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Mechanical properties of collagen-based scaffolds for heart valve tissue engineering

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Collagen, glycosaminoglycans (GAGs) and elastin are the major components of the extracellular matrix of the heart valve. This work examined scaffolds made of collagen, collagen-elastin composite, and collagen-chondroitin sulfate (CS) composite, with various relative densities (0.5% wt/v to 2.5% wt/v) and compositions (up to 80% elastin and up to 50% CS respectively). Scaffolds were prepared by freeze drying method, and had mean pore sizes ranging from 65.4μm to 201.5μm. Mechanical characterization (compression, tension and three-point bending) showed that the scaffolds all behaved as elastomeric foams. The compressive, tensile and bending moduli of the collagen scaffolds increased from 7.9±2.0 kPa, 213.1±18.9 kPa and 31.8±4.5 kPa to 213.9±11.2 kPa, 1082±132 kPa and 272.1±13.7 kPa respectively, with the increase of the relative density. By incorporating elastin or CS into the collagen scaffolds, the mechanical properties of the scaffolds were further adjusted. This work also developed a novel tri-layer structure that resembled the fibrosa-spongiosa-ventricularis structure of the native aortic valve, with each layer being collagen, collagen-CS, and collagen-elastin respectively. The different mechanical properties of each layer introduced a desirable bending anisotropy to the scaffold, which mimicked the characteristic behaviour of the native aortic valve that it is easier to bend towards the ventricularis side (with curvature) than towards the fibrosa side (against curvature). Finite element modelling of the scaffolds produced results in good agreement with the experimental data, and further facilitated the analysis of internal stress of the scaffolds and the application of distributed loading on the scaffolds.

Biography

Qi Chen is a D.Phil student of Oxford University working on biomaterials (mainly scaffolds for tissue engineering). He completed his Bachelor's degree in materials science at Shanghai Jiao Tong University, China.

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