ALTERNATIVE BIOCERAMICS FOR REPAIRING JAW BONE DEFECTS

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Historical evolution of bioceramics

Bioceramics have been used as materials of choice for repairing bone defects of the jaws since 60s. The main representative at that era was alumina (Al_2O_3). Next years different types of carbons there also were used for the same reason. In the middle of 80s zirconia (ZrO_2) became a very popular bioceramic in orthopaedics and maxillofacial surgery. Calcium phosphates in general and especially hydroxyapatite played a determent role as jaw bone defect repairing materials, mostly because the negative immune response of human body. Calcium sulphate and trioxide aggregates are nowadays also available for bone defect repairing materials. Recent decades the meanings of biomimetics, nanotechnology and functionalization led research to new paths for the development of combined bioceramics able to mimic the bone microstructure, to present the benefits of the nanoproducts and to be very irritating leading human osteoblasts to produce narrative healthy bone around them. Depending of the purpose they were intended to use, they present proportional properties as they are the mechanical properties, the porosity, the bioactivity and the absorbance. For extended areas of bone loss bioceramics with high mechanical strength, and high percentage of porosity with high porous size distribution were preferable, while in the case of small bone loss more bioactive with balanced absorbance bioceramics were preferable.

Experimental work

A brief report of five experimental studies are going to be presented, the first of which has to do with the fabrication of 3D porous scaffolds with complex geometries using a hydroxy-apatite/chitosan composite. In this work the efficiency of nanohydroxyapatite (nHA/CS) vs. hydroxyl-apatite (HA/CS) was tested (FIG. 1). The second deals with the in vitro evaluation of bioinspired, chitosan based 3D hybrid nanohydroxyapatite scaffolds where a physical proteinic cross-linker extracted from plant gardenia was used. The third presents the structural and mechanical characterization of biphasic α-tricalcium phosphate-nano-hydroxyapatite bone cements, the forth deals with the fabrication of biocements and implants by combination of nanostructured geopolymers and calcium phosphate and the fifth studies the development of 3D scaffolds using a combination of nanohydroxyapatite-carbon nanotubes-biopolymers for promoting bone regeneration. The procedures followed for the fabrication of every combined nanoceramics were different using specific laboratory techniques. From the above-mentioned experimental products, SEM images were received and EDS analysis was performed. Mechanical properties, μCT analysis for porosity 3D profilometry, cell cultures and experiments in animals were also conducted (FIG. 2).

Results and Discussion

Many authors [1-3] have proposed a numerous of techniques and materials combinations for the production of new bioceramics for repairing bone loss in the individual maxillofacial field producing HA nanocrystals and scaffold microstructure quite similar to those of the natural bone.

Experiments revealed a range of porous size distribution starting from microporosity till high porous sizes with satisfactory interconnectivity. New factors in the synthesis of the combined bioceramics can play a decisive role in their biological performance, as for example are genipine as natural cross-linker, the presence of amino acid L-arginine and geopolymers, which assist to viable proliferation of osteoblasts in the produced scaffolds and give to them better mechanical properties.

Experiments with cell cultures and implantation of new bioceramics in animals verified in the most of the cases their beneficial interaction with osteoblasts.

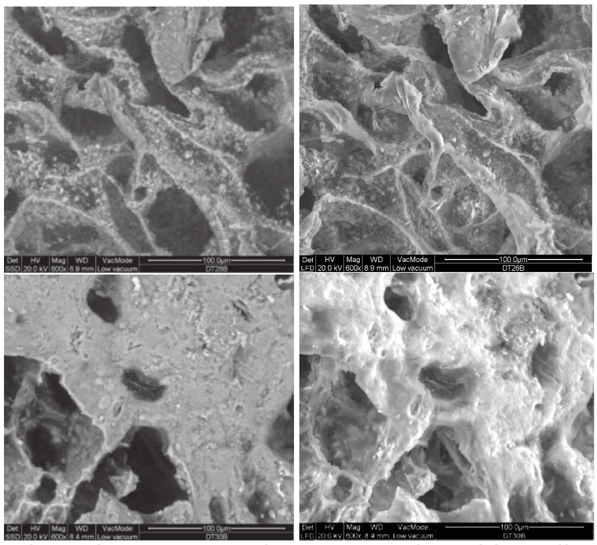

FIG. 1. SEM BEI and SEI images of HA:CS scaffolds (upper row) and nHA:CS scaffolds (lower row).

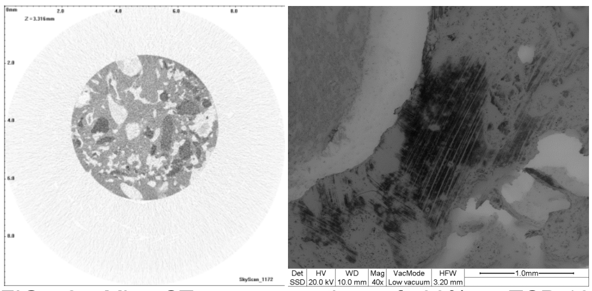

FIG. 2. MicroCT cross section of 90% α-TCP-10% geopolymer, implanted in New Zealand femur and the relevant histological picture.

Conclusions

The conclusions derived of the above-mentioned experiments are that new combinations of bioceramics produced using nanotechnology can improve efficiently the replacement of lost bone with the precondition that the correct fabrication properties and the right surgical procedures will implemented.

References

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