Evaluating The Reissner's membrane as a BioMarker of Residual Hearing Loss Post Cochlear Implantation

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Introduction

- **Residual Hearing** is the natural hearing ability one has after experiencing hearing loss.
  - Patients with **cochlear implants (CIs)** have sometimes experienced a loss of this hearing post-implantation (1), (2)
- Looking for biomarkers inside the cochlea can help us determine extent of this hearing loss
- One promising avenue involves the phenomenon called **Endolymphatic Hydrops**
  - This occurs when excess fluid in the **scala media (SM)** disrupts the delicate fluid balance in our ears (3)
- Endolymphatic Hydrops can be visualized when the **Reissner's membrane (RM)** shows deformations such as it bending and curving (3)
- Surgical trauma has been previously associated with Residual hearing loss and therefore we might identify the presence of trauma induced endolymphatic hydrops that could indicate its association to the hearing loss (4)

Our **hypothesis** is that ears with more residual hearing loss following CI surgery are more likely to show signs of endolymphatic hydrops, such as RM bulging & lengthening, and SM area increase.

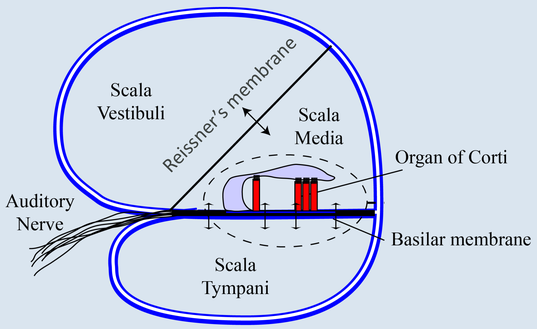


Figure 1: Schematic of a cross-section of a cochlear turn.

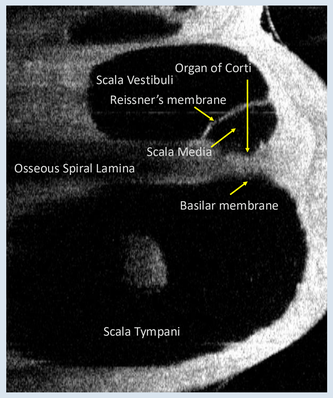


Figure 2: OCT structural scan of the basal turn of a guinea pig cochlea.

Scala Vestibuli: Upper fluid chamber

Reissner's membrane: Thin, pliable membrane dividing SV and SM

Scala Media: Middle fluid chamber with sensory cells

Scala Tympani: Lower fluid chamber

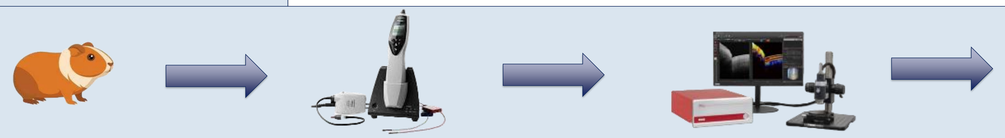
Basilar membrane: Vibrates with sound and supports hearing cells

Organ of Corti: Hosts hair cells for hearing

Osseous Spiral Lamina: Bony bridge that supports the organ of Corti

Methods

Funding: HHF ERG 969672 & NIDCD R21-DC020794 (Burwood), NIDCD R56 DC018387 (Reiss).
All procedures were undertaken in accordance with OHSU IACUC protocols and with the permission of the local ethics committee.



12 Guinea pigs were implanted for at least 8 weeks

Auditory Brainstem Responses were recorded pre-operatively and post-operatively after 8 weeks (4)

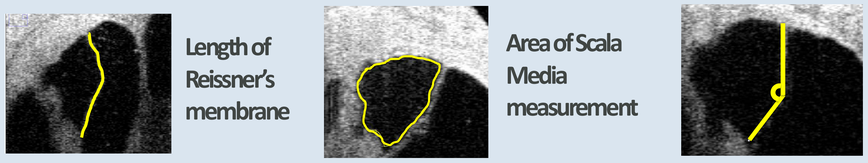
Optical Coherence Tomography (OCT) Scans were taken post-operatively after cochlea extraction (2, 4)

Images of the Reissner's membrane were analyzed using ImageJ

Figure 3: Experimental timeline and protocol

Using a subset of a database of 9,200 images we took measurements of length and angle of the Reissner's membrane as well as the Area of the Scala Media to measure the morphological changes to the membrane. with $p<0.05$ being significant.

These values were statistically tested for inter-ear differences and correlated to Auditory Brainstem Responses (ABR). 2 sample two-tailed T-tests were conducted with an alpha of 0.05 when comparing the two ears and Pearsons's two-tailed correlation table was used for the correlation tests



Length of Reissner's membrane

Area of Scala Media measurement

Angle of Reissner's membrane

Figure 4: Experimental parameters measured from the OCT cochlear dataset.

Results: RM & SM Morphology with & without CI

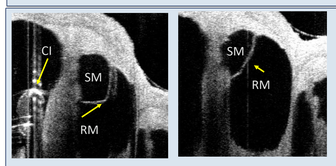


Figure 5: Left: Ear with CI. The RM is deformed and curved. Right: control ear. Scans from subject OCTV14.

- When comparing right and left ears (Figure 6) we don't see a significant difference in membrane morphology.
- This is not surprising as not all the implanted ears had residual hearing loss.

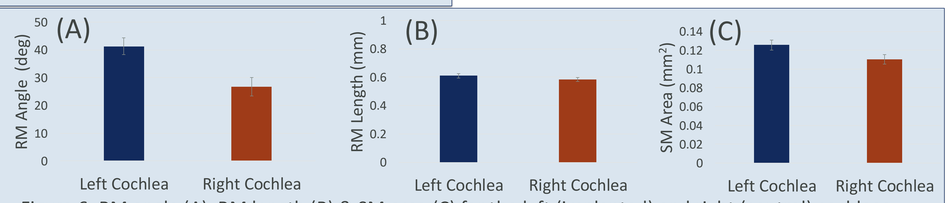


Figure 6: RM angle (A), RM length (B) & SM area (C) for the left (implanted) and right (control) cochleae (N=12). There are no statistically significant differences between the left and right ear for any parameter.

Results: RM & SM Morphology versus Residual Hearing Loss

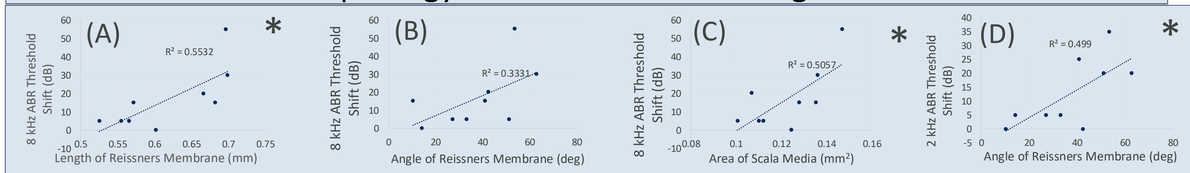


Figure 7: RM length (A), RM angle (B), SM area (C) versus 8 kHz ABR threshold change re: pre-CI. RM angle versus 2 kHz ABR threshold change (D). The correlations in A, C and D are significant (N=9).

- We see statistically significant relationships between ABR and physical changes to the membrane in 5 out of 15 frequencies, with at least one for every measurement (Figure 7).

* Indicates significant correlation and r^2 value

Conclusions

- RM & SM morphology was not statistically different between ears with & without CI.
- However, when comparing ears with CI to ABR thresholds, several statistically significant correlations were seen for each of the three RM & SM morphology measurements.
- These findings suggest a relationship between the physical changes in the Reissner's membrane and residual hearing loss post implantation.
- These findings highlight the potential of the Reissner's membrane serving as a Biomarker of Residual hearing loss.

Future Directions

- Increase the sample size to confirm the correlations.
- Use OCT imaging datasets from quickly preserved cochleae.
- Comparing the morphological changes to cochlear mechanics data.
- Assess whether RM changes precede residual hearing loss.

References

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