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In vivo evaluation of CaP produced nanocoating on laser macrostructured Ti6Al4V implants

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INTRODUCTION: Titanium alloys are frequently used as dental and orthopaedic implant materials because of their excellent mechanical properties, chemical stability and biocompatibility. However, titanium and its alloys are non-bioactive after being implanted in bone. Thus, for further improvement of its bioactivity various implant surface modifications have been investigated(1). It has been a common practice to use primarily HA to coat metal implants for enhanced bioactivity and the PLD method became a promising technique in this field by producing films of pure and crystalline HA. HA is a calcium phosphate compound with similar composition to the mineral part of the bone(2). It was found that osseoinduction was improved in surfaces with convexities(3) so a macrostructuration of the samples could benefit the bioactivity.

METHODS: The aim of this work was to evaluate in a sheep tibia model the effect of calcium phosphate nanocoatings on the bone regeneration at the interface between bone and implant of laser macrostructured titanium alloy samples.

Samples were Ti6Al4V cylinders of 10 mm long and 5 mm diameter with CaP coatings of 100 and 50 nm thick and their references without coating. Before coating, all samples, except the references, have been macrostructured with a Nd:YAG marking laser to achieve a regular pattern of craters. Thereafter, macrostructured samples have been coated with HA by using a 193 nm ArF excimer laser.

Before being implanted, the cylinders were sterilized in an autoclave.

Implantation took place into the tibia of 10 adult (Merina precoz) sheep. Four implants and a sham were implanted into one leg of each animal for 12 weeks.

Samples have been characterized with SEM and EDS before and after implantation. Microscopic evaluation using environmental scanning electron microscope (ESEM) was carried out directly on blocks of tissue embedded in resin, preceded by sectioning and fine polishing using a JEOL JSM-59110LV electron microscope. The measurements of % BIC (Bone to Implant Contact) were performed using the Omnimet® image analysis system and were checked manually using a digital plan meter. The data was evaluated using double-blind statistical analysis of variance (ANOVA) and Student t-test for small samples (paired series).

RESULTS: SEM analyses show a continuous HA layer on the surface of the samples, EDS microanalyses of the interface between implant and resin show a little Ca/P peak in coated samples before implantation, this peak on the interface still appears after implantation in bone and its intensity is bigger than before. ESEM analyses of the coated samples show a better bone-implant interface than on the uncoated samples, and that the bone enters deeply into the craters of the macrostructure when the nanothin CaP coating was present.

DISCUSSION AND CONCLUSIONS: Superficial treatment of hydroxyapatite nanocoatings improves osseointegration and it seems that it gives a more integration than the laser macrostructuration without coating. Scientifically, this study has opened a new door for the “in vivo” studies on the interface between bone and implant and technically it opens the door for the study of an industrial application in dental implantation.

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