Absorption-based micro computed tomography measurements of a human knee joint

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INTRODUCTION: High-resolution three-dimensional imaging of soft and hard tissue plays an increasing role in the understanding of the function of joints in health and disease. Micro-computed tomography (µCT) is of special interest because of its high spatial resolution. In particular, it overreaches the resolution of magnetic resonance imaging, which is considered golden standard in clinical imaging of soft tissue, even for post-mortem specimen by far.[1] Its non-destructive nature is often a selection criteria for µCT.

METHODS: The focus of this study is a post mortem human knee joint. Within 24 hours of death the knee of an 87 year-old female was fixed in formalin following the standard protocol of the Institute of Anatomy of the University of Basel. After fixation, the skin, fat and muscle tissue was removed. The goal of this study is producing high resolution images displaying not only bony tissue but also soft tissues including cartilage, tendons and ligaments with reasonable contrast. Absorption contrast based µCT experiments were performed with the nanotom® m holding the knee joint in a polyethylene container filled with the formalin solution to prevent the tissue from drying. The acceleration voltage was 150 kV and the beam current 50 µA using an additional 0.3 mm thin Cu-filter to reduce beam hardening. 2000 projections were recorded over 360 degrees. For each projection angle, the average of 10 single projections was chosen. The exposure per projection was set to 0.5 s. The resulting isotropic pixel size was 30 µm.

RESULTS: The bones are clearly represented with a high contrast allowing insights in the subarticular bone structure. The surrounding cartilage layer on the artificial surface of the femoral condyles and on the tibial plateau can be clearly distinguished along its tissue border demarcation. Also the quadriceps and patellar tendon is visualized with micro meter resolution giving a view on its fibrous strands. The cruciate ligaments and menisci are distinguishable but only partly seen on the selected image (Fig. 1).

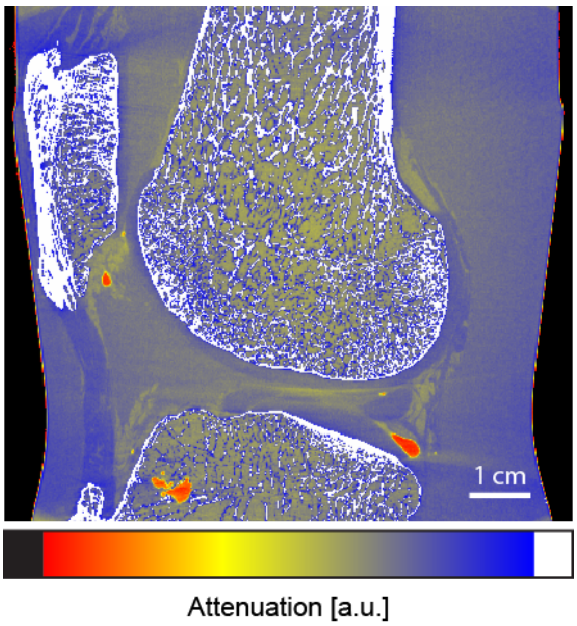

Fig. 1: Sagittal section through medial femur condyle of left knee.

DISCUSSION & CONCLUSIONS: Further preparation of the knee, in particular segmentation into smaller pieces will allow for a resolution down to a few microns. Not entirely satisfying is the contrast of the soft tissue, e.g. menisci and cruciate ligaments. Also artefacts shown in red color interfere with the actual image information. Measurements using phase-contrast modes will have the power to improve contrast for soft tissues and to reduce artefacts in the vicinity of bones.[2] Therefore, further measurements using grating-based phase contrast method promise more detailed imaging of soft and hard tissue.[3]

REFERENCES: [1] G. Schulz et al. (2012) Sci Rep **2**:826. [2] M. Holme, G. Schulz, H. Deyhle, et al. (2014) *Nat. Protoc.* **9**:1401–15. [3] J. Li et al. (2009) Osteoarthritis and Cartilage **17**(9):1193-96.