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College of Dentistry

Biomechanical Evaluation of Magnesium Alloys Implant Reinforced with Strontium Microparticles Coated By Niobium Nitride

A Thesis Submitted to

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By

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Abstract

Background: Magnesium as well as its alloys are differing from other biomaterials through providing compatible physical and mechanical characteristics to the human bones, i.e., the elastic modulus of cortical bone is 5-23GPa while for pure magnesium 45GPa and densities were somewhat close to one another which is 1.8-2.0 g/cm^3 for cortical bone and 1.74 g/cm^3 for pure magnesium. Thus, removing elastic mismatches between the bone and implants. Furthermore, the magnesium present naturally in bone structure, and it is essential metal for metabolism.

Aim of study: The microhardness and diametral tensile, corrosion resistance, push-out test and histological /histomorphometric analysis of enforced Mg by Strontium and alloyed with another biocompatible metals Zinc, Manganese then coated by niobium nitride, were examined.

Materials and methods: For *invitro* test 124 samples were prepared for microhardness, diametral tensile, contact angle and corrosion test, divided to three groups; 1st one pure magnesium (99.96%) as a control group, and the 2nd group magnesium alloy with optimum concentration of alloying elements selected for this study which consist of (Mg 94 wt.%, Zn 4wt.%, Mn 1wt.%, Sr 1wt.%) while the 3rd group coated by Niobium Nitride using magnetron sputtering.

While for *invivo* test another 80 samples were used (push-out and histological/histomorphometric analysis) which subdivided as coated and uncoated groups. For the biological part of study 80 skeletally mature male white rabbits were divided into 2 groups: 1st group for 2weeks interval for healing and 2nd group for 6weeks interval. The implants were placed into the right femoral bone two implants (coated and uncoated).

After 2 and 6 weeks of placement, push out force was measured and histological/ histomorphometric analysis were performed.

Result: Alloying of Mg with Sr, Zn and Mn shows statistically high significant improvement in mechanical properties but dropping in corrosion resistance when compared with pure Mg.

Niobium nitride coating by magnetron sputtering improved the mechanical properties significantly as well as improvement in corrosion resistance of Mg-Sr alloy. The higher mean value of push out test was obtained after coating the implants with Niobium nitride. Histological and histomorphometric study showed a higher bone formation and well differentiation of bone cells over NbN coating.

Conclusions: Alloying of pure Mg by Zn, Mn and Sr revealed a valuable improvement in microhardness and diametral tensile, but significantly dropping occurred in corrosion resistance compared with pure Mg.

Physical vapor deposition of Niobium nitride coating film to Mg alloy can cause further improvement in microhardness and diametral tensile properties. Coating Mg alloy implants with Niobium nitride reduces the corrosion rate significantly. Also, Niobium nitride coating enhance osseointegration of implant and decreasing time needed for healing after surgery concerning this study.

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