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Invited Paper

Estimation of stapes piston-motion with uni-directional measurements is prone to error

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We have shown that the vibration of the stapes in human, cat and gerbil exhibits all 3-D components of translation and rotation, but also that non-piston components do not contribute to the transmission path. In most experiments access for direct measurement of stapes motion in line with the piston axis is not available and piston motion is estimated from single component interferometric measurements done under observation directions that make angles up to 50° with the piston axis. We used a heterodyne microscope/interferometer to measure the vibration velocity of the stapes in human, cat and gerbil from different observation angles and calculated the complete set of 3-D motion components for the stapes. Using micro CT scans of the experimental ears, we could express the components in an intrinsic reference system and foretell the motion component that will be obtained when a single axis interferometric measurement is done under various angles with the piston axis. For low frequencies ($f < 2\text{kHz}$) a cosine factor provides a good correction for the axis off-set, at higher frequencies the piston component can not correctly be estimated from a single off-axis observation. We will show that this may lead to serious misinterpretations of experimental results.