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Bone density distribution in the human auditory ossicles: A synchrotron-based phase-contrast microtomography study of the human middle ear

The human middle ear hosts the three auditory ossicles, which ensure sound transmission from the environment to the inner ear through impedance matching. Unlike for long bones, the ossification of the human hearing bones is completed shortly after birth, and only little ossicular remodeling of the bone has been observed afterwards[1-4]. Nevertheless, studies have shown that the overall mineralization is much higher than for long bones[2]. Accordingly, the mineralization of the ossicles is crucial for the proper functioning of sound transmission[1-5]. Previous literature also hypothesizes that, similar to long bone, there is a different degree of bone remodeling, and hence bone density, along the ossicles due to the different loads in this tiny biomechanical system[3,6]. But, little is known about the bone density distribution along the human ossicular chain and within each ossicle itself.

In this study, we used synchrotron-based X-ray phase-contrast microtomography to scan three fresh-frozen human middle ears at the TOMCAT beamline (X02DA) of the Swiss Light Source (Paul Scherrer Institut) at a pixel size of 2.75µm.

We reconstructed the datasets using the phase retrieval method of Paganin[7] to obtain the best possible contrast for defining the bone density distribution. However, to calculate the volume and porosity of each ossicle, we used the reconstructions in absorption only to ensure the best resolution. This gained knowledge will help the ENT community to understand the pathophysiology of the middle ear ossicles better and therefore improve the surgical outcome of autologous graft placement.

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