Mechanical and Structural Characteristics of Cholecyst-derived Extracellular Matrix

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Introduction

A new acellular, natural, biodegradable matrix has been isolated from the cholecyst (CEM). This matrix is rich in collagen and contains several other macromolecules that are useful in tissue remodelling (eg, gylcosaminoglycans, proteoglycans, and elastin)[1]. The aim of developing this matrix is to optimize the mechanical properties of the scaffold to mimic the variety of clinical applications for which it can be used. The objective of this study was to characterise the matrix's native mechanical properties and structural organization. In this study, the principal material axes and biaxial mechanical properties are characterised.

Methods

CEM was isolated from fresh tissue by mechanically separating the acellular layer from the inner mucosa and outer serosa. Five square specimens measuring approximately 2.8cm^2 were attached to a biaxial testing rig, pre-conditioned, and loaded in equibiaxial strain to 5N, which corresponded to a stress of 1 MPa.

The principal material axes were found by measuring the strain at 15° increments according the method of Choi et al.[2] in 11 specimens. Aspect ratio was also calculated to determine the degree of macroscopic anisotropy. A custom algorithm (Matlab®, The Mathworks Inc.) calculated both the orientation angle with respect to the neck-fundus direction and the aspect ratio for each specimen by fitting an ellipse to the ring of markers placed during the loading process.

Results and Discussion

The average thickness of CEM was 0.13 ± 0.02mm. Fresh CEM exhibited large strains and non-linear, exponentially increasing stress-strain curve (Figure 1), similar to other matrices.[3] This data indicates that over much of the physiological range, CEM will stretch readily. The requirements of each clinical application are different, so this can be a desirable trait for some uses, and not for others. Cross-linking the matrix can increase the stiffness of the matrixl[4] and possibly increase the number of applications in which it can be used effectively.

The principal material axis was oriented 63° ± 13.7° from the long axis (Figure 2) and the aspect ratio was 0.11 ± 0.06, indicating only a weak anisotropy in that direction.

Conclusions

This mechanical analysis of CEM demonstrates it is weakly anisotropic at 63° to the neck-fundus direction and it has the ability to support large strains across a range of physiological loading conditions. This data also demonstrates a high overall strength, increasing the potential for applications in a wide range of clinical applications.

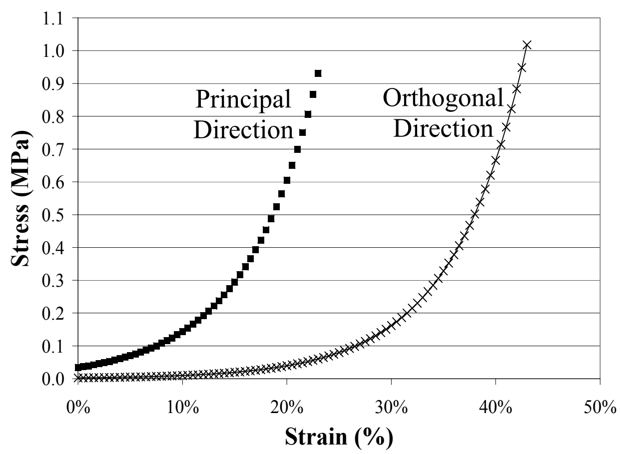

Figure 1: Stress-strain response of CEM in the principal and orthogonal directions. Note the long toe region of low stress and high strain.

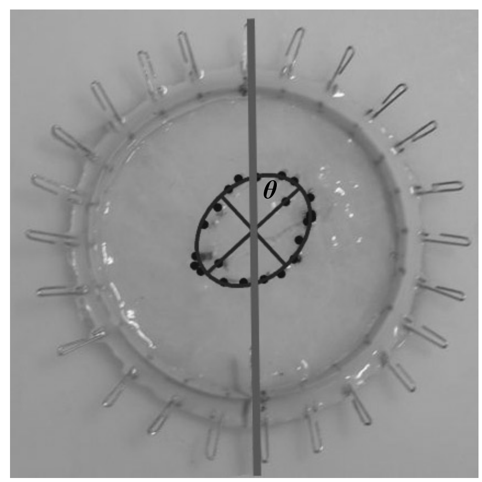

Figure 2: Digitized ellipse superimposed on specimen. Vertical line represents the anatomical long axis of the cholecyst. θ represents the principal axis angle.

References

[1] Burugapalli et al. Proc TESI Annual Mtg (2005)
[2] Choi et al. J Biomech Eng **112** (1990)
[3] Sacks et al. Ann Biomed Eng **26** (1998)
[4] Langdon et al. Biomaterials **20** (1999)

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