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Invited Paper
Middle ear morphometry from cadaveric temporal bone micro-CT imaging

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Purpose: Our goal is to develop anatomically based biomechanical models of middle ears for which middle ear morphometry data is critical. To obtain morphometry of the middle ear, histological methods have been the primary technique. However, this technique is destructive and certainly not appropriate for in-vivo imaging of individual subjects. One of the most recent advances for obtaining anatomical information is computed-tomography with um resolutions (microCT). This has been used to obtain volume reconstructions of the temporal bone of living subjects at a resolution of less than 125 μm. In-vitro resolution can be increased by an order of magnitude. Here we describe methods to determine parameters, needed for computational models, from the microCT imaging modality. Material and Methods MicroCT images, at 10-20 um resolution (both in plane and out of plane), were obtained from cadaveric temporal bone ears of human, cat, chinchilla and guinea pig using a Scanco VivaCT 40 scanner. The high-resolution images (1000 to 2000 slices) were used for 3D reconstructions of the ossicles, suspensory ligaments and tendon, tympanic membrane eardrum curvature and its relative position in the ear canal, tympanic membrane thickness, and middle ear cavities.

Results: Results indicate significant inter-subject variability amongst individual subjects and across species. Morphometry measurements will include calculations of: (1) principal axes and principal moments of inertia of the malleus-incus complex and stapes, (2) dimensions and angles of suspensory ligament and tendon attachments relative to the principal axis, (3) malleus-incus joint spacing, (4) Eardrum thickness as a function of position, (5) middle ear cavity volumes and location of septa and foreman (when present).

Conclusions: Most of the middle ear structures, including the tympanic membrane cone shape and thickness, ossicles, and suspensory soft tissue, can be visualized because there is often good density contrast between these structures and air in the ear canal and middle ear cavity. Because they provide the best resolution, histological methods remain the standard. However, microCT imaging offers some distinct advantages (Decraemer et al. 2003, JARO). These include: (1) elimination of stretching distortions commonly found in histological preparations, (2) use of a non-destructive method, (3) shorter preparation time (hours rather than 12-16 months), and (4) results already in digital format.