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Mechanical excitation of complex stapes motion in guinea pigs

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Objective: As observed and widely-accepted the natural vibration pattern of the stapes on acoustic stimulation reveals a complex motion pattern dependent on the frequency of excitation. Whereas for low frequencies the motion is predominant piston-like, significant rocking can be observed for higher frequencies. The cochlea fluid is mechanically exited by the piston like motion and two rotational movements along the short and long axis of the footplate. The rotational components produce no net volume flux of the cochlea fluid and therefore, the influence on the hearing sensation is still an open question. To investigate the response of the cochlea on complex motion of the stapes footplate, different vibration pattern on the stapes has been applied in anesthetized guinea pigs. Methods: A test rig to position the subject, an actuator and a laser Doppler vibrometer was build up using aluminum profiles. For adjustment of subject, actuator and laser micro manipulators were used. A three-axis piezoelectric actuator has been designed and coupled to the stapes head by a coupling rod of the surgically prepared guinea pig. For capturing the effective motion of the stapes 3D-Laser-Doppler vibrometry was applied. The excitation procedure to get cochlea response of arbitrary stapes motion consists of both an identification and a measurement phase to determine 1) the transducer behavior and 2) the electrophysiological measurements of the cochlea potentials on the desired piston motion. Transducer activation, spatial velocity of stapes and cochlea potentials are captured simultaneously by the data acquisition system for appropriate post-processing. Results: The task of driving arbitrary motion pattern yields a much higher complexity than classical one dimensional consideration. The load of the stapes structure to the transducer necessitates a particular control of transducer actuation to produce the desired motion patterns. The independently varied mechanical stimulation patterns reveal different intensities of cochlea response depending on the amount of piston and rocking like motion of the stapes.