BIOPRINTING FOR TISSUE ENGINEERING AND REGENERATIVE MEDICINE

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ABSTRACT

Fabrication of scaffolds via bioprinting involves precise deposition of bioinks layer-by-layer to form three-dimensional structures supporting cell attachment, proliferation, and differentiation. Various techniques, including extrusion-based syringe, inkjet-based, and laser-assisted bioprinting, offer advantages in resolution, speed, and biomaterial compatibility. Scaffold bioprinting requires selecting bioinks with biocompatibility, mechanical integrity, and promotion of cellular activities, commonly using natural polymers like alginate and gelatin, or synthetic polymers such as polycaprolactone (PCL) [1]. Incorporating bioactive molecules, growth factors, and nanomaterials into bioinks enhances scaffold biofunctionality, aiding cell adhesion, proliferation, and tissue regeneration. Advanced strategies, like multi-material and gradient printing, enable fabrication of complex scaffolds with controlled mechanical and biochemical cues, mimicking native tissue microenvironments. Computational modelling techniques aid in scaffold design optimization with predefined geometries and functionalities. These advancements hold promise for personalized medicine, organ-on-a-chip platforms, and drug screening assays [2]. In that respect, scaffold bioprinting is a potent tool in tissue engineering and regenerative medicine, offering capabilities to fabricate biomimetic constructs tailored to specific properties. In our laboratory, we have successfully printed well-defined composition scaffolds with biocompatible materials (both polymer and hybrid metal-organics; PLA, PCL, Hydroxyapatite, and select mixtures thereof), the physicochemical characterization of which (structural spectroscopic, mechanical) provided a credible profile enabling further biological evaluation. The scaffolds were exposed to cell cultures and turned out to be suitable for cell and tissue growth. To that end, the results suggest that cells (Leiomyosarcoma (LMS) cell cultures) seeded onto the scaffold surface developed into tissue, thus demonstrating the scaffold's conducive environment to growth. Cell growth was dependent on the nature (geometry) and composition (variably hybrid) of the scaffold used, thus providing a useful screen for further biological evaluation. Collectively, research has shown that well-defined scaffolds can meet the tissue engineering challenges and through bioprinting they could enter clinical work for treating various theranostics.

KEYWORDS: 3D bioprinting, biodegradable scaffolds, tissue engineering, cell culture

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