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Acoustical gain of a non-implantable electromagnetic hearing aid: Experiments using human temporal bones

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Purpose: To circumvent some of the problems inherent in conventional hearing aids, such as low gain at high frequencies due to acoustic feedback and discomfort in occlusion of the external ear canal, implantable hearing aids have been developed over the past two decades. However, since invasive surgery is necessary for implantation of these hearing aids, they have not as yet been widely employed. We have constructed a prototype of a non-implantable electromagnetic hearing aid which is mainly composed of a microphone amplifier system and an electromagnetic transducer. It can generate an excitation force to vibrate the ossicles by a coil adhered to the tympanic membrane. The electromagnetic transducer generated an excitation force equivalent to 93 dB SPL at frequencies between 0.5 and 10 kHz in an artificial middle ear and guinea pig ears. The suitability of this electromagnetic hearing aid for use in humans, however, is uncertain because frequency characteristics of human ears are different from those in artificial middle ears and guinea pig ears.

Materials and Methods: The acoustical gain of this electromagnetic hearing aid was evaluated in five human temporal bones extracted from cadavers. The frequency response of the displacement amplitude at the stapes was measured with a laser Doppler velocimeter when sound pressure was applied to the microphone of the hearing aid by an earphone. Next, the hearing aid was removed and the frequency response of the stapes was measured again with the same acoustic stimulation as that delivered to the hearing aid.

Results: With a constant sound pressure of 60 dB SPL, the mean acoustical gain was more than 20 dB even at high frequencies up to 6.0 kHz.

Conclusion: This newly developed hearing aid is applicable to patients with high-frequency hearing loss.