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#### **On the optimal coupling of an implantable hearing aid – measurements and simulations**

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The Otologics Middle Ear Transducer (MET) is a partially implantable electro-magnetic middle ear hearing device to excite the ossicular chain mechanically. Its driving rod is pushed against the incus and the applied preload plays an important role in the sound transfer.

The objective of our investigations is to assess the optimal static preloading of the MET. They are subdivided into the two branches, experiments and simulations. For the measurements with Laser-Doppler vibrometry human cadaveric temporal bones have been used. Simulations have been carried out with computational models of the middle ear with its adjacent structures and also of the MET. They are based on modelling techniques such as Finite Elements and Multibody Systems approach known from dynamical analyses of mechatronical systems.

From the measured vibrations, the transfer functions between umbo, incus and particular points of footplate were calculated. After implantation of the MET, transfer functions between transducer and ossicular chain have been measured for different coupling preloads. An optimal transfer function between the MET-transducer and the oval window could be observed when the driving rod was firmly attached to the incus and moderately preloaded. An additional preload resulted in an attenuation of transfer. Additionally, the distortion of sound transfer increased by increasing preload.

Parallel to the measurements, simulations based on the mechanical models have been carried out and the experimental findings could verify the models. A particular attention was drawn to the modelling of the coupling between actuator and ossicular chain. These mechanical models allow detailed investigations of the transfer behavior depending on several parameters, e.g. position of attachment point or preload of coupling by carrying out sensitivity analyses. Predictions can be made concerning creeping effects of ligaments or different ways of insertion of the active transducer.

Applying multicriteria optimization procedures allow for finding optimal values of design parameters with respect to sound transfer within certain frequency ranges or applicable preloads of coupling.