TIME-DEPENDENT FRACTURE TOUGHNESS OF PORCINE CORNEA

Khaow Tonsomboon, Ching Theng Koh, Michelle L. Oyen
University of Cambridge, Engineering Department, Cambridge, UK

Introduction

The fracture resistance of cornea is important for the prevention of catastrophic failure due to physical external forces or intraocular pressure. However, to date, there have been very few to no of studies of corneal toughness. In this work, fracture toughness of porcine cornea was determined from a tearing test, and the effect of extension rate on cornea's fracture toughness was also investigated.

Methods

Tearing tests were performed with a universal testing machine (model 5544, Instron, Canton, MA) with 500 N load cell at room temperature. Three groups of hydrated porcine corneas ($n = 3$), each with a 4 mm sharp notch along the superior-inferior direction (Figure 1(a)), were used in this study. Small pieces of sand paper were attached to the scleral parts to assist in gripping and prevent the slippage of specimens from the grips. Each group was stretched at different extension rates: 3, 30 and 300 mm min^{-1}. The specimens were unloaded at the same rate before fracture had propagated along the full specimen length. Tear fracture toughness (T) was calculated from the mean load (P_0) at the plateau region from load-extension curves and the specimen thickness (t_h) [Purslow, 1983, Rivlin, 1953].
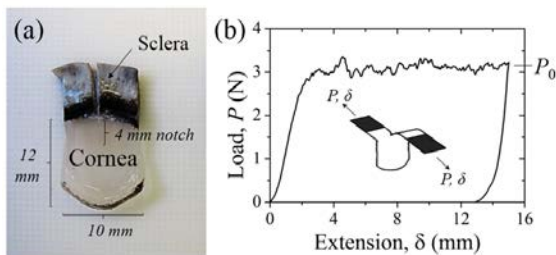
$$T = \frac{2P_0}{t_h} \qquad (1)$$

Figure 1: (a) Specimen geometry. (b) Typical load-extension curve from tearing tests on porcine cornea.

Results

A typical load-extension curve from tearing tests is shown in Figure 1(b). The load increased linearly at small extension before fluctuating around a plateau value, from which fracture toughness was calculated. The mean tear toughness for cornea at different extension rates is shown in Figure 2.
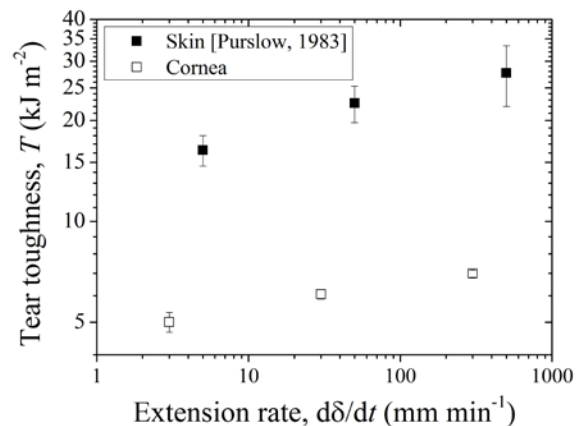

Figure 2: A comparison of the tear toughness of skin and cornea at different extension rates.

There is a linearly positive relationship between the cornea's tear toughness and the extension rate in a log-log plot ($R^2 = 0.98$). This demonstrates that the cornea's fracture toughness is time-dependent.

Discussion

The tearing test is a suitable method for obtaining fracture toughness of cornea, giving highly consistent results. Both cornea and skin [Purslow, 1983] have linear relationship between the tear toughness and the extension rate in a log-log plot.

References

Purslow P.P., J Mater Sci, 18:3591-3598, 1983.
Rivlin, R.S. & Thomas, A.G., J Polymer Sci. 10:291-318, 1953.