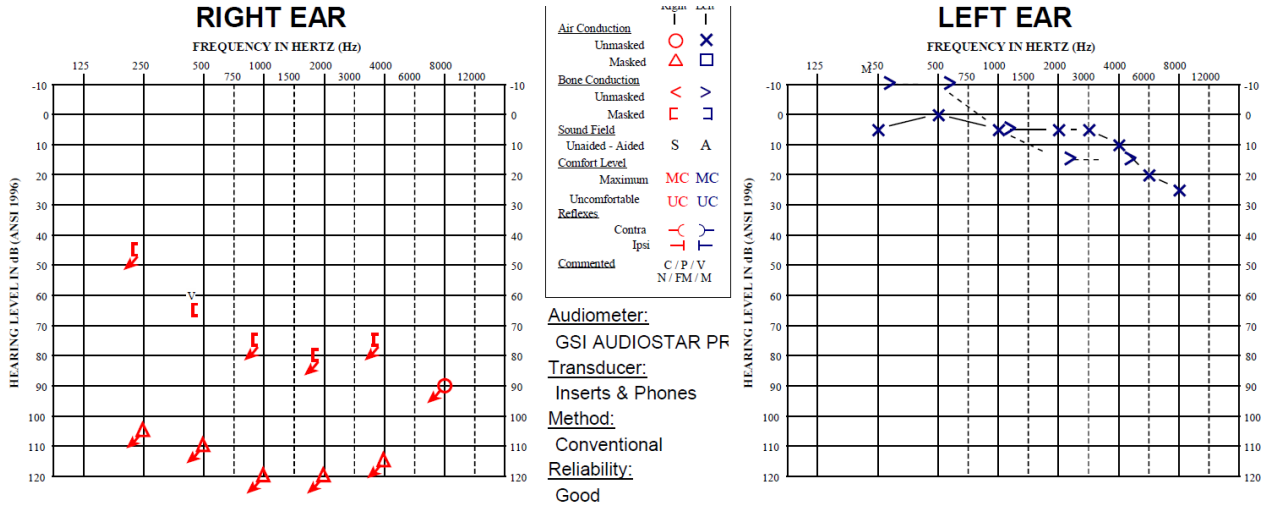


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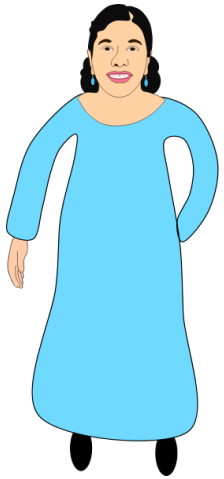

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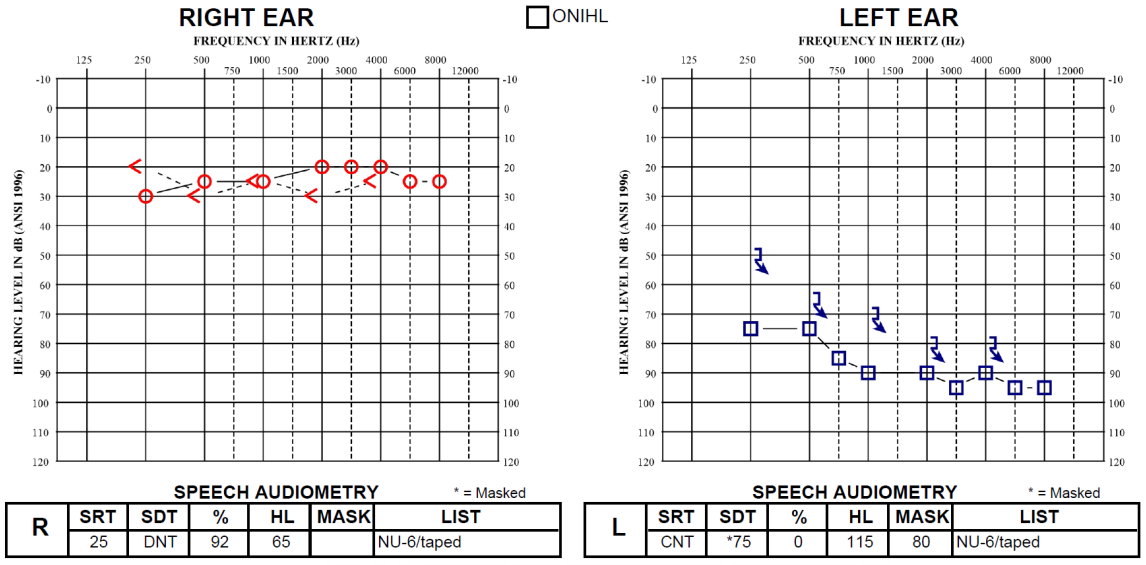


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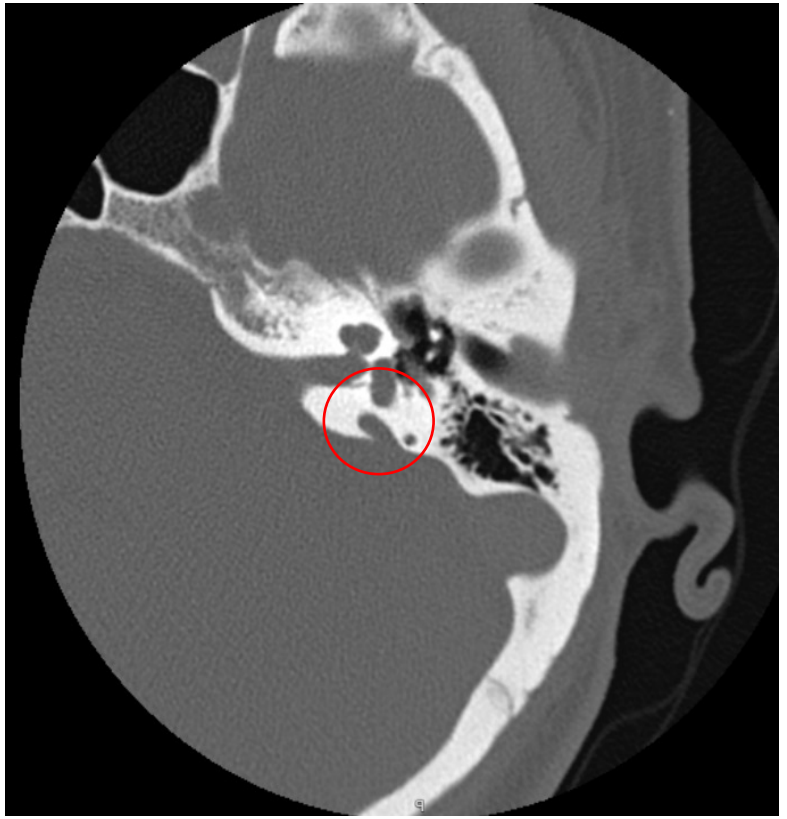

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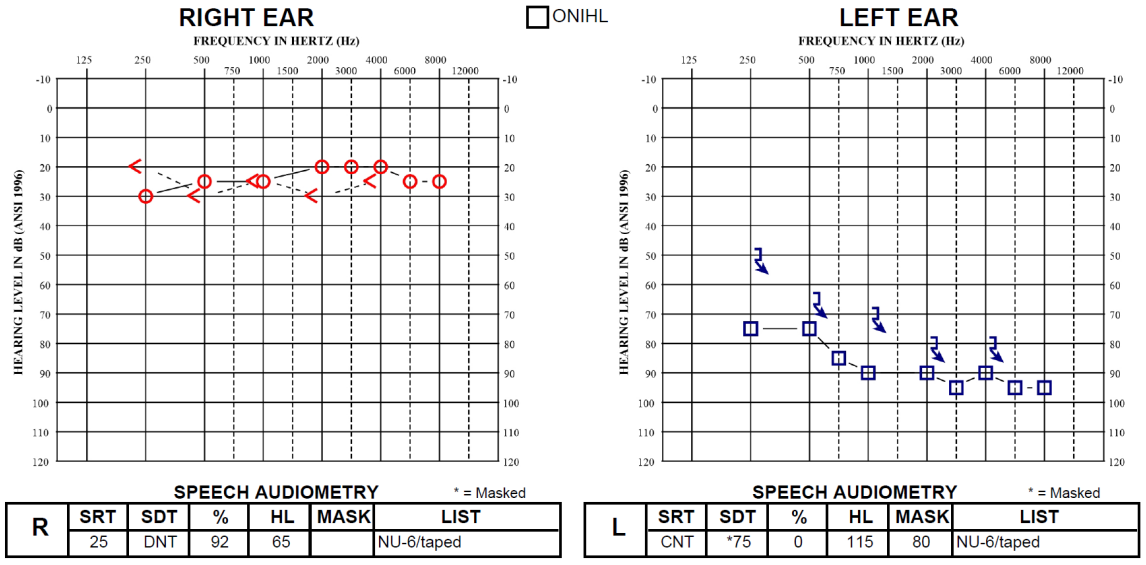


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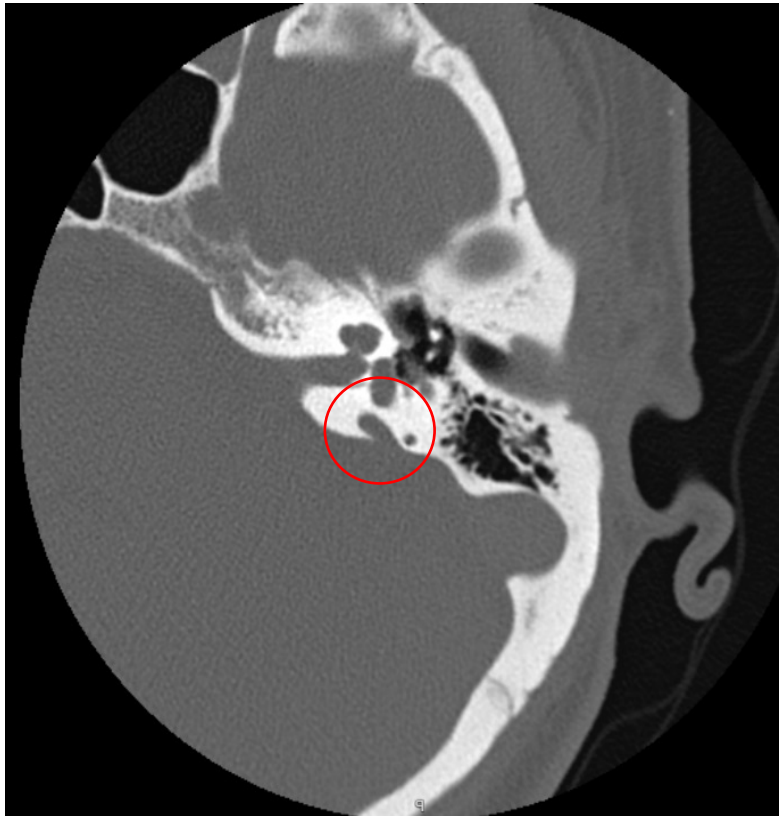

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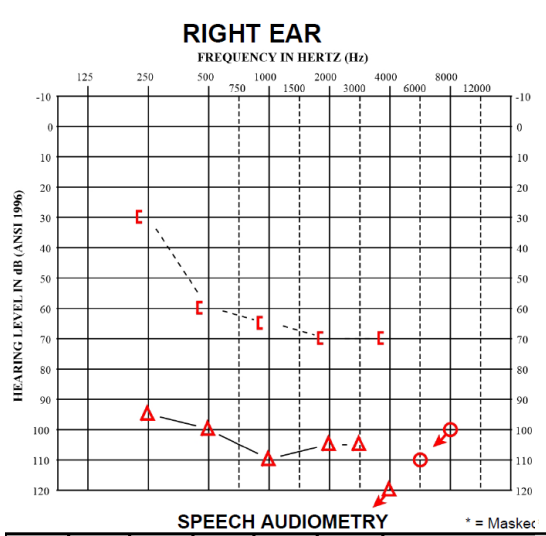
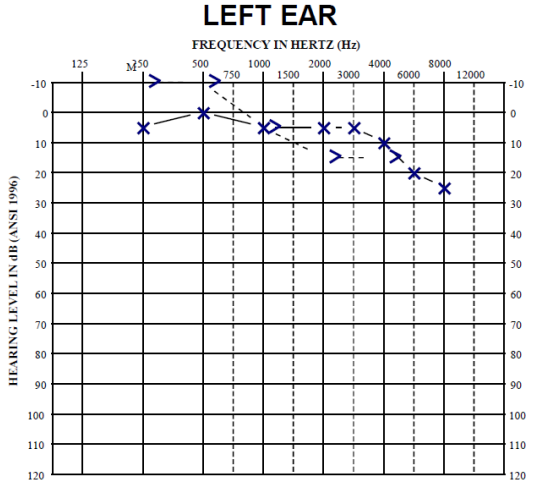



| | |
|---|---|
| Air Conduction | |
| Unmasked | O X |
| Masked | △ □ |
| Bone Conduction | |
| Unmasked | < > |
| Masked | [ ] |
| Sound Field | |
| Unaided - Aided | S A |
| Comfort Level | |
| Maximum | MC MC |
| Uncomfortable | UC UC |
| Reflexes | |
| Contra | |
| Ipsi | |
| Commented | C / P / V<br>N / FM / M |

Audiometer:
GSI AUDIOSTAR PR
Transducer:
Inserts & Phones
Method:
Conventional
Reliability:
Good

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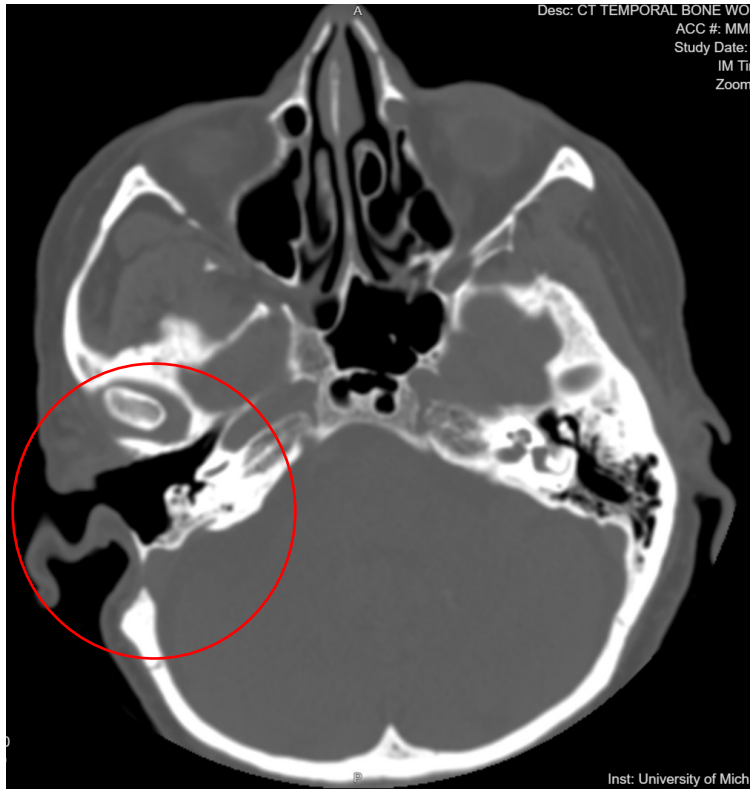

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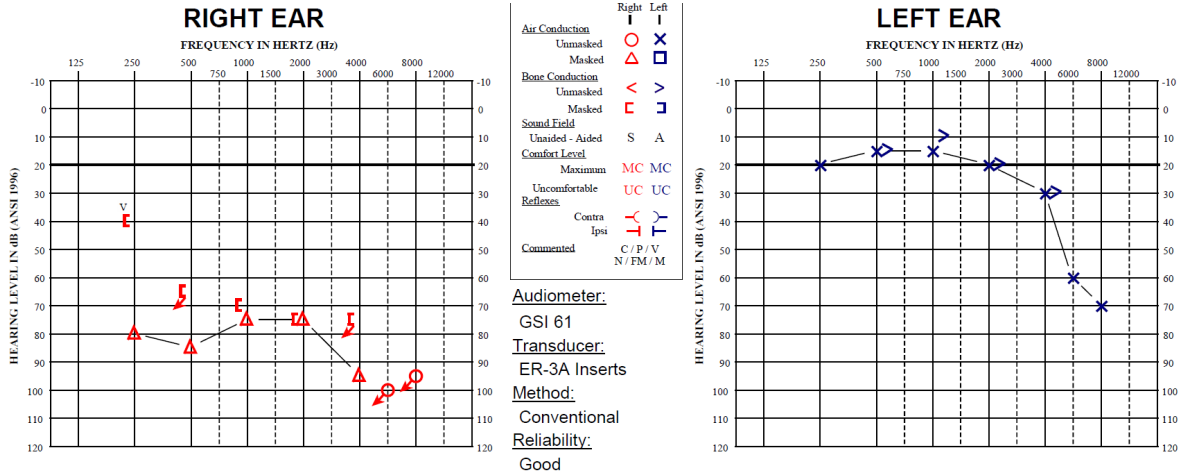


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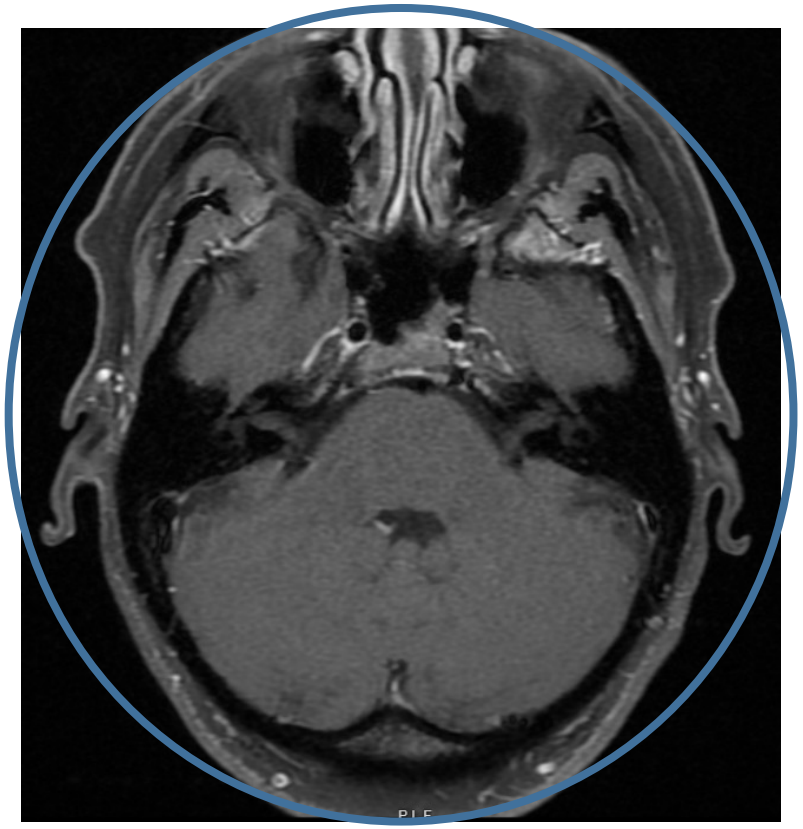

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# Causes for SSD – does it matter?

- Device category
- Radiographic surveillance needs
- Device selection
- Prognosis

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# Why do we want to treat SSD?

Overcome the head shadow effect (localization)

Binaural summation

Binaural Squelch

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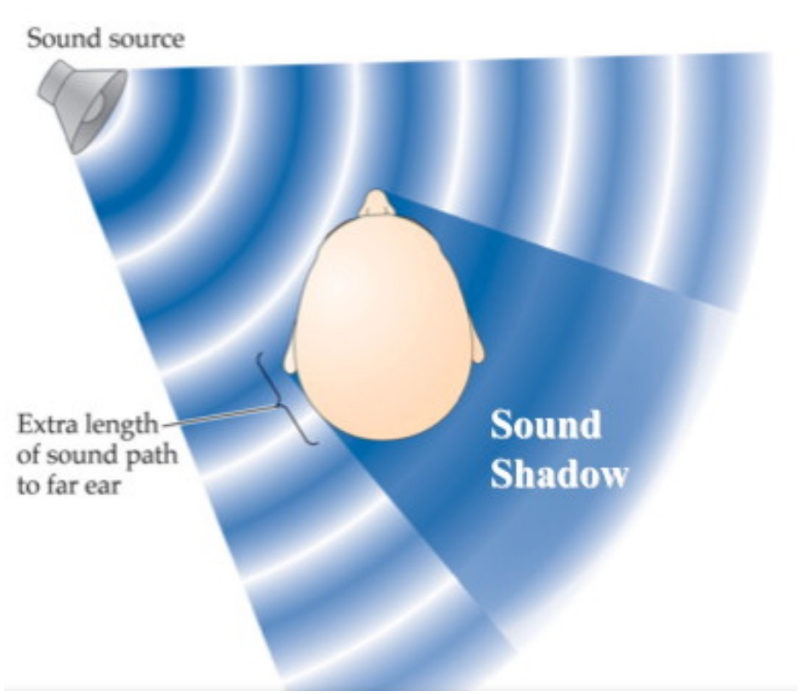
# Head shadow effect




- Localization is almost entirely based on processing of ITDs and ILDs
- Difficult in spatially separated sources

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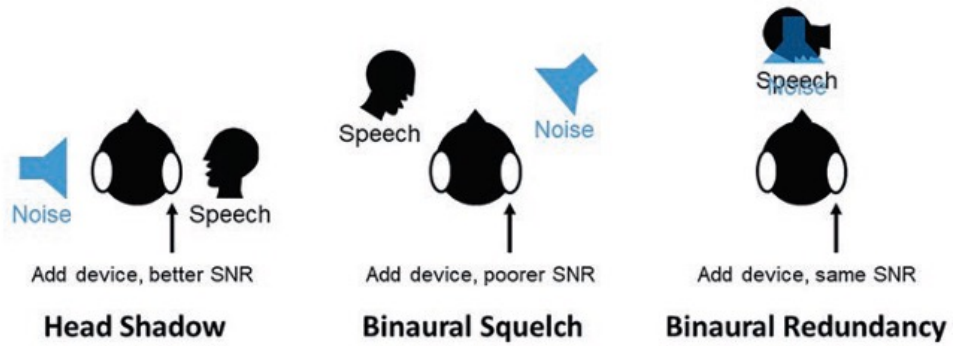
# Binaural Summation & Squelch

- Central processing
- Two ears are louder than one
- Binaural squelch is the brain understanding which ear has better SNR




Ricketts & Kan, 2021

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# Common complaints for SSD patients

1. Sound awareness
2. Speech understanding in background noise
3. Localization

Additional consideration: Tinnitus

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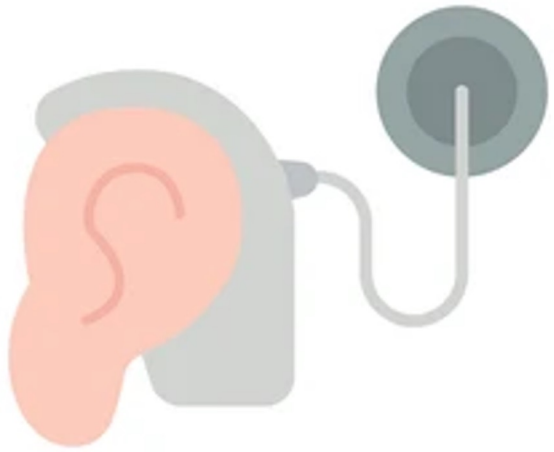
# An overwhelming number of studies show the detriments in untreated unilateral hearing loss

- Social isolation
- Distractibility
- Safety Concerns
- Tinnitus
- Poor school performance
- Less complex sentence structure
- Difficulty following directions
- Increased levels of stress

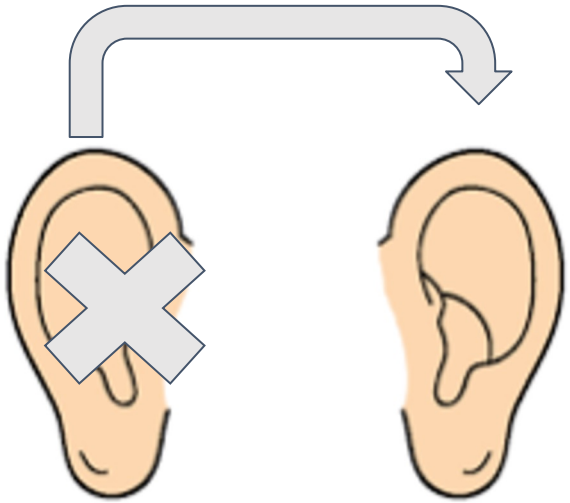
# Two options for treatment

Audibility on the affected ear



Cochlear implant

Reroute signal to the better hearing ear



CROS system
Bone conduction device (BCD)

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# What makes a cochlear implant candidate?

Etiology & contraindications

FDA indications

Duration of deafness

Case history & patient complaint

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# Medical considerations for CI for SSD

- Is there a patent cochlea + functional cochlear nerve?
- Prior surgery?
- Ongoing pathology?
- Vestibular function?
- Need for postoperative radiography?
- Duration of deafness?

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# Duration of deafness

- Speech perception scores in SSD patients are negatively correlated with duration of deafness, but limited data from CI users leads to uncertainty in clinical recommendation (Cohen & Svirsky, 2019)
- When is it considered “too long” for CI outcomes?
  - Few studies looking at this topic use a 10 year cut-off
  - There’s evidence to suggest that brain reorganization occurs as soon as 2 years post onset (Kral & Sharma, 2012) and can be rapidly restored in early implantation in young children with SSD (Polonenko, Gordon, Cushing, & Papsin, 2017)
  - More evidence in pediatric patients, with better outcomes in patients with sooner implantation

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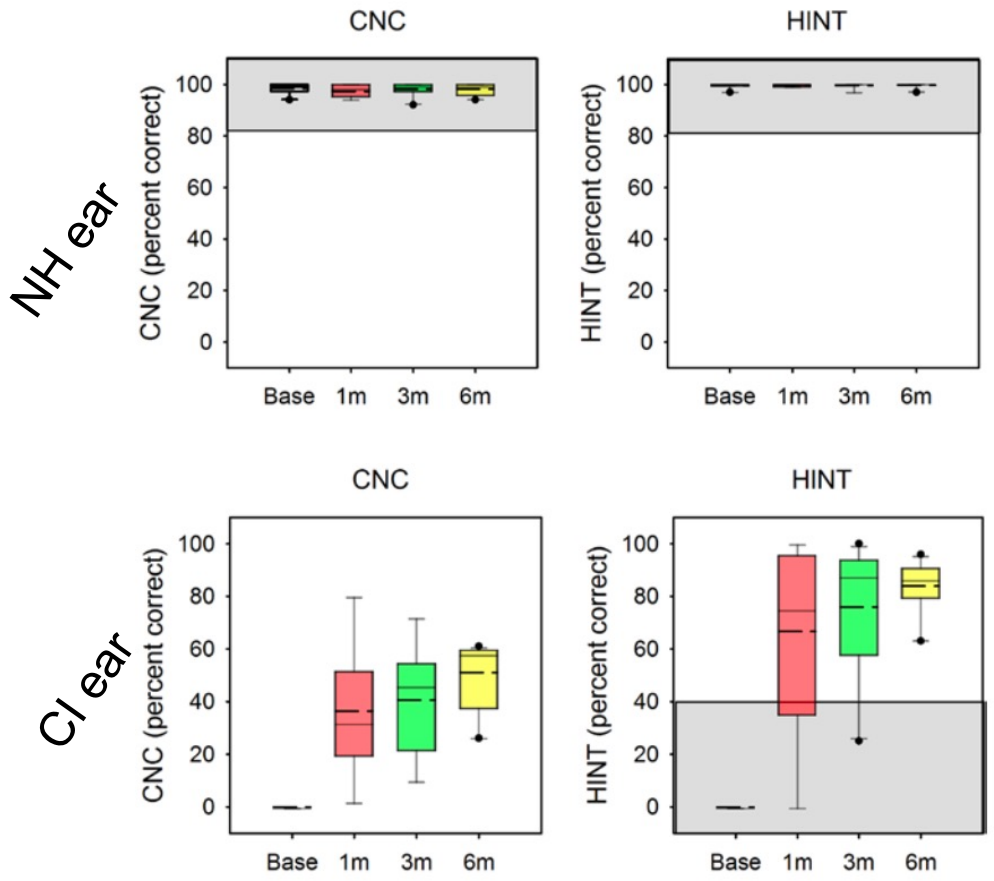
# Realistic expectations

- Galvin et al. (2019)
- Immediate improvement in speech understanding
- Also tested for localization; did not improve until after 6 months post activation
- Tinnitus severity decreased



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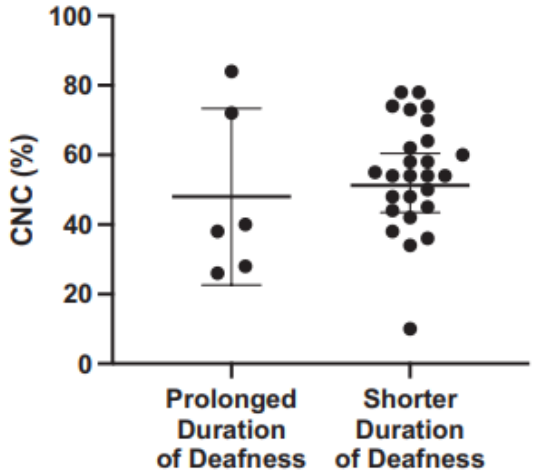
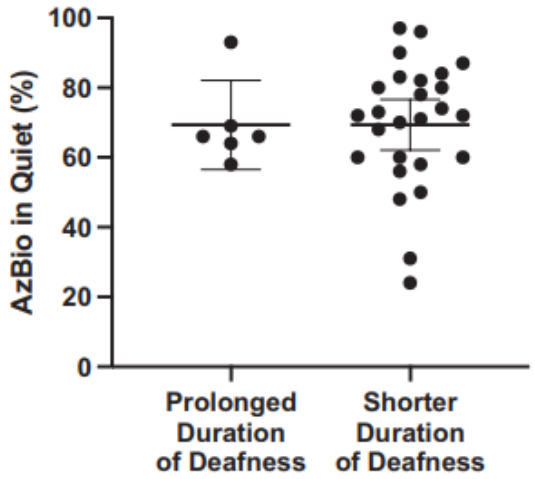
# New research on this topic

Nassiri et al (2022)

- In adult patients with acquired SSD, split into two groups: <10 years DoD and >10 yrs
- Prolonged deafness:
  - CNC 39%
  - AzBio 66%
- Shorter deafness:
  - CNC 54%
  - AzBio 72%
- Concluded that prolonged deafness alone should not preclude a motivated SSD patient from pursuing CI

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# CI for pediatric SSD

- Incidence (rises with age)
- Consequences of untreated UHL
- Age of implantation: FDA criteria is 5 years and older
  - However, evidence suggests better outcomes at younger ages
  - Imaging usually at 6 months

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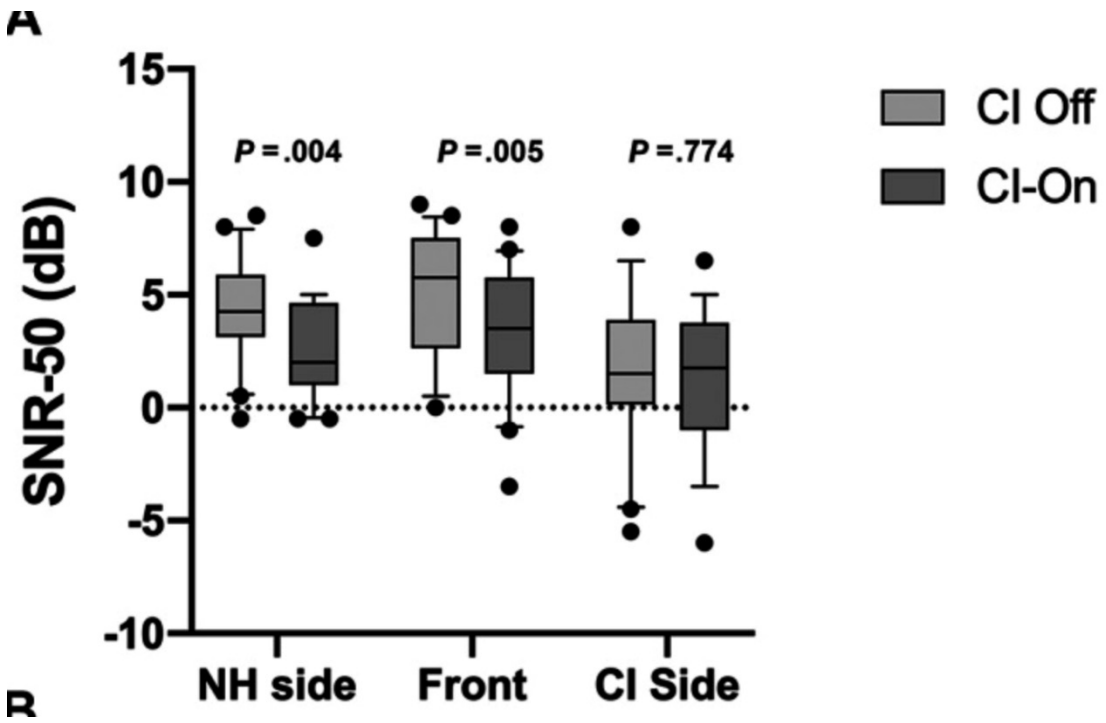
# Benefits of CI for Pediatric SSD

- Brown et al (2022) found children with unilateral hearing loss significantly benefit from cochlear implant by 12 months post activation
  - BKB-SIN improved 3.6 dB advantage
  - Improved CNC performance
  - 1.6 dB advantage in summation
  - 2.5 dB advantage in squelch



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# ACIA Taskforce Guidelines

- Recently, ACIA published guidelines in management of SSD for both adults and pediatric populations
- Supported by AAA
- AudiologyOnline presentations outline these guidelines

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# When to consider a BCD?

Etiology & contraindications

FDA indications

Duration of deafness

Case history & patient complaint

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# Surgical Considerations – Bone Conduction Device

- Anatomy?
- Need for MRI?
- Skin/wound concerns?
- Need for radiation?
- Lifestyle?

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# Bone Conduction Devices – abutment system complications

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# BCD MRI compatibility (processor removed)

- Baha Connect 1.5T or 3T
- Ponto 1.5T or 3T
- Baha Attract 1.5T
- Alpha 2 MPO (Sophono) 1.5T or 3T
- Bonebridge 1.5T
- Osia 1.5T w MRI Kit

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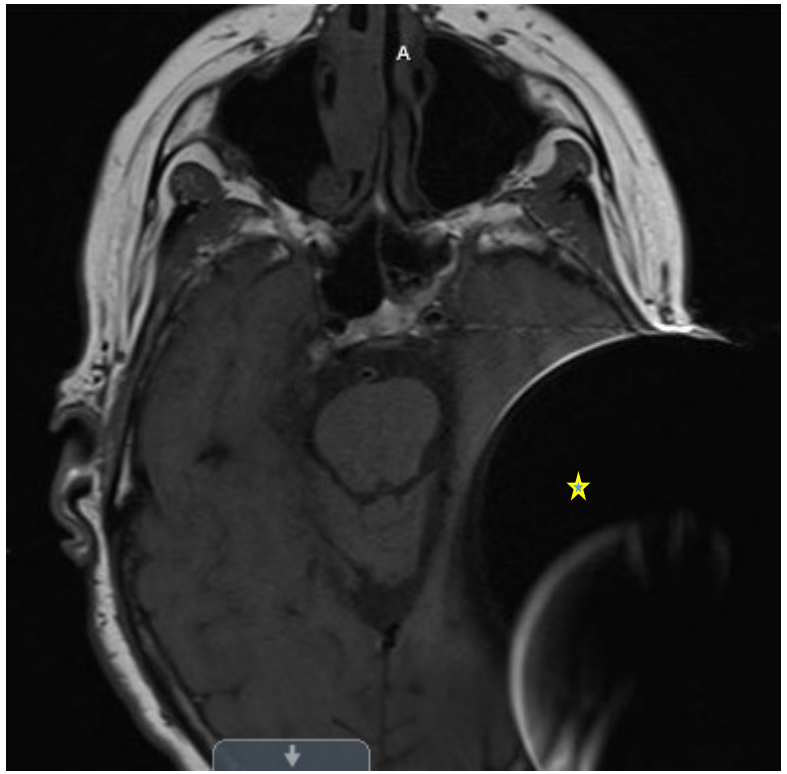
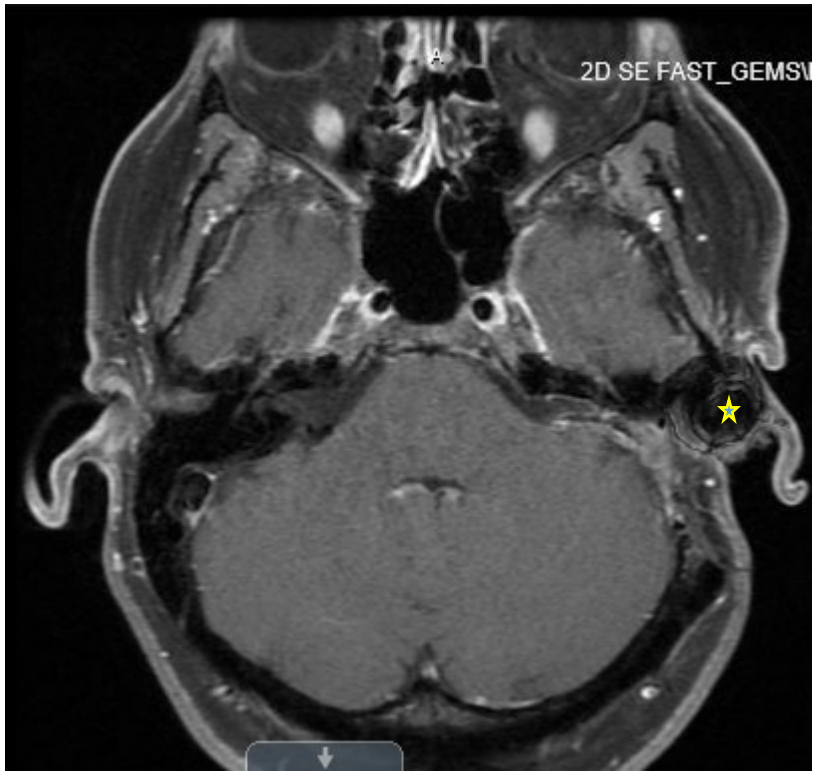
# Implant MRIs

- Artifact




Cochlear Implant




Percutaneous abutment BCD

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# BCDs for SSD vs CHL vs MHL

- Different expectations
- Hearing experience
- Localization

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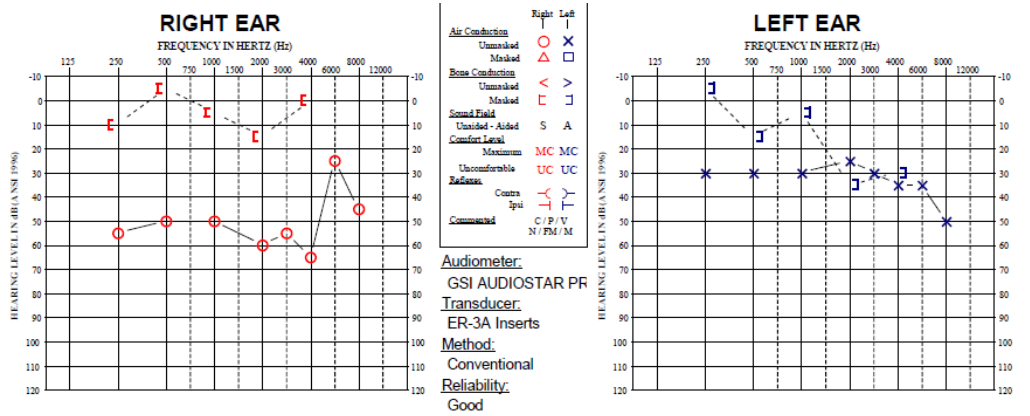
# BCDs for SSD vs conductive HL

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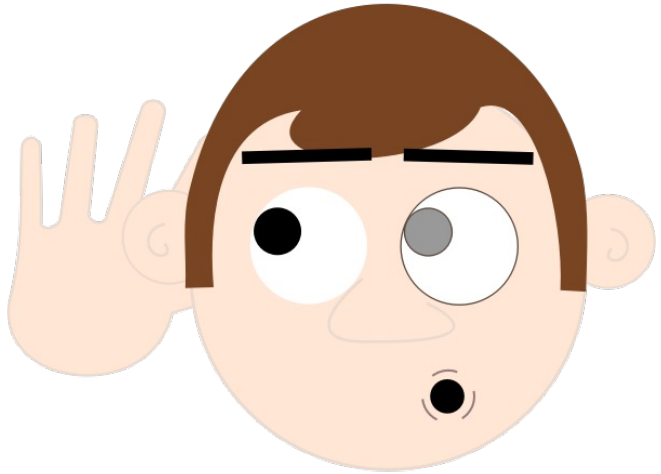
| | 30 | | 100 | 70 | REC | List 1 |



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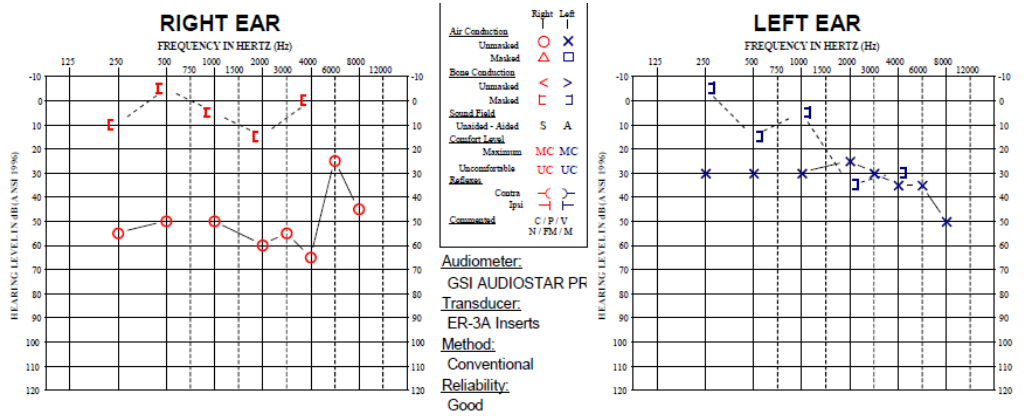
# BCDs for SSD vs conductive HL

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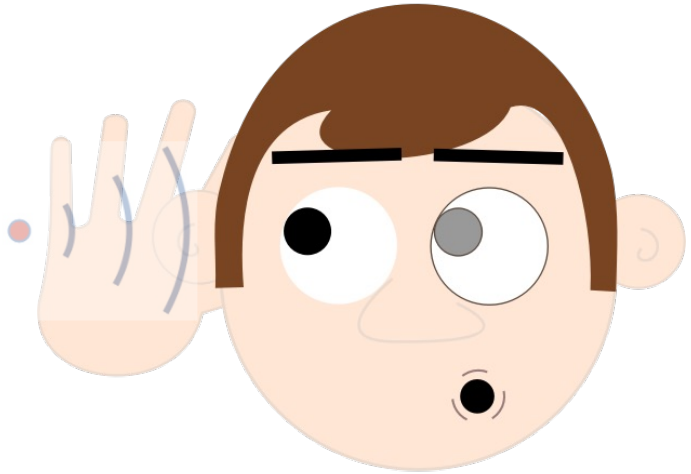

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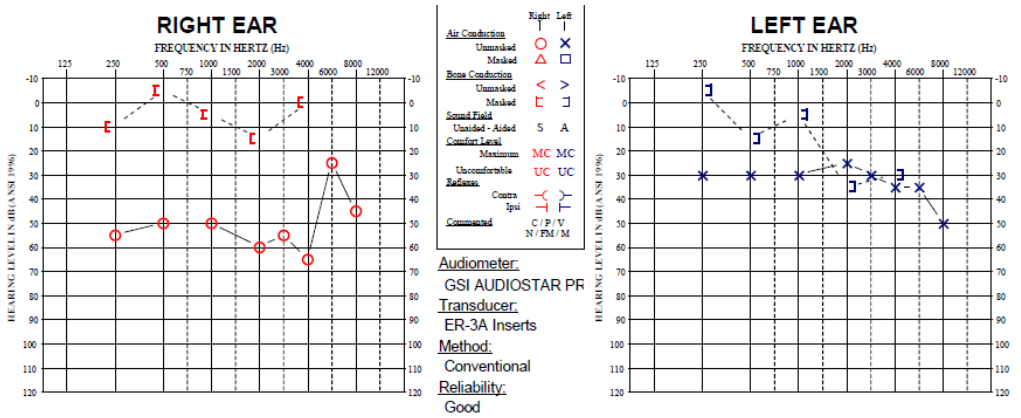
# BCDs for SSD vs conductive HL

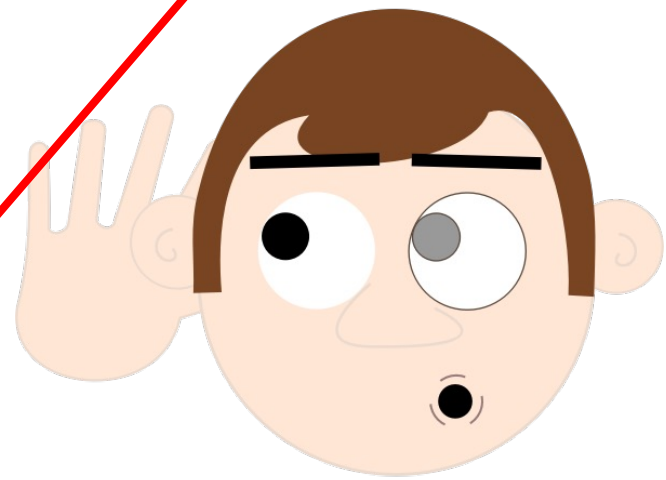


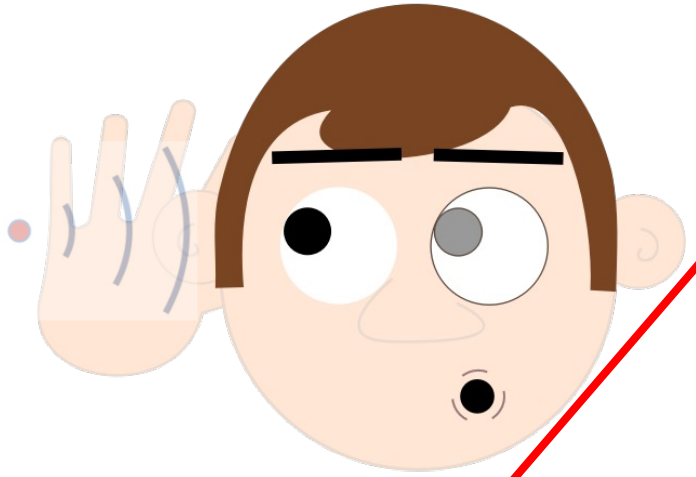

SPEECH AUDIOMETRY * = Masked

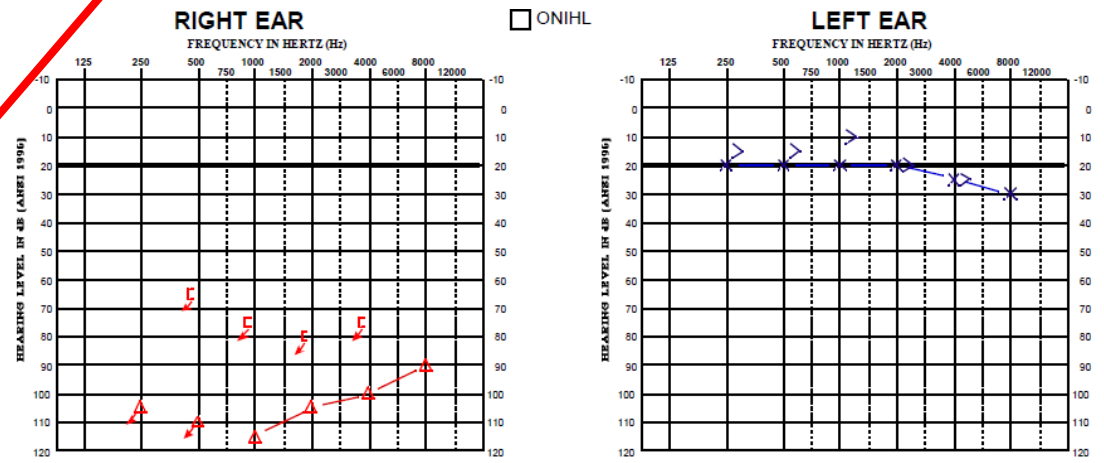
| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| R | 55 | | 100 | * 90 | REC | List 1 |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| L | 30 | | 100 | 70 | REC | List 1 |








SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | *95 | *95 | | CNT | | NU-6/taped |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | 20 | | 100 | 55 | | NU-6/taped |

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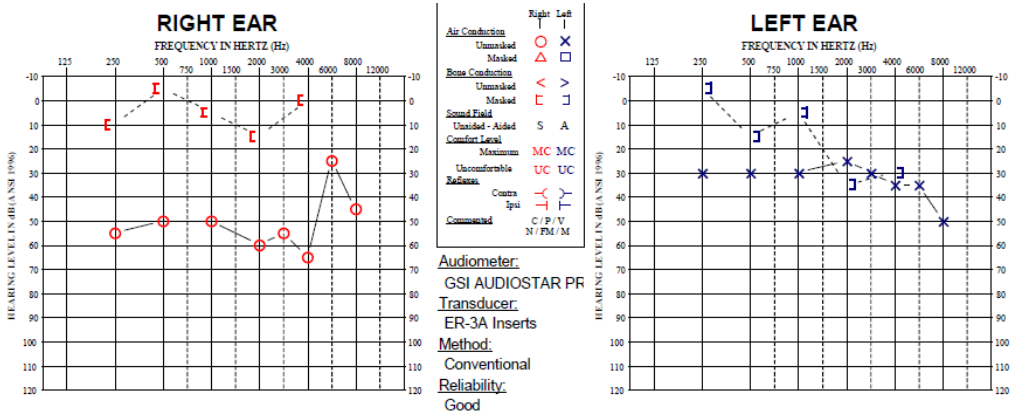
# BCDs for SSD vs conductive HL

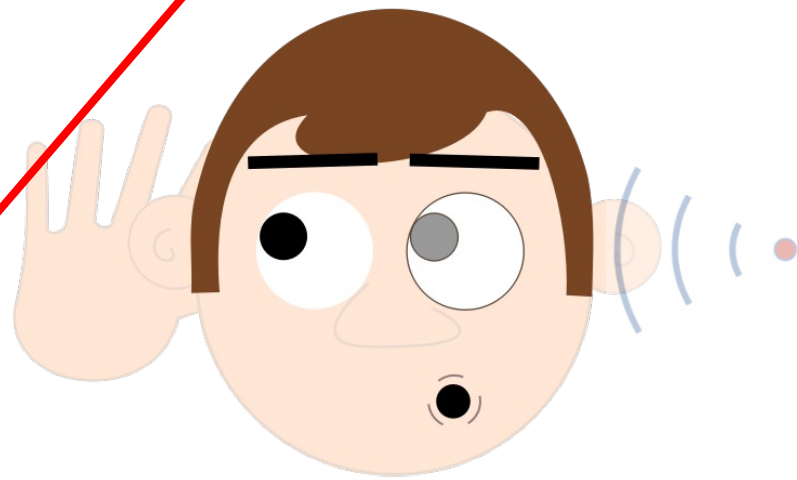


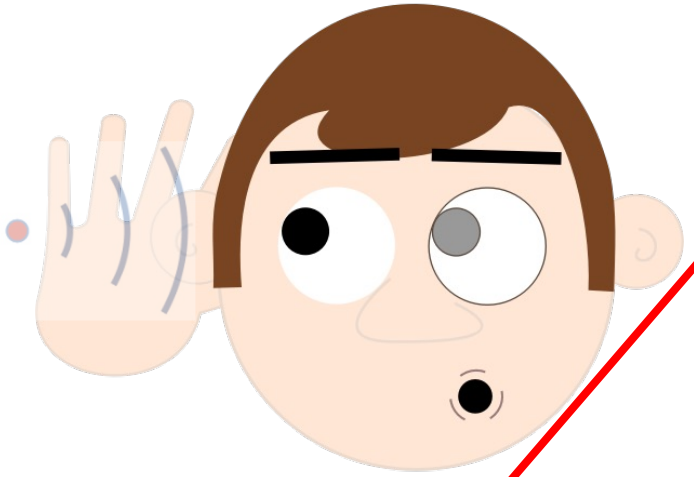

SPEECH AUDIOMETRY * = Masked

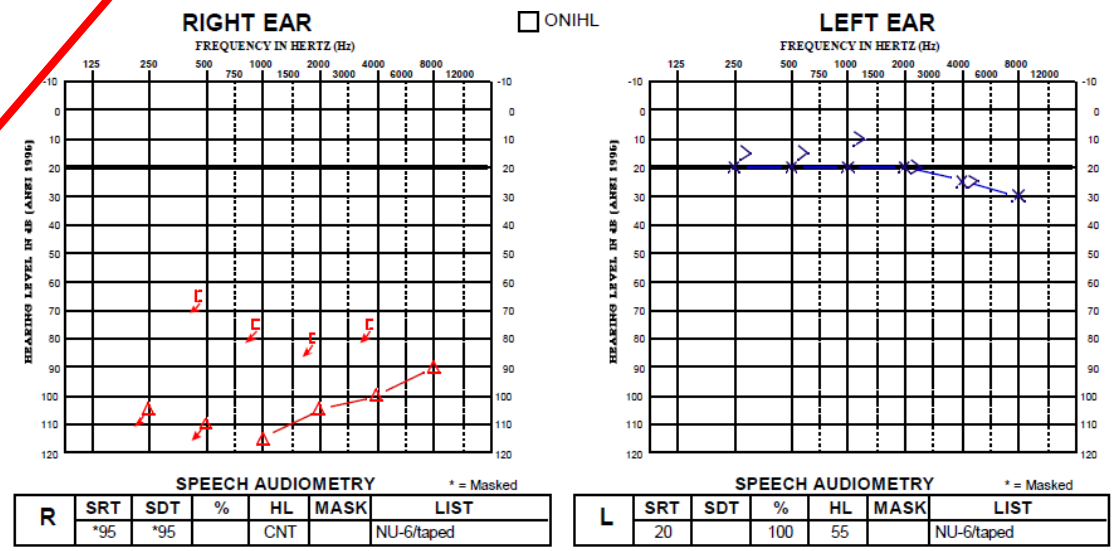
| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| R | 55 | | 100 | * 90 | REC | List 1 |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| L | 30 | | 100 | 70 | REC | List 1 |








SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | *95 | *95 | | CNT | | NU-6/taped |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | 20 | | 100 | 55 | | NU-6/taped |

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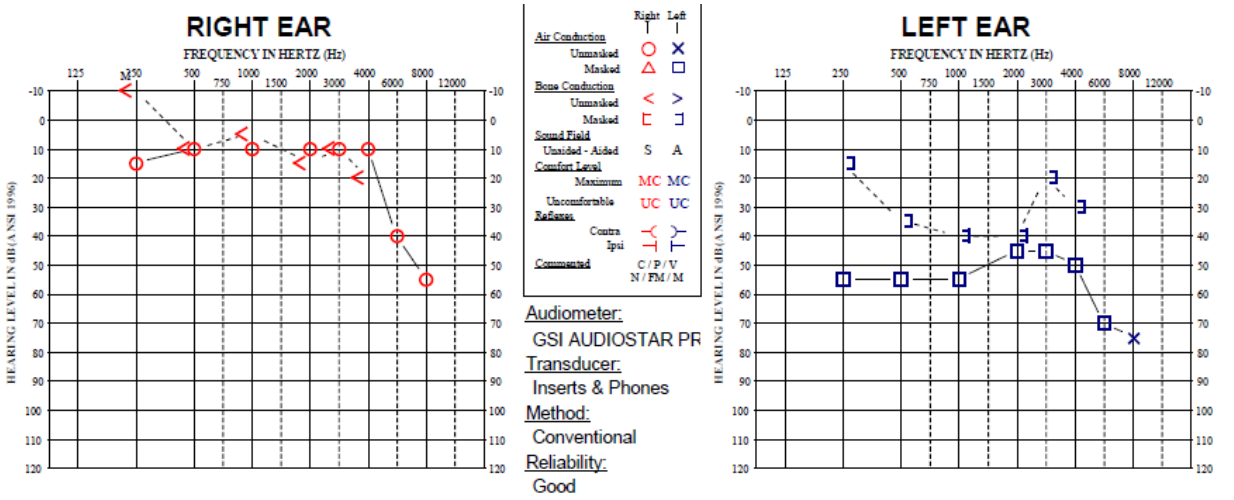
# BCDs for mixed hearing loss

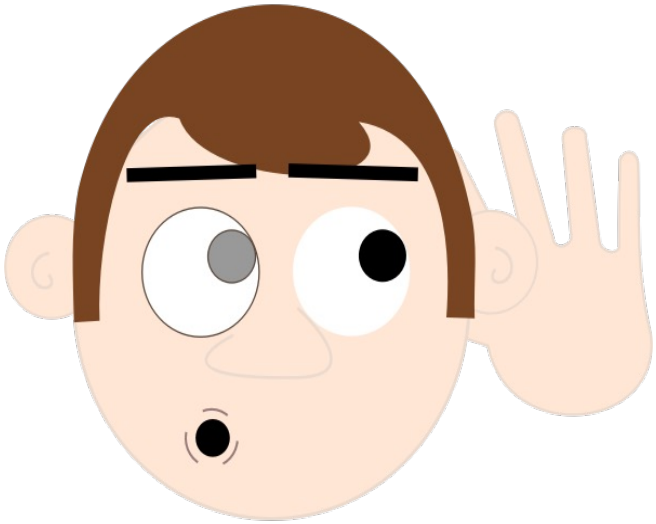



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 15 | | 100 | * 55 | REC | NU-6 LIST 2A |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | *55 | | 100 | * 90 | REC | NU-6 LIST 3A |



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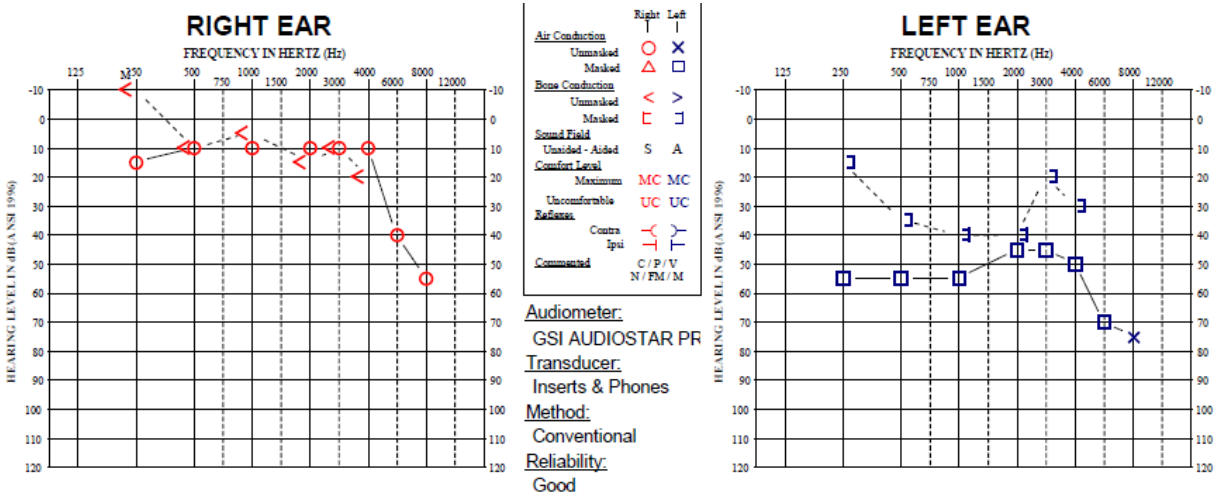
# BCDs for mixed hearing loss

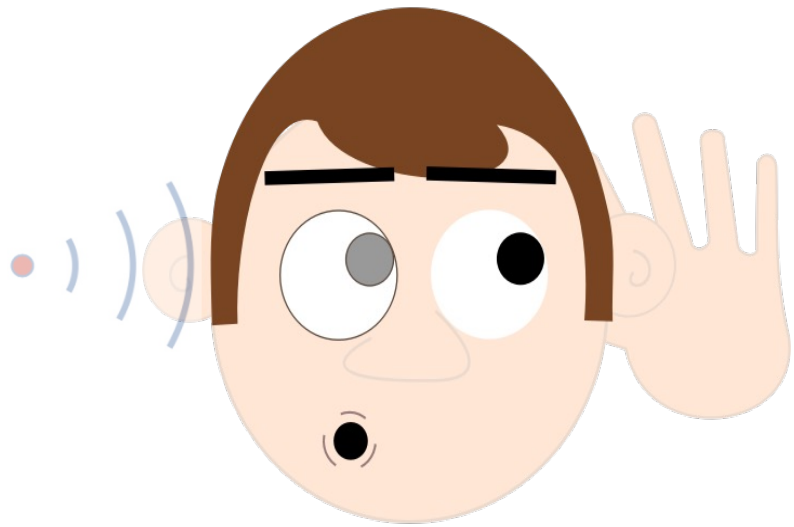



SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| R | 15 | | 100 | * 55 | REC | NU-6 LIST 2A |

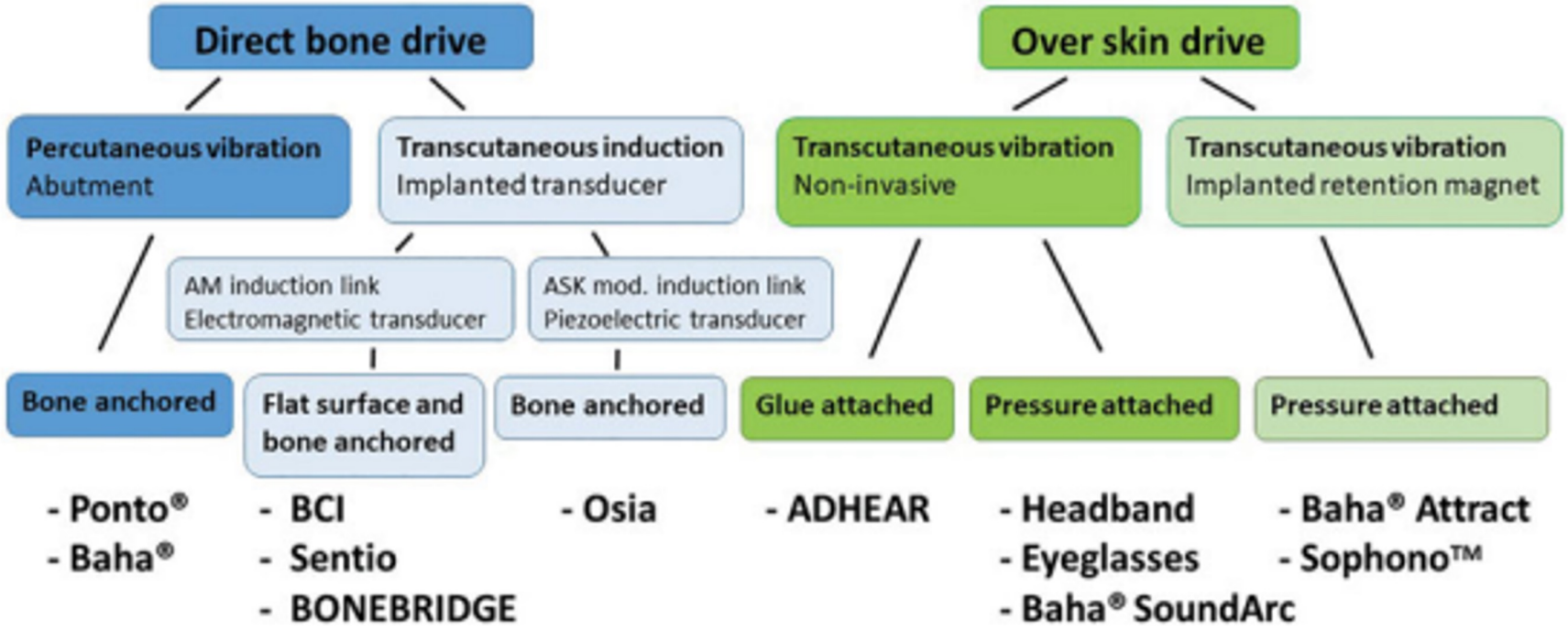
SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| L | *55 | | 100 | * 90 | REC | NU-6 LIST 3A |



# Bone Conduction Devices

## Transmission and attachment modalities




*Hakansson et al, 2019*

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# New additions to the BCD device selection

Osia

Cochlear Americas


Bonebridge

MEDEL

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# Comparing the two new devices

- Osia and Bonebridge perform comparable or better than BAHA via abutment (Pla-Gil et a., 2020; Huber et al., 2013)
- Very limited data to show performance differences in the two
- Schwam et al. (2022) published a clinical capsule report in *Otology & Neurotology* and compared implants
  - No statistically significant difference in outcomes
  - OSIA had higher rates of issues with audio quality and poor cosmesis
  - BB required special techniques

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# Non-surgical option: CROS HA

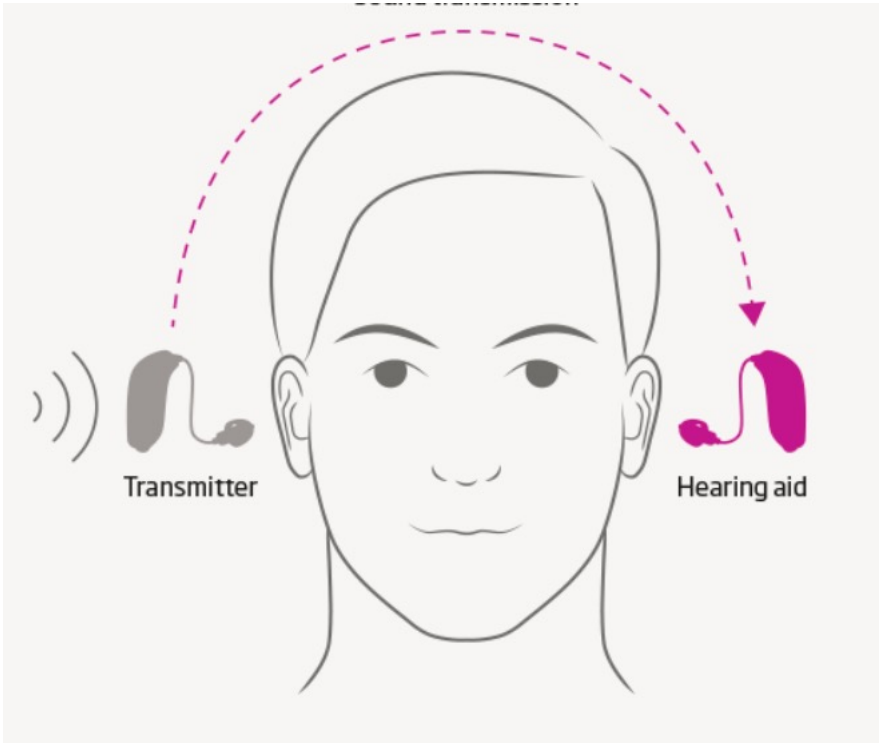


Photo courtesy of Oticon

| | MEDEL CI | MEDEL Bonebridge | Cochlear Americas - CI | Cochlear Americas - OSIA | Cochlear Baha (Attract & Connect) |
|---|---|---|---|---|---|
| **Thresholds: Better ear** | -Mild to mod severe SNHL<br>-PTA ≤ 55 dBHL (.5, 1, 2, 4 kHz)<br>-≥ 15 dB difference in PTA between ears | AC PTA ≥ **20** dBHL (0.5, 1, 2**, 3** kHz) | AC PTA ≥ **30** dBHL (0.5, 1, 2, **4** kHz) | AC PTA ≥ **20** dBHL (0.5, 1, 2**, 3** kHz) | AC PTA ≥ **20** dBHL (0.5, 1, 2**, 3** kHz) |
| **Thresholds: Worse ear** | PTA ≥ 90 dBHL (0.5, 1, 2, 4 kHz) | Profound SNHL | PTA > 80 dBHL (0.5, 1, 2, 4 kHz) | Profound hearing loss | Profound hearing loss |
| **Speech understanding** | Adult: Aided CNC ≤ 5%<br>Age 5-18: ≤ 5% on age appropriate monosyllabic word test | No criteria | Aided CNC or developmentally appropriate word test ≤ 5% | No criteria | No criteria |
| **Age** | 5 years and older | 12 years and older | 5 years and older | 12 years and older | 5 years and older |
| **CROS Trial** | At least 1 month trial with a CROS or other relevant device without subjective benefit | Recommend AC/BC device experience prior to surgery | Recommend at least 2-week trial with CROS or other suitable hearing device | Recommend AC/BC device experience prior to surgery | Recommend AC/BC device experience prior to surgery |
| **Other Details** |  | Also indicated for any patient who is a candidate for a CROS system but cannot/will not use a CROS | | Also indicated for any patient who is a candidate for a CROS system but cannot/will not use a CROS | Softband options for patients <5 years |

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# Objective measures preoperatively

- Performing booth testing with demo devices can provide realistic expectations and guide management recommendations
- Can adjust testing to patient needs
- Speech in noise testing

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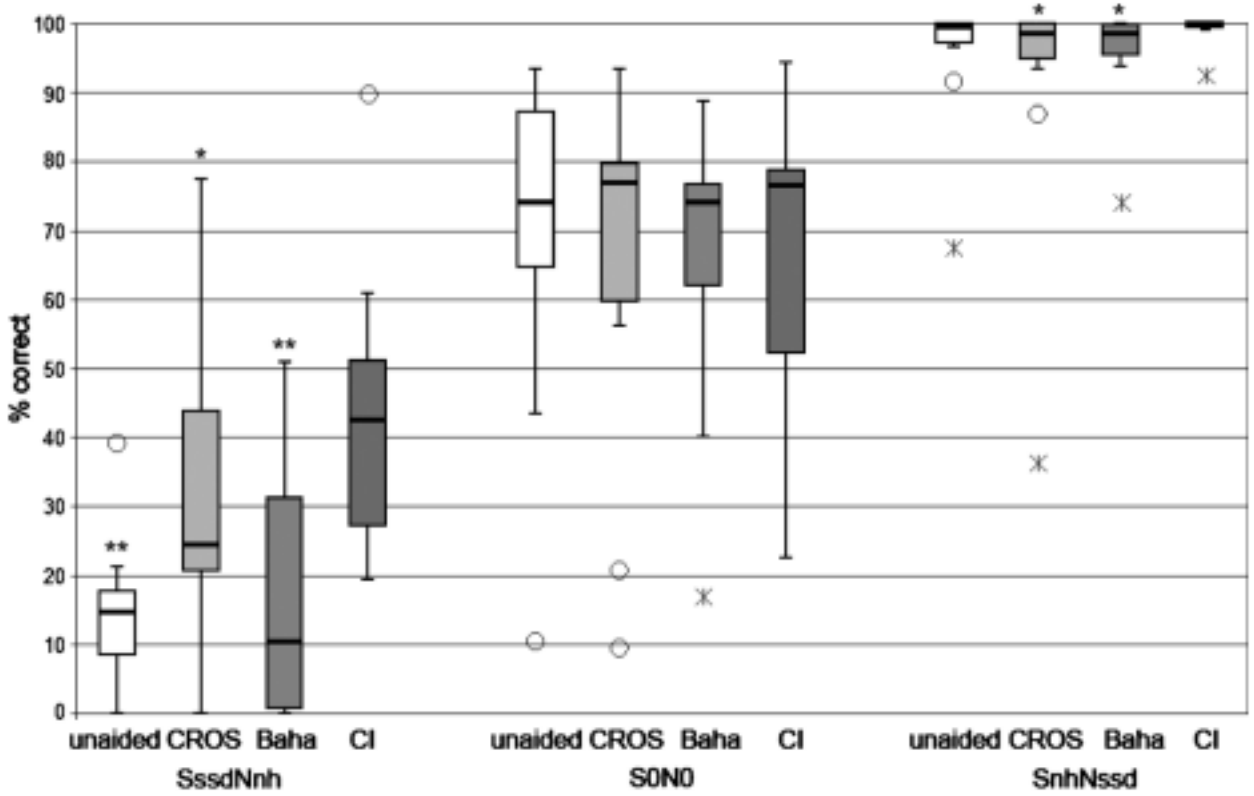
# Arndt et al. (2011)

- N=11, mean DoD 25 months
- Tested with unaided, CROS, Baha softband, and post-op CI




Noise = NH
Speech = HL

Noise & Signal
0 deg azimuth

Noise = HL
Speech = NH

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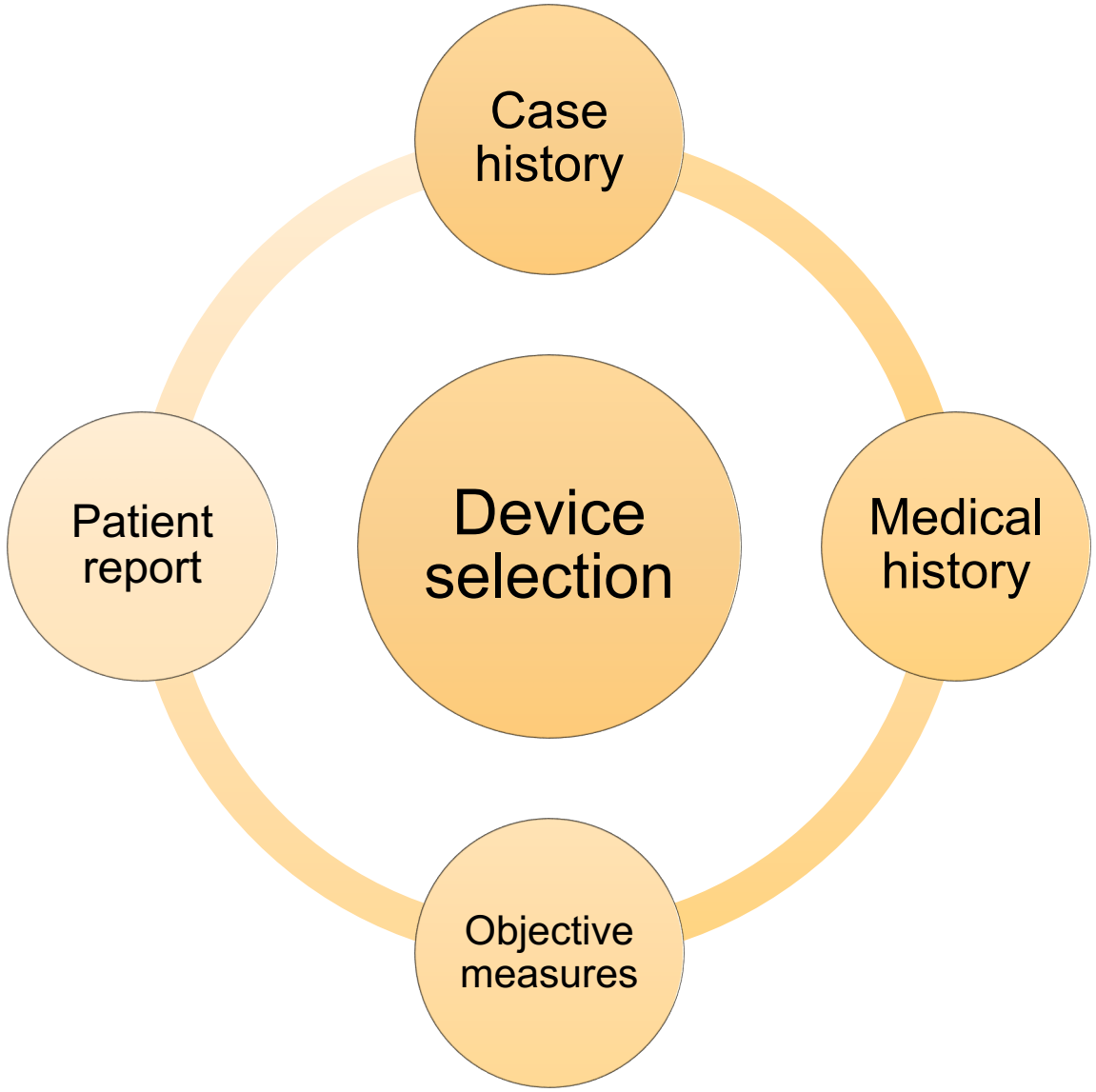
# How to decide?



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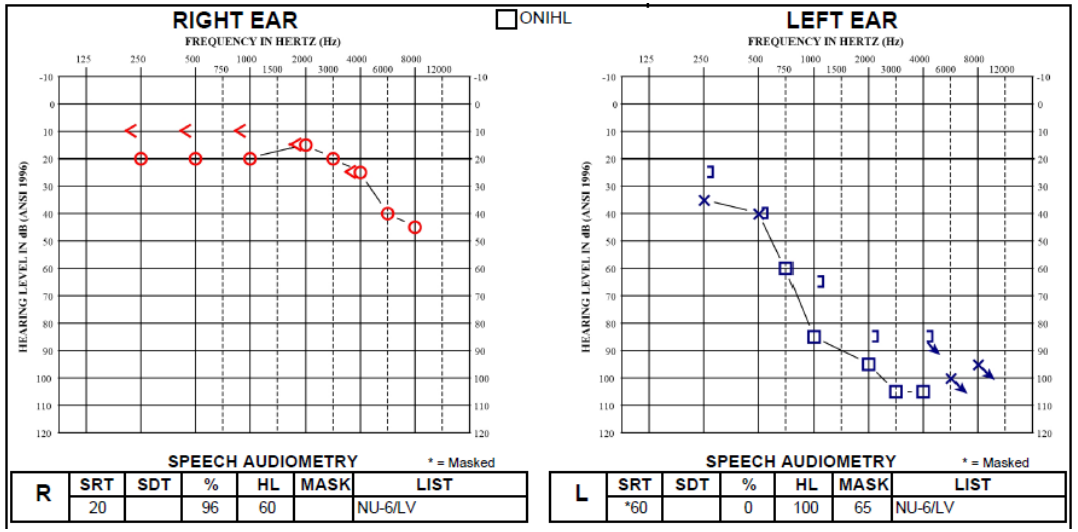
# Patient A

- 45 year old female
- Bilateral SSNHL in 2010, with recovery only in right ear
- Primary complaints:
  - Significant tinnitus perception (THI = 66)
  - Work environment (SSQ = 1.4)




| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | 20 | | 96 | 60 | | NU-6/LV |
| L | *60 | | 0 | 100 | 65 | NU-6/LV |

| | CNC, Quiet *Signal⁰* | QuickSIN *Signal⁰, Noise⁰* | *AzBio -Quiet* |
|---|---|---|---|
| *Everyday listening condition: unaided* | DNT | 2.5 dB SNR Loss | DNT |
| *Left Aided (Right plugged/muffed)* | 0/25 = 0% | 19.5 dB SNR Loss | 17/154 = 11% |
| *BP6: Left (Right plugged/muffed)* | 17/25 = 68% (likely cross hearing)* | 7.5 dB SNR Loss | DNT |
| *CROS Left* | DNT | 1.5 dB SNR Loss | DNT |

*masking could not be performed due to equipment limitations.

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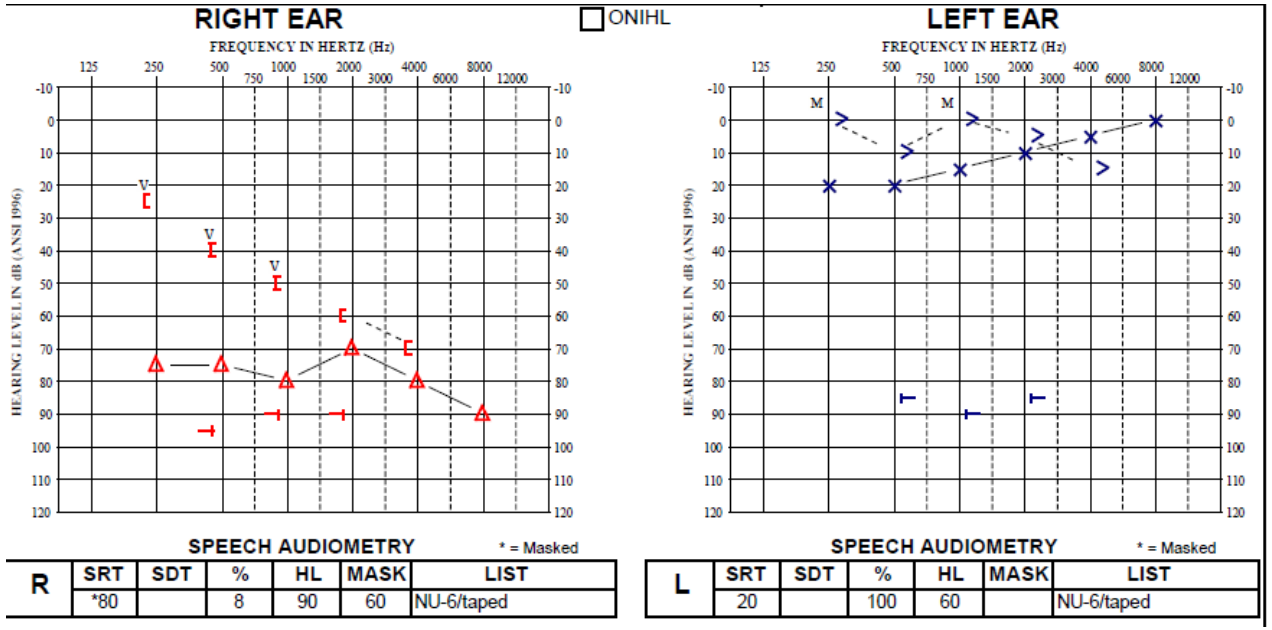
# Patient B

- 43 yo female
- Right SSD from birth, imaging reveals EVA diagnosis
- Previously tried traditional hearing aid without benefit
- Everyday hearing difficulties
  - 1. In the car
  - 2. Localization
  - 3. Noisy environments




SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | *80 | | 8 | 90 | 60 | NU-6/taped |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | 20 | | 100 | 60 | | NU-6/taped |

| | QuickSIN *Signal$^0$, Noise$^0$* |
|---|---|
| *Everyday listening condition: no amplification* | 0.5 dB SNR Loss |
| *Baha 6: Right (Left plugged/muffed)* | 0.5 dB SNR Loss |
| *CROS Right* | -0.5 dB SNR Loss |

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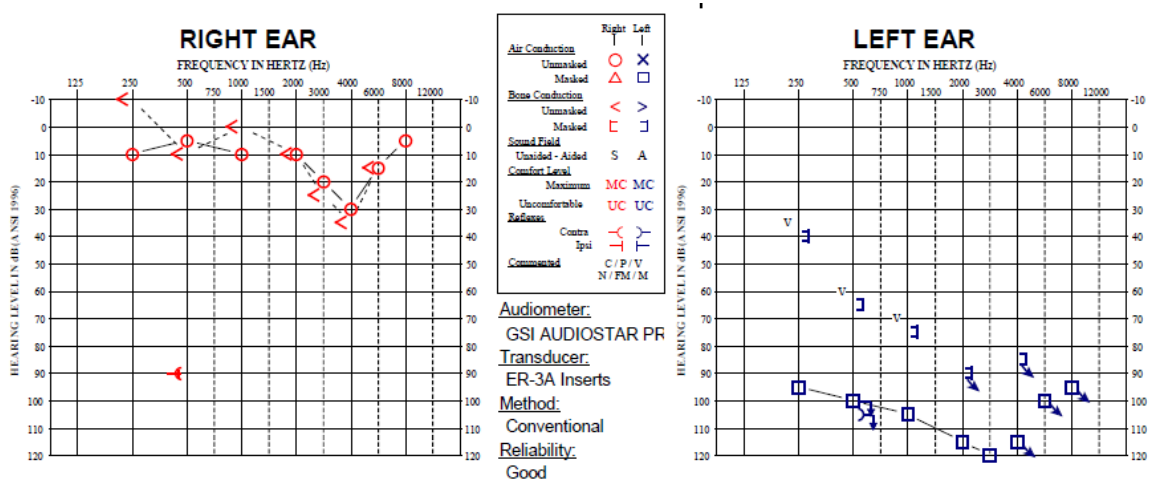
# Patient C

- 56 yo male
- Congenital left HL
- Primary complaints:
  - Sound awareness
  - Conversations with wife
- Denies tinnitus, localization difficulties




SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| R | 20 | | 100 | 60 | REC | NU-6 LIST 2A |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| L | NR | *90 | | CNT | taped | NU-6 |

| | CNC, Quiet *Signal*$^0$ | QuickSIN *Signal*$^0$, *Noise*$^0$ |
|---|---|---|
| *Everyday listening condition: no amplification* | DNT | 3.5 dB SNR Loss |
| *BP6: Left* | 24/25 = 96% | 1.5 dB SNR Loss |
| *CROS Left* | DNT | 2.5 dB SNR Loss |

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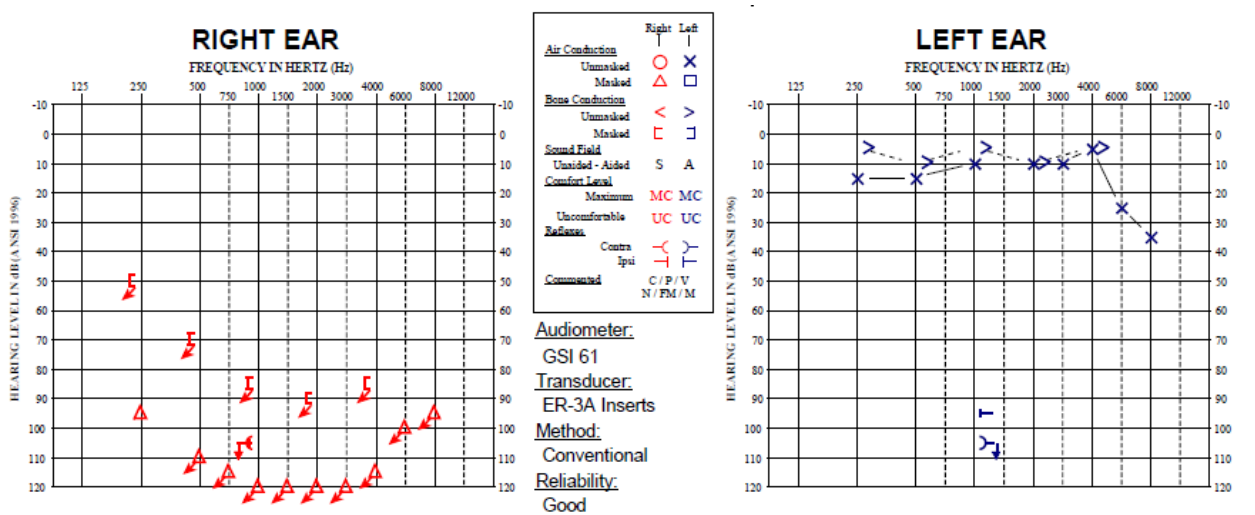
# Device?

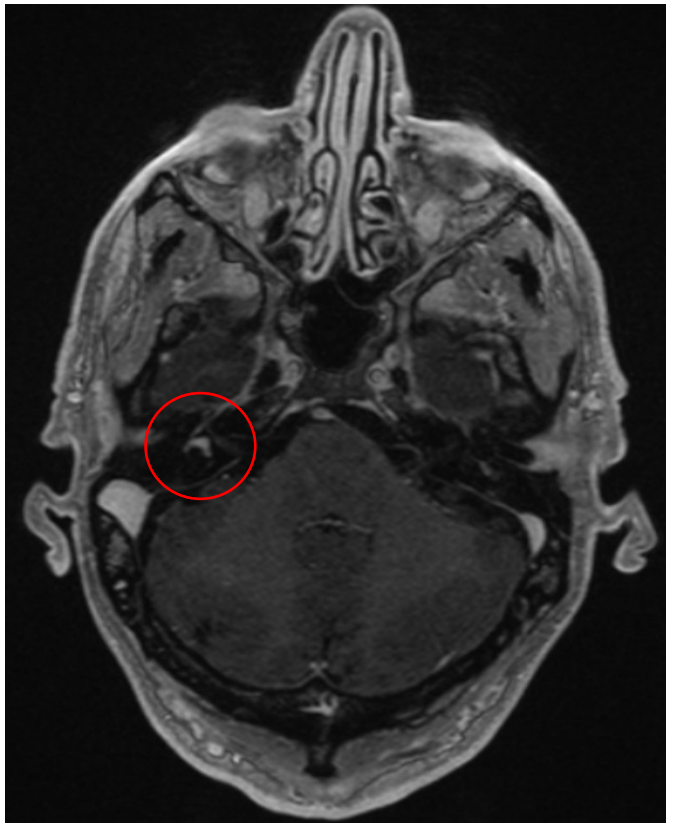



**SPEECH AUDIOMETRY** * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | | *95 | | CNT | taped | NU-6 |

**SPEECH AUDIOMETRY** * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 10 | | 100 | 70 | taped | NU-6 |



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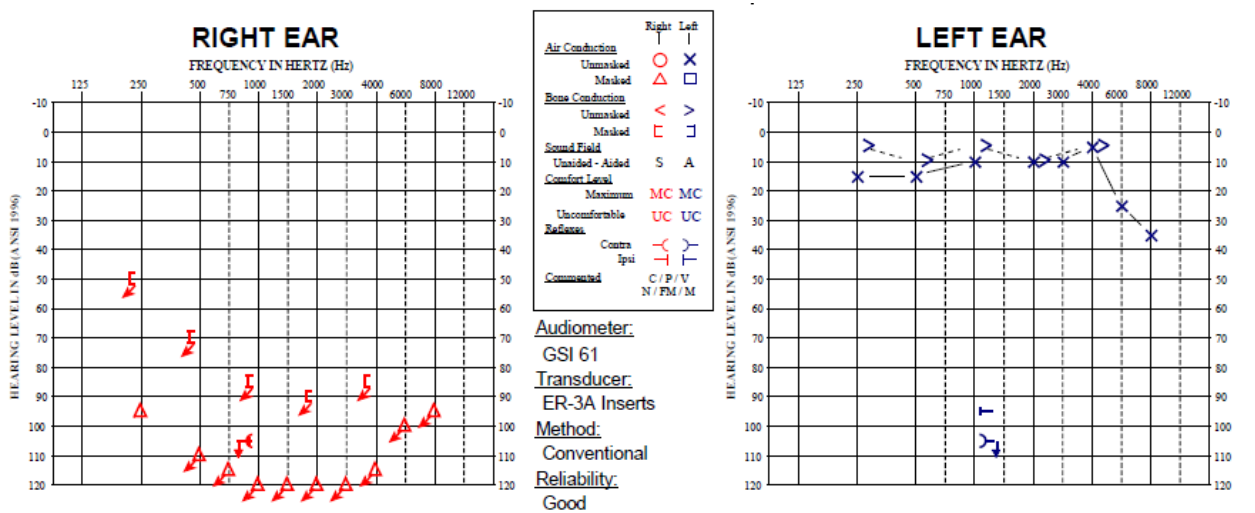
# Right cochlear implant/labyrinthectomy

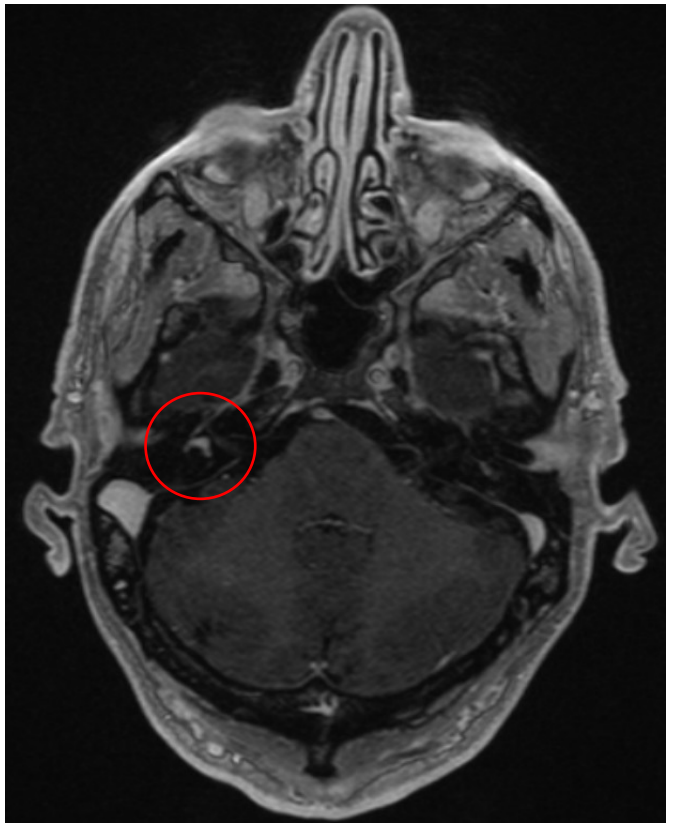



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | | *95 | | CNT | taped | NU-6 |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 10 | | 100 | 70 | taped | NU-6 |



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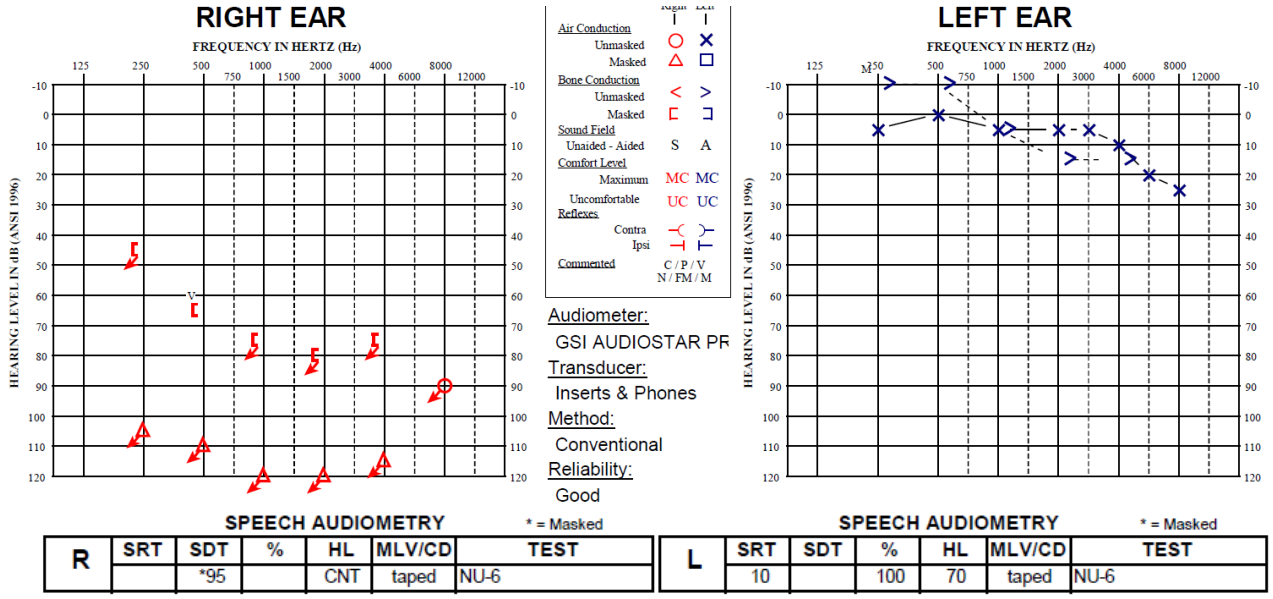
# Device?

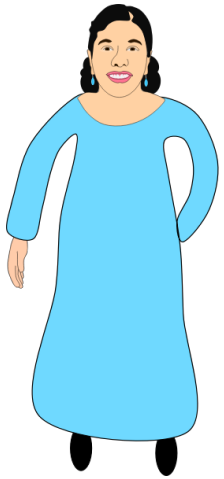



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | | *95 | | CNT | taped | NU-6 |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 10 | | 100 | 70 | taped | NU-6 |



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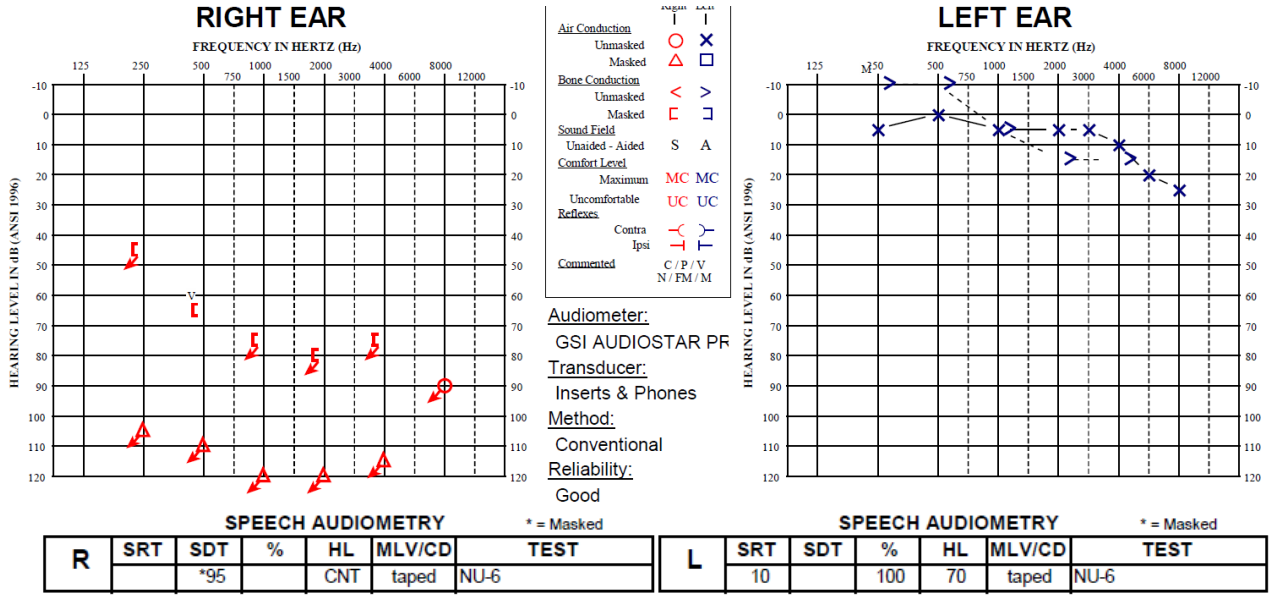
# Right BCD (percutaneous vs active transcutaneous)

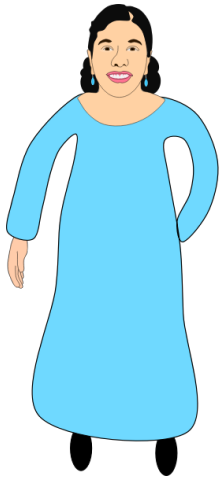



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | | *95 | | CNT | taped | NU-6 |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 10 | | 100 | 70 | taped | NU-6 |



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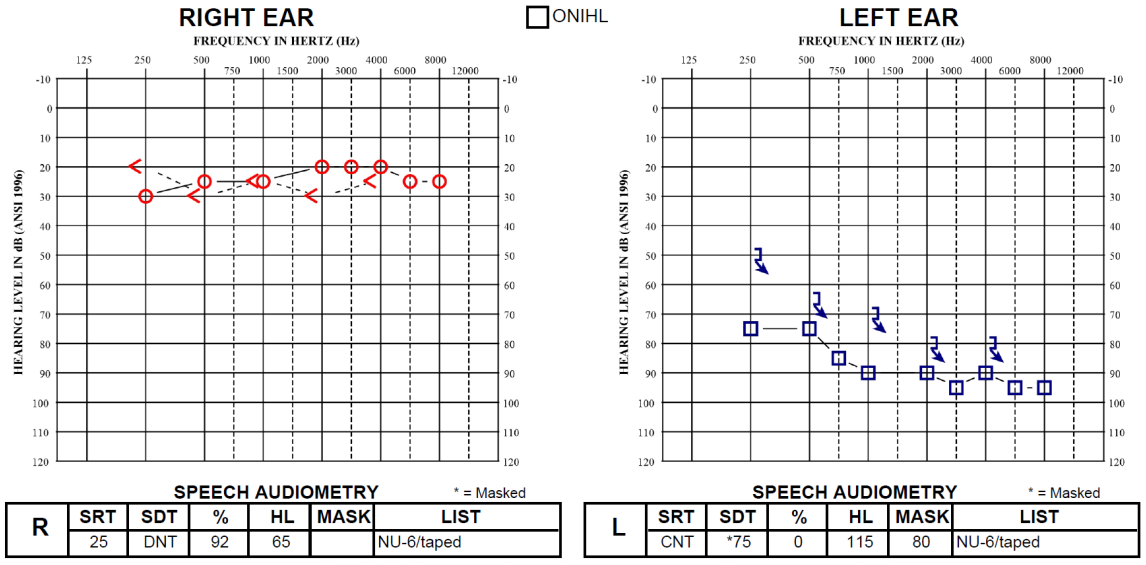
# Device?

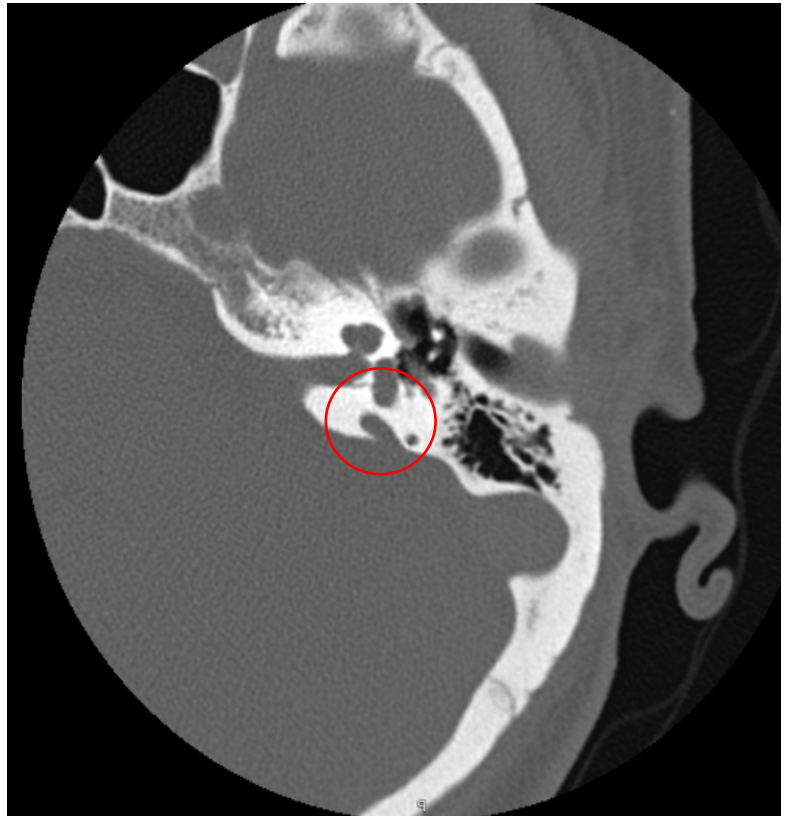



SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | 25 | DNT | 92 | 65 | | NU-6/taped |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | CNT | *75 | 0 | 115 | 80 | NU-6/taped |



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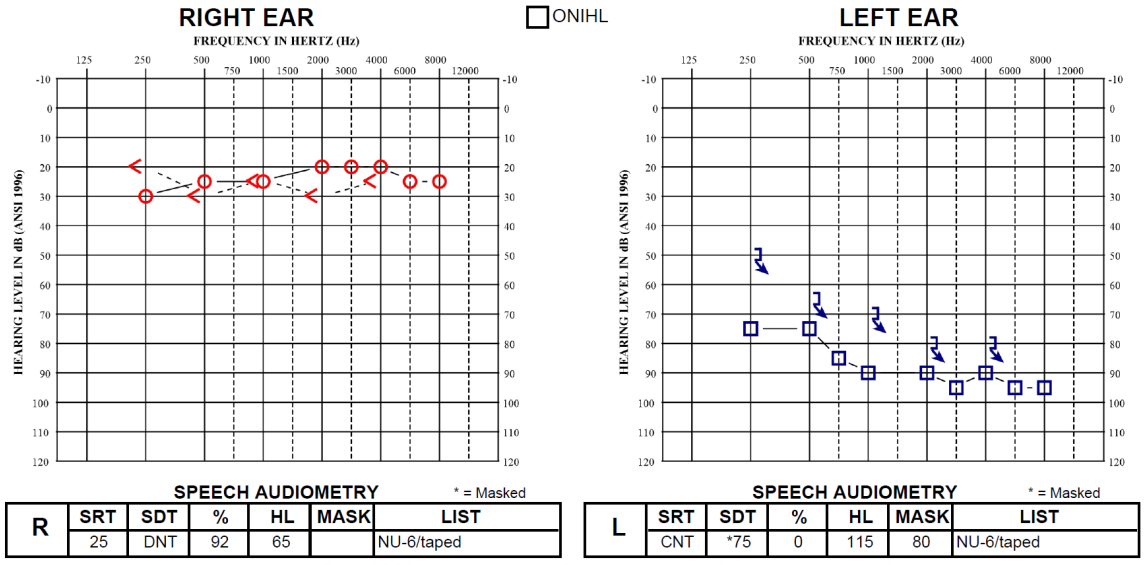
# Left cochlear implant



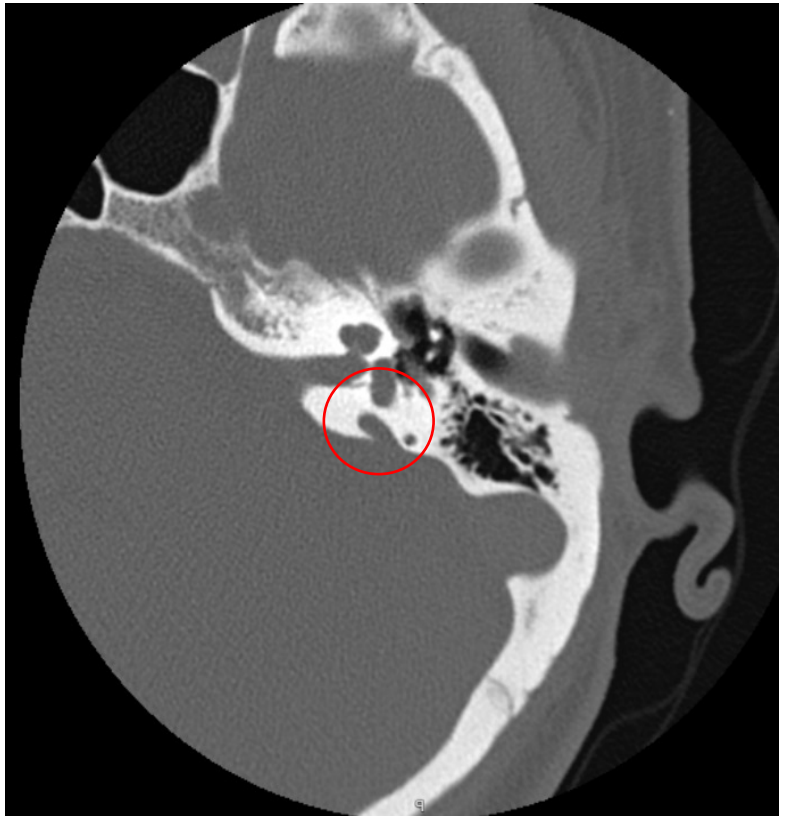

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | 25 | DNT | 92 | 65 | | NU-6/taped |




SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | CNT | *75 | 0 | 115 | 80 | NU-6/taped |



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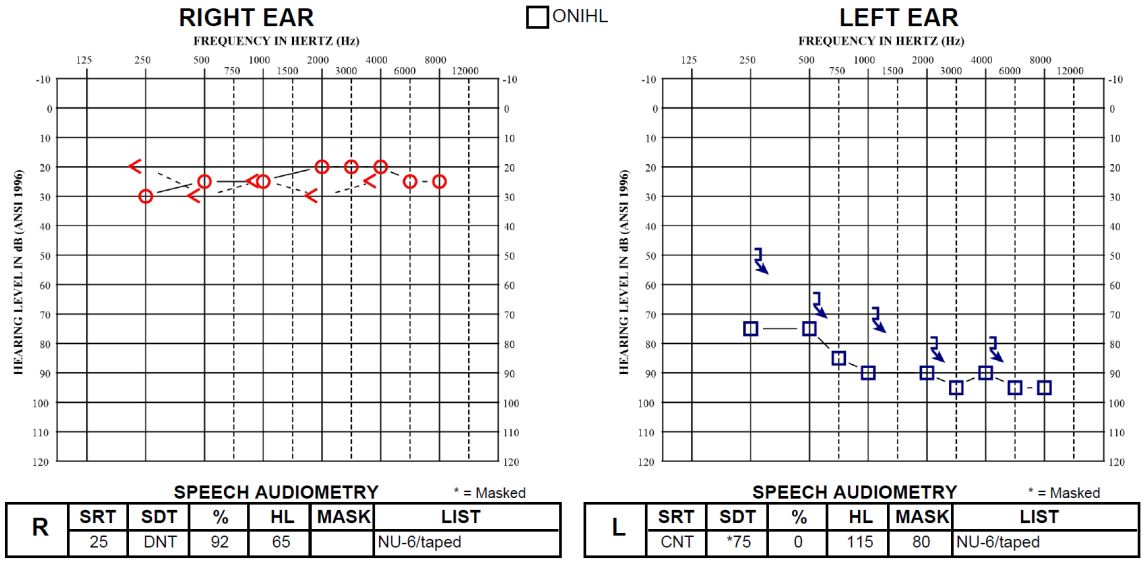
# Device?

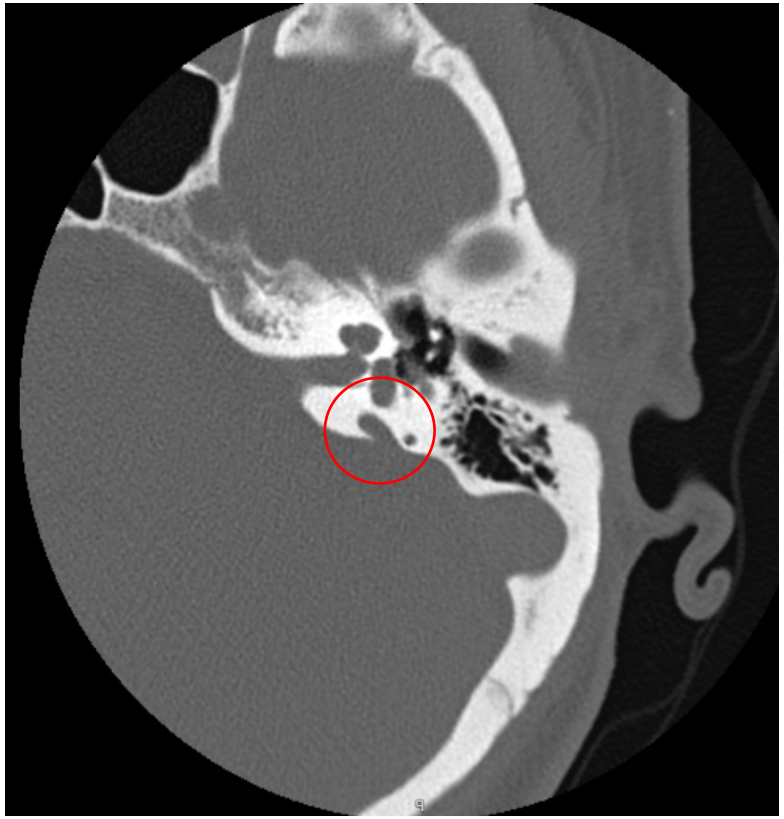



SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | 25 | DNT | 92 | 65 | | NU-6/taped |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | CNT | *75 | 0 | 115 | 80 | NU-6/taped |



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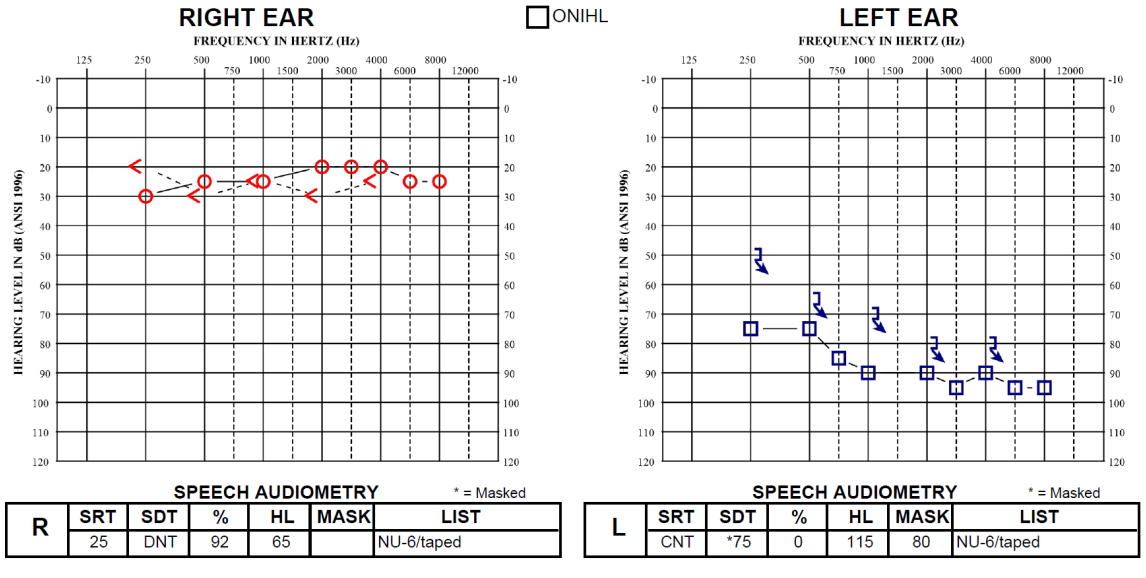
# Left BCD (active transcutaneous)

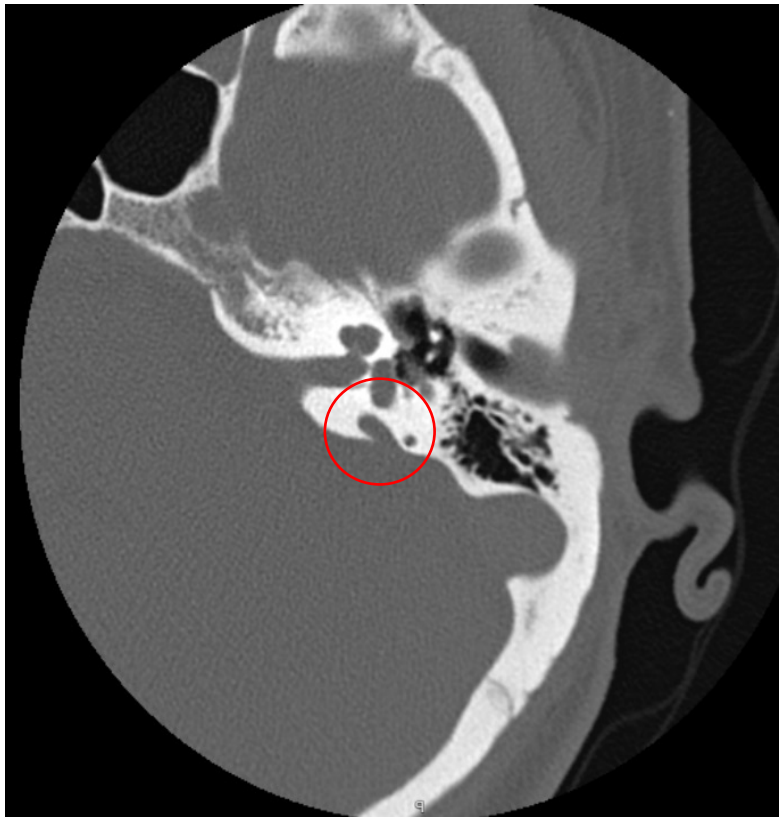



SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| R | 25 | DNT | 92 | 65 | | NU-6/taped |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MASK | LIST |
|---|---|---|---|---|---|---|
| L | CNT | *75 | 0 | 115 | 80 | NU-6/taped |



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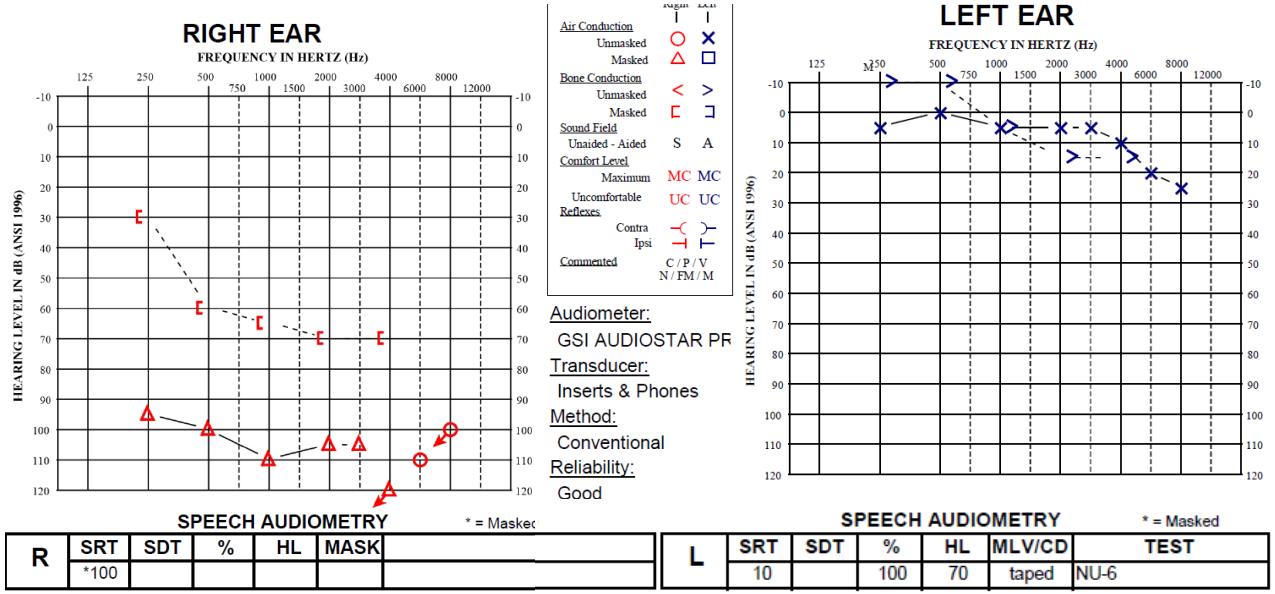
# Device?

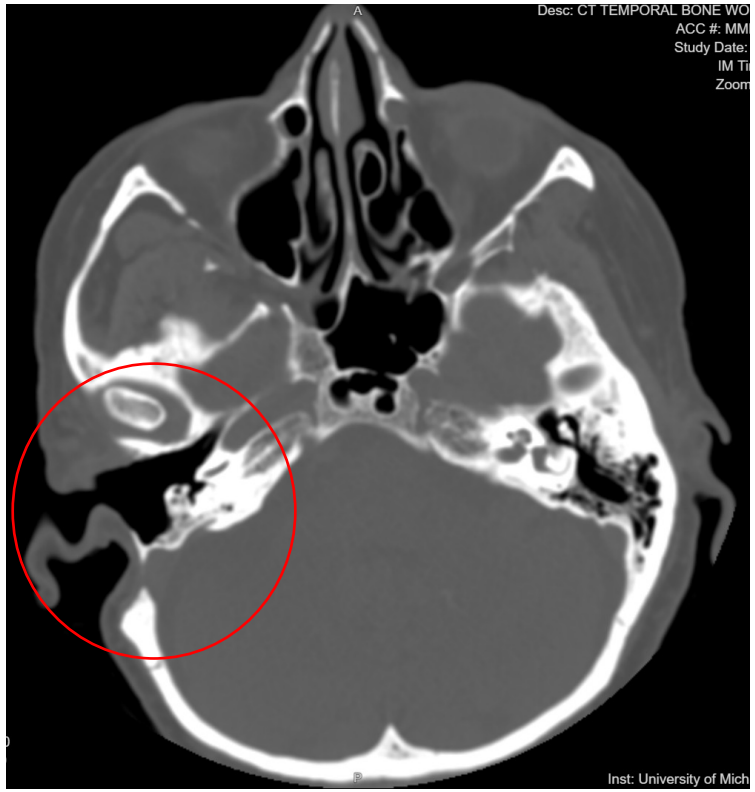



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MASK | |
|---|---|---|---|---|---|---|
| | *100 | | | | | |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 10 | | 100 | 70 | taped | NU-6 |



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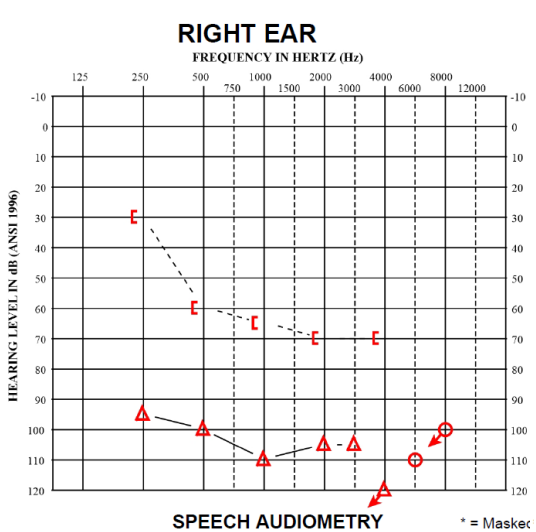
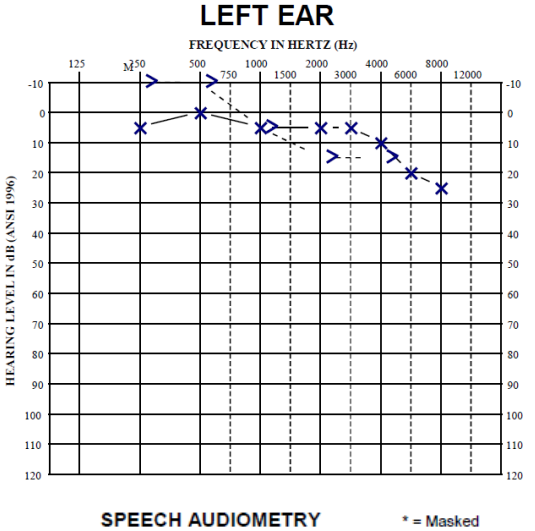
# Right BCD (active transcutaneous)




| | Right | Left |
|---|---|---|
| Air Conduction | | |
| Unmasked | O | X |
| Masked | △ | □ |
| Bone Conduction | | |
| Unmasked | < | > |
| Masked | [ | ] |
| Sound Field | | |
| Unaided - Aided | S | A |
| Comfort Level | | |
| Maximum | MC | MC |
| Uncomfortable | UC | UC |
| Reflexes | | |
| Contra | | |
| Ipsi | | |
| Commented | C / P / V N / FM / M | |

Audiometer:
GSI AUDIOSTAR PR
Transducer:
Inserts & Phones
Method:
Conventional
Reliability:
Good

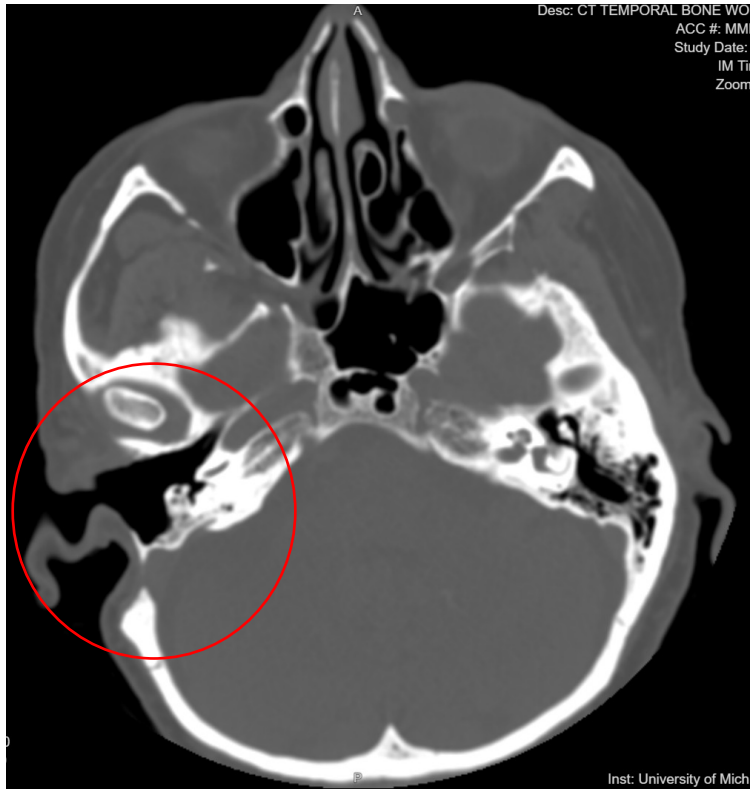



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MASK | |
|---|---|---|---|---|---|---|
| | *100 | | | | | |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 10 | | 100 | 70 | taped | NU-6 |



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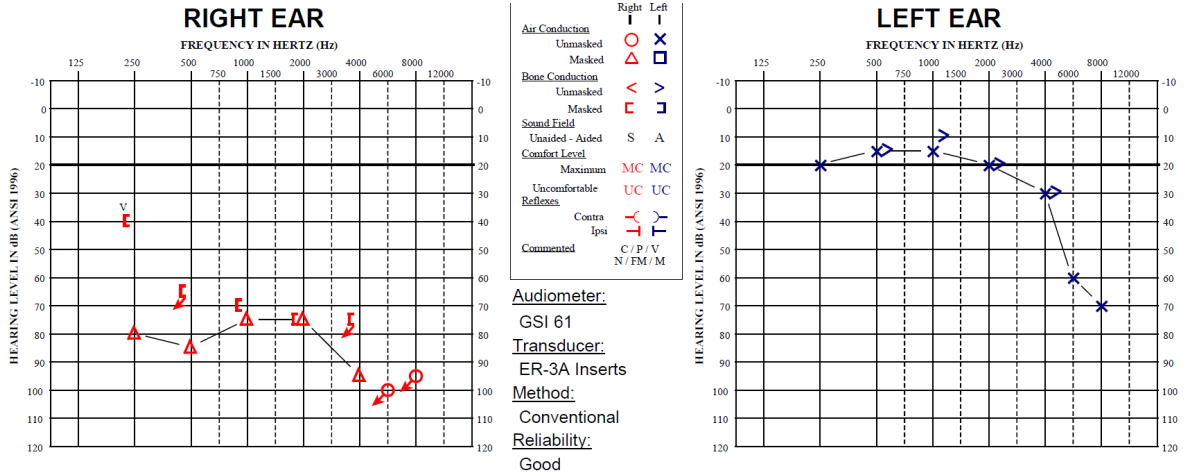
# Device?



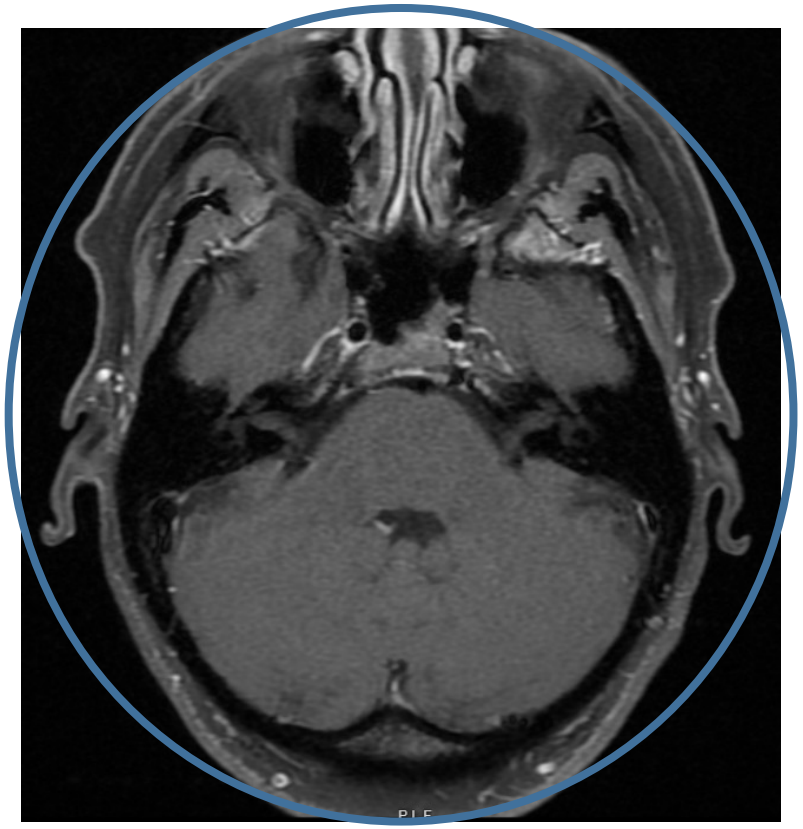

Audiometer:
GSI 61
Transducer:
ER-3A Inserts
Method:
Conventional
Reliability:
Good

**SPEECH AUDIOMETRY** * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | | *65 | 0 | * 105 | LV | List 1 |

**SPEECH AUDIOMETRY** * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 15 | | 96 | 60 | LV | List 1 |



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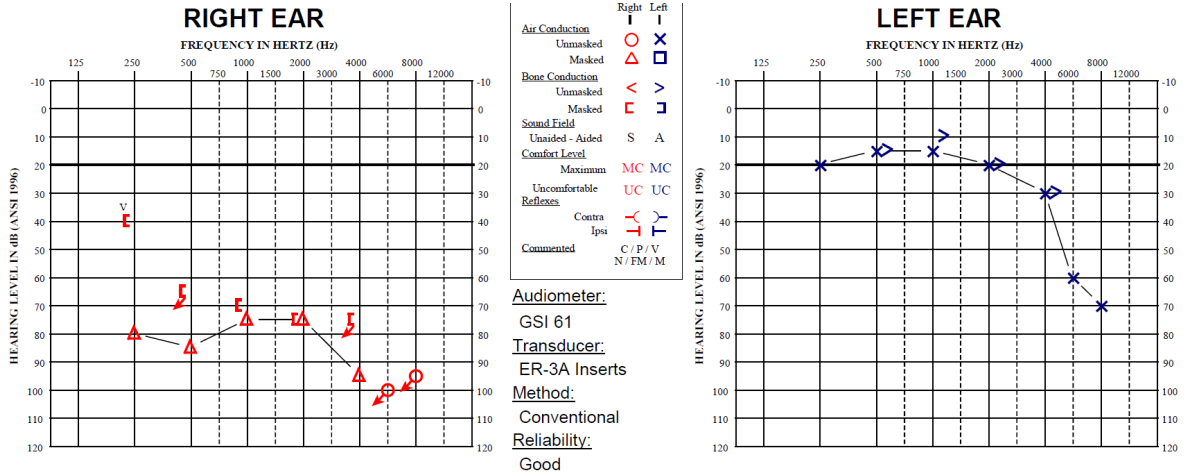
# Right cochlear implant (vs BCD)



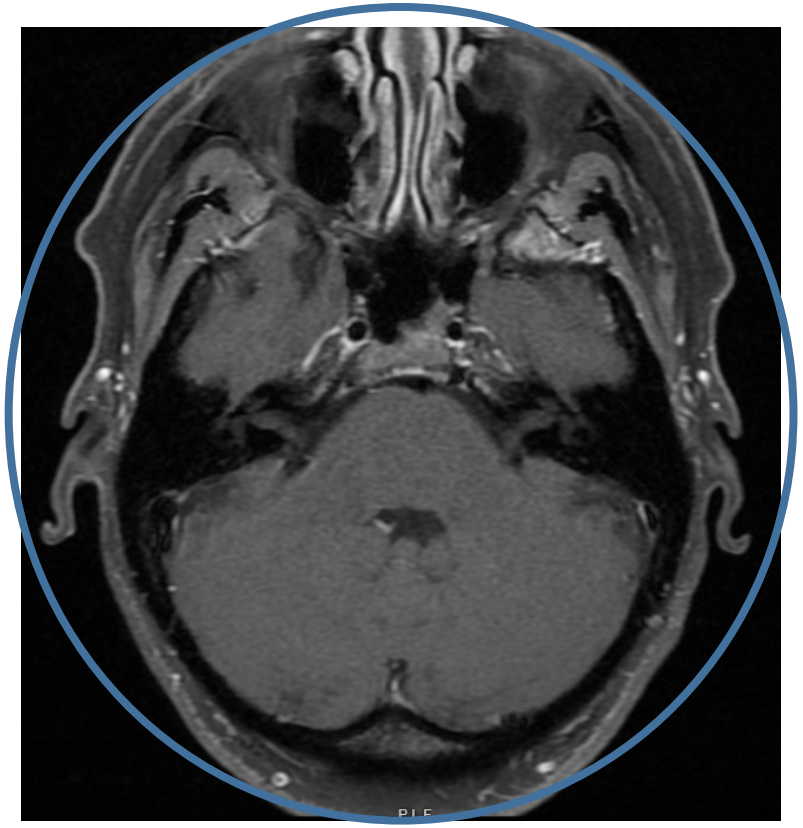

Audiometer:
GSI 61
Transducer:
ER-3A Inserts
Method:
Conventional
Reliability:
Good

SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | | *65 | 0 | * 105 | LV | List 1 |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 15 | | 96 | 60 | LV | List 1 |



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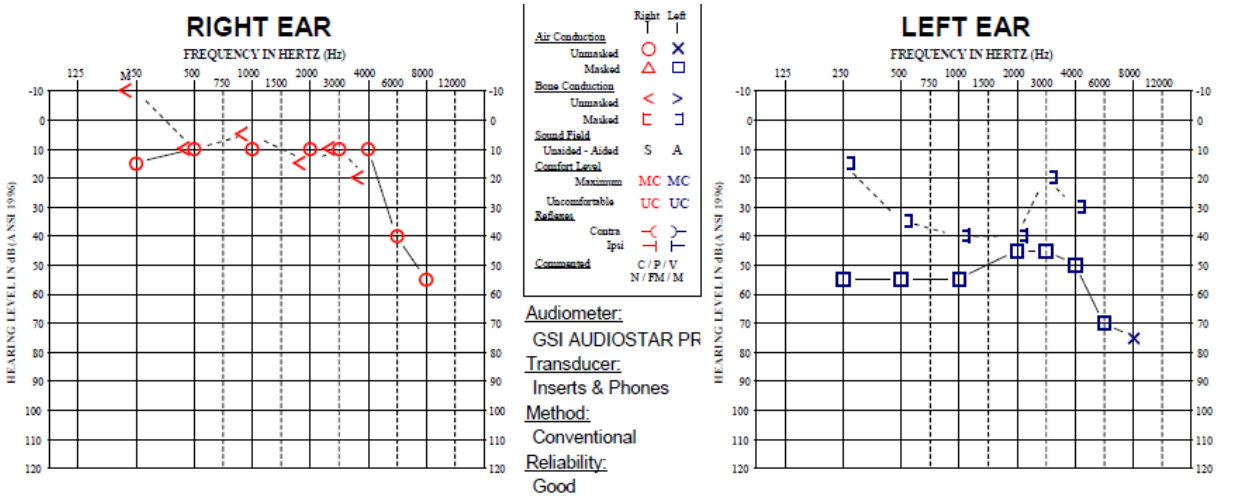
# Device?

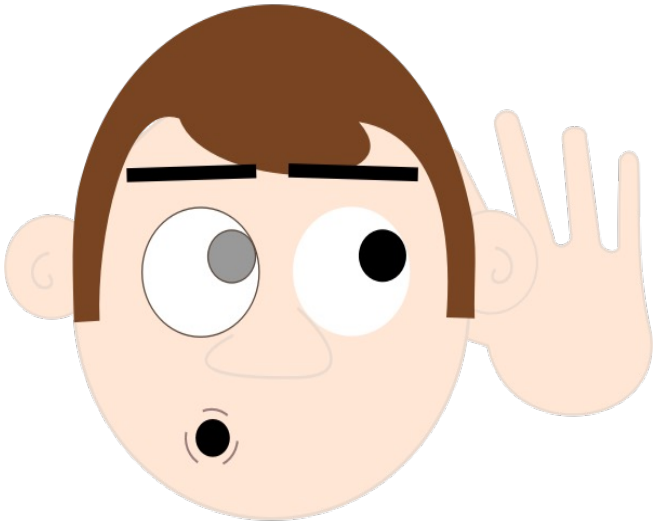



SPEECH AUDIOMETRY * = Masked

| R | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | 15 | | 100 | * 55 | REC | NU-6 LIST 2A |

SPEECH AUDIOMETRY * = Masked

| L | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| | *55 | | 100 | * 90 | REC | NU-6 LIST 3A |



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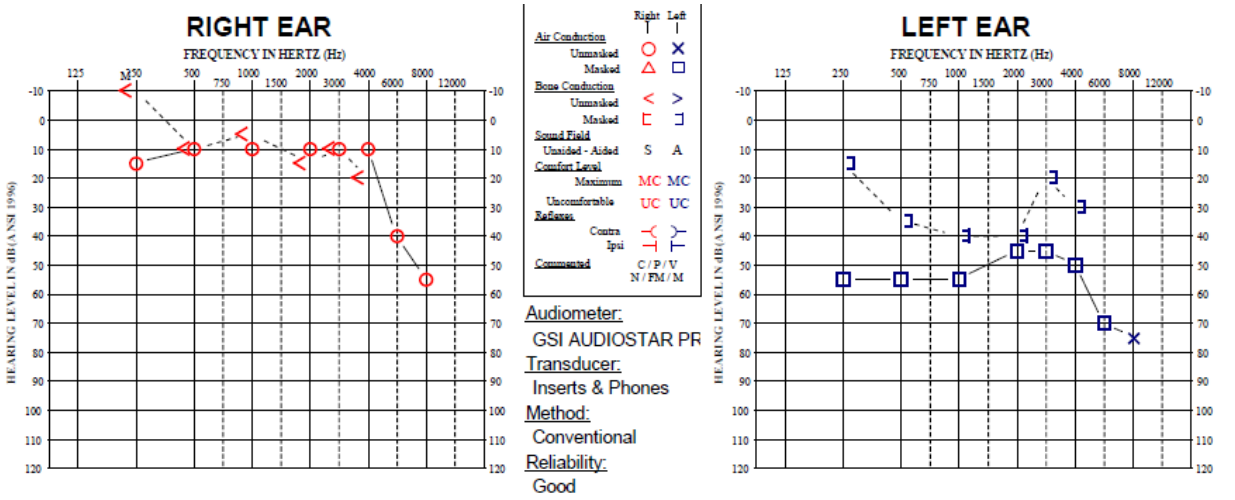
# Conventional air conduction hearing aid

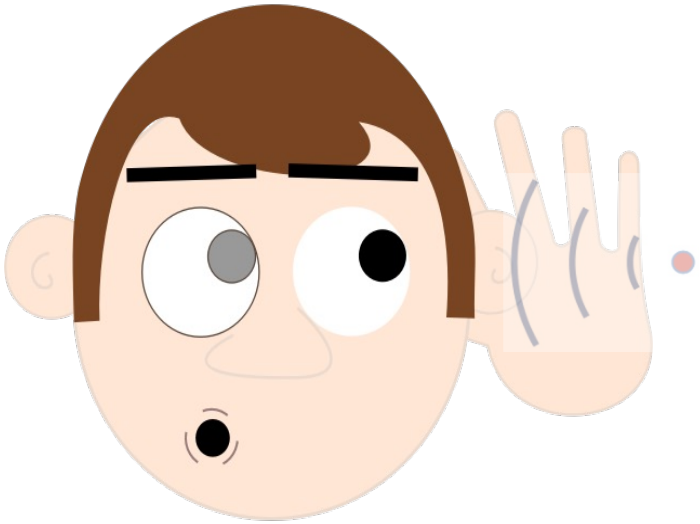



SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| R | 15 | | 100 | * 55 | REC | NU-6 LIST 2A |

SPEECH AUDIOMETRY * = Masked

| | SRT | SDT | % | HL | MLV/CD | TEST |
|---|---|---|---|---|---|---|
| L | *55 | | 100 | * 90 | REC | NU-6 LIST 3A |



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# Thank you!

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