Medical Applications

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Imaging and diagnosis of the joint disease by means of DFI

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Introduction

The anterior cruciate ligament (ACL) is the major stabilizing ligament of the knee joint. The ACL is located in the centre of the knee joint and runs from the femur to the tibia, through the centre of the knee joint. Usually the tearing of the ACL occurs with a sudden direction change or when a deceleration force crosses the knee joint. The diagnosis of a tearing ACL is usually performed by an X-ray imaging with a stress test and/or a magnetic resonance imaging (MRI) at the knee joint. Since the ACL do not heal on its own, the ACL reconstruction is surgery to replace the ligament in the centre of the knee with a new ligament. The most common reconstruction involves harvesting the patellar tendon (BTB) or the hamstring tendon (STG). After surgery, recovery varies highly form case to case, medical assessment of the reconstructed ACL have been performed by knee-arthroscopy and physical therapeutic methods. If the reconstructed ACL image and process of the reconstruction are observed by the X-ray DFI (dark-field-imaging), most patients will be spared by the puncture pain of the knee at the post-operative arthroscopy.

Experiment

The top view of the experimental arrangement for the DFI including a Si (220) Laue-analyser is shown in Fig.1. The vertical and horizontal sizes of the exposure field are 30 mm and 34 mm, respectively. The inclination of the Si Laue-analyser was adjusted on the vertical and horizontal planes in the micro-radian scale to keep the dark-field conditions [(1)]. The forward diffracted image was detected by a mammography film that spatial resolution was on the order of 5μm. The sample used was the raw knee joint bone of the Landrace Large-White Duroc (LWD-pig). The diameter of the drilled tunnel is about 8 mm, through which the new ACL (raw STG of the LWD-pig) about 6 mm width was inserted.

The X-ray image of the sample is shown in Fig. 2. The new ACL in the drilled bone is clearly delineated by the DF image. Present image quality do not describe the fine structures of the ligament because of the overlap by the trabecula bone in the femur. In comparison with the image quality of the MRI, the DFI presents better signal-to-noise ratio on the ACL image and there are no image-artefact at the screws or clips in the femur [(2)].

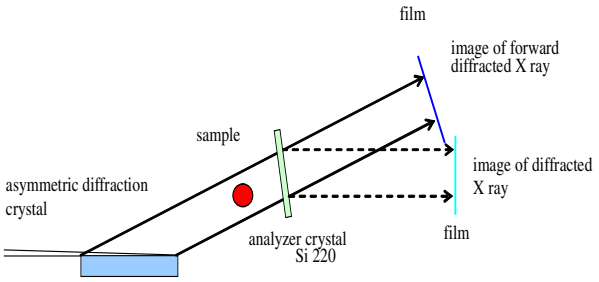

Fig. 1 Imaging system for the DFI
The surface of the asymmetrical crystal had a 5 degree inclination to the Si (220) plane. The X-ray energy for imaging is 30 keV. Typical exposure time for the film-imaging is 3 min. at the single-bunch operation.

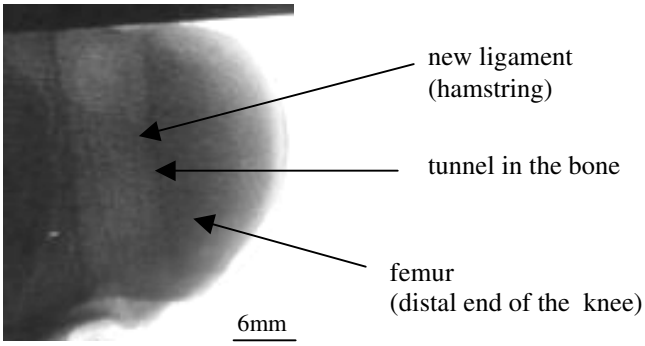

Fig. 2 X-ray image of the forward diffracted X-ray
The new ligament in the bone tunnel is clearly observed. The procedure of medical reconstruction of the ACL is explained as follows. The reconstruction begins with a small incision in the leg where small tunnels are drilled in the bone, next a new ACL (BTB or STG) is pulled through the bone tunnel. Usually, the new ACL is held in place with bio-absorbable screws or clips.

References

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