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Results report

１． Title of Research and Development: Bio-functionalization of Ti-based materials for osseointegrated implants

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４． Results of Research and Development:

The main aim of this project is to develop a new generation of bio-multifunctional Ti-based surfaces for osseointegrated implants. In particular the goal is to play with different surface modification techniques in order to obtain surfaces capable of being biologically selective (promoting, simultaneously, an adequate adhesion of osteoblastic cells while minimizing the possibilities of colonization by unwanted microorganisms), together with high corrosion and tribocorrosion resistance. Special focus will be given towards the understanding of the underlying mechanisms governing each phenomenon. This project aims at interrelating three complementary research activities, namely: (1) electrochemical surface treatments and sputtering techniques to obtain surfaces with different micro and nano-topographies, structures and chemistry (doping with bioactive and antimicrobial species), (2) in particular, micro-nano-porous and nano-tubular surfaces will be produced. Further, immobilization of organic PEG, RGD and/or collagen molecules will be carried out by electrodeposition techniques, (3) investigation of the corrosion and tribocorrosion mechanisms of the surfaces through the integration of electrochemical corrosion techniques in tribological tests, and (4) investigation of the mechanisms governing the adhesion of osteoblastic cells and microorganisms with the different surfaces. Surface parameters governing the competition between osteoblastic cells and microorganisms to adhere to the surface will be studied in detail.

The multi-disciplinary team integrating this proposal bridges Materials Engineering, Biomedical Science and Biology. It is expected that this team will be able of progressing in the scientific understanding of the fundamental mechanisms governing osseointegration, microbial colonization and tribocorrosion behavior. Hereto an integrated approach will be followed addressing the interactions between these mechanisms. By doing so, guidelines will become available for the future production of improved implant multifunctional surfaces. Also, the involvement of young MSc and PhD students that will benefit from the networking and complementary expertise of the Brazilian and Japanese teams will bring an added value for their carrier progression. Finally, collaborative high quality publications will be expected throughout the project.

The purpose of the project was to create a next generation multi-functional titanium surface with osseointegration. In particular, surface modification techniques strongly adhering osteoblast and simultaneously preventing bacterial adhesion has been focused. In this budget year, an acquirement of antibacterial property due to the addition of oxide layer containing Ag, an animal evaluation of micro-arc oxidation (MAO), characterization of structure of a Ti-Zr-Mo alloy, investigation of the possibility of MAO treatment of the alloy, immobilization of a new functional molecule to Ti surface were attempted.

In Ag-containing technique and evaluation of antibacterial property, the relation between the Ag concentration in the oxide layer and antibacterial property was elucidated. In addition, both bone formation and antibacterial properties that are opposite properties were appeared. MAO treatment was effective according to the results of animal test. Furthermore, polarization treatment of MAO oxide layer accelerated bone formation on the oxide. On the other hand, β-type Ti-15Zr-7.5Mo alloy was melted and formed, followed by the evaluation of mechanical property. Also, utility of MAO treatment against Ti-15Zr-7.5Mo alloy was investigated. The Ti-15Zr-7.5Mo alloy consisted of β phase and α" phase and ω phase. Vickers hardness of the alloy was larger than that of Ti-6Al-4V alloy and Young's modulus of the alloy was as the same as that of Ti-6Al-4V alloy. MAO treatment was also effective to Ti-15Zr-7.5Mo alloy because porous oxide layer was formed on the Ti-15Zr-7.5Mo alloy. Therefore, the Ti-15Zr-7.5Mo alloy has good mechanical property as a medical material. It is possible to obtain both good mechanical property and hard tissue compatibility in the Ti-15Zr-7.5Mo alloy because porous oxide layer was easily formed on the alloy by MAO treatment. In addition, immobilization of MPC polymer on Ti was performed and the effect of the immobilization was appeared.