| ESRF | **Experiment title:** 3D analysis of implant related particle exposition and the corresponding bone tissue alterations in patients undergoing revision surgery | **Experiment number**: md1300 |
|---|---|---|
| **Beamline**: ID17 | **Date of experiment**: from: 8/10/2022 to: 11/10/2022 | **Date of report**: 5/3/2022 |
| **Shifts:** 9 | **Local contact(s)**: Luca Fardin & Michael Krisch | *Received at ESRF:* |

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## Report

**Background:** The aim of this experiment was to investigate the distribution of implant-derived metal exposure and its effect on bone remodeling and bone marrow matrix composition in samples biopsied during revision surgeries to repair or replace failed hip or knee implants. The samples formed three groups related to different implant types (i.e. metal-on-metal, ceramic hip joint, knee), plus a control group of bone samples not exposed metal particles. Additionally, our in-house developed 3D Organ-on-a-chip model [1] was used to expose bone chips to 3 different particle types (Ti, Co/Cr, ceramic).

**Experiment:** The experiment was awarded 9 shifts of beam time on ID17, during which the samples were scanned using two different pink-beam microtomography setups at pixel sizes of 3.58 µm (the low-resolution (LR) scans) and 0.7 µm (the high resolution (HR) scans). The W150C wiggler gap was set at 75 mm, with 1.13 mm vitrous carbon, 0.92 mm Al, and 0.68 mm Cu filtering to give an average X-ray beam energy of ~55 keV. A total of 609 CT scans were performed, covering the entire sample with z-series of LR scans, and focusing on a central region of interest at the higher resolution. In total we have scanned >60 different bone speimens, each with both resolutions.

**Reconstructions**: The tomographic reconstruction, ring correction, and merging of the zseries scans into single volumes was carried out with the PyHST software on the ESRF cluster. With 21 TB of projection data acquired during the beamtime, this was a time-consuming process, which was further slowed down by some issues with the beamline alignment: due to a slight tilt in the camera axis, automatic finding of the rotation axis position in projection images generally was not successful, and the optimal value had to be manually found for each scan. Additionally, the LR scans suffered from low-frequency ring artefacts (most likely due to doping inhomogeneities in the scintillator), which reduce the visibility of soft tissue in the scans. Most of the acquired scans remain usable, however, and their analysis is ongoing as outlined in the beamtime proposal.

**Results**: Preliminary images of the data show dense particles in many of the implant-exposed samples, mostly in the soft tissue outside of the bone. As can be seen in Fig. 1, these bright particles occurboth as isolated particles, and as agglomerates of many dense particles near the bone surface. The effect of these dense particles on the mineralization and morphology of nearby bone will be a major result of a more in-depth analysis of the images. The image quality is sufficient to also investigate the bone marrow structure which is important for the characterization of *the bone-on-a-chip* samples.

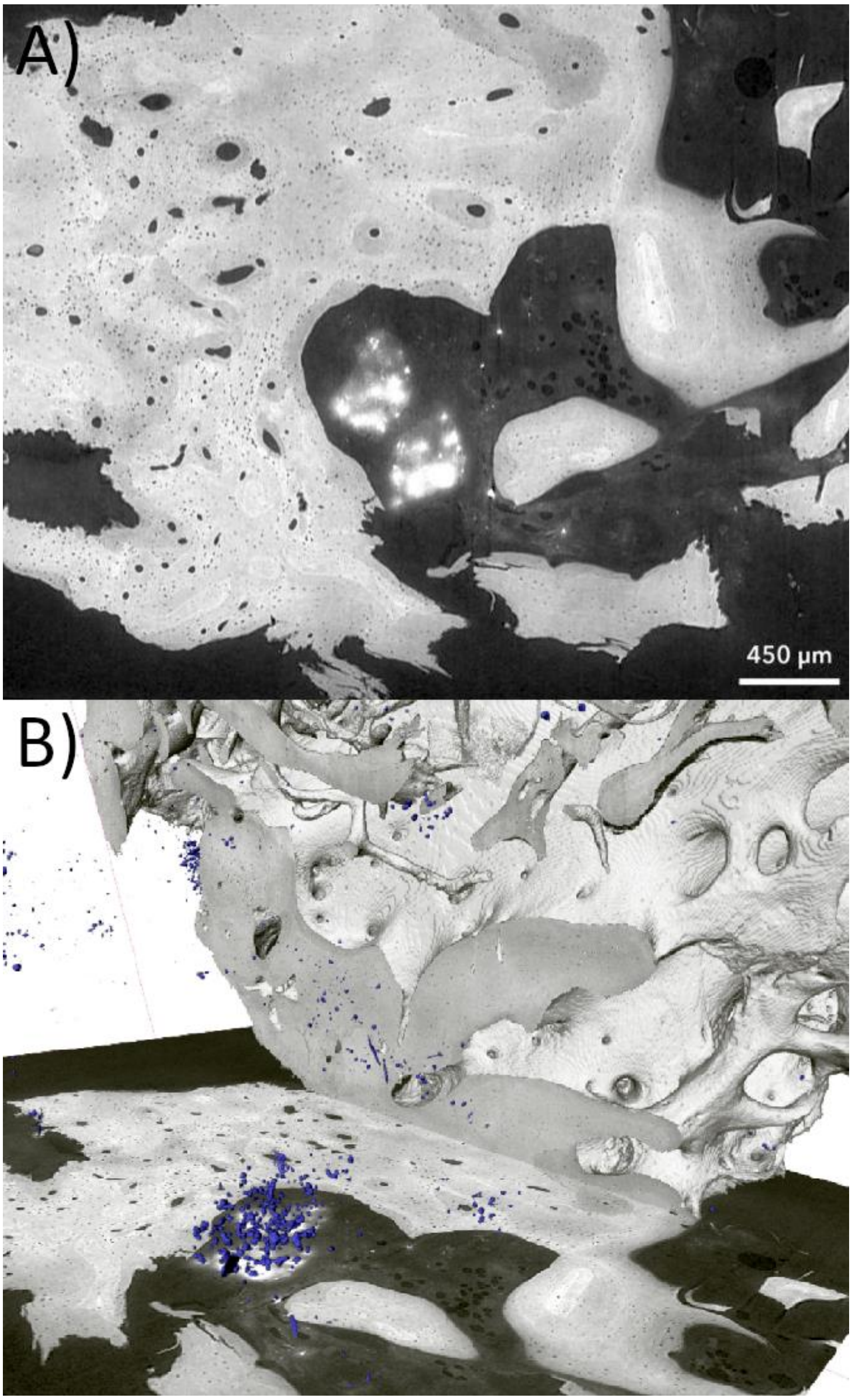


Figure 1: A) A cross-section through one of the implant-exposed samples, showing an agglomeration of metal particles in the soft tissue, as well as isolated, smaller metal particles. Differences in bone mineralization are also clearly visible, with less mineralized bone around blood vessels appearing in a darker shade. The small, dark spots visible within the bone are osteocyte lacunae. B) A 3D view of the same sample, with a rendering of the metal particles in blue, and a partial rendering of the bone volume in white, showing the 3D morphology of the bone.

**References:**

[1] Schoon J, Hesse B, et al.,Geissler S.. Metal-Specific Biomaterial Accumulation in Human Peri-Implant Bone and Bone Marrow. Adv Sci. 2020.