

Application of the Analyzer-Based Imaging Technique on Cartilage and on Metal Implant Healing Study at the ESRF

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Monitoring the progression of osteoarthritis (OA) and the effects of therapy during clinical trials is still a challenge for present clinical imaging techniques since they present intrinsic limitations and can be sensitive only in case of advanced OA stages.

In very severe cases, partial or complete joint replacement surgery is the only solution for reducing pain and restoring the joint functions. For this reason, the precise determination of the state of bone ingrowth into the microscopic vicinity of the metal implants is a crucial issue in implant surgery. Unfortunately, the low local resolution caused by beam hardening at the metal surface in conventional radiography highly impairs the evaluation of the healing process.

Poor imaging quality in practically all medical imaging technologies with respect to joint surfaces and to metal implant imaging calls for the development of new techniques that are sensitive to stages preceding the point of irreversible damage of the cartilage tissue.

In this scenario, X-ray phase contrast modalities could play an important role since they allow to observe contrast due to the phase modulation of the signal, even if the amplitude modulation is weak or absent, with a tissue radiation dose similar or even reduced compared to conventional absorption radiography. In this study, the Analyzer-based imaging (ABI) technique allowing non-invasive 3-dimensional visualization has been successfully applied in vitro on excised human samples and sheep implants and in vivo on an animal model.

ABI can provide dramatic gains in contrast over conventional radiography by utilizing X-ray refraction and scatter rejection in addition to the absorption of conventional technique.

Pathological and healthy joints as well as metal implants have been imaged in projection and computed tomography ABI mode at high resolution and clinically compatible doses (< 10 mGy). Volume rendering and segmentation permitted to visualize the cartilage from volumetric CT-scans. Images of the same samples were compared with conventional CT scanners and MRI, used as golden standard; histology provided the final diagnosis.

Results demonstrated that ABI can provide an unequivocal non-invasive diagnosis of the state of disease of the joint and be considered a new tool in orthopaedic research.

KEYWORDS: Osteoarthritis; metal implant healing; analyzer-based imaging; 3D rendering