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Intermediary between medicine and engineering: metals

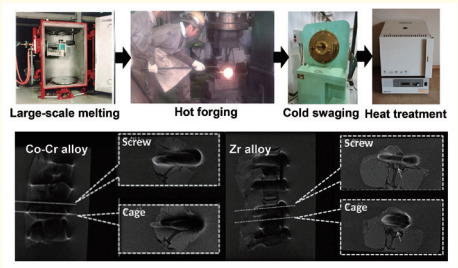
1. **Development of Zr-based alloys for minimizing MRI artifacts**
2. **Bio-functionalization of metals with electrochemical surface modification**
3. **Development of titanium alloys by severe working**
4. **Establishment of nano/micro-topography that controls differentiation of stem cells**
5. **Effort to minimize metal allergy**

1. Ishimoto T, Yamada K, Takahashi H, Takahata M, Ito M, Hanawa T, Nakano T: Trabecular health of vertebrae based on anisotropy in trabecular architecture and collagen/apatite micro-arrangement after implantation of intervertebral fusion cages in the sheep spine, Bone 108, 25-33, 2018.
2. Takada R, Jinno T, Tsutsumi Y, Doi H, Hanawa T, Okawa A: Inhibitory effect of zirconium coating to bone bonding of titanium implants in rat femur, Mater Trans 58, 113-117, 2017.
3. Chen P, Aso T, Sasaki R, Tsutsumi Y, Ashida M, Doi H, Hanawa T: Micron/submicron hybrid topography of titanium surfaces influences adhesion and differentiation behaviors of the mesenchymal stem cells, J Biomed Nanotechnol 13, 324-336, 2017.
4. Sato M, Chen P, Tsutsumi Y, Hanawa T, Kasugai S: Effect of strontium ions on calcification of preosteoblasts cultured on porous calcium- and phosphate-containing titanium oxide layers formed by micro-arc oxidation, Dent Mater J 35, 627-634, 2016.
5. Tsutsumi Y, Niinomi M, Nakai M, Shimabukuro M, Ashida M, Chen P, Doi H, Hanawa T: Electrochemical surface treatment of a β-titanium alloy to realize an antibacterial property and bioactivity, Metals 6, 76, 2016.

To improve the performance of metals that occupy 70% of implant devices, we are striving to develop new alloy designs and manufacturing processes and to create new surface treatments and modification techniques. We base our work on the accumulated knowledge and the techniques of research and evaluation in materials science and engineering. Furthermore, we pursue a variety of collaborative research projects to commercialize the results.

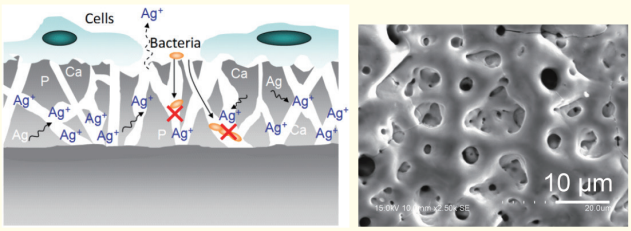
Development of MRI-compatible zirconium alloys

To decrease MRI artifacts caused by the magnetization of metallic implants, zirconium alloys with low magnetic susceptibility are being developed: Large-scale melting, forging, swaging and heat-treatment processes are being investigated based on an evaluation of crystal structure, mechanical properties, corrosion mechanisms, cytocompatibility, and etc.



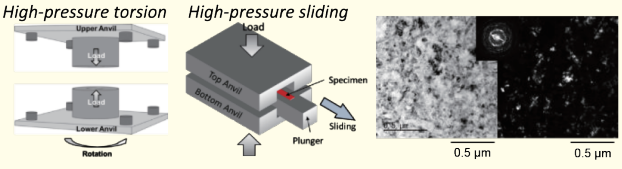
Development of multi-biofunctional implant surfaces

To achieve multiple biofunctional surfaces, surface treatments based on electrochemical techniques are being developed. In addition to hard-tissue compatibility, antibacterial properties are successfully obtained through micro-arc oxidation with small amounts of antibacterial agents (Ag, Cu, Zn, etc.) on Ti.



Strengthening of titanium alloys for narrow dental implants

Narrow dental implants are applied in situations with limited horizontal space, and they require thin diameters and high strength. We have succeeded in strengthening titanium alloys through grain refinement while retaining almost the same elongation, by applying high-pressure torsion or high-pressure sliding.



Control of differentiation of stem cells on nano/micro-topography

A highly orientated and extended cellular morphology was achieved on the hierarchical topography, which also modulated the multi-lineage differentiation, such as osteogenic and chondrogenic differentiation.