

Middle Ear Laser Doppler Vibrometry Assessment for improved Electrocochleography

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Introduction

Electrocochleography (ECoChG) records electrical potentials generated in the inner ear in response to acoustic stimulation. ECoChG is a promising monitoring tool to improve preservation of residual hearing during cochlear implantation. However, the success rates of ECoChG are highly affected by measurement-specific, patient-specific, or surgery-specific factors [1]. The aim of this project was to investigate surgery-specific factors by analyzing vibrations of the middle ear ossicles using Laser Doppler Vibrometry (LDV).

Materials and Methods

In our study, the velocity of the incus short process of a whole head cadaver specimen was measured through a transmastoid posterior tympanotomy using LDV. Three effects were analyzed: (1) the effect of opening the middle ear cavity (partially or completely), (2) the effect of cerumen or liquids in the ear canal, and finally (3) the effect of inserting a cochlear implant array. A middle ear circuit model was used to validate the experimental results.

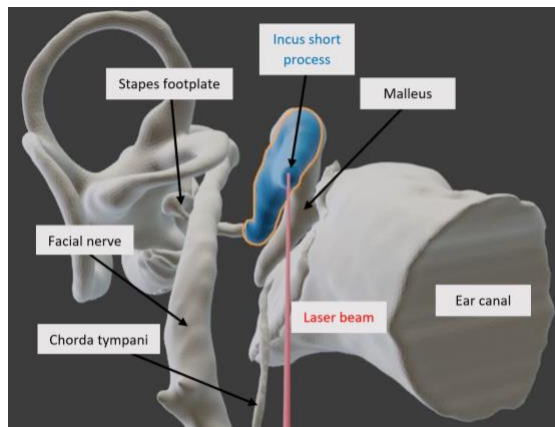


Fig. 1 3D view of the human ear. LDV measurements of the incus short process were taken through a transmastoid posterior tympanotomy (Ear model source [2]).

Results

Complete or partial opening of the middle ear cavity resulted in an increase in admittance of the incus

short process, except around 2 kHz. The presence of cerumen in the ear canal caused a decrease in middle ear admittance.

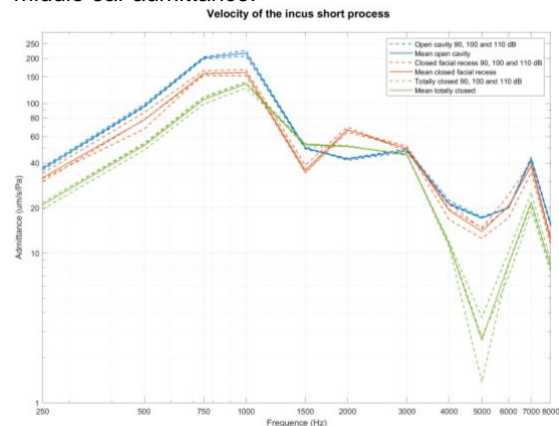


Fig. 2 Admittances of the incus short process with an open middle ear cavity (blue), a partially closed cavity (red), and a totally closed cavity. The curves were normalized by the ear canal sound level pressure.

Discussion

Measurements made with a probe microphone inserted into the ear canal are not sufficient to analyze the effects of surgery-specific factors on the middle ear. The opening of the middle ear cavity mainly leads to an increase in the compliance of the tympanic membrane. This leads to a decrease in middle ear impedance which results in an increase in ossicle velocity.

References

- [1] Weder et al. "Toward a Better Understanding of Electrocochleography", Ear and Hearing, Wolters Kluwer Health, 2020.
- [2] Sieber et al. "The OpenEar library of 3D models of the human temporal bone based on computed tomography and micro-slicing", Scientific Data, 2019.

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