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Mechanics of Human Hearing

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Abstract. For a mathematical description of the hearing process, suitable models are necessary. Applying Finite Element method or Multibody systems approach, the equations of motion are generated for mechanical models of the human middle ear. The estimation of the belonging mechanical parameters are based on measurements from clinical practice and the lab. Simulations of particular sound events offer an insight into the complex dynamical behavior and allow a reflection about mechanisms of hearing injuries. The sound transfer in normal, pathological or reconstructed situations with passive or actively driven implants is studied depending on the kinematical concept of driving and the coupling of implants and ossicles. Feedback effects and distorted sound transfer is considered. The aim of this research is a detailed mechanical description of the hearing process to investigate the influence of spatial motions of the stapes on hearing sensation, to support the development of passive and active implants and to give instructions for its practical use.

Key words: *Human middle ear, Sound transfer, Mechanical models, Reconstructed ear, Feedback, Distortion.*

This text is an excerpt from the book *Computational Models in Biomechanics*, edited by E. B. de Las Casas and D. C. Pamplona. Barcelona: CIMNE, 2003.

1. Introduction

Airborne sound as pressure fluctuations p is superposed to the static pressure p_{stat} and can be sensed by humans in a highly dynamical process in the range between 16 Hz and 16 kHz. One path to the receptor cells of the inner ear is by structural vibrations via bony structures of skull (med.: bone conduction) the other is via the middle ear (med.: air conduction). In air conduction the sound pressure p is transformed by the ear drum into mechanical vibrations of ear drum and ossicular chain consisting of malleus, incus and stapes, Figure 1. A small part of the airborne sound is transferred through the air filled tympanon. It is ventilated by the eustachian tube and the mastoidal cavities act as buffer.