Biomechanical Properties of Calf Pericardium

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INTRODUCTION

Calf pericardium is currently employed in the manufacture of valve leaflets for the replacement of diseased human heart valves. The tissue may also be used as a substrate for the evaluation of biomaterials and medical devices. To characterize the biomechanical properties of the pericardium, tensile testing has been traditionally utilized. However, the common tensile tests typically provide a large variation in data.[1] Additionally, tissue is difficult to grip during tensile testing. In this study, we compared the biomechanical properties of calf pericardium as measured by a punch test, with those measured during a tensile test.

MATERIALS AND METHODS

Fresh calf hearts with pericardium were obtained from a local abattoir. The animals were between ages of 8-12 months and weighed about 110-160 kg. Upon receiving, the pericardial sacs were separated from the hearts. The connective and fatty tissues on the pericardium were removed. For the punch tests, the tissue sample was cut into a 25×25 mm specimen and secured between two metal plates with a circular punching area of diameter 11 mm. Two hearts were used for each testing condition (total 6 hearts tested). Each pericardium produced 30 testing specimens. A spherical punch probe head with three diameters, 6.4, 3.2 and 1.6 mm, was used. An Instron 5544 tester with a 500-N load cell was used. The crosshead speed was 50 mm/min. The maximum load was recorded. For tensile tests, the same Instron with a 100-N load cell was used. The crosshead speed was 127 mm/min. A dumbbell specimen (total length = 37 mm, narrow section length = 20 mm, width = 14 mm, testing section width = 4.5 mm) was cut by a die cutter. Each pericardial sample yielded 13 to 15 specimens for tensile testing. A total of three pericardium samples was used. The tissue thickness was measured by a Mitutoyo Absolute digital gauge (Model ID-C1012EB). All tests were conducted at room temperature.

RESULTS AND DISCUSSION

The experimental results showed that the variation in results from the punch tests was much smaller than that from the tensile tests. Fig 1 displays the tensile strength of calf pericardium. A coefficient of variation (COV) of 43 to 45% in tensile strength was observed in this study, which is comparable to the published data (36 to 42%)[1]. The average tensile strength of three pericardium samples tested on three different days ranged from 10.62 to 12.26 MPa, which is also comparable to the published data[1]. There were no statistical differences in tensile strength from three hearts among the three samples (ANOVA, $p>0.67$). The COV for punch strength was 21 to 26%, much less than that for tensile strength. Fig 2 illustrates the dependence of punch strength on the diameter of the probe tip. Clearly, the punch strength increased significantly with the increased probe diameter, which can be described very well by a power law, $\boldsymbol{s = 40.17d^{1.25}}$ with $\boldsymbol{R^2 = 0.997}$, where $\boldsymbol{s}$ is punch strength and $\boldsymbol{d}$ diameter. When diameter was increased from 1.6 mm to 3.2 mm, the punch strength increased by 135.8%; when diameter was increased from 3.2 mm to 6.4 mm, the punch strength increased again by 138.8%. To examine the variation in pericardium thickness, the thickness for pericardium from 9 hearts is presented in Fig 3. The thickness varied from 0.327 to 0.413 mm, with most falling within the range of 0.369 to 0.408 mm. Generally, the peak punch load increased with the pericardium thickness, as shown in Fig 4. However, when this peak force was normalized by thickness, the force showed no clear dependence on the thickness.

SUMMARY

Biomechanical properties of calf pericardium were investigated by tensile and punch tests. The study indicated that the punch tests yielded much more consistent results than the tensile tests. The relationship between punch strength and probe diameter could be described by a power law.

REFERENCES

1. Paez, J, et al, Biomaterials 24 (2003), p1671.

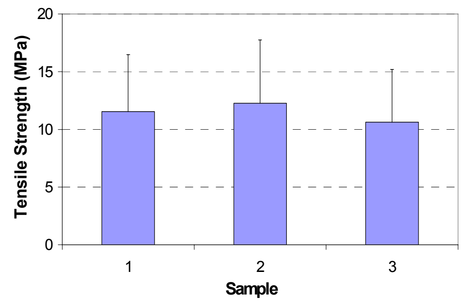

Fig 1. Tensile strength of three pericardium samples

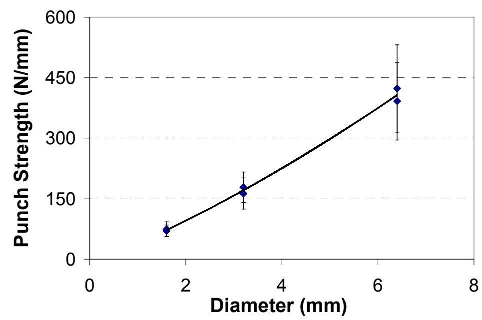

Fig 2. Dependence of punch strength on probe diameter

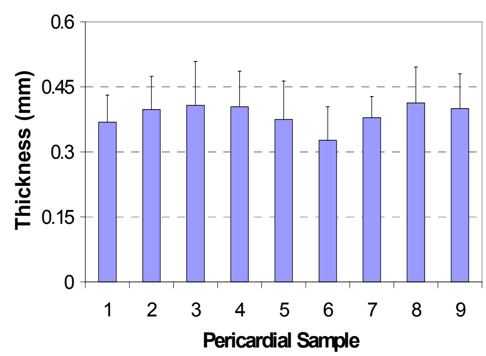

Fig 3. Variations in pericardial tissue thickness

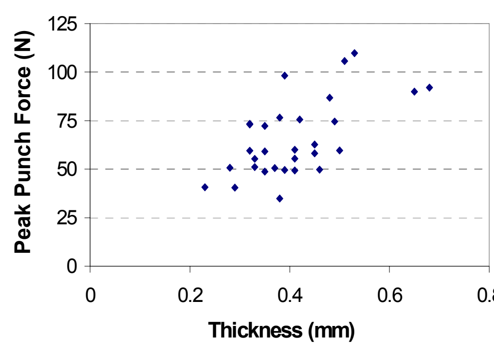

Fig 4. Change of punch strength with tissue thickness