EUROPEAN SYNCHROTRON RADIATION FACILITY
INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Monitoring Titanium implant ingrowth into bone by Diffraction Enhanced Imaging	**Experiment number**: MD74
Beamline: ID17	**Date of experiment**: from: 25 April 2004 to: 02 May 2004	**Date of report**: 06 September 2005
Shifts: 9	**Local contact(s)**: Alberto BRAVIN	*Received at ESRF:*

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Report:

The precise determination of the state of bone ingrowth into metal implants is a key issue in orthopaedic surgery. Even in animal studies, histological evaluation suffers from the fact that it can only give information on very restricted portions of the implant because of the micrometer-scale thickness of individual sections. Conventional radiology is limited in its use in bone/implant evaluation because of physical restrictions originating by the radiographic setup (X-ray tubes, continuous spectrum, imperfect optics, geometry of the beam path). Even though radiography allows the evaluation of an implant as a whole, at least along one axis of sight, it is finally hampered by low local resolution caused by beam hardening based on the incident polychromatic light, thus, resulting in un-correctable image errors.
It has been demonstrated DEI provides an indirect measure of the bone/metal implant healing because of its inherent property to generate particular signals from edges. We have found the refraction images to contain the greatest level of information concerning bone ingrowth due to their ability to detect edges – both of tissue and of the implant. Since implants have elaborate edges, in particular when coated with minerals such as hydroxyapatite, the initial X-ray refraction signal from those edges is particularly intense, as seen in our un-implanted samples. Any ingrowth of bone into these three-dimensional edge structures will weaken the signal, thus providing an indirect measure of implant integration (figure 1)
Thanks to results obtained during this beamtime, we are able to prove that DEI may allow for destruction-free determination of implant healing in animal models, avoiding elaborate sample preparation for histology or destructive mechanical testing.

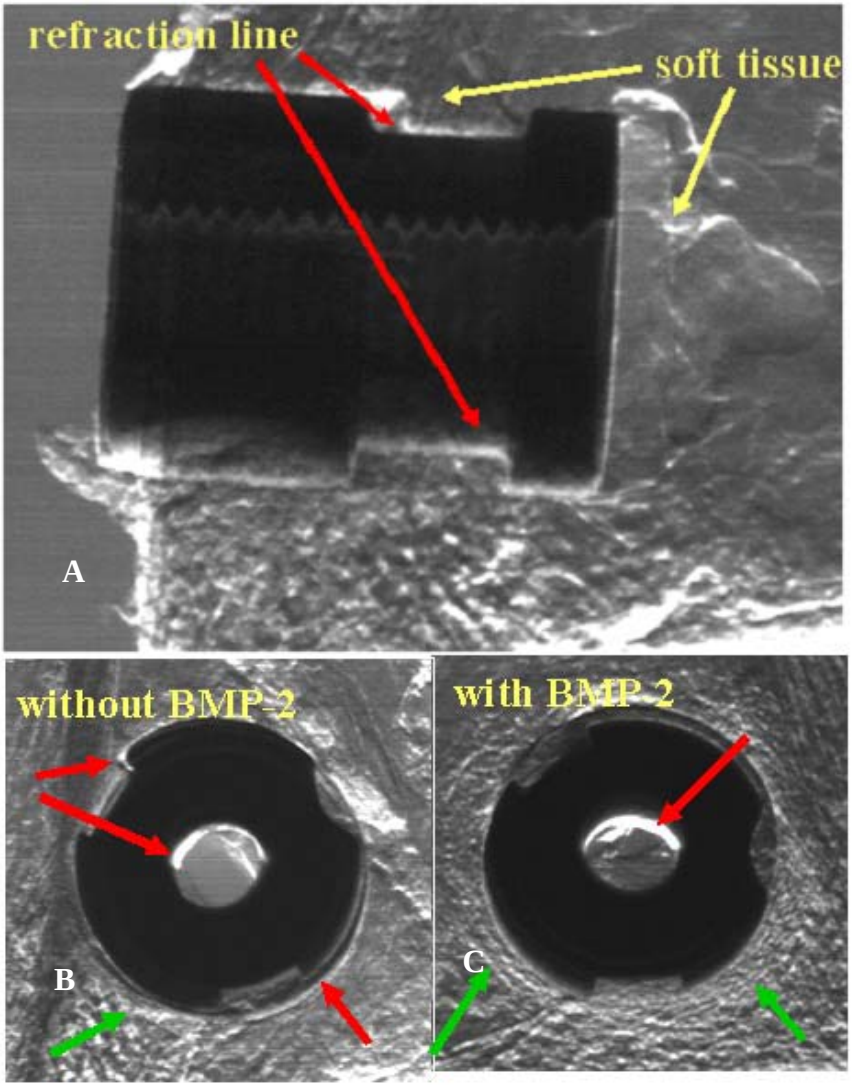

Figure 1. Sheep implants with and without ingrowth factor (BPM-2): DEI images at 50keV. Note the blank resp. white refraction lines around the BMP-less cylinder in A and B. Histology (not here presented) indicates absence of new bone in this regions. The intricate trabecular network visible in C is highly suggestive and corresponds to the BMP-2 treated cylinder which is surrounded by re-oriented trabecular elements. DEI reveals the correct state of healing by displaying both features that signal correct healing: lamellar re-orientation together with loss of edge signals in the BMP-2 coated sample whereas the image gained from the control still highlights the edges of the drilling canal.