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Determination of the specific acoustic input impedance of the ear for diagnostic of middle ear transmission disorders

*J. Rodriguez Jorge¹, MM. Maassen¹, W. Hemmert², A. Gummer¹, HP. Zenner¹,
Tübingen; Germany¹, Infineon Technologies AG²*

Introduction: The information obtained through measurements of the acoustic impedance at the eardrum permit conclusions concerning middle-ear function.

Materials and Methods: We use the laser-doppler vibrometer (LDV) in combination with a microphone to evaluate the specific acoustic impedance (SAI) at the umbo. A commercial laser- Doppler vibrometer (Model OFV-3001 with an OFV- 302 sensor head, Polytec) is used for the measurements of the tympanic membrane. The laser is coupled to a standard operation microscope (OMPI MDM, ZEISS) with a 200 mm front lens, equipped with a continuous zoom with magnification factors from 0.6 to 2.4.

Results: The specific acoustic impedance response of the mean value of 55 male and 40 female subjects at 60 dB SPL is compared with patients with otosclerosis, malleus head fixation, luxation of the ossicels and after contraction of the stapedial muscle. One can observe that the middle ear is poorly adapted to low and high frequency range. The region between 700 Hz and 7 kHz has the smallest impedance amplitude. The two resonances, the first around 1 kHz and the second around 3 kHz, have the minimal impedance amplitude which could be 10 times larger than that of a plane wave in air. Displacements from the otosclerotic ear were distinguished by abnormal low amplitudes below 1 kHz proportionally to the hearing loss (-10 dB relative to normal subjects) and a distinct resonance around 2 kHz. In case of incomplete malleus head fixation, the calculated SAI versus frequency shows only the increase of impedance in low frequency ranges. The case of ossicular interruption, the impedance shows a high decrease in low frequency ranges and a frequency shift of the first resonance up to 500 Hz instead of around 1 kHz.

Conclusion: Here we describe a method for in vivo measurement of middle-ear dynamics based on vibrations of the tympanic membrane which consequently allows the determination of the specific acoustic input impedance of the ear and the differential diagnosis of middle ear pathology.