Monitoring of bone and cartilage pathologies by diffraction-enhanced imaging (DEI)

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Standard technologies for diagnosis of joint disorders include conventional X-ray techniques. This method is however hampered by limited resolution and by the inability to visualize tissue with low or absent mineralization. In contrast, DEI [1] allows separation of the absorption part and the scattering part of X-ray radiation from a sample. The combination of these properties permits to visualize soft tissue as well as bone in the same image. Selected specimens of human normal tissue samples and samples with arthritic changes were brought into the beamline W2 at HASYLAB. The linescan system included a parallel monochromatic beam behind a tunable monochromator and a silicon (111) crystal analyzer rotated in defined angles (micro radians) with a piezoelectrical drive. The image was captured by a 5 cm wide photodiode array with 25 µm pixel size.

We were able to image cartilage and bone at high resolution. Both tissues revealed major changes in their internal structure when affected by osteoarthritis or necrotic processes in the underlying bone of the joints. It appears that DEI might prove to be a valid method for early diagnosis of joint diseases.

Figure: A comparison between a healthy and an arthritic human hip head in a refraction image from DEI. The arrow points into an artificial defect (removed plug) of the joint cartilage, visible in the healthy joint as a relatively homogenous „glassy“ structure and separated from the underlying bone by a defined dark line, the subchondral bone plate. Pointing to the left next to the arrow is a severed ligament (*) that holds the hip head within hip cup and that is deeply inserted within the joint cartilage. The bone itself displays concentric trabecular elements, which consist of bone mineral. In case of the diseased hip head in the right image, cartilage and ligament are transformed into a fibrous tissue, the subchondral bone plate has disappeared and is replaced by irregular trabecular structures. The normal bone trabeculae have partially disappeared (+) and their orientation is severely disturbed.

References