Interconnected collagen scaffolds prepared with sacrificial templates for cartilage tissue engineering

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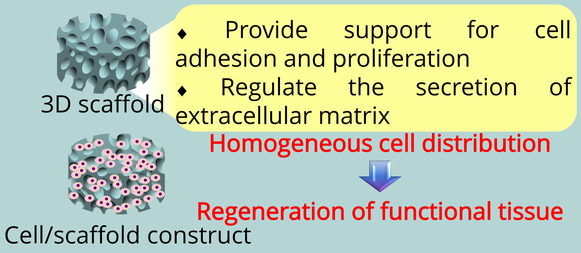
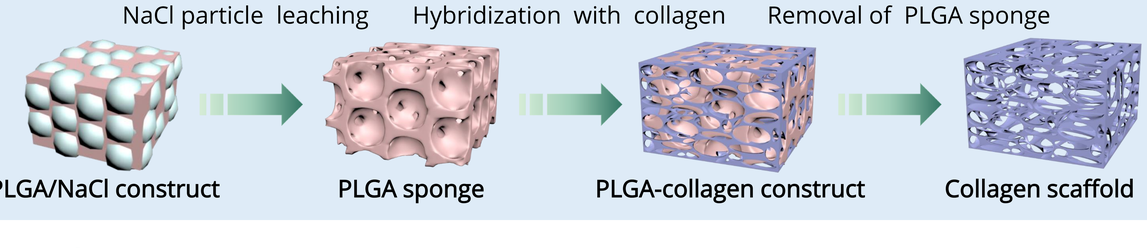
Introduction

Articular cartilage is avascular, aneural and alymphatic tissue with limited spontaneous healing capability.
Cartilage tissue engineering requires homogeneous cell distribution throughout the scaffolds to guarantee the regeneration of functional cartilage tissue.
In this study, PLGA sponges were used as sacrificial templates to precisely control the interconnectivity of collagen scaffolds.

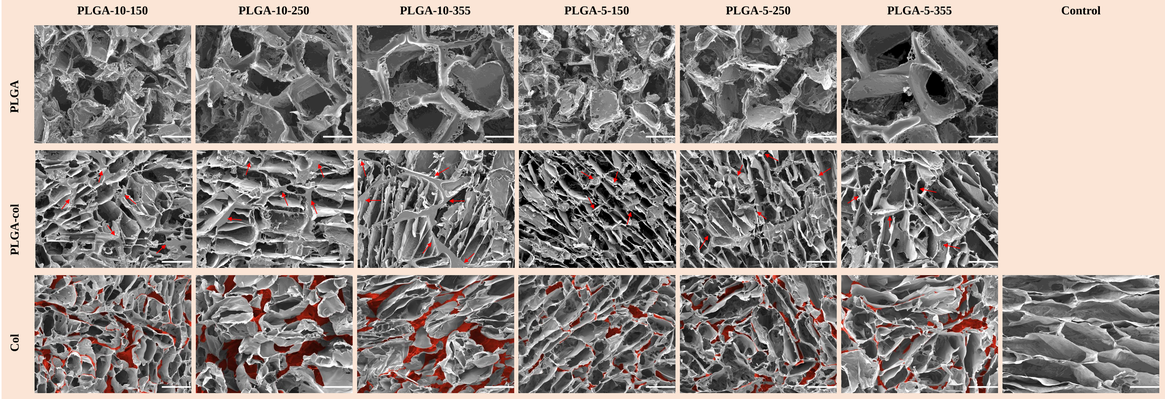


Materials and methods



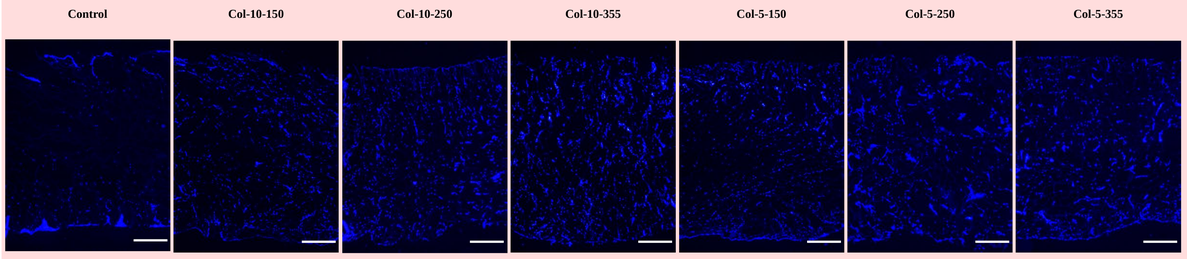
Results

Morphology of PLGA templates, PLGA-collagen constructs and collagen scaffolds



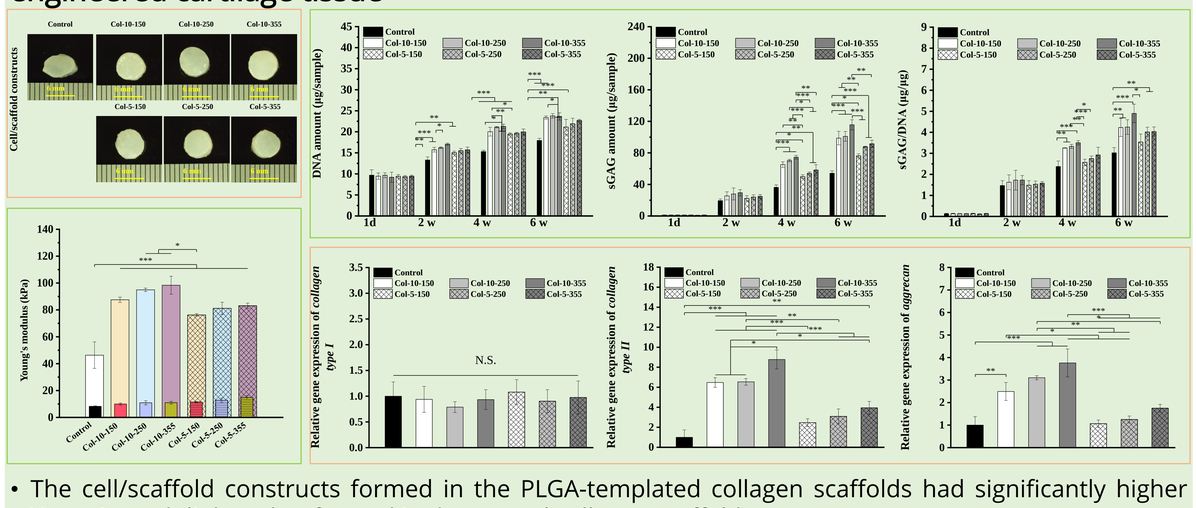
The pores were the negative replicas of the NaCl particulates and their size and shape were determined by the salt particulates. Pore size increased with increasing size of the salt particulates. The pore walls became thicker when a higher PLGA ratio and larger salt particulates were used. Hybridization with collagen resulted in the formation of collagen microsponges in the pores of the PLGA sponges. After selective removal of the PLGA sponge templates, collagen scaffolds were obtained. Removal of the PLGA templates left negative replica spaces (see the red highlighted regions in the images) in the collagen scaffolds, which formed interconnecting channels in the scaffolds. The interconnecting channels linked the pores of the collagen microsponges, making the whole pore structures well interconnected. Scale bar: 200 μm.

Cell distribution in the collagen scaffolds



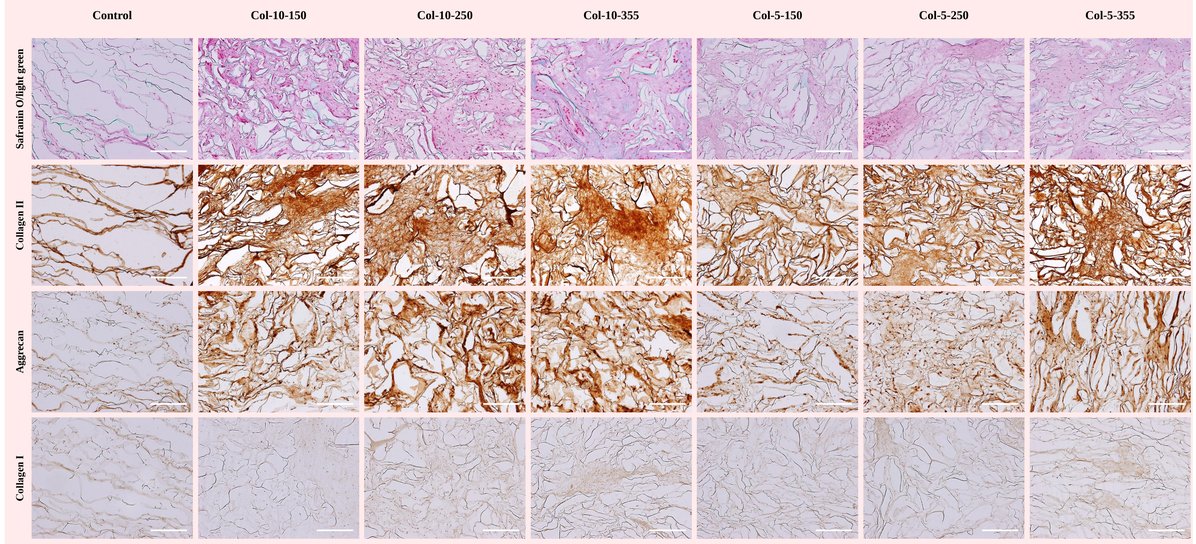
Nuclear staining showed that cells were densely distributed on the scaffold surface of the control collagen scaffold and fewer cells were distributed in the central regions. On the other hand, cells were more homogeneously distributed in the PLGA-templated collagen scaffolds. From the top surface to the central region and bottom region, cells were detected at almost the same frequency. The good interconnectivity of the PLGA-templated collagen scaffolds facilitated cell penetration and resulted in homogenous cell distribution throughout the scaffolds. Scale bar: 500 μm.

Gross appearance, mechanical properties, DNA and sGAG and gene expression of engineered cartilage tissue



- The cell/scaffold constructs formed in the PLGA-templated collagen scaffolds had significantly higher Young's moduli than that formed in the control collagen scaffold.
- The PLGA-templated collagen scaffolds were favorable for cell proliferation and the production of cartilaginous ECM.
- The expression levels of cartilaginous genes increased in the PLGA-templated collagen scaffolds.

Histological and immunohistochemical staining



Histological and immunohistochemical staining were carried out to investigate the secretion and distribution of cartilaginous extracellular matrix after in vitro culture for 6 weeks. Safranin O staining showed abundant cartilaginous extracellular matrix (ECM) throughout the PLGA-templated collagen scaffolds and sparse ECM in the control collagen scaffold. Immunohistochemical staining showed that collagen type II and aggrecan were more strongly stained and more homogeneously distributed in the PLGA-templated collagen scaffolds than in the control collagen scaffold. Scale bar: 500 μm.

Summary

❖Collagen scaffolds with high interconnectivity were prepared using sacrificial PLGA sponge templates.
❖Chondrocytes adhered and distributed homogeneously in the collagen scaffolds and showed a high proliferation rate, high expression of cartilaginous genes and secretion of cartilaginous extracellular matrix.
❖The PLGA-templated collagen scaffolds facilitated the formation of homogenous tissue with high compression strength.

Reference: J. Mater. Chem. B, 2021,9, 8491-8500.

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