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The effects of complex stapes motion on the response of the cochlea in guinea pigs

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Purpose: Studies into the vibration modes of the stapes in response to acoustic stimulation of the normal ear have revealed a complex movement pattern of its footplate. These complex vibrations can be expressed as one translational displacement and two rotational movements around the long and short axes of the stapes. According to the classical theory of hearing, the rotational motions induce no volume displacement of cochlear fluid and, therefore, no cochlear activity (i.e. hearing sensation). It is the goal of this study to verify this hypothesis.

Material and Methods: The external and middle ear of anesthetized guinea pigs were surgically exteriorized, hereby, exposing the stapes superstructure. In turn, a custom-built, three-axis piezoelectric actuator, capable of eliciting any desired vibration mode, was coupled to the remaining stapes superstructure. When producing different movement patterns, electrophysiological measurements of the cochlear potentials were simultaneously recorded.

Results: Mechanical stimulation of the stapes according to the three elementary motions delivered three cochlear potentials of different amplitude. The greatest potential resulted from translational displacement.

Conclusion: The results of the present study show a cochlear excitation in all performed movement patterns of the stapes, including rotational movements. Hence, the prevailing hypothesis was not verified.