Section: **Effizienz**

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Abstract-Title:
LASER DOPPLER VIBROMETRY: TOOL FOR ACTIVE MIDDLE EAR IMPLANT ADJUSTMENTLASER-DOPPLER-VIBROMETRY: WERKZEUG FÜR DIE JUSTAGE VON AKTIVEN MITTELOHRIMPLANTATEN

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Abstract-Text:
Purpose:
The currently used electrically driven hearing devices (IHD) apply either electromagnetic coupling or piezoelectric actuation to drive the ossicular chain. They represent optimal hearing improvement for an increasing number of specific indications and can be used for the rehabilitation of patients with either conductive (BAHA Classic, Rion MEI), mixed (BAHA Cordelle) or sensorineural hearing loss (Vibrant Soundbridge, Soundtec, Otologic). One of these is the MET ossicular stimulator (Otologics, LCC., Bolder, CO, USA), a semi-implantable hearing aid with an internal unit consisting of an electromagnetic transducer with the option to vary static preload intraoperatively. This internal unit is coupled to the incus by a coupling rod that is inserted in a previously made whole and adjusted by a microadjustive screw to achieve an optimal static preload. Optimal preload is crucial to achieve maximum transmission of the implant vibrations onto the ossicular chain resulting in maximum footplate displacement. Determining the optimal preload by acoustical measurements is intraoperatively limited due to possible occlusion effects of the ear canal.The laser Doppler velocimeter (LDV) is an excellent technique for non-contact vibration measurements in ears with high precision. LDV is considered as the standard for evaluating the performance of IHDs and allows in vivo measurements as well.
The aim of this study is to determine with LDV measurements both, in vitro and in vivo, the transfer functions in relation to different static preload conditions of the MET. Method:
LDV was used for the selection of three temporal bones with different vibrational patterns (VP). Transfer functions were calculated between vibration patterns of the measurement points at the coupling rod, umbo, incus (INC) and footplate. The MET was implanted, coupled to the ossicular chain and the vibration patterns were measured at the incus, umbo and footplate with different preloads corresponding to MET advancements of 0 µm, 62 µm, 125 µm and 188 µm or screw rotation of 0°, 90°, 180° and 270°, respectively.
In addition, intraoperatively acoustical and mechanical measurements were done during three MET implantations at the same time. A probe microphone that was inserted into the subsequently sealed ear canal was used for the acoustical measurements. For the vibration measurements, the developed and subsequently optimized setup according to Rodriguez Jorge and Hemmert was used consisting of a LDV that is coupled to an operation microscope. We stimulated the MET ossicular stimulator with 9 simultaneous

pure tones (250 Hz, 500 Hz, 750 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz) and the microadjustive screw was turned to obtain the maximum incus displacement amplitude. The incus vibration amplitude was measured twice while the laser beam was focused onto the incus body. Results:
In vivo, the highest amplitudes (40 µm/V - 80 µm/V) were found with a screw rotation of 0° - 90° (0 to 0.0625 mm). In vitro, optimal transfer function between the MET transducer and the oval window was achieved during contact when the coupling rod advanced 0.0625 µm (90° rotation).If the microadjustive screw was rotated 180° in vivo, the amplitude decreased by 14 dB - 20 dB. Altogether, an optimal preload was achieved with a rotation of 90° corresponding to a coupling rod advancement of 0.0625 mm.

Conclusion:
1. The described setup is a sensitive and precise technique for intraoperative vibration measurements and precise adjustment of the coupling of active middle ear implant with the ossicular chain. 2. Based on our findings we are of the opinion that optimal force loading occurs between contact situation (0°) and 0.0625 mm (90° rotatation). For intraoperative usage we recommend an advancement of 0.0312 mm (45° rotation) in order to avoid an overloading. Overloading might result in a decreased efficacy of the MET.

Bild 1/JPG

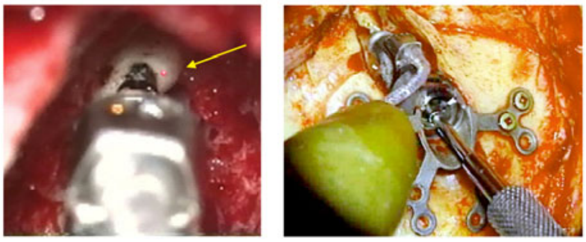

Fig. 1: a) To achieve proper loading of the ossicular chain with the transducer, the adjustment screwdriver is turned clockwise in order to advance the probe tip of the transducer until it enters the hole in the incus. b) Detailed view of the MET when coupled to the incus via a coupling rod (arrow shows LDV measurement point on the incus).

Bild 2/JPG

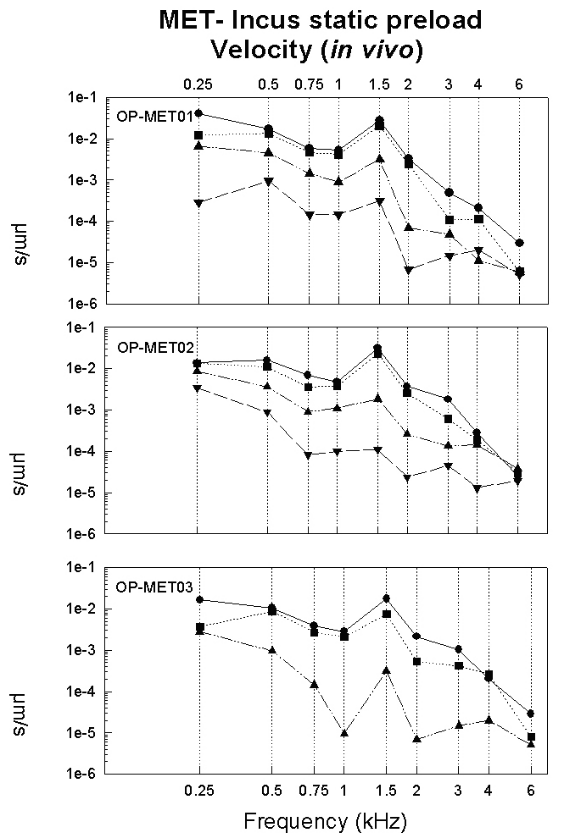

Fig. 2: OP-MET01, OP-MET02, OP-MET03 intraoperatively measurements. Velocity amplitude (µm/s/1V) versus frequency during different loading conditions (solid lines = direct contact without coupling, i.e. 0° rod advancement; dotted lines =0.0625 mm (90°) coupling rod advancement; dash-dot lines = 0.125 mm (180°), dash-dash lines = 0.187 mm (270°) coupling rod advancement.