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PRELIMINARY EVALUATION OF THE EFFECT OF CALCIUM PHOSPHATE COATING OVER A BIPHASIC SCAFFOLD FOR SIMULTANEOUS ALVEOLAR BONE AND PERIODONTAL LIGAMENT REGENERATION

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KEYWORDS

Periodontal regeneration, osteoblasts, CaP coating.

ABSTRACT

Periodontal disease is a condition which destroys soft and hard tissues around teeth ultimately resulting in their loss. In this work, a biphasic scaffold capable of delivering both bone and ligament tissue into one single tissue engineered construct was used. Calcium phosphate (CaP) coating was used in order to improve the quality of this construct's bone tissue compartment.
A polycaprolactone (PCL) Fused Deposition Modeling (FDM) scaffold was coated with a CaP layer and then hot-pressed into a PCL melt electrospun mesh. Osteoblasts were then seeded into the FDM component and cultured for 6 weeks into osteogenic or basal conditions. The osteoblasts's performance was investigated by quantifying ALP activity and cellular proliferation. Mineralization was assessed by µCT scanning. CaP coating showed to increase ALP activity and the amount of mineralized tissue was significantly higher. This study demonstrates that a CaP coating can improve the quality of this biphasic construct's bone compartment enhancing its potential applicability to periodontal regeneration.

INTRODUCTION

Periodontal disease is an aggressive condition which may ultimately result in teeth loss due to destruction of its surrounding soft and hard tissues. This kind of disease can be treated to a certain extent by guided tissue regeneration which is a dental surgical procedure that utilizes barrier membranes to direct the growth of new bone and other site-specific tissues at sites where they have been destroyed. In bone tissue engineering, matrices with better osteoconductive properties have been achieved by combining nanocrystallites of inorganic biological compounds such as CaP salts with polymer matrices. This is due to the fact that ceramic particles allow for improved tissue integration by buffering pH change and providing a suitable microenvironment which mimics the host tissue's inorganic phase (Rezwan et al 2006). Given the benefits of both these technologies it becomes pertinent to combine them together in order to try to obtain an improved treatment solution for periodontal disease.

MATERIALS AND METHODS

In this work, a previously developed biphasic scaffold, capable of delivering both bone and ligament tissue into one single tissue engineered construct, was used. This scaffold was produced by hot pressing a polycaprolactone (PCL) Fused Deposition Modeling (FDM) scaffold into a PCL melt electrospun mesh. For the purpose of this work, the FDM part of the scaffold was coated with a CaP layer by immersion into simulated body fluid (SBF) solution before the hot pressing step. The coated scaffolds (as also non coated scaffolds) were then seeded with sheep mandibular osteoblasts (SMOB) and cultured in both osteogenic and basal culture media for 6 weeks. At 2, 4 and 6 weeks timepoints, samples were removed from culture and prepared for characterization, namely by MTS and

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DNA Quantification. Micro-CT analysis was also performed on all specimens before and after the 6 week culture.

RESULTS

By examining the results obtained from the MTS/DNA analysis (Figure 1), it was possible to determine that, when comparing coated and uncoated constructs in the same culture medium (osteogenic or basal), the production of extracellular matrix was always greater when the CaP coating was present. As for the differences found when comparing different types of culture media, these were *a priori* expected since osteogenic medium is a known enhancer of osteogenic activity.

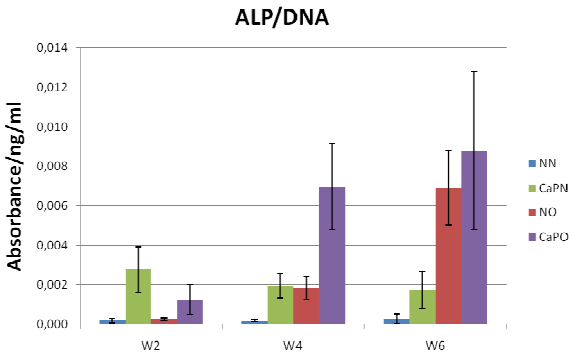

Figure 1- Extracellular matrix production by Alkaline phosphatase activity quantification after 2, 4 and 6 weeks culture. NN:non coated scaffolds in basal medium, CaPN: coated scaffolds in basal medium, NO: non coated scaffolds in osteogenic medium, CaPO:coated scaffolds in osteogenic medium.

These results show that the presence of a CaP coating is capable of enhancing the ECM production either in the presence of a basal medium or osteogenic medium. This same tendency was again found when performing micro-CT analysis. Although not visible in the micro-CT images (Figure 2), by quantitatively comparing the increase in ECM volume in the various conditions (Figure 3) it was again possible to verify that the presence of the CaP coating resulted in a greater increase in the ECM volume either in the presence of basal or osteogenic medium.

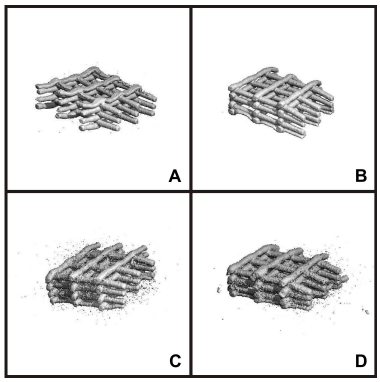

Figure 2- Micro-CT images of constructs after culture for 6 weeks. Constucts are 5mm wide and 2 mm thick. A: non coated scaffolds in basal medium, B: non coated scaffolds in osteogenic medium, C: coated scaffolds in basal medium, D:coated scaffolds in osteogenic medium.

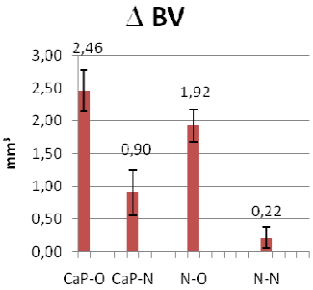

Figure 3- Quantification of the increase in extracellular matrix volume by Micro-CT analysis. CaP-O:coated scaffolds in osteogenic medium, CaP-N: coated scaffolds in basal medium, N-O: non coated scaffolds in osteogenic medium, N-N:non coated scaffolds in basal medium.

DISCUSSION AND CONCLUSIONS

This study demonstrates that a CaP coating can improve the quality of this biphasic construct's bone compartment enhancing its potential applicability to periodontal regeneration.

REFERENCES

Rezwan K, Chen QZ, Blaker JJ, Boccaccini AR. Biodegradable and bioactive porous polymer/inorganic composite scaffolds for bone tissue engineering. Biomaterials 2006;27:3413–31.

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