Preparation

Motion measurements were performed on 140 hair bundles from cochleae of nine gerbil lizards. To visualize the micromechanical components, the animals were sacrificed and a dorsal approach to the cochlea was taken. The basilar membrane was removed with a sharpened dental pick and the cochlea was filled with a suspension of fluorescent phloxine B dye. The right cochlea was then flattened against a glass plate using a covering of liquid paraffin to facilitate photographic analysis. Afterwards, the left cochlea was observed with a microscope and a laser beam was directed onto the cochlea from a dye laser (He-Ne, 632.8 nm, 1 mW). Dye lasers were used to illuminate the cochlear structures at the stimulus frequency and its harmonics. The left plot shows the magnitude of the motion of the bundle, as seen from the base of a hair bundle (RL), for a given RL displacement. TM-RL is computed as shown at left.

RESULTS

1. Gross Motion

Images are obtained at different phases of the stimulus waveform using stroboscopic illumination. The figure to the left illustrates motions between images of a single hair bundle by extracting the same one of points from each image and stacking them. The resulting image shows changes in brightness as a function of position (x) and time (t). The sound stimulus was a 500 Hz, 120 dB SPL, 500 ms pure tone. Higher harmonics were more than 36 dB smaller.

2. TM/RL Ratio

The plots below show the magnitude and phase of TM/RL vs. frequency for the same bundle shown in section 2. The phase is near 0°.

3. (TM-RL)/RL

The plots below show the magnitude and phase of (TM-RL)/RL vs. frequency for the same bundle shown in section 2. The plots to the left show the magnitude and phase of the ratio (TM-RL)/RL in 100% for all bundles.

4. (Tips-RL)/(TM-RL)

The plots to the right show the magnitude and phase of (Tips-RL)/(TM-RL) vs. frequency for the same bundle shown in section 2. The phase is near 170°.

DISCUSSION

For All Nine Cochleae:

- TM displacement was smaller than RL displacement; the TM did not resonate.
- TM shear was smaller than that of RL displacement.
- The deflection of the hair bundles was smaller than that of the electrical response to sound.
- The RL, tips of hair bundles, and TM all moved in phase.
- None of the transfer functions or measurements showed sharp frequency selectivity.

However,

- No electrical response to sound was detected from the excised cochleae. It is possible that some components of the transduction apparatus (e.g., tip links) were not functioning properly. These results might be expected if the mechanical properties of the cochlea had been disturbed.
- Hair cells in our preparation often developed blebs, which reduced the membrane, adjacent to the kinocilium. Although we reversed the vibrating stimulus before preparations of an artificial endolymphatic fluid, the initial bending process may have caused invisible damage.

Implications for Cochlear Mechanics

- In our preparations, motions were largest at the tips of hair bundles, and decreased toward the tips of the bundles and the TM.
- Motions of the bases and tips of hair bundles and the TM were not resonant.
- The transfer functions examined are not sufficient to explain the Q(0) values and high-frequency slopes of tuning curves measured in auditory nerve fibers innervating the region.

References

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