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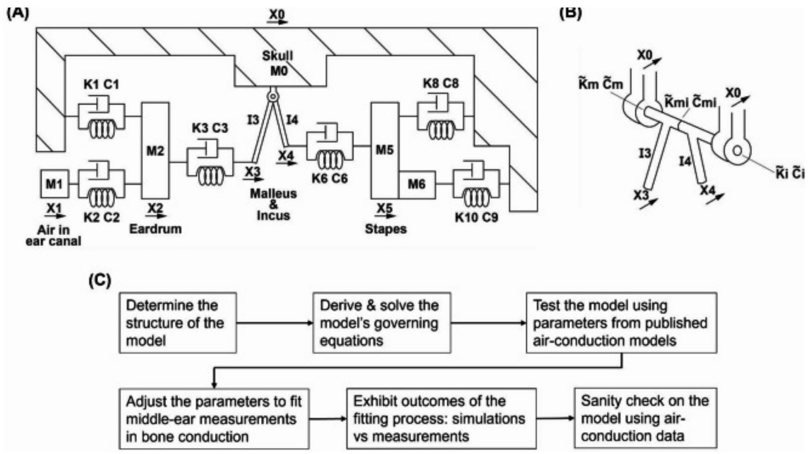
HYPERACUSIS RESEARCH
Stop Noise-Induced Pain



This graphic in Scientific Reports shows the schematic of the lumped-element model of the human ear (A), the detailed schematic of the two of the tiny ear bones (ossicles) malleus and incus (B), and the workflow from solving the model, constraining its parameters, to validating the simulations (C).

A Computer Model of the Human Middle Ear to Better Understand Bone Conduction

Bone conduction is an important modality of hearing. It allows us to hear through vibrations in the skull. It also helps differentiate between conductive and sensorineural hearing loss. Conductive hearing loss is a problem with the outer or middle ear, while sensorineural hearing loss is when there is a problem with the inner ear. In addition, bone conduction allows us to perceive sounds despite a disabled middle ear, and listen to conversation and music privately without blocking the ear canal.

Yet the mechanism underlying bone conduction is not fully understood mainly because the bone-conducted vibrations in the skull simultaneously stimulate the outer ear, the middle ear, and the cochlea. The nature of the parallel stimulation on those interconnected parts makes it difficult to contemplate the dynamics in each compartment and the influences they impose on one another.

As published in Scientific Reports in July 2025, Xiying Guan, Ph.D., describes developing a human ear computer model for bone conduction. The model comprises lumped (simplified) mechanical components—masses, springs and dampers—to represent structures such as eardrum, ossicles, ligaments, joints, and cochlear fluid.

He adjusted the parameters of those components by fitting the simulated ossicular vibrations to the measured counterparts of the most extensive bone conduction middle ear dataset. In other words, he "tuned" the computer model so its simulated results lined up closely with real world data on how the tiny bones of the middle ear (the ossicles) move during bone conduction.

The results show that the model-predicted vibrations generally match the experimental results not only in a typical ear condition but also after various altered conditions, such as adding mass on the eardrum.

This new computational model can serve as the bedrock not only to better understand how the middle ear vibrates during bone conduction and what may cause bone-conduction hyperacusis, but also to develop new diagnostics for middle ear conditions and inform the design of novel hearing devices.

This is adapted from the paper in Scientific Reports. Xiying Guan, Ph.D., is an assistant professor of audiology in the department of communication sciences and disorders at Wayne State University in Detroit. His 2016 ERG grant was generously funded by Hyperacusis Research.

For references, see hhf.org/references.