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Comparative Study of Chitosan Scaffolds via 3D Printing and Freeze-Drying - Abstract

Chitosan is a natural biopolymer with excellent biocompatibility. Chitosan has been used extensively in wound healing and soft tissue applications due to its ability to promote cell adhesion, proliferation, and tissue regeneration brought on by its hydrophilicity. While both 3D printing and freeze-drying have been extensively studied for the preparation of chitosan-based scaffolds, few studies have directly compared how these methods influence critical properties such as degradation kinetics, swelling behavior, and structural integrity under physiological conditions. Additionally, variations in pore interconnectivity, distribution, degradation rates, and functional stability add further difficulty in selecting the optimal fabrication technique. This study aims to identify the fabrication-dependent differences that affect reproducibility, durability, and manufacturing scalability.

To assess the impact of each fabrication technique, scaffolds will be characterized based on swelling behavior, accelerated degradation, and microstructural features using scanning electron microscopy (SEM). Swelling is critical for wound healing applications, as it influences the scaffold's ability to absorb, exudate and maintain a moist environment, which is essential for tissue regeneration. Degradation studies are to be done under accelerated simulated physiological conditions to ensure scaffold degradation rates match tissue proliferative and remodeling phases of healing, quantified by weight loss measurements with a target of 50% weight loss in 3 weeks, and complete degradation by 6 weeks. SEM analysis will assess pore size, distribution, and interconnectivity which directly affect adequate cell infiltration, cell migration, nutrient diffusion, and vascularization. Additionally, comparing fabrication parameters, such as total processing and material preparation time, solvent use, and equipment requirements will be performed to determine the feasibility of scaling up for each technique.

By clarifying the structure-property relationships of chitosan scaffolds, this research provides critical insights for optimizing scaffold fabrication in regenerative medicine. These findings will guide the selection of fabrication techniques for wound healing applications, potentially advancing soft tissue engineering strategies and improving clinical outcomes.