11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

CHARACTERIZATION AND COMPUTATIONAL MODELING OF ANTERIOR CRUCIATE LIGAMENT BIOMECHANICS

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Key Words: *Anterior Cruciate Ligament, Soft Tissue Biomechanics, ACL Characterization, Computational Methods.*

The material properties of the Anterior cruciate ligament (ACL) of the knee are nonlinear, anisotropic, and viscoelastic. The tissue structures that make up the ACL also exhibit mechanical heterogeneity. The ACL is particularly challenging to experimentally characterize; in its anatomically relevant state, it is twisted and partially extended regardless of knee flexion angle. The ACL consists of two bundles that are not simultaneously unloaded under any configuration, and a novel approach to accurately characterize each bundle is described. Our experimental methods involve mechanically testing in uniaxial loading as well as anatomical positions using digital image correlation analysis to accurately describe the strain fields arising from mechanical heterogeneity in each experimental condition. We demonstrate that the anterior bundle of the ACL is functionally graded whereas the posterior bundle is mechanically homogeneous. We have developed a non-linear viscoelastic mathematical model of the ACL and implemented it into a finite element framework for computational analysis of the ACL during physiologically relevant loading conditions. In our computational environment we can transition from the uniaxial loading state to the anatomically correct loading state and predict the strain fields in the ACL during an anterior tibial translation. This motion is relevant to ACL injury as the ACL tears when the tibia anteriorly translates excessively relative to the femur. Our computational model is able to predict the location of ACL tears in the proximal third of the tissue.

REFERENCES

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