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Metallic biomaterials in endoprosthetics: The surface microstructure of retrieved hip and knee endoprostheses

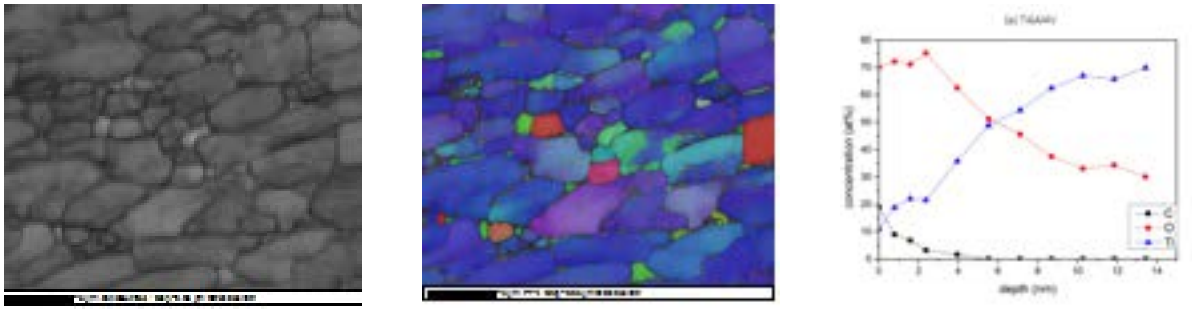
Monika Jenko[1], Matjaž Godec[1], Matevž Gorenšek[2], Boštjan Kocjančič[3] and **Drago Dolinar[3]**
[1]Institute of Metals and Technology, Slovenia
[2]MD-Medicina, Slovenia
[3]University Medical Centre, Slovenia

Statement of the Problem: The endoprosthetics of hip- and knee-joint replacements is currently the most common and successful methods in advanced surgery to treat degenerative joint disease for relieving pain and for correcting deformities. While these surgeries have positive outcomes, approximately 10% of the implants fail prematurely. The most common causes for revision surgeries are aseptic loosening and implant infection.

Orientation: Microstructure is a neglected factor in implant design, and a detailed microstructure characterization is required to determine the role of prematurely failed implants that determine the biological responses, such as the composition and structure of the surface oxide film, the surface contamination and the surface topography. The release of metal ions and the lack of the wear resistance of biomaterials result in implant loosening, which leads to implant failure. The release of metal nanoparticles and polyethylene debris into the soft tissue at the site of the implants is decisive for osteolysis and the implants' longevity.

Findings: The surface chemistry of Ti alloys (Ti6Al4V, Ti6Al7Nb) and the CoCrMo alloy of (retrieved and new) hip and knee endoprostheses components were studied in detail using advanced electron spectroscopy techniques FE-SEM, EDS, EBSD, AES and XPS. We will present the findings from the clinical and materials sciences point of view. All the retrieved implants were sent for sonication in Ringer's solution for cleaning and pathology analysis. Later, they were dried and stored in special sterile Wipak medical Steriking bags. All the X-ray images of implants in the patients are stored in the database of the UMC.

Conclusion & Significance: The surface chemistry results showed that thin oxide films on the Ti alloys prevent further corrosion, improve the biocompatibility, and affect the osseointegration. It is obvious that we need to keep an optimal microstructure with regards to the corrosion and mechanical properties, which can be controlled through processing parameters and be standardized in the near future.



EBSD mapping of Ti6Al4V phases, (a)band- contrast image, (b) phase-map image red Ti (hcp), green Ti -cubic (bcc), (c) AES depth profile of thin oxide film on Ti6Al4V alloy.

Recent publications

1. Jenko M, Gorenšek Matevž, Godec Matjaž, et al. (2018) Surface chemistry and microstructure of metallic biomaterials for hip and knee endoprostheses. Applied Surface Science 427:584-593.
2. Dolinar D, et al. (2018) Biomaterials in endoprosthetics, Materiali in tehnologije 52(1): 89-98,
3. Raphel J, Holodniy M, Goodman S B and Heilshorn S C (2016) Multifunctional coatings to simultaneously promote osseointegration and prevent infection of orthopaedic implants. Biomaterials 84:301-314.
4. Le D H, Goodman S B, Maloney W J and Huddleston J I (2014) Current modes of failure in TKA: infection, instability, and stiffness predominate. Clin. Orthop. Relat. Res. 472:2197-2200.
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Biography

Monika Jenko completed her PhD in Material Science at the University of Ljubljana. For 11 years she was the Director and Initiator at the Institute of Metals and Technologies (IMT) and later joined the Jožef Stefan International Postgraduate School with Advanced Metallic Materials in the frame of the Nanoscience and Nanotechnology study program. She has worked in different national and international projects in the field of Material Science, Applied Surface Science, Surface Engineering, and Nanoscience and has been very active in the field of Biocompatible Materials since the last five years. She has published several papers in reputed journals and is a member of different international working groups.

monika.jenko@imt.si

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