Quantitative MicroCT Analysis of SCPP-Erythromycin (EM)-PVA Scaffold

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INTRODUCTION

Strontium(Sr)-doped calcium polyphosphate (SCPP) represents a promising bioceramic material because of its biocompatibility, biomechanical strength, and osteo-conductive nature. Erythromycin (EM) is effective in improving periprosthetic inflammation and osteolysis in patients with aseptic loosening (AL). We have developed a SCPP-EM-Polyvinyl Alcohol (PVA) composite as a sustained EM release device for the prevention and treatment of AL. The aim of this study was to assess the 3D morphological organization of three SCPP scaffolds (SCPP, SCPP-PVA and SCPP-EM (5%)-PVA) by microCT approach.

MATERIALS AND METHODS

Preparation of SCPP-EM-PVA composite: The frit of calcium phosphate monobasic monohydrate ($Ca(H_2PO_4)$) containing 1% Sr was calcined at 500ºC to form polyphosphate. After compressing, the scaffolds (1×5 mm cylinder) were sintered at 800ºC and cooled. For EM incorporation, EM-ethanol solution was added into the SCPP matrix and the final EM concentration was 5% (w/w). SCPP-EM composite was soaked in 7% PVA solution before freezing at -80ºC. SCPP-EM-PVA composite was dried in a freeze dryer (-50ºC, 14Ap) for over 10h. Imaging: Each scaffold was scanned with the Scanco VivaCT 40 using a voltage of 70 kVp and a current of 114 uA at 10um resolution. A cylindrical volume of interest was selected (54 slices) for each scaffold and an optimal threshold of 300 was determined. The morphology of the scaffolds was determined using software from the manufacturer to measure the average wall thickness (Tb.Th), average pore size (Tb.Sp), porosity, pore size distribution and interconnectivity.

RESULTS

Structural analysis: A 3D representation of the scaffold structure is shown in figure 1. The average pore size for the scaffolds decreased from 0.18 mm to 0.08 mm with PVA coating. When the EM was added this value was 0.12 mm. The porosity decreased from 66% to 13% when the PVA coating was added. Pore size distribution: The pore size distribution also differed between the scaffolds. There was a higher percentage of pore size in the 150 um – 250 um range for the SCPP scaffold than the other coated scaffolds (Fig 2). Interconnectivity: The percentage of pores that were connected to the outside environment was 92%, 33% and 88% for the SCPP, SCPP PVA and SCPP PVA EM scaffolds through 20 um openings (Fig 3). These percentages dropped to 42%, 2% and 8% for 200um openings.

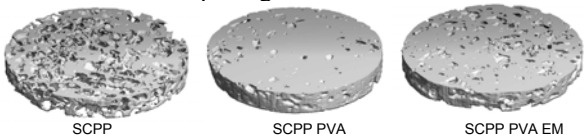

Figure 1. 3D Depiction of Scaffolds

Sample	Percentage of Porosity (%)	Tb.Th (mm)	Tb.Sp (mm)
SCPP	66%	0.09	0.18
SCPP PVA	13%	0.21	0.08
SCPP PVA EM	33%	0.13	0.12

Table 1. Scaffold Morphology

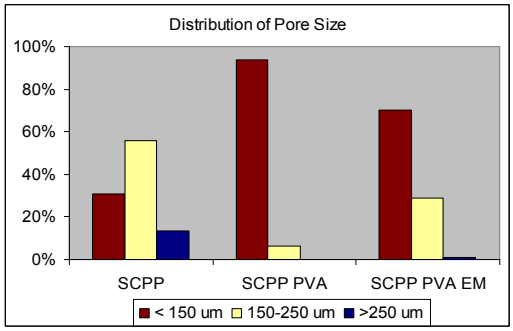

Figure 2. Distribution of Pore Size

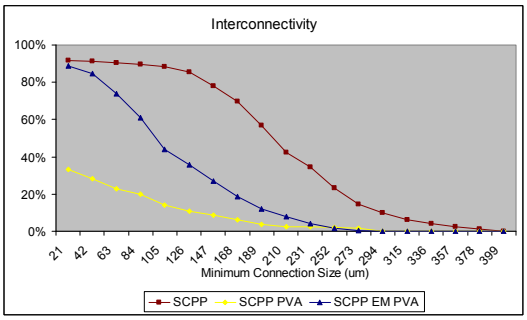

Figure 3. Interconnectivity

CONCLUSIONS

Data generated from this study established quantifiable information about 3-D macro-pore organization of SCPP scaffolds. In this study, PVA coating changed scaffold morphology, as indicated by the values given for percentage of porosity, Tb.Th and Tb.Sp. The osteo-conductivity of scaffolds is affected by the porosity and pore size. A pore size of >100 um and a porosity of >50%-60% has been suggested as sufficient for osteo-conduction[1,2]. PVA coating reduced the porosity, pore size and interconnectivity which may reduce the osteo-conductivity of SCPP scaffolds. This can be improved by the incorporation of EM to some extent. The generation and interpretation of microCT based 3-D pore model provides further insight into the expected osteo-conductive dynamics and therefore might serve as a platform for further development of scaffold geometry as well as for further quantification of bone ingrowths within the SCPP scaffolds.

REFERENCES:

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