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## Next generation metallic implant materials: contribution of nanoscience and nanotechnology

Statement of the Problem: A disadvantage of using metals as biomaterials is that they are typically artificial materials and have no biofunction. Therefore, metals require additional properties before they can be used as medical devices. To respond to requirements, new alloy designs and many techniques for the surface modification of metals have been investigated. Nano-metastable structure: we are investigating zirconium alloys to decrease magnetic resonance imaging (MRI) artifact. It is known that magnetic susceptibility of implanted devices correlates artifact volume. Thus, medical alloys with low magnetic susceptibility are required for reducing artifacts. In our study, spinal fixators consisting of Zr-1Mo alloy showed much smaller artifacts than those of Ti-6Al-4V alloy implanted in sheep spine. The mechanical property is governed by nanometer size precipitates in the matrix crystal. Dual-function surface: micro arc oxidation (MAO) treatment accelerates bone formation on titanium. Silver nano-cluster is easily contained in the surface oxide layer by the addition of silver in the electrolyte for MAO. Bone formation and antibacterial property, a dual function, are simultaneously performed by MAO. Nanometer-topography accelerating differentiation of stem cells: we investigated the adhesion of human mesenchymal stem cell (hMSC) to titanium surfaces with three different topographies; namely, micron, nano, and hybrid grooves created using a femtosecond laser. In addition, immune-fluorescent detection of the differentiation of hMSC, cultured on specimens after differentiation was conducted. The different surface features had different effects on the differentiation of hMSC. Immobilization of biofunctional molecules to titanium: both ends of PEG molecule are terminated with –NH2 (NH2–PEG–NH2) and dissolved in an aqueous solution. When the cathodic potential is applied to Ti in the solution, the terminated PEGs are electrodeposited on the Ti cathode. The PEG-immobilized surface inhibits the adsorption of proteins and adhesion of platelets and bacteria.

### Recent Publications

1. Sun X, et al. (2017) Fabrication and characterization of a low magnetic Zr-1Mo alloy by powder bed fusion using a fiber laser. Metals 7:501.
2. Chen P, et al. (2017) Micron/submicron hybrid topography of titanium surfaces influences adhesion and differentiation behaviors of the mesenchymal stem cells. J Biomed Nanotechnol 13:324–336.
3. Kondo R, et al. (2016) Effect of heat treatment and the fabrication process on mechanical properties of Zr-14Nb Alloy. Mater Trans 57:2060–2064.
4. Tsutsumi Y (2016) Electrochemical surface treatment of a β-titanium alloy to realize an antibacterial property and bioactivity. Metals 6:76.
5. Hanawa T (2013) Research and development of metals for medical devices based on clinical needs. Sci Technol Adv Mater 13: 064102

## Biography

Takao Hanawa is a Professor at the Department of Metallic Biomaterials, Institute of Biomaterials and Bioengineering (IBB), Tokyo Medical and Dental University (TMDU) since 2004. He is now a Member of the Science Council of Japan and was a President of the Japanese Society for Biomaterials and Japanese Society for Dental Materials and Devices. He received his PhD from Hokkaido University in 1989 and Tohoku University in 1998. He has experience as an Assistant Professor in Hokkaido University, Associate Professor in Tokushima University, and Deputy-in-General of Biomaterials Research Center, National Institute for Materials Science (NIMS). He has developed several new metallic biomaterials and is now operating several research projects on metal-based medical and dental materials. In particular, zirconium alloys showing low magnetic susceptibility to decrease MRI artifact, strengthening titanium alloy remaining ductility by severe working, surface modification techniques to add dual-function to titanium, and nano-topography to accelerate the differentiation of stem cells by femtosecond laser.

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