3D Printed Bioceramic/Biodegradable Polymer Scaffolds for Bone Tissue Engineering

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Abstract

Amino acid-based poly(ester urea)s (PEUs) have mechanical properties similar to biological tissues and degrade hydrolytically into non-toxic byproducts. Our previous in vitro and in vivo studies have shown the potential for 1,6-hexanediol L-phenylalanine-based PEU to be used in bone defect repair. In this work, varied amounts of hydroxyapatite were blended with 1,6-hexanediol L-phenylalanine-based PEU to enhance bone mineralization. These composites have been fabricated into porous scaffolds (80% porosity) by fused deposition modeling 3D-printing and cultured in vitro to examine differentiation of MC3T3-E1 pre-osteoblast cells. The resulting 3D-printed scaffolds exhibited a compressive modulus of ~50 MPa after 1-week incubation in PBS at 37 °C, a cell viability of >95%, and an enhancement of radio-contrast. The influence of HA on the MC3T3 proliferation and differentiation profile was also measured using immunohistochemistry, biochemistry and quantitative real time polymerase chain reaction. By 4 weeks, alkaline phosphatase activity was significantly enhanced for the composite with 30% HA with values reaching 3-fold greater compared to the control. The gene expression data also indicated a significantly enhanced 880-fold higher expression of bone sialoprotein and 15-fold higher expression of osteocalcin for MC3T3s on the 30% HA composite polymer compared to the control. Histology imaging demonstrated increased mineralized extracellular matrix deposition after 4 weeks of cell culture in samples with higher HA content. 3D-printed HA-containing polymer composites provide an efficient and customized method to promote bone regeneration and have the potential to be used in orthopedic applications.