Three-dimensional imaging of brain tissue by grating-based micro computed tomography using synchrotron radiation

Simone E. Hieber[1], Christos N. Bikis[1], Anna Khimchenko[1], Georg Schulz[1], Gabriel Schweighauser[2], Jürgen Hench[2], and Bert Müller[1]

[1]*Biomaterials Science Center, University of Basel, Basel, Switzerland.* [2]*Institute of Pathology, Department of Neuropathology, University Hospital Basel, Basel, Switzerland*

INTRODUCTION: Imaging the brain tissue remains a challenge for both clinical and laboratory purposes. Presently, magnetic resonance (MR) imaging is considered the method of choice for three-dimensional visualization of soft tissues, but synchrotron radiation-based micro computed tomography (SRμCT) in phase contrast mode reaches comparable contrast without the application of contrast agents and with a higher spatial resolution relative to MR microscopy.[1] Thus, human brain tissues were scanned to prove the performance of the grating-based method.

METHODS: *Post mortem* samples of the cortex were cut from a human brain of a 73 year-old male who suffered from ischemic stroke. The samples were selected to represent both healthy and diseased tissue. The specimen were fixed in 4 % histological grade buffered formalin, dehydrated in ethanol, transferred to xylenes and embedded in a paraffin/plastic polymer mixture (Surgipath Paraplast®, Leica Biosystems). Cylindrical punches measuring 6 to 9 mm in diameter were extracted from the paraffin blocks. The specimens were scanned at the beamline ID 19 (ESRF, Grenoble, France) with a photon energy of 19.5 keV using synchrotron radiation. The grating-based phase imaging resulted in an effective pixel size of 5 μm. Over a range of 360° 1199 projections with four phase-stepping images over one period of the interferometer fringe pattern.

RESULTS: The grating-based phase tomography data reveal a variety of tissue types including white and gray matter. It should be highlighted that one can distinguish between the healthy and necrotic tissue of the neocortex as demonstrated in the selected virtual slice in Fig. 1. The brain tissue, represented in the upper part of the image with a light gray color, was affected by a stroke and therefore has been degenerated. Presumably located in the gray matter, the boundary between the healthy and diseased tissues is well defined. Blood vessels visible in black could be identified in the gray (darker gray color) and the white matter (medium gray color). They are orthogonally oriented to each other.

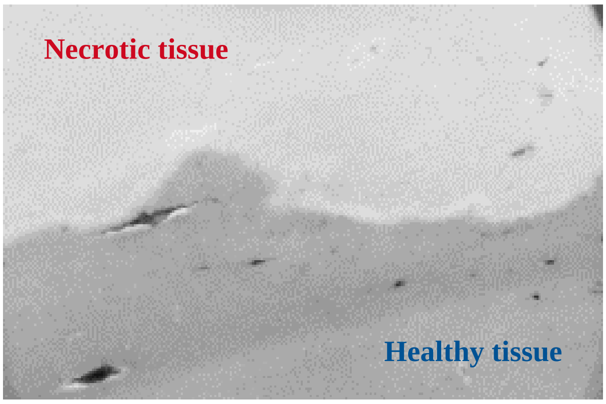

Fig. 1: Reconstructed slice of a human brain tissue scan. The upper part shows necrotic brain tissue due to a stroke that clearly separates from the healthy part represented on the bottom. The slice corresponds to an area of 4.2 mm × 2.8 mm.

DISCUSSION & CONCLUSIONS: Grating-based micro computed tomography is a powerful modality to image human brain tissue *post mortem*. The data sets feature a comparably high contrast at reasonable spatial resolution. Using propagation-based methods the spatial resolution can be further improved but the contrast becomes weaker.[2] The presented tomography data will serve for the selection of the histology slices to be prepared. As histology also yields functional information the two methods are regarded as complementary.

REFERENCES: [1] G. Schulz et al. (2012) *Multimodal imaging of human cerebellum - merging X-ray phase microtomography, magnetic resonance microscopy and histology* Sci Rep **2**:826. [2] S. Lang et al (2014) *Experimental comparison of grating- and propagation-based hard x-ray phase tomography of soft tissue* J Appl Phys **116** :154903.

ACKNOWLEDGEMENTS: The project was supported by the ESRF (proposal MD-861).