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Mechanical problems in human hearing

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A description of the hearing process is given using three-dimensional mechanical models. By means of simulation normal, pathological and reconstructed situations can be investigated. The development of new concepts and prototypes as well as the optimization and the way of insertion of passive and active implants is facilitated by carrying out virtual tests. Mechanical models of spatial structures of the middle ear and its adjacent regions are established by applying multibody systems and finite element modeling approach. In particular, the nonlinear behavior of the elements is taken into account. For the determination of parameters such as coupling parameters in reconstructed ears, measurements using laser Doppler vibrometry (LDV) were carried out. The governing differential equations of motion allow the investigation of transient and steady state behavior by time integration and frequency domain methods. Optimization methods can be applied for determination of design parameters such as coupling stiffness and damping, the characteristics of actuator, the position of attachment and direction of actuation. Mechanical models enable non-invasive interpretation of dynamical behavior based on measurements such as LDV from umbo or multifrequency tympanometry. It is shown: The transfer behavior is depending on static pressures in the ear canal, tympanic cavity or cochlea. For reconstructed ears, the coupling conditions are governing the sound transfer substantially. Due to restricted coupling forces the excitation of inner ear is limited and the sound transfer gets distorted. Other sources of distortion are nonlinear coupling mechanisms. In reconstructions with active implants, the actuator excites the microphone whereby feedback effects may occur.