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Multi-layer scaffolds for heart valve tissue engineering

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Native heart valve has the fibrosa-spongiosa-ventricularis tri-layer structure, with the main extracellular matrix (ECM) material of each layer being collagen, glycosaminoglycans (GAGs), and elastin respectively. It is because of this layered structure that the heart valve exhibits a flexural anisotropy, that is, it is easier to bend towards the ventricularis side (VS) (known as 'with curvature') than towards the fibrosa side (known as 'against curvature'). In this present study, a bi-layer structure was introduced to the scaffolds for heart valve tissue engineering, with one layer rich in collagen and the other rich in elastin. Flexural properties of the bi-layer scaffolds were examined by three-point bending tests, which showed that the scaffolds had anisotropic bending modulus (21.9±4.1 kPa with curvature VS 39.3±3.6 kPa against curvature). A finite element approach (ANSYS) was used here to simulate the three-point bending tests, and had been in good agreement with the experimental data. Simulated bending tests with distributed loading were performed, and showed that the bi-layer scaffold would have a 0.4mm difference in the deflection under 500 Pa, depending on which direction it was bent. Internal stress analysis found that there was a higher shear stress (~800 Pa) at the layer interface than in the region less close to it (~400 Pa). The findings of this work served as a step forward to the tri-layer scaffold, and also provided guidance for better designing a mechanically qualified scaffold for heart valve tissue engineering.

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