Effect of technical parameters on porous structure and strength of 3D printed calcium sulfate prototypes.

Abstract
Additive manufacturing methods such as three-dimensional printing (3DP) show a great potential for production of porous structure with complex internal and external structures for bone tissue engineering applications. To optimize the 3DP manufacturing process and to produce 3D printed parts with the requisite architecture and strength, there was a need to fine-tune the printing parameters. The purpose of this study was to develop optimal processing parameters based on a design of the experiments approach to evaluate the ability of 3DP for making calcium sulfate-based scaffold prototypes. The major printing parameters examined in this study were layer thickness, delay time of spreading the next layer, and build orientation of the specimens. Scaffold dimensional accuracy, porosity, and mechanical stiffness were systematically investigated using a design of experiment approach. Resulting macro-porous structures were also studied to evaluate the potential of 3DP technology for meeting the small-scale geometric requirements of bone scaffolds. Signal-to-noise ratio and analysis of variance (ANOVA) were employed to identify the important factors that influence optimal 3D printed part characteristics. The results showed that samples built using the minimum layer thickness (89 µm) and x-direction of build bed with 300 ms delay time between spreading each layer yielded the highest quality scaffold prototypes; thus, these parameters are suggested for fabrication of an engineered bone tissue scaffold. Furthermore, this study identified orientation and new layer spreading delay time as the most important factors influencing the dimensional accuracy, compressive strength, and porosity of the samples.

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