Research Week 2023

Faster biomineralization and osteogenesis on-a-chip using 3D bioprinting and microfluidics

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Keywords

Tissue engineering, human bone regeneration, bioprinting, microfluidics, biomineralization

Abstract

Bone defects can occur after trauma, infection, or oncologic resection and autologous bone grafting is the current treatment option. However, this method has its limitations in more severe injuries as it may cause infection and scarring at donor sites. Thus, developing biomaterials that are osteoinductive with live cells is essential for treating bone defects. We are creating a bone-like structure that are biomineralized to the nanoscale level and embedded with human mesenchymal stem cells (hMSCs) that undergo osteogenic differentiation without any conventional supplements. To enhance the regenerative capacity and fasten the mineralization process, we developed a microfluidic cell culture system and created a mineralized bone like structure with osteogenesis in 3 hours compared to the conventional osteogenesis process that takes 21 days. In this study, we developed a microfluidic cell culture system that recapitulates biomineralization and early osteogenesis on injectable microgels. We used a DLP (Digital light processing) printer to 3D bioprint microgels of GelMA encapsulated with hMSCs. These microgels were mineralized under flow within 3 hours with calcium and phosphate rich media, in a custom-made chip, which was characterized by alizarin red and von Kossa staining. Live/dead staining showed hMSCs viability after mineralization underflow, while OCN, RUNX2 & PDPN expression indicated successful osteogenic stem cell differentiation in the presence of fluid shear stress (FSS). Our novel approach provides an effective strategy for developing treatments for bone defects by recapitulating biomineralization and osteogenesis on an injectable microgel.