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Fabrication and Investigation of Commercial Pure Titanium / Bioactive Glass Ceramic Functionally Graded Material as a Material for Dental Implant

A Thesis Submitted to
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Abstract

The ultimate goal of modern implantology is fasting osseointegration. Biointegration is the optimum circumstances of osseointegration in which there is acontinuity of ceramic implant with the bone without intervening space. To achieve such a circumstances, this study aimed to fabricate a functionally graded materials,a cylindrical implant fabricated from Bioglass at the surface and commercial pure titanium as a core to produce a biomaterials that satisfy the mechanical, physical and biological requirements of dental implants.

In in vitro part of the study, a functionally graded materialswere fabricated, by using powder metallurgy method, from Bioglass 45S5 as surface layer of cylindrical specimen and commercial pure titaniumas core of cylindrical specimen. Then the compacted specimens were divided into three groups according to sintering temperature 800°C, 900°C and 1000°C, with 3 hours holding time for each specimen in its sintering temperature. After that the specimens of each group analyzed by using Scanning Electron Microscope and Energy Dispersive X-ray Spectroscopy, and the porosity percentage was evaluated then mechanical evaluations have been done by using Vickers hardness test and compressive strength test. In in vivo part, three groups of cylindrical implant specimens were prepared from functionally graded material, commercial pure titanium and titanium alloy. Each group composed of 40 implant specimens. The femur of 40 white male New Zealand rabbits, were chosen as implantation sites. Push out test was performed to measure bone bonding strength between implant specimen and bone after 2 and 4 weeks healing periods (20 rabbits for each periods). For each time interval 30 implant specimens for each group, which implanted in 10 rabbits. Histological study for evaluation of tissue response and histomorphometric analysis was performed for measurement of new bone at two time intervals.

Results; in in vitro part of study, the scanning electron microscope shows fusion of powder particles, decreasing the pores size among particles, anddiffusion of commercial pure titanium towards the Bioglass at interface which also appear clearly in energy dispersive X-ray spectroscopy analysis. In porosity test, specimens sintered at 1000ºC had the lowest percentage of porosity with mean value (5.66348%) while the specimens sintered at 900ºC had mean value (6.71128%), and sintering at 800ºC were (7.73149%). Mechanical tests revealed that the specimens sintered at 1000ºC, 900ºC and 800ºC had the following Vickers hardness and compressive strength mean values (674.007 Kg/mm^2) and (5.146497 Mpa), (520.487 Kg/mm^2) and (2.802548 Mpa) and (459.85 Kg/mm^2) and (2.318471 Mpa) respectively. In vivo part, the results of push out force and new bone formation area appeared that functionally graded material implant specimens were a statistically highly significant mean values than that of titanium alloy and commercial pure titanium implant specimensafter 2 weeks and 4 weeks of implantation. In histological examination, there was an active osteoid tissue around functionally graded material implants and hematopoietic tissues around commercial pure titanium and titanium alloy implants after 2 weeks, and there was an osteoid maturation with observation of reversal lines around functionally graded material implants and new bone formation with osteocyte around commercial pure titanium and titanium alloy implants after 4 weeks of implantation.

The functionally graded material sintered at 1000ºC had the best mechanical properties and efficient in increasing bone bonding strength to implant at bone implant interface as compared with commercial pure titanium and titanium alloy implants.