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Dual 3D Printing Hierarchical Nano/Micro Vascularized Bone Tissue

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Abstract: The vascularization is the most significant to achieve efficient supplement of the nutrients and oxygen for tissue and organ regeneration. However, there is a remaining challenge to fabricate a durable and functional vascularized tissue. Currently, 3D printing has emerged as a promising technique to fabricate vascular networks in many studies due to its superior controllability, reproducibility, and repeatability. In the current study, the main objective is to utilize an advanced dual 3D printing technique including stereolithography (SLA) and fused deposition modeling (FDM) to create a biomimetic bone tissue with perfusable vascular networks. Specifically, the vascularized bone construct was fabricated by SLA with an optimized bioink of 70 wt% nanocrystalline hydroxyapatite, 10% concentration of gelatin methacryloyl, 1% concentration of 2-hydroxy-4'-(2-hydroxuethoxy)-2-methylpropiophenone photoinitiator, and poly (ethylene glycol) diacrylate. In addition to that, a water-dissolvable poly (vinyl alcohol) based Y-shape sacrificial template was 3D printed by FDM to be embedded within the SLA printed bone matrix to form a perfusable vessel channel with a diameter of ~500 μm. Upon the completion of structural and ink optimization, the fabricated vascularized bone construct has shown excellent mechanical properties and minimum mass swelling. After co-culture of human bone marrow mesenchymal stem cells and human umbilical vein endothelial cells, our vascularized bone constructs exhibited outstanding cell viability, cell growth morphologies, as well as osteogenesis and angiogenesis in a dynamic culture condition. The advanced 3D dual printing platform provided a promising approach to create a hierarchical vascularized bone tissue mimicking the natural one, which also possesses great potential for various vascularized tissue and organ regeneration.

Keywords: 3D printing; vascular network; bone; tissue regeneration; nanomaterials

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