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Scaffolds Based on Si-Doped-A-Tcp Cement for Tissue Engineering Applications Fabricated by Indirect 3D Printing

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Abstract – Porous structures of numerous build architectures aimed at tissue engineering (TE) application were fabricated using the three-dimensional printing (3DP). The employment of 3DP to fabricate these non-random constructs offers many advantages over conventional scaffold fabrication techniques as patient specific scaffolds with well-defined architectures and controllable pore sizes can be fabricated accurately and rapidly. Direct 3DP, where the final scaffold materials are utilized during the actual 3DP process, imposes several limitations on the final scaffold structure. This study describes an indirect 3DP protocol, where molds are printed and the final materials are cast into the mold cavity to overcome the limitations of the direct technique.

As digital 3D data source for the scaffolds to be build, CT, MRT or otherwise scanned or designed 3D data can be used, which will be prepared for the layer by layer dispensing process within an device specific software. To evaluate the resolution available in this technique, scaffolds (20 mm diameter, 5mm height) were produced by FDM process in acrylonitrile-butadienene-styrene (ABS) materials with three-dimensional interconnectivity (Figure 1). Calcium phosphate cements (CPC) are defined as blends of calcium phosphates powders, that by mixing with an aqueous solution of orthophosphoric acid or its salts, and other additives, form a viscous and moldable paste that sets into a firm mass within a few minutes as a result of the precipitation of a crystalline entanglement, or the formation of an amorphous gel, of a different calcium phosphate. Among all available CPC, the one which setting is based on the hydrolysis of $\alpha\text{-}Ca_3(PO_4)_2$ (α-TCP) to $Ca_9(HPO_4)(PO_4)_5OH$ (CDHA) seems to have proper strength, resorption rate, biocompatibility and bioactivity for bone repairing applications. Lately, the substitution of trace elements in the α-TCP crystal network as a way to enhance its bioactivity and osteoinductivity has received great attention. Several trace elements which play an important role in the growth of healthy bone and cartilages have been tested. Especially silicon, which can partially substitute phosphorus in the tetrahedral sites, has attracted great interest due to the osteogenic and osteoinductive properties attributed to this element. The use of CPC on the development of scaffolds is not yet well defined; however, this material seems to have some advantages on the fabrication of porous bodies since its moldability permits the design of complex pieces. Thus, the aim of this work is the development of scaffolds on the Si-doped-α-TCP cement. Characterization will determine the size and percentage of pores and their interconnectivity. Furthermore, as a way to initially investigate the scaffold biocompatibility a SBF soaking test will be performed.

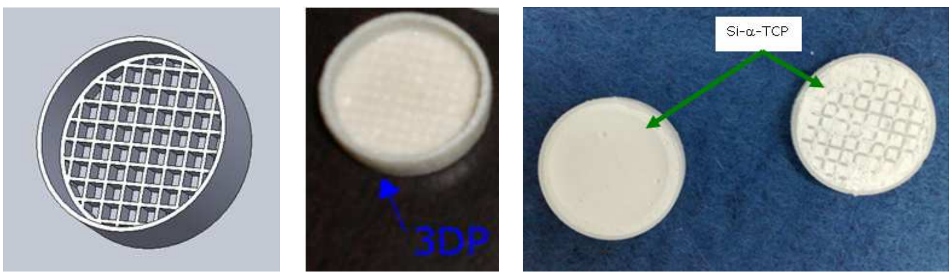

Figure 1: CAD model, physical mold, and biomaterial scaffold.

References

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