3.6

Measurements of stapes velocity in live human ears

W. Chien[2], JJ. Rosowski[2], ME. Ravicz[1], SN. Merchant[2], Boston; USA[1,2]

Purpose: While there are many measurements of how the tympanic membranes of live humans respond to sound, few measurements of stapes velocity have been reported in live humans. Consequently, our understanding of human middle-ear transmission comes mostly from studies in live animal and human cadaveric ears.

Materials & Methods: In this study we used Laser-Doppler Vibrometry (LDV) to measure sound-induced stapes velocity intra-operatively in 10 patients undergoing cochlear implantation. These patients had no history of middle-ear pathology, and their ossicular chains appeared normal on intra-operative inspection and palpation. The measurement angle between the LDV beam and the direction of piston-like stapes motion was large (65-80 degrees).

Results: The raw Vs, the component of stapes velocity measured by the LDV (normalized by ear canal sound pressure), had a bandpass shape: roughly proportional to frequency below 700 Hz, flat between 700 Hz and 4 kHz, and decreasing at higher frequencies. The phase of the normalized Vs decreased smoothly from 0.2 periods at 300 Hz to -0.8 periods above 4 kHz. The mean Vs in the ten ears is similar to the mean of the 7 ears in the only published live human stapes velocity measurements [Huber et al., Ann. ORL 110: 31-35, 2003] and to Vs measured at similar measurement angles in 8 fresh cadaveric human temporal bones. When corrected by the cosine of the measurement angle below 2 kHz [Chien et al., Audiol. Neurotol., in press], Vs is stiffness-dominated at low frequencies and decreases at frequencies above a broad resonant peak near 1 kHz, similar to Vs measured at small measurement angles in cadaveric ears.

Conclusions: The LDV angle in measurements of stapes motion during cochlear-implant surgery is a significant frequency- dependent factor in understanding the measured velocity. With the proper measurement angle corrections, stapes velocity in live and cadaver ears are similar. [Supported by NIDCD]