EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Investigation of the chemical causations of peri-implant osteolysis in human bone specimens.	**Experiment number**: MD-1161
Beamline:	**Date of experiment**: **ID16B** from: 2018/07 to: 2018/08 **ID21** from: 2018/06 to: 2018/06	**Date of report**:
Shifts:	**Local contact(s)**: ID16B-NA (C07), 9 shifts, Remi Tucoulou ID21 (C07), 9 shifts, Bernhard Hesse	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Main proposer:

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Report for experiment MD-1161

Proposal Title:
Investigation of the chemical causations of peri-implant osteolysis in human bone specimens.

Proposal summary:
The release of metallic wear and corrosion products from orthopedic implants is a long known but still topical problem in total hip arthroplasty. In previous studies we have proved exposure to multi-elemental metallic nanoparticles in the peri-implant region including bone marrow. Local particle exposure has been correlated to the major clinical problem in joint arthroplasty, the periprosthetic osteolysis. Thus, our first aim is the simultaneous multi-elemental exposure assessment in human periimplant bone sections from patients with artificial hip joints. Secondly, we aim at assessing particle internalization of phagocyting and non-phagocyting cells involved in the maintenance of vital bone tissue homeostasis in the ex vivo samples. We consider ex vivo XRF mapping of peri-implant specimens as an expedient tool to support risk assessment in revision and primary arthroplasty and to guide individual implant choice in the future. By learning more about the biocompatibility

of commonly and newly used orthopedic implant materials, and the local toxicokinetics of released particles we follow the overall aim to keep patients' safety at the highest possible level.

Major findings:
We were able to show that human peri-implant bone and bone marrow are distinctively exposed to metallic micron- and nanoparticles from artroplasty implants [1]. Our work indicates that the metal uptake is explicitly different for cobalt, chromium and titanium. The detected metal quantities and their element- and tissue-specific distribution clearly indicate that a peri-implant membrane does not chemically isolate implant components from bone and bone marrow. Our work reveals toxicokinetic mechanisms and a novel view on the long-term effects of degradation products from metal-based biomaterials in the human body. Our findings request a paradigm shift, considering bone and bone marrow as the relevant organs for pre-clinical testing and post-clinical risk-benefit evaluation of orthopedic biomaterials.

Related Publications:
We were able to publish the research data collected at ID16B and ID21 in *Advanced Science*. The manuscript is the result of a close collaboration between physicists, biologists, physicians, chemists and toxicologists. We are certain that our work is of interest to a broad range of professionals including those who aim to improve patient care, to assess risks and benefits of applied metallic biomaterials and to engineer alternative metal-based biomaterials. Moreover, we are very happy that our work was choosen as a ESRF highlight in 2020 [2].

[1] J. Schoon, B. Hesse, A. Rakow, M.J. Ort, A. Lagrange, D. Jacobi, A. Winter, K. Huesker, S. Reinke, M. Cotte, R. Tucoulou, U. Marx, C. Perka, G.N. Duda, S. Geissler, Metal-Specific Biomaterial Accumulation in Human Peri-Implant Bone and Bone Marrow, Advanced Science (Weinh) 7(20) (2020) 2000412

[2] NEW INSIGHTS INTO METAL DISTRIBUTION IN PERI-IMPLANT BONE AND BONE MARROW, ESRF HIGHLIGHTS 2020, Page 163-164