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Evaluation of Niobium as an alternative to (coated and uncoated) commercial pure titanium dental implant: mechanical and histomorphometric study

A Thesis Submitted to
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Abstract

Commercially pure titanium is widely used as dental implant material Although it was found that titanium exhibited high modulus of elasticity and the lower corrosion tendency in media representing conditions normally found in the human mouth. At the same time Ti alloys such as (Ti6Al4V) may lead to serious danger, It was reported that aluminum(Al) and vanadium (V) were dissolved from Ti alloy (Ti6Al4V) in oral media. Niobium was chosen for this study as an alternative to Commercially pure titanium CpTi implant material due to its bioinert behavior and good elastic modulus and moderate cost in addition to corrosion resistance.

This study was done to evaluate the ability to bioactivate niobium by biomimetic coating process, the use of niobium as a dental implant through mechanical and histological study, and compare this evaluation with Commercially pure titanium dental implant material.

A total of 40 plates were fabricated (20 for niobium and 20 for Commercially pure titanium)and each material subdivided into 10 plates for control group and 10 plates for coated group. The in vitro study involved etching the disc samples of each material in hydrochloric acid HCl under inert atmosphere of Argon for 2 hours and soaking in 10M sodium hydroxide NaOH aqueous solution at 60ºC for 24 hours. These samples were then immersed in a 5 times concentrated simulated body fluid. The immersion was done under static biological conditions at 37ºC and pH 7.4 for 14 days respectively. To understand the changes occurred on the surface, both elemental analysis and morphological investigations were done (Scanning Electrone Microscopy , Energy Dispersive X-ray analysis and X-Ray Diffraction).

A total of 160 screws were fabricated and divided into 80 titanium and 80 niobium main groups then each main group was subdivided into 40 coated and 40 non coated groups that further subdivided into 2 weeks and 4 weeks healing period. For each healing period removal torque test and histological

analysis was made (10 screws for each test). The in vivo study was done by the implantation of screw-shaped implants (two from each material, uncoated and the other is biomimetically coated) in the tibias of New Zealand rabbits. After 2 and 4 weeks of healing period, 20 rabbits were sacrificed for each period. A removal torque was done for ten animals in each group, whereas the other ten were used for histological testing and histomorphometric analysis with optical microscope.

The results obtained from the in vitro experiments showed that the use of 14days immersion in a concentrated simulated body fluid (5 times) produced a homogenous layer of calcium phosphate. The biomechanical test revealed that the force required to unscrew the implants was higher among the coated implants than the uncoated ones over different time periods. In addition, the quality of bone response was also improved among the coated screws. also the histomorphometric analysis revealed that new bone formation increase significantly in niobium than Commercially pure titanium and in coated than uncoated and in 4 weeks than 2 weeks healing periods.

The approach used in this study supports the ability to bioactivate niobium by coating with calcium phosphate through biomimetic process. The niobium screws (coated or uncoated) had better biomechanical and biological properties than commercially pure titanium implants and niobium may be used as a promising alternative to titanium implants.