Acoustics of the ear canal and middle ear cavity probed with high spatial resolution

Christopher Bergevin[1], Elizabeth Olson[1]
[1]Columbia University

The tympanic membrane (TM) is a diaphanous cone-shaped structure integral in sound transmission to the inner ear. Given its highly complex mechanical response, the common description of the TM as a piston driven on one side appears too simple within the context of more modern theories of middle ear function. For example, various model classes incorporate traveling waves along the TM surface, or sound radiation on the backside of the TM into the middle ear cavity and the subsequent reflections from the back bony wall. Our present goal is to measure ear canal and middle ear cavity acoustics in order to determine the validity and relative importance of these considerations, and ultimately what they imply for TM function. We report data from gerbil (Meriones unguiculatus), using miniaturized pressure sensors (Olson, 1998 JASA 103:3445-3463) that allow for measurement in small spaces, sensitivity out to 60 kHz, and fine spatial resolution (on the order of 10 um). Several salient results are noted here. First, the pressure measured across the TM (middle ear cavity relative to canal) close to the TM surface revealed a significant, frequency-dependent drop of ~10-30 dB. This finding argues against sound reflections from the back cavity wall having a significant effect upon TM motion. Second, pressure measured along the canal-side face of the TM, within ~20-30 um of the surface, revealed variations on the order of 10 dB or less. Further study is needed to determine if these variations can be linked to the TM's complex wave-like motion. Lastly, postmortem experiments where the temporal bone is presumably drying out, indicate that the TM impedance can significantly affect canal acoustics, such as standing wave notch frequencies.