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Bio- Mechanical Properties of Niobium oxide\ Poly Ethylene Glycol Composite Coating on Commercially Pure Titanium Implants after Immersion in Antimicrobial Agent (In Vitro - Vivo Study)

A Thesis

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Abstract

Titanium is considered to be the common material for dental implants, due to its biocompatibility and higher mechanical strength. Coating of dental implant with biomaterials is mandatory to enhance osseointegration by formation of rough surface which act as local drug carrier to control surgical bed infection. Unique modality is performed to make the implant surface antibacterial thereafter inhibit bacterial adhesion and formation of a biofilm on implant surface.

This study was carried out to assess *in vitro and in vivo* the biological response of tissues to commercially pure titanium (Cp Ti) screws either coated with niobium oxide (Nb_2O_5) or with niobium oxide \ polyethylene glycol (Nb_2O_5\PEG) composite using RF magnetron sputtering. The coatings were characterized by X-ray Diffraction Spectroscopy (XRD), Scanning Electron Microscopy (SEM), Field Emission Scanning Electron Microscopy (FESEM), Energy Dispersive Spectroscopy (EDS), Atomic Force Microscopy (AFM) and Fourier-Transform Infrared Spectroscopy (FT-IR).

Bacteriological effectiveness of composite coating was evaluated by application of minimum inhibitory concentration (MIC) followed by agar diffusion test over 24, 48 and 72 h incubation periods.

In vivo tests were performed by implantation of both Nb_2O_5 (control group) and antimicrobial Nb_2O_5\ PEG composite coated screws (experimental group) into rabbit femurs for 2 and 6 weeks. Total of 16 animals were utilized in the study, 8 rabbits were sacrificed for each period. A removal torque was performed for five animals in each group, whereas the other three animals were used for histological, histomorphometric and immunohistochemical analyses.

Histomorphometric investigation was carried out by direct cell counting and with the application of image-processing software for osteoblast, osteocyte,

osteoclast cells,trabecular width, trabecular separation, trabecular number and marrow space volume .

Immunohistochemical expression of TGF β1 and IL-6 markers was carried out with certain parameters scoring.

Results showed the formation of thin, uniform and rough coatings deposited on CpTi substrate by RF magnetron plasma sputtering.

Bacteriological assessment revealed that Nb_2O_5\ PEG composite coated implants after immersion in antimicrobial peptide (AMP, vancomycin) showed slow diffusion and clear inhibition zones over the three incubation periods.

Significant bone-implant attachment for antimicrobial Nb_2O_5\ PEG biocomposite coated implants ($p<0.05$) than Nb_2O_5 coated implants in both healing intervals was recorded.

The comparison of bone quality (osteoblast and osteocyte counting, trabecular number, trabecular width and Marrow space star volume) as well as immune response regarding TGF β1 and IL-6 cytokines, revealed significant differences and great enhancement ($p<0.05$) associated with biocomposite coated implants than Nb_2O_5 coated implants.

In conclusion, this is the first study of RF magnetron plasma-sprayed Nb2O5\ PEG biocomposite on titanium screws after immersion in antimicrobial peptide (AMP, vancomycin) that showed better performances concerning the osseointegration, bone quality and antibacterial activity than the Nb_2O_5 coated implants, therefore coating by RF plasma sputtering could be recommended to coat metallic implants with an osteoconductive composite materials.