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Clinical Significance of Stapedioplasty Biomechanics: Swimming, Diving, Flying after Stapes Surgery

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Abstract

A piston prosthesis in stapedioplasty significantly modifies the function of the normal ossicular chain. Due to the fact that the ear works as a pressure receptor, a piston prosthesis will be displaced at ambient air pressure changes in a different way than the normal stapes. Our ear is constantly exposed to these pressure changes in daily life, for example during swallowing, with tubal opening, with wind gusts at the external ear, during flying, or diving. Temporal bone experiments showed that elevated static pressures, like in tympanometry, can displace a piston up to 0.5 mm in the vestibule. These large movements, which are caused by the missing attachment of the piston to the annular ligament, may explain why a short piston can be lifted out of the footplate perforation (e.g. after sneezing) or a piston with excessive length might come into contact with the membranous labyrinth, causing vertigo with an inward movement. Flying or diving can be performed by the patients after stapedioplasty, provided that a test with tympanometry is tolerated without evoking vertigo.

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The middle ear, working as a highly sensitive pressure receptor, not only transmits the acoustic sound pressure to the inner ear, but is also exposed to enormous changes of ambient atmospheric pressures: the sound pressure at the pain threshold (114 dB) reaches 10 million μPa , which corresponds to a static pressure of 1 mm water column (daPa). However, atmospheric pressures of several 100 mm water column are tolerated by the ear without any problem. Our ear is constantly exposed to these pressure changes in daily life, for example during swallowing, with tubal opening, with wind gusts at the external ear, in tympanometry or pneumatic otoscopy, during flying, or diving.

A pressure change of ± 400 mm H_2O (daPa) displaces the tympanic membrane and the malleus inwards and outwards up to 1 mm. In the normal ossicular