

Bacterial Cellulose Structuring in Confined Environments for Bone Tissue Engineering

Abstract

Bacterial cellulose has been used for different biomedical application due to its biocompatibility and adaptable mechanical properties. However, little is known about how it forms and organizes in confined environments. Understanding these interactions could help develop predictive models for guiding bacterial cellulose biofabrication, particularly for bone tissue engineering. This study aims to explore how bacterial adhesion, biofilm formation, and fiber organization are influenced by spatial constraints, contributing to the development of biofabricated bone scaffolds with improved microarchitecture. The research will focus on creating controlled microenvironments using volumetric 3D printing, where bacterial cellulose-producing bacteria will be embedded in a bioresin matrix with tunable mechanical properties. Different confinement conditions will be tested by varying aspect ratios from 1:2 to 1:10 and stiffness levels between 100 Pa and 100 kPa. Fluorescence microscopy and SEM imaging will be used to analyze bacterial adhesion and cellulose fiber formation, while image analysis software (FIJI/ImageJ) will quantify fiber orientation and biofilm density, establishing links between confinement parameters and bacterial cellulose structuring. This study is expected to reveal how mechanical constraints shape bacterial cellulose formation. Higher stiffness may promote structured fiber alignment, while lower stiffness could lead to a more disordered architecture. By identifying the optimal conditions for bacterial cellulose structuring, this work will contribute to improving scaffold design for bone tissue engineering. Ultimately, these findings will support the development of predictive biofabrication strategies, enhancing the use of bacterial cellulose for biomedical applications.

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