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Research paper

The effect of sintering temperature on the microstructure and mechanical properties of a bioceramic bone scaffold

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ABSTRACT

Micro and nanostructural properties are believed to play a critical role in the osteoinductive capacity of bioceramic bone scaffolds. Physical characteristics also play an important role for optimum biological performance, including osteoconductivity and strength. In this study microstructural and nano-mechanical properties of a bioceramic bone scaffold were investigated as a function of the sintering temperature in the range of 950–1150 °C, through the use of scanning electron microscopy (SEM), X-ray diffraction (XRD) and nanoindentation testing. Although the samples presented the same crystallographic phase, an increase in sintering temperature resulted in increased grain size, density and crystallite size. The intrinsic mechanical properties were measured by nanoindentation testing and analyzed with the Oliver–Pharr method. The nanoindentation tests consisted of a series of fourteen partial unload tests ($n = 14$ per treatment) of twelve steps ranging from 1 to 12 mN. Statistically significant increases in hardness and elastic modulus were measured for increasing sintering temperature. These results support the development of clinically successful bioceramic scaffolds with mechanical properties that encourage bone ingrowth and provide structural integrity.

1. Introduction

It is estimated that approximately 28.6 million people suffer from musculoskeletal injuries annually, representing more than a half of all injuries in the United States alone (Weinstein, 2000). Osteoporosis, a major health concern in an aging population, reduces bone mineral density and strength, resulting in diminished skeletal integrity and potential fracture of bones, predominately in the hip, wrist, knee and spine. As a result, significant research efforts have been placed in regenerative medicine with an overall goal to restore damaged tissue to its normative state and function. Porous calcium phosphate (CaP) scaffolds, in particular hydroxyapatite (HA) and tricalcium phosphate (TCP), have seen an increase in clinical and research applications due to their inherent biocompatibility, osteoconductivity, bioactivity, bioresorbability and chemical similarity to the mineral phase of bone (David et al., 1998; Kasten et al., 2008; Riminucci and Bianco, 2003; Yuan et al., 1998). These scaffolds are implanted at the defect site and provide mechanical and biological

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