Time Dependent Properties of the Aortic Valve: Contribution of the Glycosaminoglycans
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Introduction
The aortic valve (AV) is characterised by a complex mechanical behaviour which is closely linked to its structural components. The central layer of the AV is rich in glycosaminoglycans (GAGs) which are responsible for the lubrication of the other two layers and play an important role in the resistance to compressive force. The biomechanics of the aortic valve has been analysed and highly anisotropic behaviour has been described and quantified1, however the effect of the single components on the time dependent behaviour is still unknown. In this study the effect of glycosaminoglycans on biaxial time dependent behaviour of porcine AV was analysed and quantified.

Materials and Methods
Fresh AV cusps (right-coronary) were dissected from adult pig hearts (30–36 months) sourced from a local abattoir. The specimens were either treated enzymically to remove all of the GAGs (-GAGs group, n = 10) or left untreated (control group, n = 9). The cusps were cut into 1cm x 1cm square sections and mounted with special grips on a biaxial system (Bose Electroforce). The sample was stretched in both the radial and circumferential direction to a physiological load equal to 1.1 N/cm and allowed to relax for 1000 seconds. Force values and strain levels were measured continuously during the test. Afterwards, a cycle of load-displacement measurements was recorded for radial and circumferential axes. The Fung form for the reduced stress relaxation function was fitted to the experimental data2. Constants C, \( \tau_1, \tau_2 \) (\( \tau_2 > \tau_1 \)) were calculated using trust-region-reflective algorithm implemented in MATLAB.

Results
Biaxial stress relaxation test was performed on porcine aortic valve specimens from both control and -GAGs groups. The reduced stress relaxation function was calculated from the experimental data and fitted using the QLV theory (see figure 1). Statistical difference was found between the values of \( \tau_1 \) in the radial and circumferential direction for the -GAGs group (6.13±3.20 s for circumferential direction, 3.57±2.71 s for the radial direction, p<0.05), while no statistical difference was present in the control group.

Fig.1. Numerical fitting of experimental force (F) values with reduced stress relaxation function.

Discussion and Conclusions
The presence of GAGs influences the biomechanics of the AV in terms of time dependent mechanical behaviour. \( \tau_1 \) value was statistically different in the two directions for the -GAGs group. The removal of GAGs seemed to increase the anisotropicity of the AV; therefore their effect has to be taken into account for the design of tissue engineered AV constructs.

References

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