

Hearing Technology 101: Hearing Aids, Implants, and Remote Microphone Systems

EHDI Conference

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Financial Disclosures

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No honorarium is being accepted for this presentation.

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No honorarium is being accepted for this presentation.

Agenda and Learning Objectives

Agenda

- Auditory Anatomy 101
- Hearing Differences Overview
 - Types and Degrees
- Hearing Devices 101
- Device Candidacy
- Questions

Learning Objectives

- Identify key structures involved in hearing.
- Describe differences between hearing aids and cochlear implants.
- Understand device candidacy for children with hearing differences.
- Explain the purpose of remote microphone systems and real-world applications.

The Auditory System: Key Structures (Periphery)

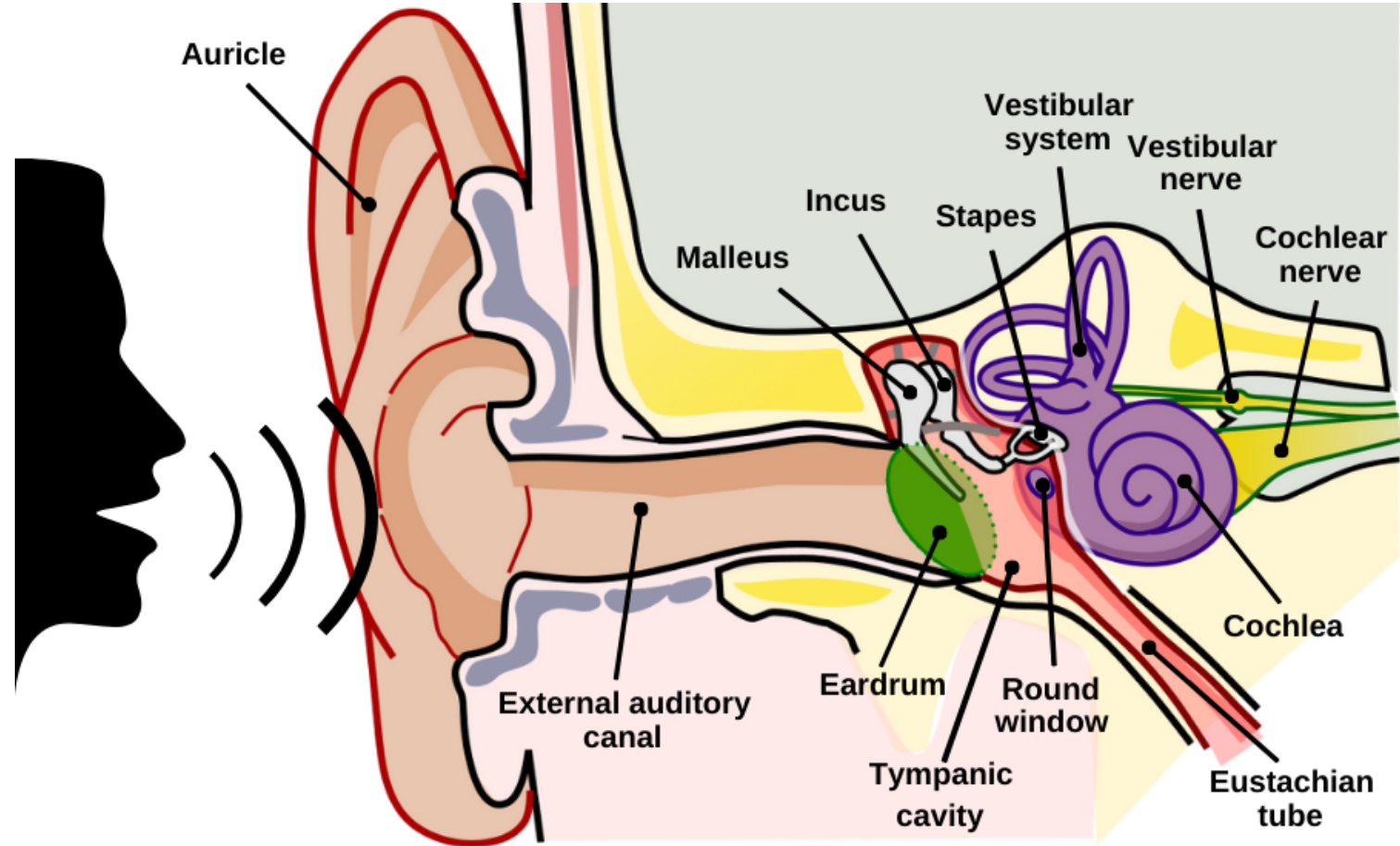


Photo Credit: <https://speechneurolab.ca/en/the-peripheral-auditory-system/>

Hearing Differences: Conductive vs. Sensorineural

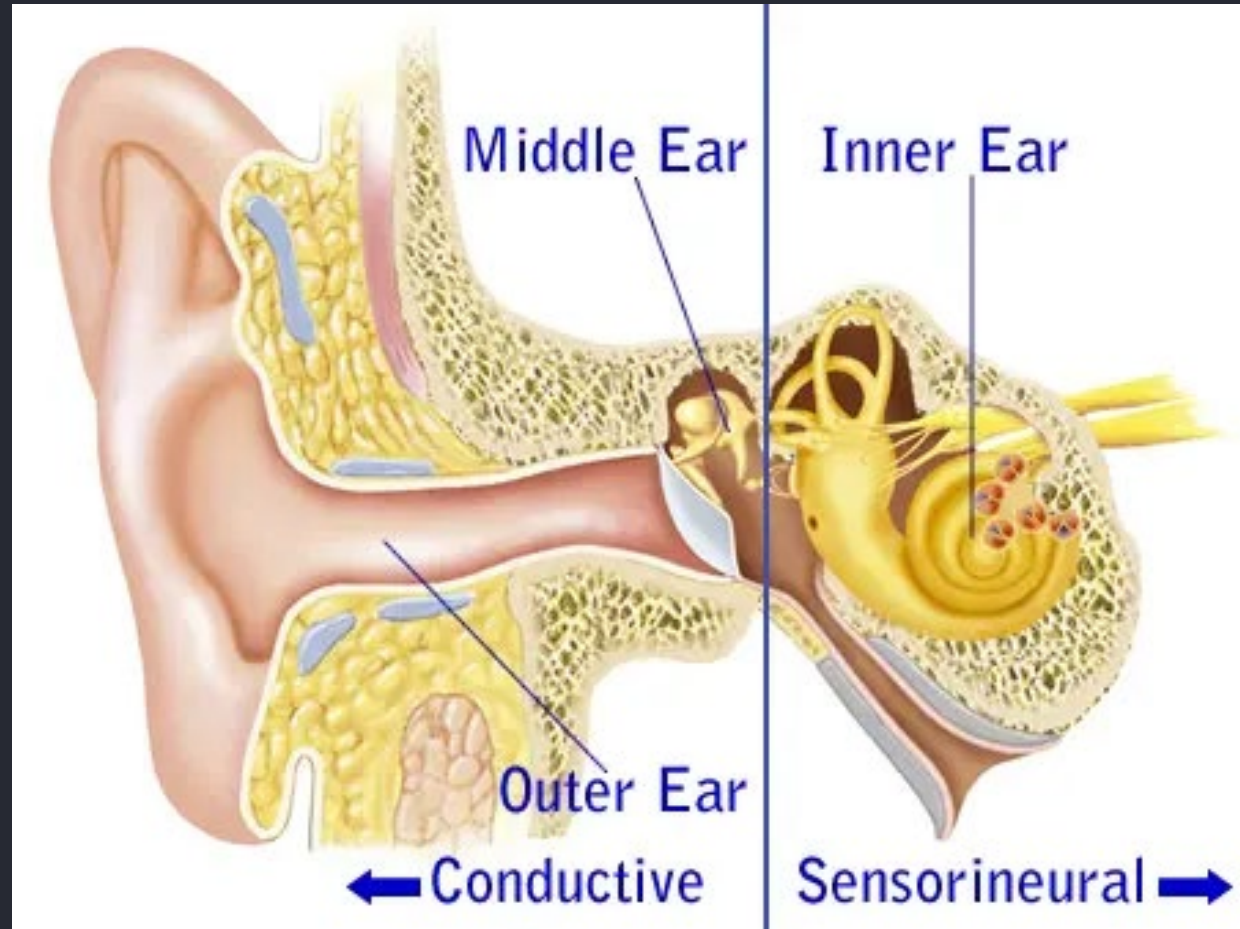
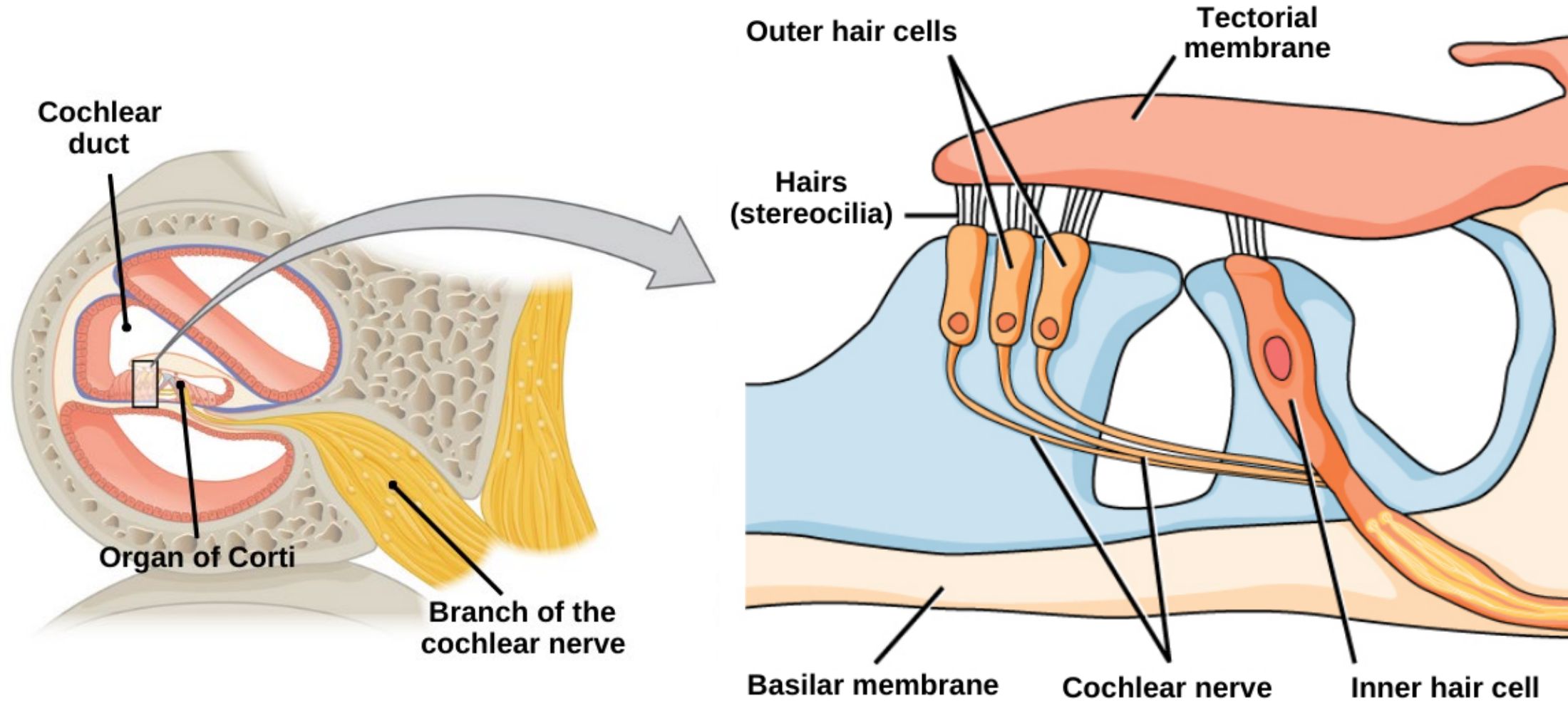


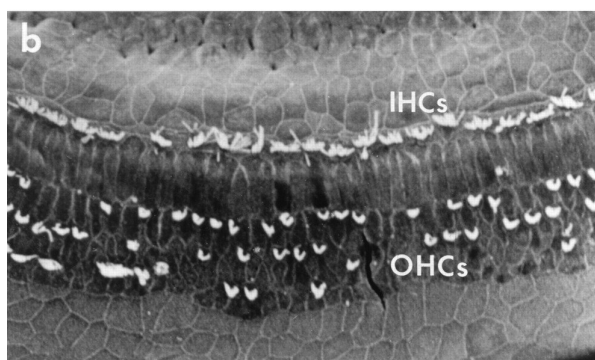
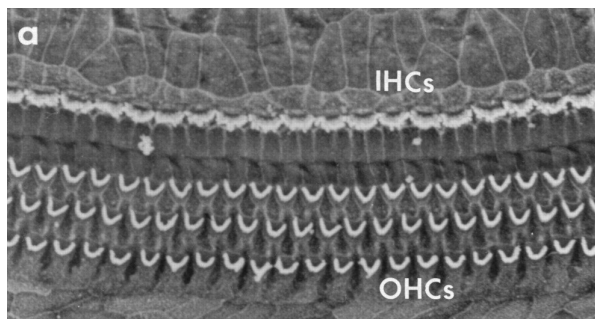
Photo Credit: <https://www.dallasear.com/education/hearing-loss/general-hearing-loss-information/types-of-hearing-loss/>

The Auditory System: Key Structures (Cochlea, Hair Cells)

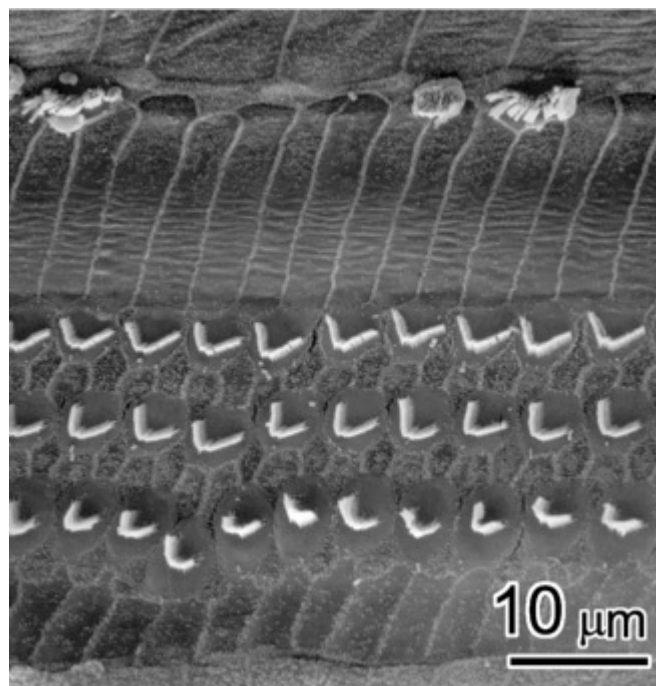


Hearing Differences: Outer vs. Inner Hair Cells

- Outer Hair Cells: Move in response to low-level sound; Mild-Moderate SNHL
- Inner Hair Cells: Transmit sound information to the brain; critical for clarity and speech understanding; Severe-to-profound SNHL



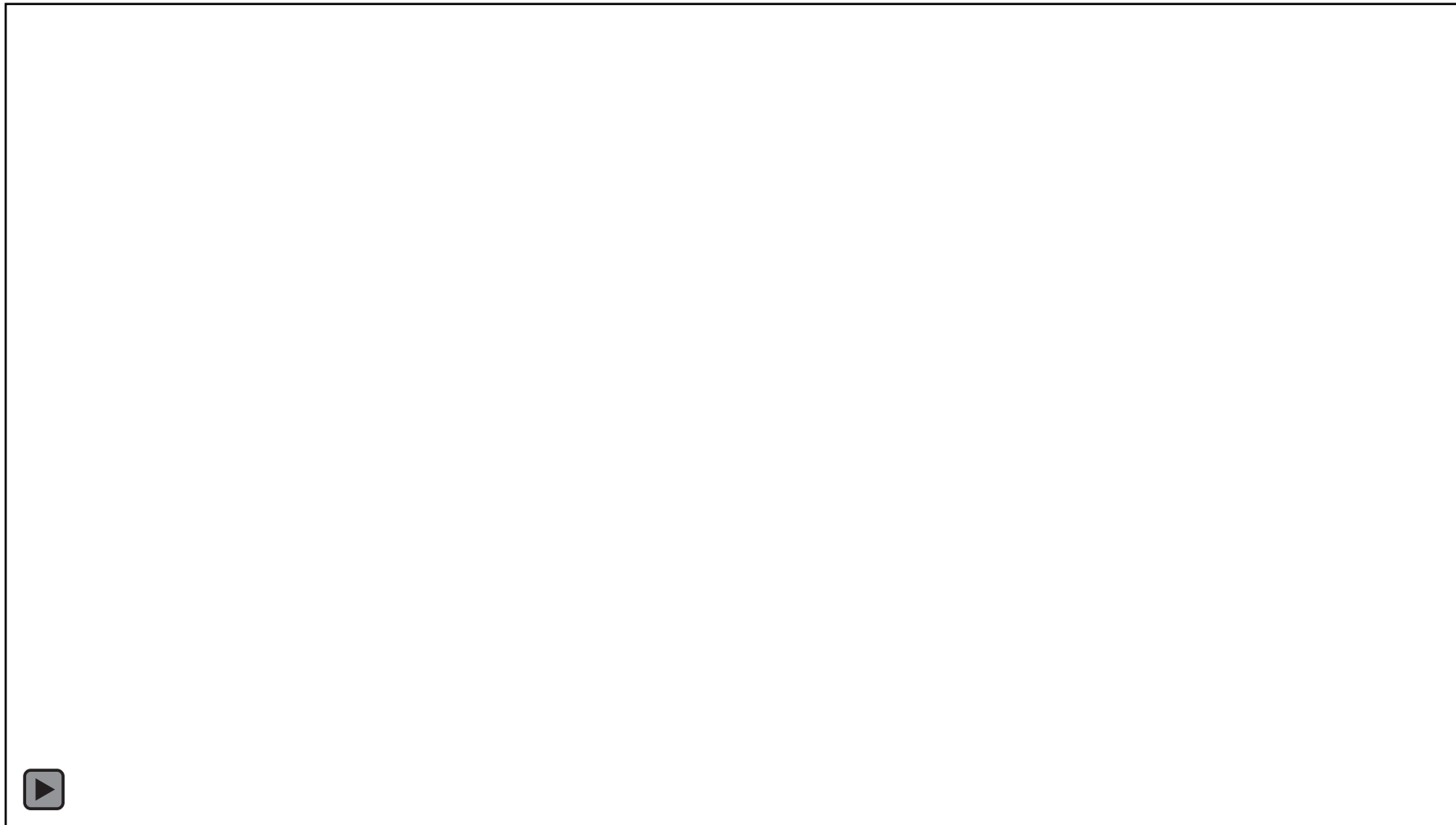
<https://www.pnas.org/doi/10.1073/pnas.97.13.6939>



<https://lab.research.sickkids.ca/harrison/background/hearing-loss/>



Video: Journey of Sound”



Hearing Aids: How They Work

- Amplify sound with the goal of restoring audibility for soft, average, and loud sounds while avoiding discomfort.
- Mostly for mild-to-moderately-severe hearing loss. Less effective for severe to profound HL.



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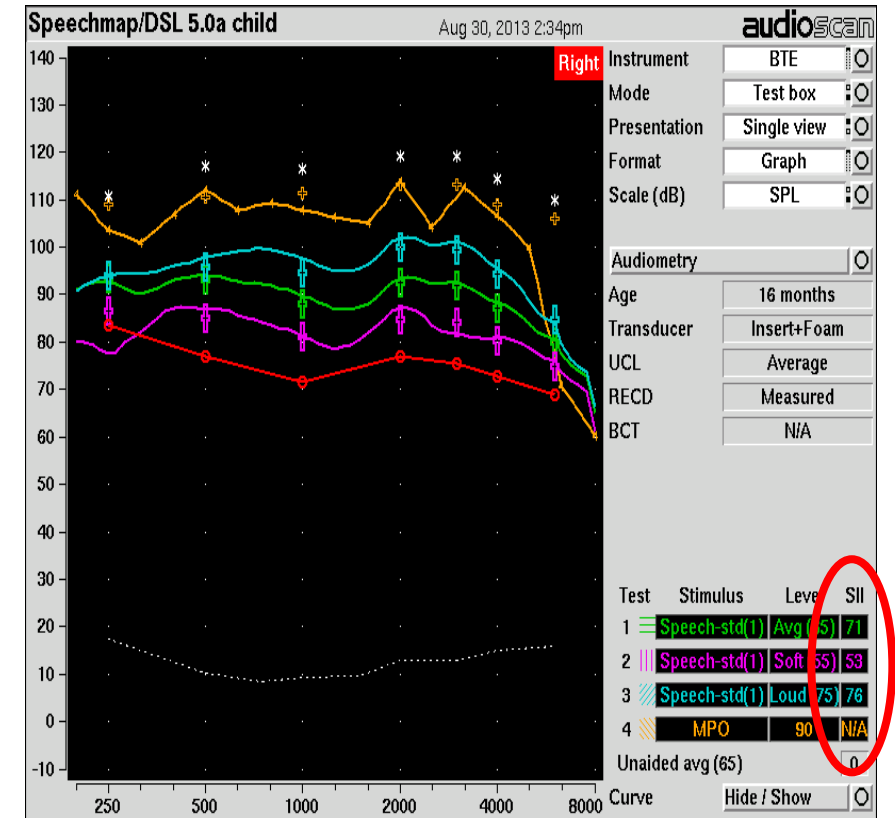
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Speech Intelligibility Index

- Estimate of the **proportion of speech that is audible to a listener**
- McCreery et al. (2013) suggests limited outcomes for children with **SII below 65**
- SII takes into account distortion that may occur when listening at high levels, but does not consider frequency lowering



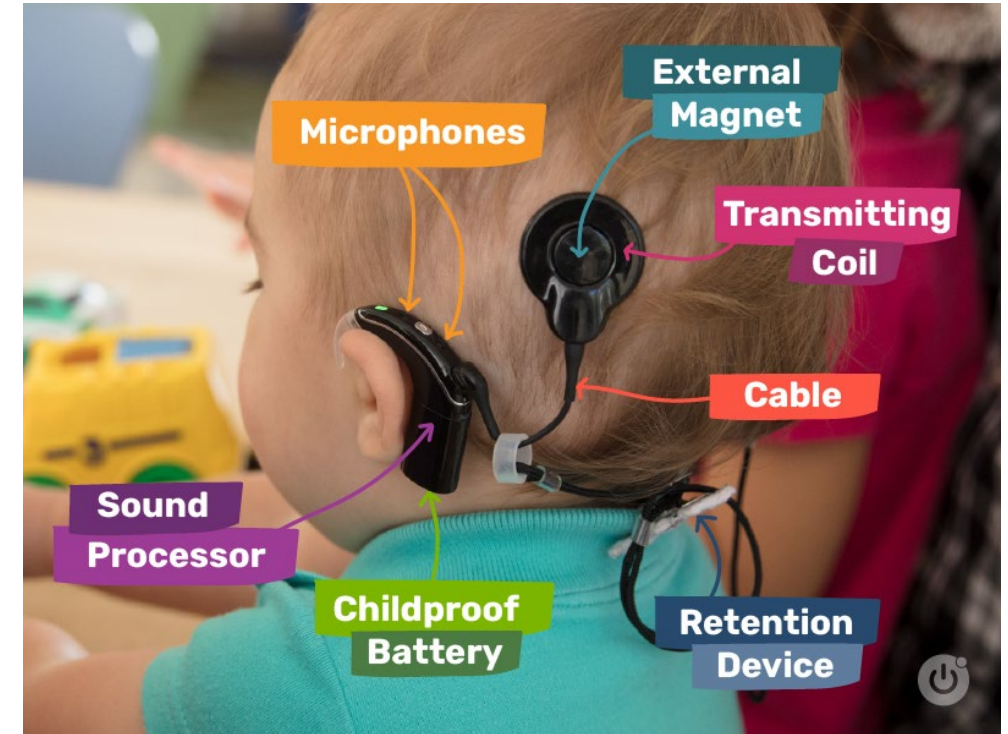
Cochlear Implants: How They Work

- Bypass damaged hair cells and stimulate auditory nerve directly.
- Suitable for severe and profound hearing loss.
- Components: External processor, internal electrode array.



Hearing Aid vs. Cochlear Implant: Key Differences

Hearing Aid: Amplifies acoustic sound energy, delivered via the ear canal.



Cochlear Implant: Direct electrical stimulation of auditory nerve.

*Candidacy depends on a number of factors including degree of HL, age, functional progress with auditory and spoken language skills, etc.

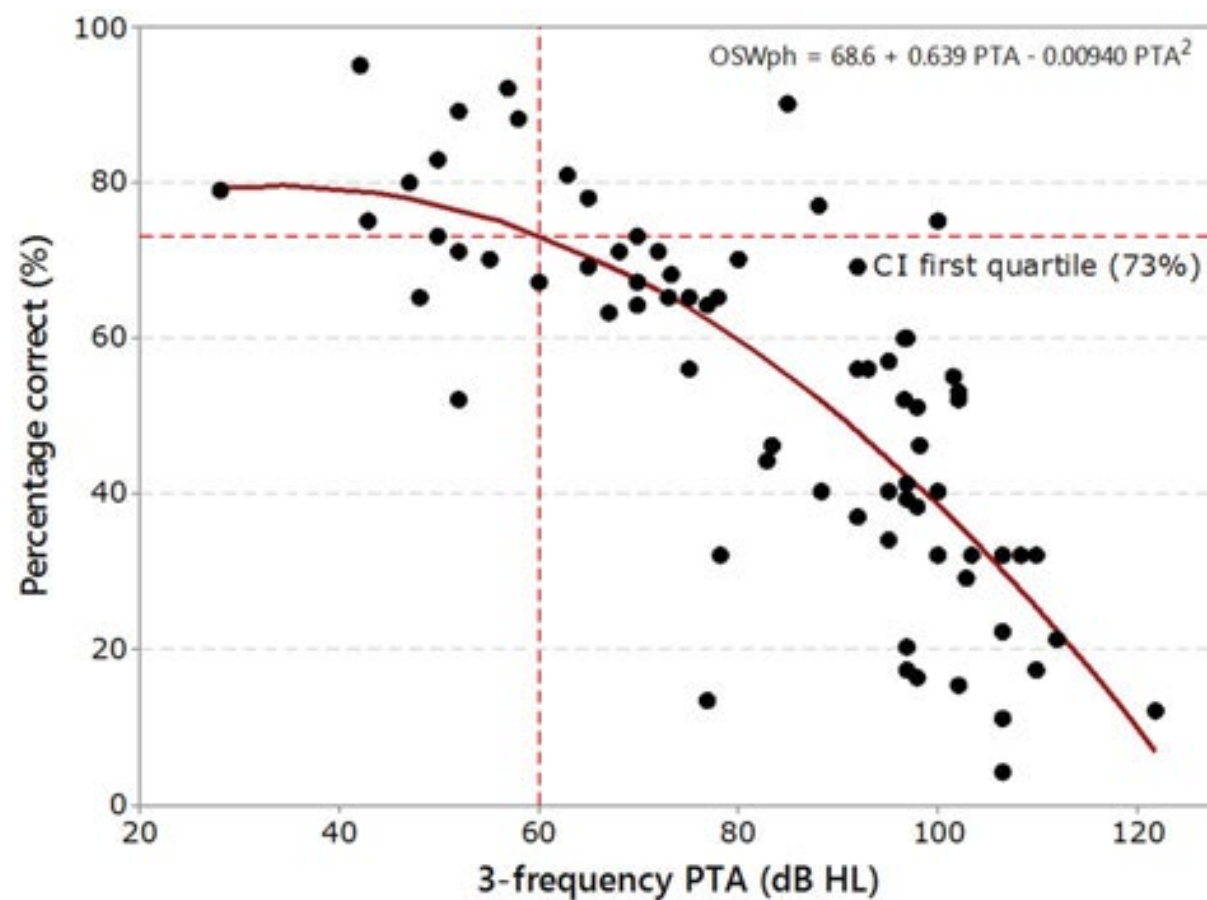
Considerations for Pediatric Cochlear Implant Candidacy (US): FDA Guidelines 2020

- Degree of hearing loss (bilateral profound sensorineural hearing loss at 9 months; bilateral Severe-Profound ≥ 2 yrs)
- Limited benefit from appropriately fitted hearing aids. Poor speech understanding
- Access to follow-up services and family commitment to rehabilitation.
- Age: Younger implantation associated with improved outcomes.

NOTE: These are FDA-approved indications of use/guidelines; professionals and families can combine knowledge regarding a child's needs and abilities with evidence-based, best practice clinical services to determine if cochlear implantation may be in a child's best interest, even if the guidelines above are not met.

CI vs. Hearing Aid Performance

75% of children with cochlear implants have better speech recognition than children with hearing aids and a hearing loss of 60 dB HL or worse



60 dB HL corresponds to Moderately-severe HL. Not currently FDA approved for implantation.

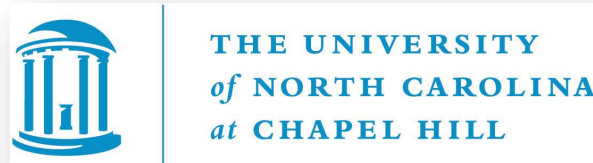
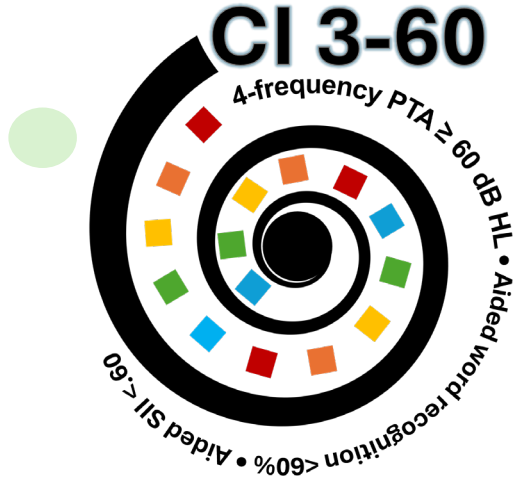
Off-Label Implantation is Fairly Routine



- 78% of surveyed neurotologists had performed off-label implantation in the previous 2 years.
- The high percentage of surgeons performing implantations for off-label or nontraditional indications reflects the overly restrictive and dated status of current implant guidelines.

Carlson et al (2018). Survey of the American Neurotology Society on Cochlear Implantation: Part 1, Candidacy Assessment and Expanding Indications. *Otology & neurotology*, 39(1), e12–e19.

When to refer a child for a CI evaluation? *A Guideline for Pediatrics*



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University of North Carolina at Chapel Hill



Andrea Warner-Czyz, PhD
University of Texas at Dallas

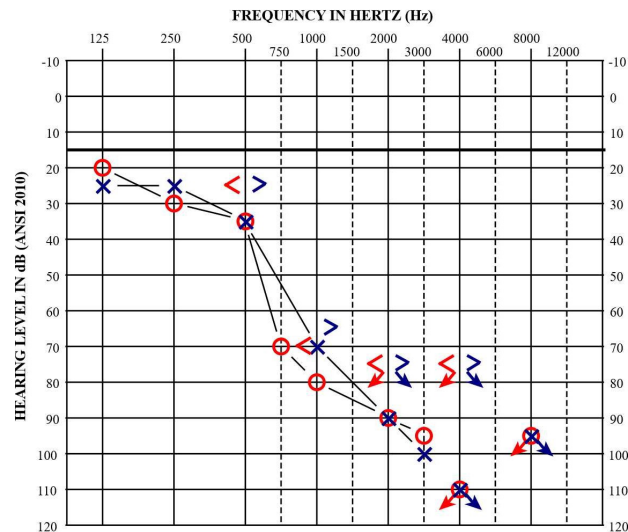


Jourdan Holder, AuD, PhD
Vanderbilt University

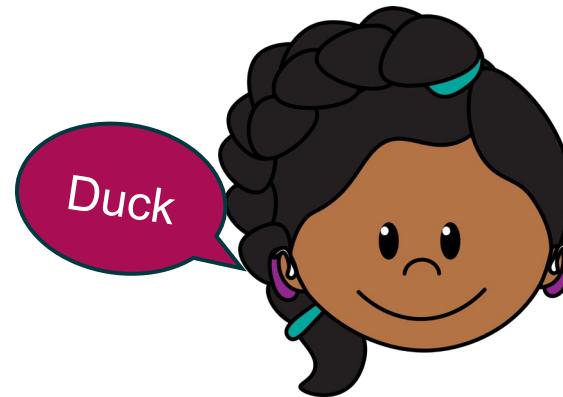
3-60 criteria for CI candidacy evaluation.

- N = 1,179 children under 14 yrs from 3 centers

≥ 60 dB HL poorer
ear 4-freq PTA



$\leq 60\%$ aided word recognition in
either ear with appropriately-fit
HA



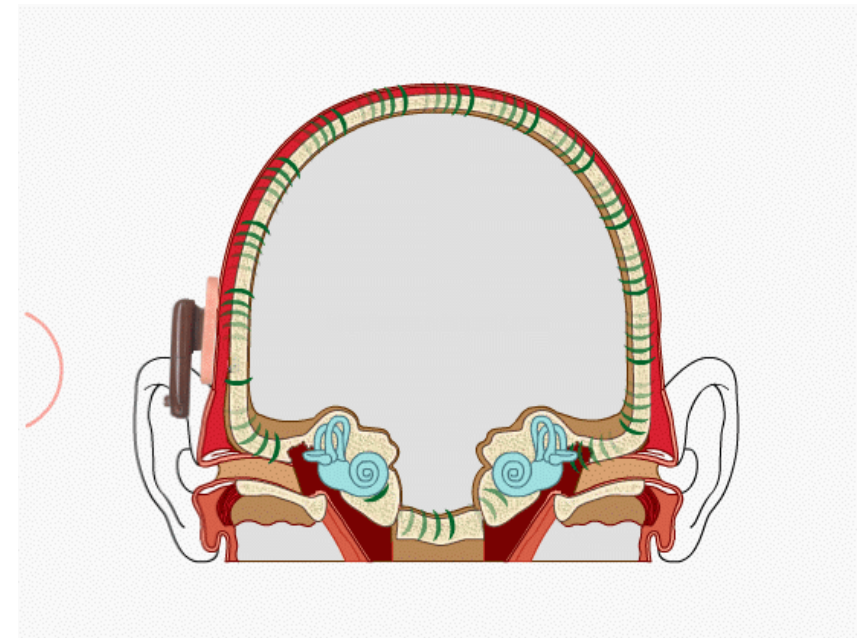
SII of $\leq .60$ in either ear
with appropriately-fit HA





Bone conduction devices

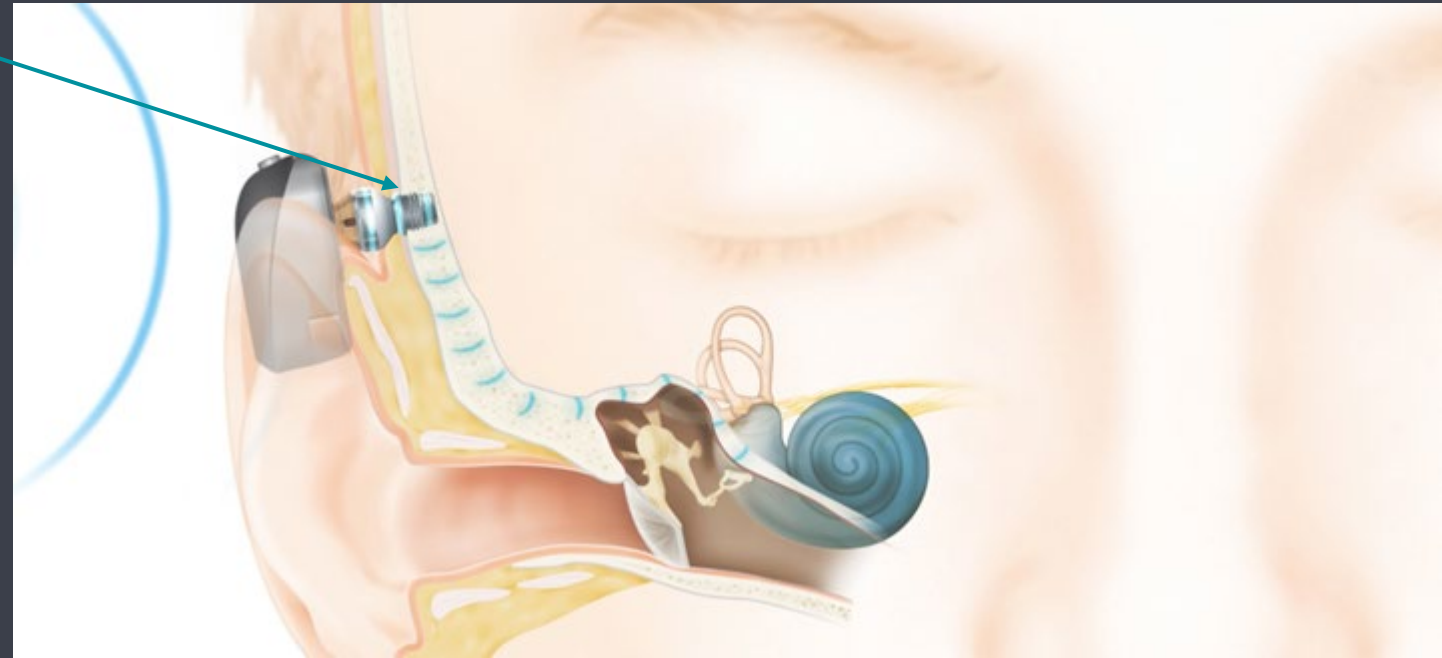
- Bone conduction hearing device, Osseointegrated Implants
- Sound transmitted through vibration of skull, bypassing outer and middle ear



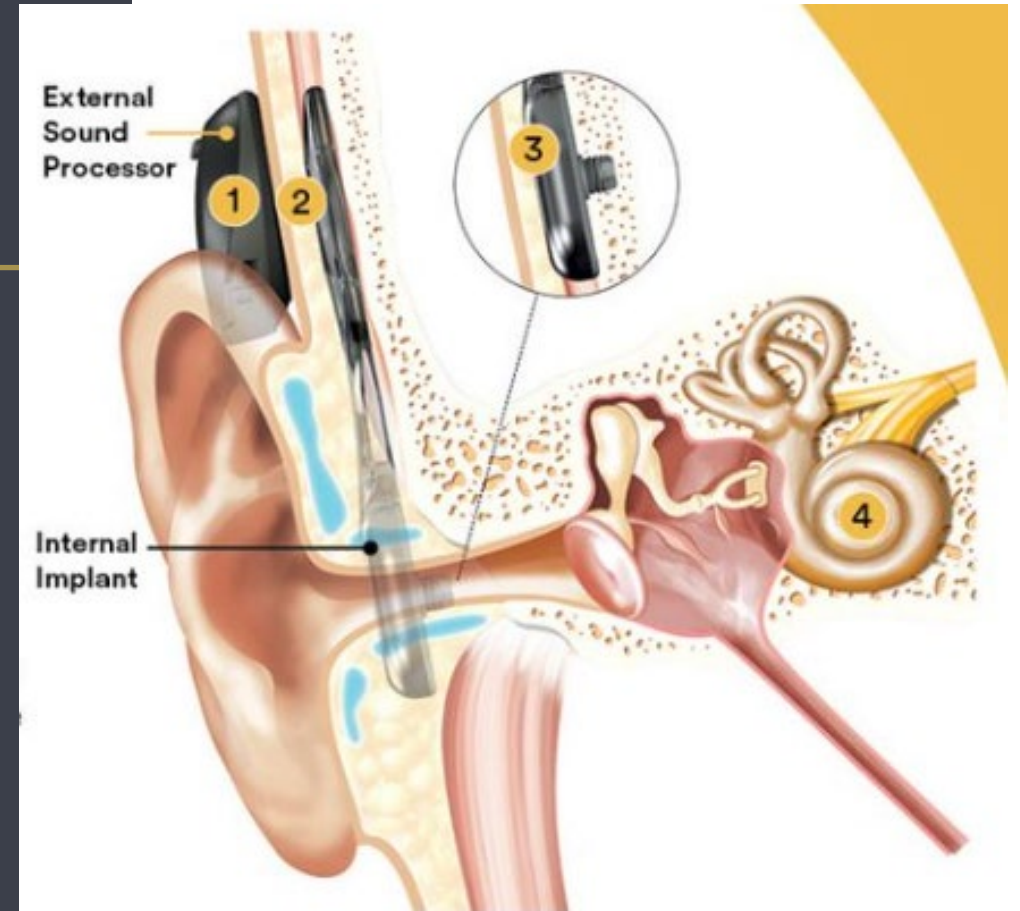
Transcutaneous Bone Conduction Implants



Percutaneous Bone Conduction Implants



Active Bone Conduction Implants



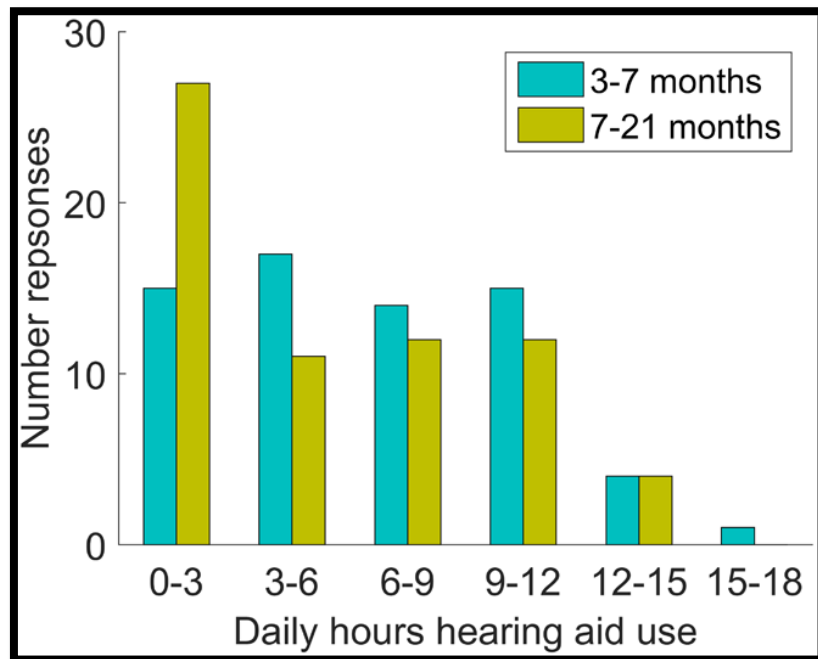
Bone Conduction Device Candidates

- (Permanent) mixed or conductive hearing loss, Limited Usable Hearing Unilaterally (LUHU)
- Common indications:
 - Atresia (absent external ear)
 - Recurrent, unresolvable otitis media
 - Conductive or mixed hearing loss not suitable for traditional hearing aids
 - LUHU: One ear has little to no functional hearing
- Criteria:
 - Non-surgical options suitable for children of all ages
 - Osseointegrated options (e.g., BAHA) suitable for children 5+ years (to allow skull thickness for implantation)



Importance of Consistent Device Use

- Keys to Success (in addition to EHDI):
 - Full-time use of well-fit devices
 - Rich language exposure in home - talk, read, sing with your baby



(Visram et al., 2020, Figure 4)

Child's Age	Goal - Average Hours Hearing Technology Use a Day
0-12 Months	8 Hours
13-24 Months	9 Hours
2-5 Years	10 Hours
6-10 Years	11 Hours
11 Years and Up	12 Hours

(Wolfe, 2022)

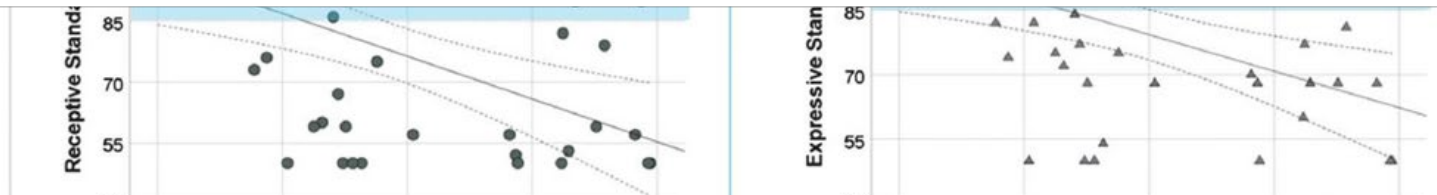
<https://www.audiologyonline.com/articles/20q-hearing-aid-cochlear-implant-wear-time-28169>

Wear Time Makes Great Outcomes Probable!

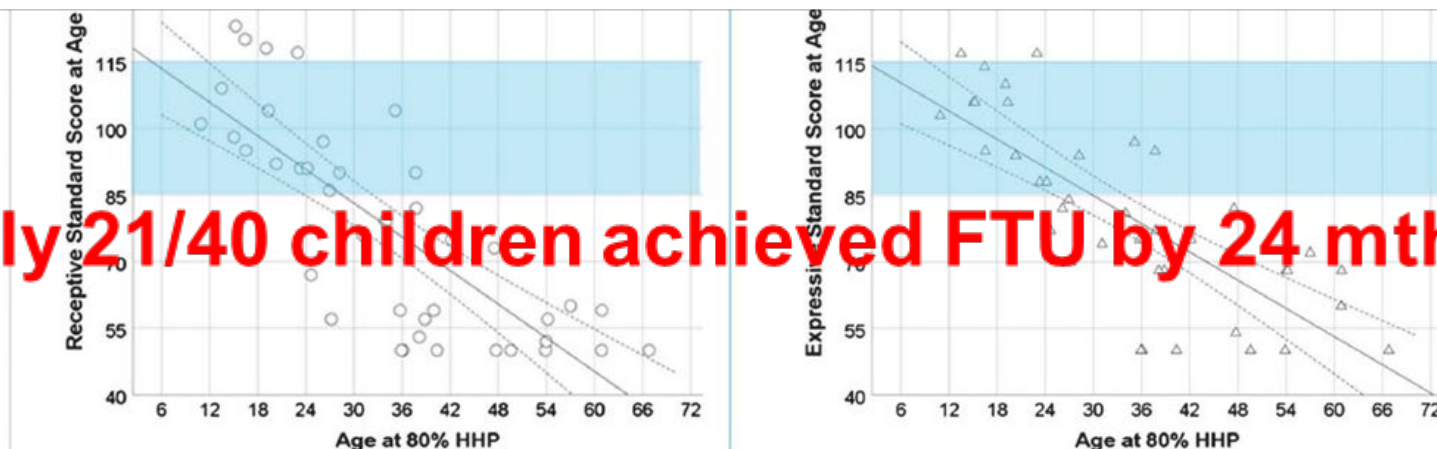
All children who achieved FTU by 24 mths had WNL language by 36 mths



Age at FTU was better predictor of outcomes than age at CI!



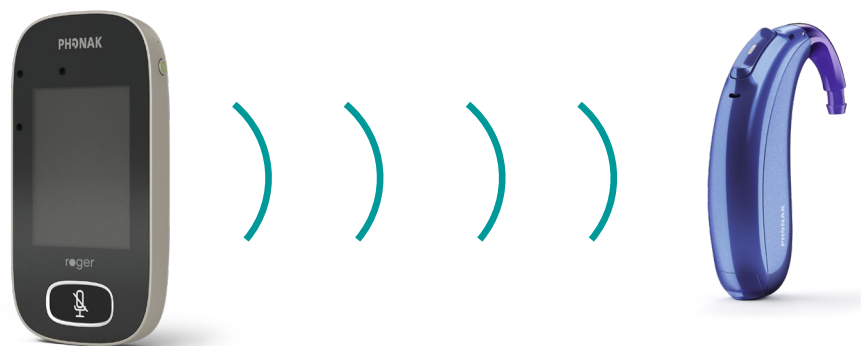
On average, it took 17 mths for children to achieve FTU



Only 21/40 children achieved FTU by 24 mths

Remote Microphone Systems

- Purpose: Improve listening in acoustically unfavorable environments (noise, reverberation, distance)
- Connects wirelessly to hearing devices
- Real world applications: Classroom, Car, Playground, Stroller, Group Activities



Noise Abounds

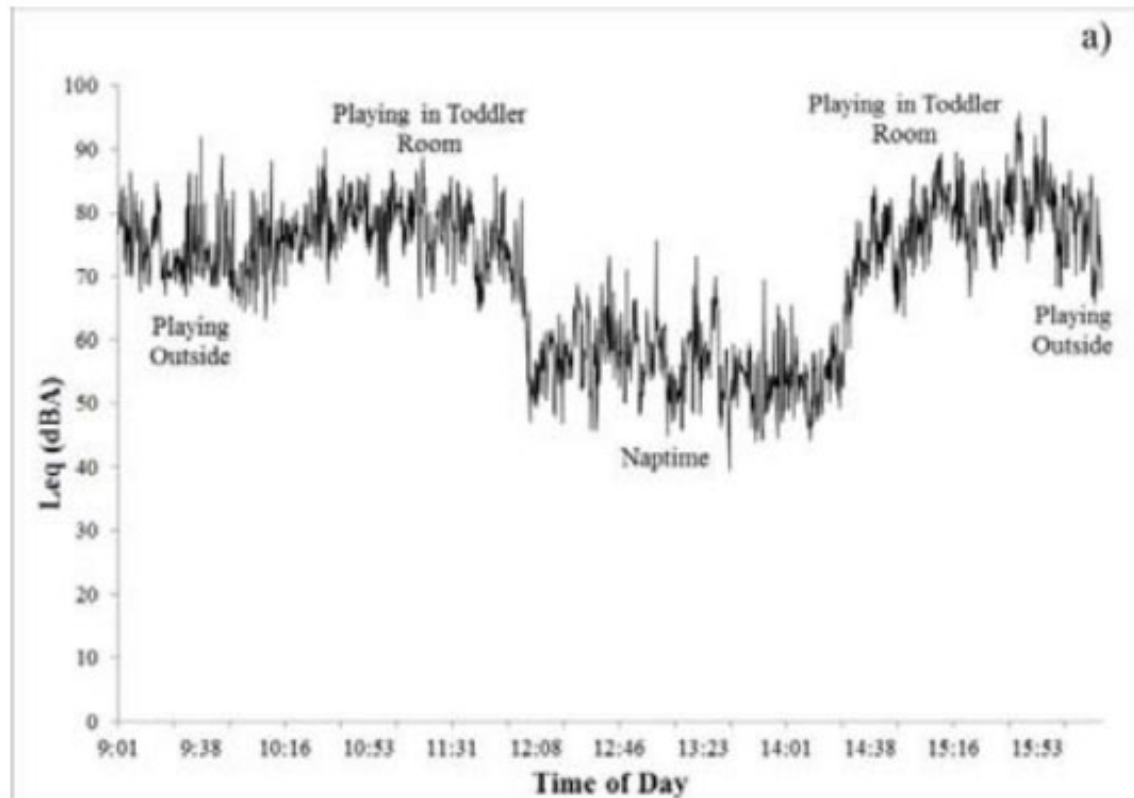
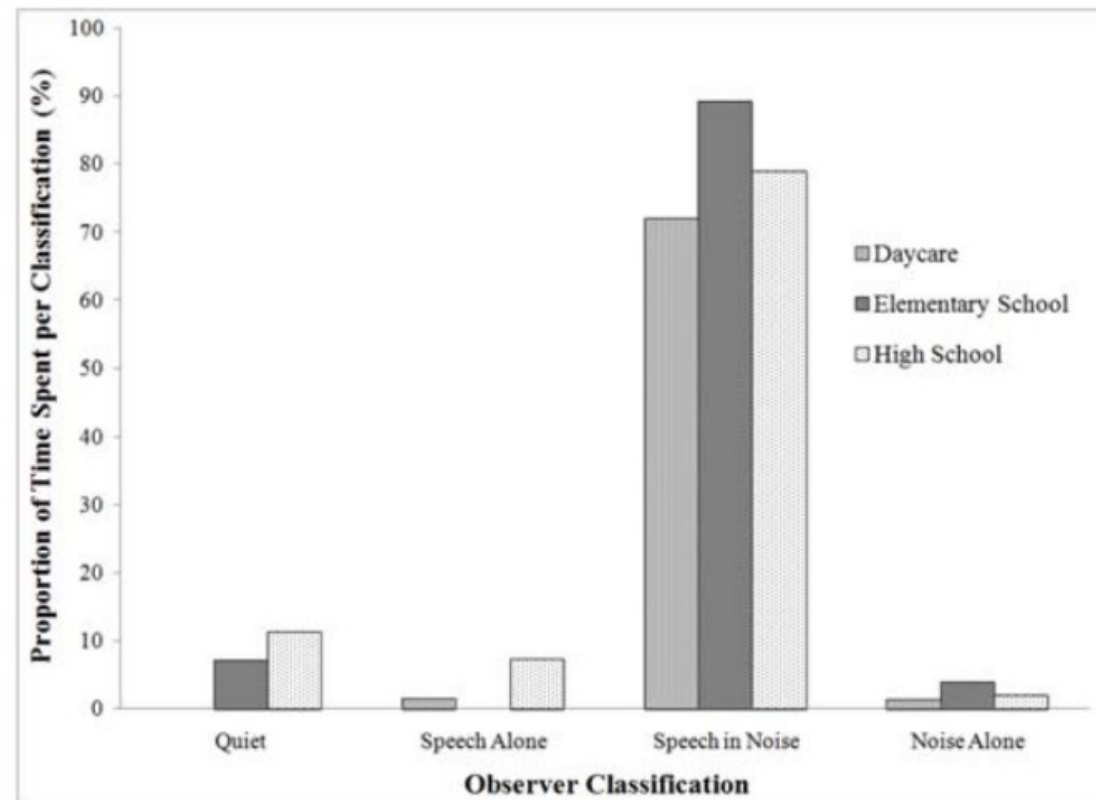


Figure 5. Proportion of time spent in each sound environment, as classified by the observer for each site.



Cruckley et al., 2011.

Questions and Discussion



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Thank you!



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