Synchrotron-radiation-based micro computed tomographic imaging of the human Organ of Corti

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The human hearing apparatus has found wide attention in many areas of science. Due to its anatomical, biochemical and functional complexity it is subject to intensive research. High-resolution investigations, however, cannot be performed *in vivo*. Furthermore, structural studies are *per se* destructive, histological sections are mostly used. For the immuno-histochemical, microscopic, and electron-microscopic studies the cochlea has to be destroyed; classical medical imagery has insufficient spatial resolution. Synchrotron-radiation-based micro computed tomography (SRμCT) is non-destructive and provides a spatial resolution down to the sub-cellular level. Consequently, SRμCT could be appropriate for a detailed study of the cochlea and the Organ of Corti itself with equidistant, high resolution and homogeneous spatial resolution in all coordinates.

The cochlea was explanted from a cadaver in a suitable time window post mortem, prior to the onset of autolytic destructive processes. The bony hull was drilled away as completely as possible, without destroying the cochlea itself. The specimen was further prepared and fixated in Karnovsky solution, buffered with Caco and ethanol. Preliminary SRμCT-experiments have shown that freshly explanted cochleae from untreated human cadavers do not exhibit sufficiently high x-ray absorption contrast to visualize the tiny features of the soft-tissue structures of the Organ of Corti. Therefore, the specimen was stained with 1% OsO_4 for 45 minutes and subsequently fixed in SPURR, a standard procedure in classical histology. Using the setup for tomography in absorption contrast mode at the beamline BW 2, we have obtained tomograms that reveal the complex anatomy of the human hearing organ, almost comparable to histological sectioning. It is possible to differentiate single-layer cellular membranes, inner and outer hair cells, and other structures on the micrometer scale. The osseous structure of the cochlea, specifically the center of the spiral arrangement of the cochlea, the modiolus, and the radially extending orrary structures that support and host extremely complex neural and vascular structures of the cochlea can be imaged and are shown in the figure.

Currently, we investigate the vascular system of the human cochlea, viz. at the spiral ligament and inside the lamina radialis, in detail. This will provide a better understanding of the blood supply and will allow the creation of more sophisticated models of the cochlea for educational purposes. Moreover, these studies will eventually enhance the understanding of inner ear diseases. Even more important is the visualization of the filigree membranes, which are shown in the inset of the figure. These spatially isotropic data allow creating models in 3D space and can subsequently be incorporated into physical models and advanced simulation to better decode the physics of sound perception.

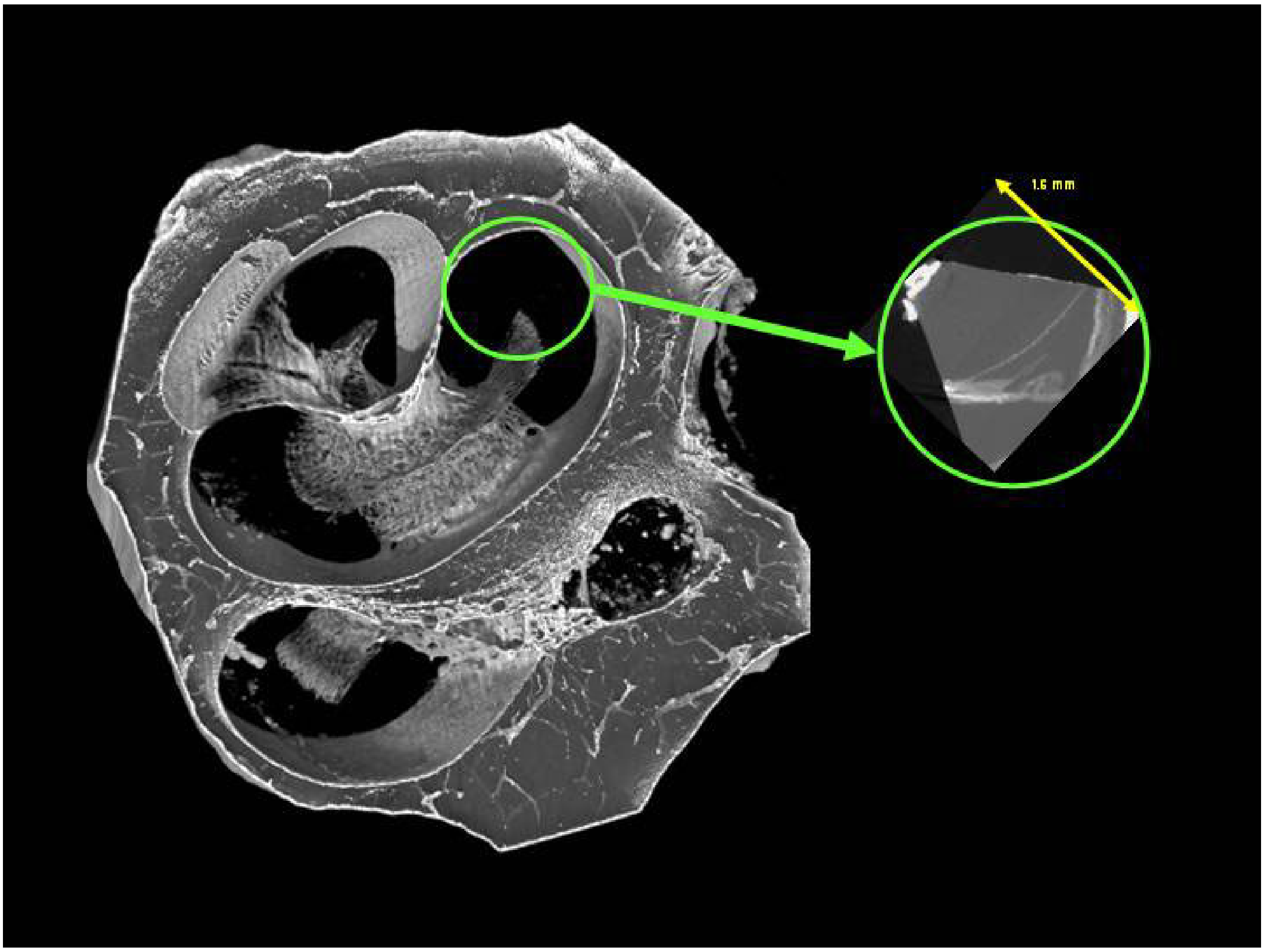

Figure: The highly detailed three-dimensional representation of the osseous structure of a human cochlea shown with SRµCT. SRµCT combined with the appropriate sample preparation allows resolving the *lamina radialis*, the radial ray-like structures pointing from the axis of the cochlea - the *modiolus*. The radio-dense structures in the petrous bone hosting the cochlea can be interpreted as nourishing vascular structures of the petrous bone.

The inset demonstrates the excellent level of detail in uncovering cellular membranes, i.e. Reissner´s membrane and other sub-structures of the Organ of Corti, viz. the tectorial membrane, supporting cells, and even Nuel´s space. These images were obtained at the photon energy of 22 keV with a spatial resolution of 2 µm; the edge length of the inset is 1.6 mm (arrow).