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Do non-piston components contribute to scala vestibuli pressure behind the footplate in gerbil?

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The stapes moves predominantly piston-like but at higher frequencies tilting of the footplate is also observed. The gain between the sound pressure in the earcanal and the acoustic pressure in the perilymph of the scala vestibuli close to the stapes is a smooth function of frequency while the frequency response of the piston component of the stapes, normalized to earcanal pressure, exhibits pronounced maxima and minima. We explored whether the tilting could fill in the gaps in the frequency response of the piston component to produce the smooth intracochlear pressure response. Young adult anesthetized mongolian gerbils were used: we first measured the scala vestibuli pressure using a micro-pressure sensor (Olson, JASA,1998) and then, using a confocal heterodyne interferometer, vibration velocity of the stapes was measured from different observation angles to allow for the calculation of the 3-D motion components (Decraemer, HR 1990). A micro-CT scan from the temporal bones was made later to determine the 3-D anatomy and experimental geometry. We present results from 3 animals. Pressure gain curves are remarkably smooth. They start at their lowest value (~ 5) at 190 Hz and rise to a maximum (~10 to 20) around 1.25 kHz. Then the curves show gradual fluctuations between 5 and 30. For two animals there is a broad minimum at ~ 30 kHz followed by an increase of ~ 20 dB. For the third animal the gain remained nearly constant above 6 kHz. The gains were similar to those in the recent report by Dong and Olson (J.Neurophysiol., 2006). For all animals, the pressure transfer function phase steadily decreased from +900 at 190 Hz to about -500o at 40 kHz. The frequency response of the piston component and the pressure gain exhibit both similarities and differences. The piston amplitude increases with frequency more slowly than the pressure gain. Then it follows the gross trend in pressure gain, but it shows fluctuations that are larger and sharper compared to those found in the gain. Above 30 kHz the amplitude rises to a maximum at about 35 kHz, and then drops off again. A gain dip at 5 kHz is reproduced in the piston amplitude of all three animals but the dip at 10 kHz is accompanied by a maximum in piston amplitude. The location of the peak and dips in the amplitude of the tilting components does not show that a smoothing effect of the gain could be inferred from a summing of the displacements caused by piston and tilting components. As a closing remark, more recent experiments show that the intracochlear pressure and stapes piston are relatively similar when measured simultaneously and with a more direct observation angle to the stapes; these methodological improvements reduce the need to hypothesize that non-piston components contribute to the transmission path