EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: High resolution Phase Contrast Imaging of ex-vivo maturating cartilages.	**Experiment number**: MD1097
Beamline: Id17	**Date of experiment**: from: 9 .02.2018 to: 12.02.2018	**Date of report**: 13.03.2018
Shifts: 9	**Local contact(s)**: Herwig Requardt	*Received at ESRF:*

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Report:

Scientific background and objectives

Osteoarticular diseases are the most prevalent chronic pains and long term disabilities with hundreds of millions people affected worldwide. The potential benefits of a therapeutic strategy is a complicated task due the lack of imaging modality able to assess structural changes in cartilage tissues. Indeed no x-ray imaging technique presenting a sensitivity good enough for all the different tissues of the joint and/or a sufficient 3D spatial resolution, exists today to allow for this early stage detection of the different illness. For instance, the performances of X-ray absorption based CT restrain its use to bone defects and indirect cartilage depiction whilst MRI struggle to render properly the bony changes and the micro- calcifications. In contrast, X-ray Phase Contrast Imaging (PCI) provides enhanced contrast of the various joint tissues. X-ray near-field speckle based imaging (SBI) [1,2] has been recently introduced and form a new class of X-ray PCI technique sensitive to the first derivative of the phase. The main advantage of the SBI technique is its relatively simple experimental setup. Motivated by previous works (md1012), we imaged small volumes of ex-vivo cartilages biopsies as well as full mice joints at an intermediate resolution (6.1µm) in order to achieve a better understanding of osteoarticular disease as well as the cellular transformation during cartilage maturation from samples prepared with several cultural media.

Description of the experiment

The acquisitions were divided into four phases:

1) phase-I we imaged the samples with Propagation Based Imaging (PBI) technique
2) phase-II we tested and chose the speckle generator
3) phase-III we imaged the samples with two different SBI acquisition methods namely XSVT and XSS
4) phase-IV we tested different acquisitions scheme in order to allow a virtual radiation dose reduction

Samples. A total of 60 samples were imaged: bovine cartilage explants and mice joints (excised under sterile conditions). In order to be quantitative we also imaged home-made contrast and resolution phantoms.

PCI set-up. The photon energy peak was set at 52 keV. The phase contrast images were acquired by using a PCO (5.5) camera with a resulting pixel size of 6.1µm. For the SBI experiment we used sandpaper and home made diffusor membranes to obtain a random speckle.
PCT image reconstruction and analysis. The propagation images were first reconstructed by FBP algorithm. The data processing consists in the reconstruction of the CT data by using different CT algorithms. Our main purpose is to investigate matrix structure of the samples for a better understanding of osteoarticular diseases on different models. The data reconstruction and processing is presently in progress; the first reconstructions shows promising results. Our results will be compared to conventional imaging modality as MRI or standard micro-CT.

Preliminary results

The first phase of the data processing has consisted in reconstructing the CT images by using the standard filtered back-projection algorithm and Paganin phase retrieval method[3]. For the SBI reconstruction part we tested different speckle algorithms (XSS[4] and XSVT[5]) to retrieve the phase signal.
The figure 1 presents an image obtained in PBI and reconstructed with Paganin method. These results are at a preliminary stage as all the processing to reduce the artefacts were not already applied. Nevertheless, all the components of the cartilage matrix of the sample are clearly depicted meaning that these results are very promising and need to be improved. The further step will be an evaluation made by our biomedical partners (CHU Grenoble) to show the potential of PCI and SBI in OA diagnosis and therapeutic follow up.

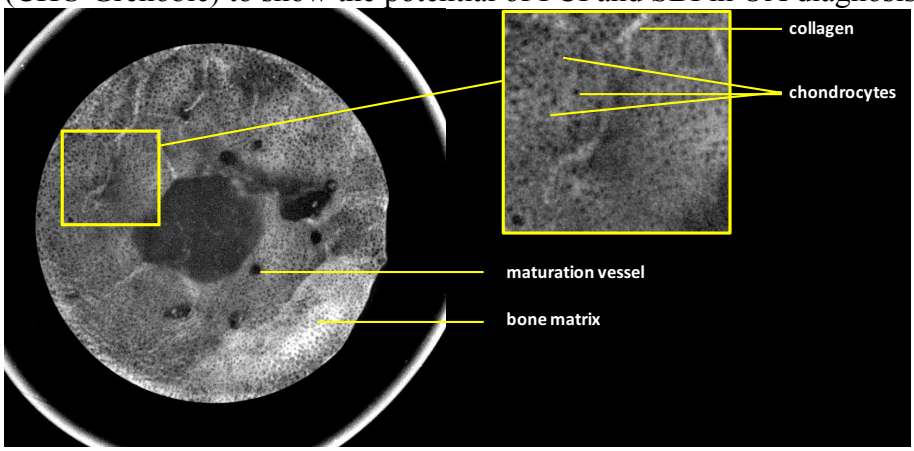

Figure 1: The figure 1 presents a reconstruction of bovine cartilage explant using paganin parameters (6.5µm).

Concluding remarks

Our first goal was to demonstrate the potential PCI and SBI compared to conventional imaging modality as MRI or standard micro-CT.

Our next step will be start clinical experiments by preparing an experiment on in vivo animals.

Acknowledgements

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References

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