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Deposition of Tantalum Oxide and Tantalum Nitride Film on CpTi Implant Osseointegrated in Diabetic Induced Rabbit by Modified Reactive Plasma Sputtering Technique

A thesis
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By
Hasan Jawad Farhan AlMasoodi
B.D.S., H.D.D, M.Sc.

Supervised by

Prof. Dr. Raghdaa Kareem Jassim
B.D.S., M.Sc., Ph.D.

Prof. Dr. Thair Latif Al-Zubaydi
B.Sc., M.Sc., Ph.D.

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Abstract

Background: The new trend of implants is to find materials which accelerate bone formation at bone implant interface and improve Osseo integration to provide immediate or early loading after placement and eliminate waiting period which is uncomfortable and disturbs patients. Titanium as an implant material still need some modification. When associated with other elements which often offers better mechanical properties compared to the pure form. Tantalum is gaining more attention as a new metallic biomaterial. Tantalum has been shown to be bioactive in vivo. Sputtering is a process whereby particles are ejected from a solid target material due to bombardment of the target by energetic particles, particularly gas ions .For changing surface topography, increasing surface roughness, and in increasing the wettability of the surface, for this purpose, plasma tantalum oxide(Ta_2O_5) and tantalum nitride(TaN) can be used.

Aim of study: To evaluate the effect of tantalum oxide and tantalum nitride coating by modified plasma sputtering treatment of commercially pure titanium implant screw on wettability, surface roughness, surface chemical composition in comparison to un-coated CpTi in diabetic induced rabbit.

Materials and methods: In the vitro part of study, commercial pure titanium disks were coated with Ta_2O_5 and TaN for 4,6,8, hr. using modified reactive plasma sputtering apparatus. X-ray diffraction (XRD) analysis, scanning electron microscope (SEM), energy dispersive spectroscopy (EDS), atomic force microscope (AFM) and contact angle measurement test examinations were carried out on the coated and un-coated surfaces of the disks.

In the vivo part of study, fourty adult white New Zeeland male rabbits weighing 2 -2.5 kg were used. Diabetes mellitus induced in a half number of rabbit. The

femur of New Zealand white rabbits was chosen as implantation sites. One femur of each rabbit received two screws, one coated with tantalum oxide and the other screw coated with tantalum nitride, the other femur received the non-coated screws. A total of 120 screws were implanted. Torque removal test was performed (by digital torque meter) to measure bond strength between implant and bone, after 2 and 6 weeks healing periods for each normal and diabetic rabbits. For each period of time 54 screws were tested for the torque required to remove the implant from the bone (include normal and diabetic rabbit) and 12 screws were kept for histological and histomorphometric examination.

Results: In vitro part of study: The 8 h. coated time was selected from (4,6,8) hr. coating time interval which was used in Ta_2O_5 and in TaN coating. The results revealed that the wettability of CpTi coated with Ta_2O_5 disk was more hydrophilic than CpTi coated with TaN disk and un-coated CpTi disk. X-ray diffraction analysis show new peak formation of Ti, Ta, O and N for CpTi coated with Ta_2O_5 and TaN. For AFM analysis, the roughness and feature of CpTi coated with Ta_2O_5 disk exhibited a surface characterized by rough grooves in which valley reached 6.5 µm and roughness of 0.855 nm, while for CpTi coated with TaN exhibited a surface characterized by rough grooves, in which valley reached 3.5 µm and roughness of 0.575 nm. The surface examination by SEM analysis showed the shape of the coated layers was nanochips and arranged uniformly and fully in Ta_2O_5 coated disk more than TaN coated disk, uncoated CpTi disk show fairly smooth with some scratches

In vivo part of study, in normal rabbit the results revealed that the torque removal means values for the Ta_2O_5 coated implants after 2 and 6 weeks was (31.222, 66.556 Ncm,) respectively and for TaN coated implants was (27.667, 59.889 Ncm) respectively and for non-coated implants was (26.111, 56.556 N.cm,) respectively. In diabetic rabbit the results revealed that the torque removal means values for the Ta_2O_5 coated implants after 2 and 6 weeks was

(28.333, 61.889 Ncm) respectively and for TaN coated implant was (22.778, 52. 333 Ncm) respectively and for non-coated implants were (21.556, 47.333 Ncm) respectively.

Regarding the histological results which obtained from longitudinal slices including bone and implant screw in each normal and diabetic rabbit, Ta_2O_5 coated implant after 2 weeks of implantation shows new bone trabeculae lined by osteoblast cell, osteoblast arranged as a rim of cells on the bone surface and osteoid tissue, after 6weeks histological findings of Ta_2O_5 coated implant shows compact bone and osteocyte cells, also the bone around the implant was mature. Regarding the histomorphometric analysis, the mean values of bone cell in all experimental groups non-coated CpTi, Ta_2O_5&TaN coated implant after two and six weeks' implantation in non-diabetic rabbit, a higher mean values of OB, OC was observed in an implant coated with Ta_2O_5 (31.43,46.00,53.57&66.43) after 2 and 6weeks implantation respectively. The highest mean values of bone cells appear in implants coated with Ta_2O_5 implanted in diabetic rabbit after 2&6 weeks

Conclusion: Within the limitation of this study. Modified plasma sputtering technique was an effective method in coating CpTi surface with Ta_2O_5 and TaN in diabetic rabbit, Ta_2O_5 surface indicate adequate bone implant interface in biomechanical, histological and histomorphometric analysis.