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Abstract

3D-printed silk fibroin as a resorbable biomaterial in wound healing

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Wound healing is a complex biological process that involves the restoration of tissue integrity and functionality. Traditional wound dressings often lack the ability to provide an optimal environment for tissue regeneration. To address this limitation, there has been growing interest in the development of advanced biomaterials for wound healing applications.

The scientific understanding of the impact of the extracellular matrix on cell interactions and desired regenerative outcomes supports the need to replace or cover the wound matrix with biomimetic and biocompatible materials following an injury. Silk fibroin, a natural protein derived from silkworm cocoons, has gained considerable attention as a promising biomaterial due to its remarkable properties, including biocompatibility, biodegradability, and mechanical strength. Multiple investigations have demonstrated stimulating effects on proliferation, migration, and adhesion, as well as benefits for vascularization, reepithelialization, and cell differentiation. Silk protein elicits a low to mild immune response without serious reactions and is absorbable, depending on its modifiable mechanical properties. In wound healing, subcellular mechanisms have been identified for targeted exploitation using small particles or molecules to enhance effective tissue regeneration. Advanced techniques allow for the modification and functionalization of silk fibroin at the molecular level. Recently, 3D printing technology has emerged as a powerful tool for fabricating complex structures with precise control over their geometry and architecture. By combining 3D printing and silk fibroin, it is possible to create customized scaffolds that mimic the native tissue environment and promote efficient wound healing.

Here we focus on translating basic research into clinical applications, where silk, as an innovative wound material, will be 3D-printed using an algorithm based on artificial intelligence (AI). In this process, the wound defect will be scanned, and the dataset will be optimized through AI to enable the printing of patient-specific, custom-fit silk-based "patches."

The utilization of 3D-printed silk fibroin scaffolds in wound healing provides numerous advantages due to their porous structure, which allows for cell infiltration, nutrient exchange, waste removal, and tissue regeneration facilitation. The mechanical properties of silk fibroin can be adjusted by modifying printing parameters, ensuring mechanical stability and support during the healing process. Additionally, AI-driven printing techniques provide numerous advantages for 3D-printed silk fibroin in wound healing, including improved precision, customization, and personalization of wound dressings, as well as enhanced time and cost efficiency, and accelerated research and development. AI algorithms optimize the design and fabrication process based on patient-specific data, resulting in better-fitting dressings, quicker production, and more favorable wound healing outcomes.

AUTHOR'S STATEMENT
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