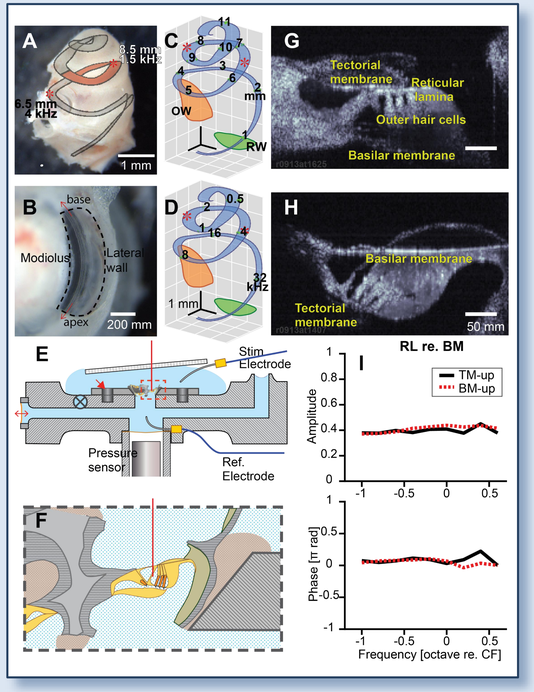
Higher-Order Mode Vibrations in the Organ of Corti

Wei-Ching Lin[1], Jong-Hoon Nam[1,2]
[1] Department of Mechanical Engineering, [2] Department of Biomedical Engineering, University of Rochester

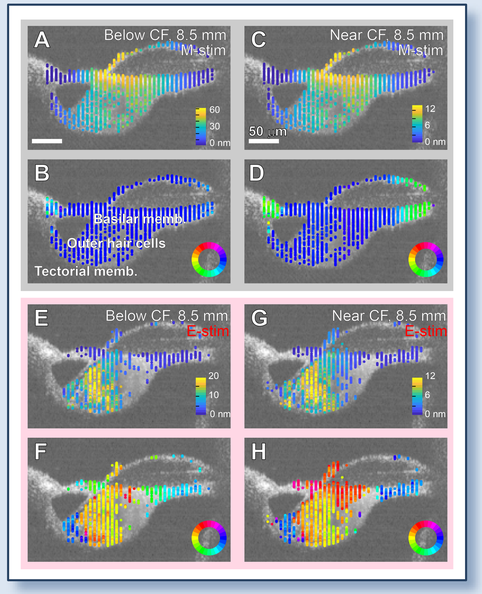
Abstract

The mechanical gradient of the basilar membrane (BM) and the tectorial membrane shapes the traveling waves of the mammalian cochlea. The outer hair cells (OHCs) are cellular actuators that modulate the traveling waves. The shape of cochlear traveling waves represents hearing sensitivity and selectivity. While longitudinal vibrating patterns (traveling waves) of the BM have been researched extensively, little is known about its radial vibrating patterns. We measured the radial vibrating patterns of the BM in excised gerbil cochleae at the resolution fine enough to distinguish the displacement of individual cells. A 3-D finite element model of fully deformable organ of Coti was exploited to analyze the measured data in detail. While pressure-driven vibrations resulted in primary-mode vibrations, OHC motility generated higher-mode vibrations of the BM. Our results indicate that the BM acts as if a mechanical reference for OHC motility.

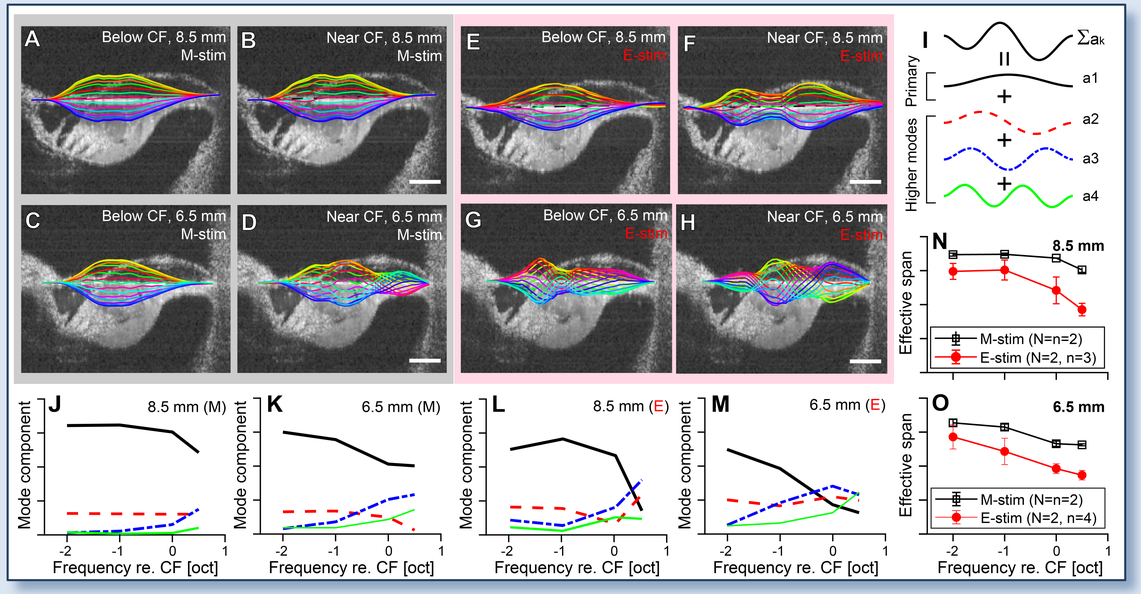
1. Vibrations of excised gerbil cochlea



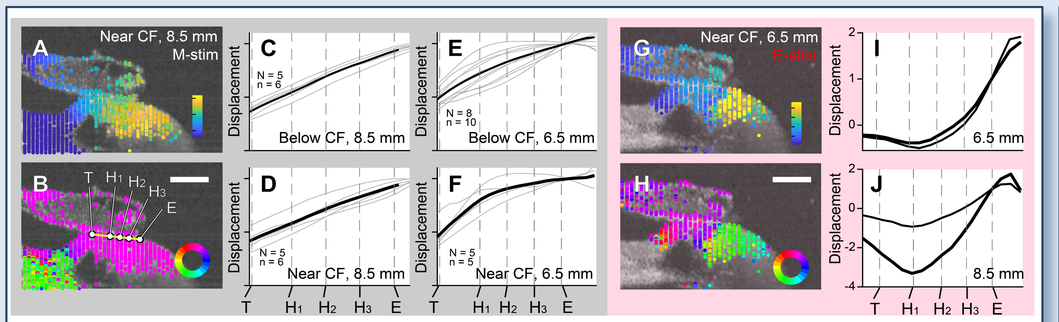
2. Transverse vibrations along the radial axis



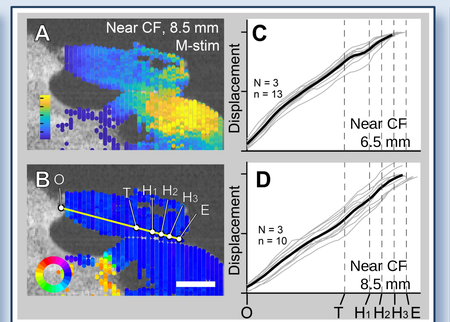
3. Basilar membrane vibration patterns



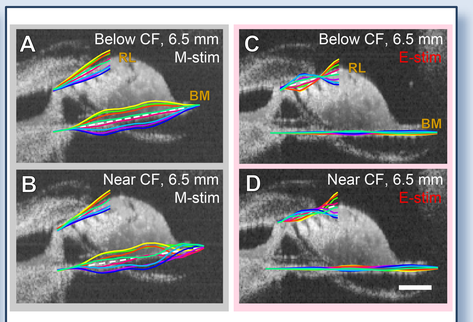
4. Reticular lamina vibration patterns



5. Tectorial membrane vibration patterns



6. Basilar membrane as the reference



Conclusions

- Higher-order mode vibrations were observed in the OoC radial section.
- When mechanically stimulated the primary mode was dominant.
- When electrically stimulated higher-order modes were prominent.
- TM vibrated like a hinged bar.
- RL bended regardless of stimulation types.
- BM vibrated minimally when electrically stimulated.
- BM acts like the mechanical reference for the cochlear actuators (OHCs).

To see animations of this work, visit.

Supported by NIH NIDCD R01 DC014685

UNIVERSITY of ROCHESTER

Hearing & Balance Research Collective