DETERMINING HUMAN POSTERIOR KNEE CAPSULE MATERIAL PROPERTIES

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Introduction

Currently, there is considerable interest to evaluate the material properties of the human knee capsule which has a variable thickness and a complex structure for developing an accurate subject specific 3D knee model. As far as we are aware of, there are no data available concerning the mechanical properties of the knee capsule to perform some modelling simulations. The goals of this study are to develop a 3D geometrical model of the knee capsule and to quantify the mechanical properties, defined by a stress-strain curve including the stiffness and the yield stress of the posterior human knee capsule by performing tensile tests.

Methods

Nine posterior knee capsule specimens which are dissected from three different donors (male, 80 yrs; female, 84 yrs; and male, 69 yrs) were used to perform tensile tests. All capsules were cut approximately 5 mm in width in frozen condition from three different locations in the knee capsule, resulting in a medial, intermedial and lateral specimen. The global stress value was obtained by measuring the cross sectional area (CSA) of the specimen in the initial condition and the force value during tensile test using a MTS machine. An alginate mould was used to measure the CSA and to develop a 3D reconstruction of each specimen. Tensile tests were performed under displacement control at 1 mm increments to get stress-strain curves. Each increment was held for 10 second before proceeding until a final displacement of 25 mm was reached. Moreover, the initial length of knee capsule and the controlled displacement of MTS machine were calculated to obtain the strain values.

Results

3D specimen image reconstructions have successfully developed from each cutting-set alginate moulds. Nine stress-strain curves of the specimens displayed classical mechanical soft tissue behavior. The capsule stiffness was randomly distributed over the knee capsule locations. A strong correlation (R^2=0.89) was found between stiffness and strength. Tissue relaxation during the 10 sec. pauses between loading increments caused a considerable stress drop of 45.14% (±9.13%) on average. Failure of the tissue did not necessarily occur at the location of the lowest cross-sectional area.

Discussion

The results of the current study can be used for development of a 3D model of a knee capsule with which it is possible to carry out a finite element analysis. From tensile test, the results suggest that the posterior capsule of the knee does not have a systematic distribution of material properties. Material stiffness did not correlate with location, and the location of failure was not associated with the lowest cross-sectional area. Further analysis of the material constituents (fiber orientation and distribution) should provide further insight into the mechanical behavior of the capsule. Further specimens will be tested, in which also local deformation will be monitored.