World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:13, No:03, 2019

Human Bone Marrow Stem Cell Behavior on 3D Printed Scaffolds as Trabecular Bone Grafts

Authors : Zeynep Busra Velioglu, Deniz Pulat, Beril Demirbakan, Burak Ozcan, Ece Bayrak, Cevat Erisken

Abstract : Bone tissue has the ability to perform a wide array of functions including providing posture, load-bearing capacity, protection for the internal organs, initiating hematopoiesis, and maintaining the homeostasis of key electrolytes via calcium/phosphate ion storage. The most common cause for bone defects is extensive trauma and subsequent infection. Bone tissue has the self-healing capability without a scar tissue formation for the majority of the injuries. However, some may result with delayed union or fracture non-union. Such cases include reconstruction of large bone defects or cases of compromised regenerative process as a result of avascular necrosis and osteoporosis. Several surgical methods exist to treat bone defects, including Ilizarov method, Masquelete technique, growth factor stimulation, and bone replacement. Unfortunately, these are technically demanding and come with noteworthy disadvantages such as lengthy treatment duration, adverse effects on the patient's psychology, repeated surgical procedures, and often long hospitalization times. These limitations associated with surgical techniques make bone substitutes an attractive alternative. Here, it was hypothesized that a 3D printed scaffold will mimic trabecular bone in terms of biomechanical properties and that such scaffolds will support cell attachment and survival. To test this hypothesis, this study aimed at fabricating poly(lactic acid), PLA, structures using 3D printing technology for trabecular bone defects, characterizing the scaffolds and comparing with bovine trabecular bone. Capacity of scaffolds on human bone marrow stem cell (hBMSC) attachment and survival was also evaluated. Cubes with a volume of 1 cm^3 having pore sizes of 0.50, 1.00 and 1.25 mm were printed. The scaffolds/grafts were characterized in terms of porosity, contact angle, compressive mechanical properties as well cell response. Porosities of the 3D printed scaffolds were calculated based on apparent densities. For contact angles, 50 µl distilled water was dropped over the surface of scaffolds, and contact angles were measured using 'Image J' software. Mechanical characterization under compression was performed on scaffolds and native trabecular bone (bovine, 15 months) specimens using a universal testing machine at a rate of 0.5mm/min. hBMSCs were seeded onto the 3D printed scaffolds. After 3 days of incubation with fully supplemented Dulbecco's modified Eagle's medium, the cells were fixed using 2% formaldehyde and glutaraldehyde mixture. The specimens were then imaged under scanning electron microscopy. Cell proliferation was determined by using EZQuant dsDNA Quantitation kit. Fluorescence was measured using microplate reader Spectramax M2 at the excitation and emission wavelengths of 485nm and 535nm, respectively. Findings suggested that porosity of scaffolds with pore dimensions of 0.5mm, 1.0mm and 1.25mm were not affected by pore size, while contact angle and compressive modulus decreased with increasing pore size. Biomechanical characterization of trabecular bone yielded higher modulus values as compared to scaffolds with all pore sizes studied. Cells attached and survived in all surfaces, demonstrating higher proliferation on scaffolds with 1.25mm pores as compared with those of 1mm. Collectively, given lower mechanical properties of scaffolds as compared to native bone, and biocompatibility of the scaffolds, the 3D printed PLA scaffolds of this study appear as candidate substitutes for bone repair and regeneration.

Keywords : 3D printing, biomechanics, bone repair, stem cell
Conference Title : ICBBM 2019 : International Conference on Biomaterials and Bioinspired Materials
Conference Location : Dubai, United Arab Emirates
Conference Dates : March 21-22, 2019