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Invited Paper

Coupling problems in middle ear reconstruction

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The normal and reconstructed middle ear can be considered as a mechanical vibrating system. After the implementation of tympanoplasty as a standardized surgical technique various reconstruction techniques and implants were suggested for the reconstruction of the tympanic membrane and the ossicular chain. Laser–Doppler-vibrometry and model calculations have given new insight into the vibration modes of the normal and reconstructed middle ear during the recent years. Nowadays it can be concluded, that not only material properties of implants but also coupling factors have an important influence on good hearing results. We investigated coupling factors between tympanic membrane and the surrounding bone, between the tympanic membrane and middle ear implants and between the prosthesis and the ossicular chain using model calculations and temporal bone experiments. The quality of the tympanic membrane, which can be considered as the "motor of the middle ear", has the most important impact on the sound transfer to the inner ear. Ventilation and mucosa problems can damp the tympanic membrane vibrations as well as the reconstruction techniques or the mechanical properties of transplants. The coupling of the tympanic membrane to either the surrounding bone or the cartilage transplants has an influence on the stiffness. The contact of the tympanic membrane to the malleus handle is of importance in order to allow good sound conduction to middle ear prostheses in the high frequency range. Furthermore the contact of prostheses to the stapes head or the footplate may influence hearing results. In our investigations the angle of prostheses towards the tympanic membrane and the stiffness of coupling plays an important role. Concerning the angle it is of importance to distinguish between the x and y – direction. An absolutely stiff contact between malleus and stapes can reduce the sound transfer and increase the risk of prosthesis dislocation or even damage of the annular ligament. Even nowadays modern middle ear reconstructions can only simulate the simple function of a columella. In future it may be important to invent middle ear implants which will be able to fulfill both required middle ear functions – the sound transfer and the compensation of atmospheric pressure changes. It can be assumed that hearing results may improve due to an unstressed coupling of middle ear prostheses by taking the above mentioned techniques and findings into consideration.