The Effect of Pores in Dual Nano Hydroxyapatite Coating on Thermally Oxidized Commercial Pure Titanium: Mechanical and Histological Evaluation

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ABSTRACT

Introduction: Titanium and its alloys are often used in dentistry in replacement of lost dentition in the form of implants, however their inertness and low biocompatibility are the most drawbacks for biomedical applications. In order to improve their biocompatibility, Hydroxyapatite is often coated on surface of metallic implants. Hydroxyapatite is a bioactive material that is the main inorganic constituent of human hard tissue whose coatings provide requisite surface bioactivity to the bone implants.

Objective: This study was done to evaluate the effect of pores of nano Hydroxyapatite dual coatings on the bond strength between the bone and implant.

Materials and methods: A thick TiO_2 layer was thermally grown as a diffusion barrier on CP Ti substrate prior to electrophoretic deposition of HA coatings, to enhance the coating's compatibility, then electrophoretic Deposition technique (EPD) was used to obtain a uniform coating for each one of four types of Hydroxyapatite coatings on CP Ti screws (micro HA, nano HA, dual nano HA with micro pores, dual nano HA with macro pores) where carbon micro particles were used as fugitive material that is deposited within the dual coat, so as to be removed by thermal treatment to create porosity. For examination of the changes occurred on the substrate, SEM, SPM and XRD were used to evaluate the thickness, morphological characteristics, surface roughness and phase constituent of titanium oxide while coatings were characterized by XRD, SEM and interfacial shear strength measurements. The in vivo study was done by the implantation of 64 screws of 3mm diameter, 8 mm length and 1 mm pitch height .The tibiae of 16 white New Zealand rabbits were chosen as implantation sites. four implants were implanted in the tibiae of each rabbit, in the right tibia implant coated with nano HA was implanted medially and implant coated with

micro HA was implanted laterally in the same tibia, while in the left tibia of the same rabbit implant coated with nano with micro pores HA was implanted medially and implant coated with nano with macro pores was implanted laterally in the same left tibia.Removal torque and histological tests were performed after 2 and 4 weeks healing periods. 8 rabbits were sacrificed for each period. A removal torque was done for 7 animals in each group, whereas the other was used for histological testing with optical microscope.

Results: The results mentioned the formation of 1.6μ thick rutile TiO_2 with nano roughness, SEM showed that the size of pores corresponds to the size of carbon particle and the shear strengths of the nano coat is higher than that of micro coat while shear strength of dual nano HA coats are higher than that of the single nano coats. Statistical analysis of the removal torque tests showed highest means for the single nano HA layer at 2 and 4 weeks implantation intervals and the equality of means of removal torque value between 2 and 4 weeks implantation intervals were significant at p=0.05 for dual coat with pores >50 μ. Histological analysis revealed that there was a faster reaction of bone and higher osteoblasts activity towards thermally oxidized CP Ti implants coated with nano HA compared to thermally oxidized CP Ti implants coated with micro and early formation of haversian system observed after 2 weeks of implantation at bone implant interface in screws coated with nano HA with macro pores.

Conclusion: Carbon particles as a fugitive material within nano HA coat to produced porosity. The mechanical and biological properties of the bone-implant interface associated with implants coated with nano HA were improved comparing to the implants coated with micro HA. Presence of pores > 1μ in nano HA coats did not achieve highest removal torque values nor highest osteoblasts activity in 2 and 4 weeks implantation intervals.