Bioengineering Xenoantigen-Free Xenografts for Enhanced Recellularization

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Abstract

Eliminating xenoimmunogenicity while promoting effective recellularization remains a major challenge in developing implantable xenografts. We developed a novel bioengineering strategy combining optimized decellularization with the removal of major xenoantigens to generate biocompatible scaffolds with reduced immunogenicity. This study evaluated the safety, and efficacy of this approach and investigated its ability to support mesenchymal stem cell (MSC)-mediated recellularization. Xenografts were decellularized using a multistep detergent-based protocol followed by xenoantigen removal. Biomechanical integrity was assessed by tensile testing and permeability analysis, while xenoantigen removal was evaluated using carbohydrate-binding lectin staining. The resulting scaffolds were seeded with human MSCs, and recellularization, cellular differentiation, and extracellular matrix remodeling were examined by histological and immunohistochemical analyses. Xenoantigen-free scaffolds maintained their histological architecture and biomechanical properties without significant alterations following processing. Carbohydrate-binding lectin expression was markedly reduced, confirming effective elimination of major xenoantigens. Compared with untreated controls, the scaffolds demonstrated significantly greater MSC infiltration, accelerated recellularization, enhanced cellular differentiation, and increased extracellular matrix remodeling. Biocompatible xenoantigen-free xenografts preserved biomechanical integrity while supporting efficient MSC-mediated recellularization. These findings demonstrate the potential of this bioengineering strategy to generate implantable scaffolds with enhanced regenerative performance for tissue engineering.

Keywords

Xenografts, Tissue engineering, Decellulariation, Recellularization.