World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:12, No:09, 2018

Multiscale Syntheses of Knee Collateral Ligament Stresses: Aggregate Mechanics as a Function of Molecular Properties

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Abstract : Knee collateral ligaments play a significant role in restraining excessive frontal motion (varus/valgus rotations). In this investigation, a multiscale frame was developed based on structural hierarchies of the collateral ligaments starting from the bottom (tropocollagen molecule) to up where the fibred reinforced structure established. Experimental data of failure tensile test were considered as the principal driver of the developed model. This model was calibrated statistically using Bayesian calibration due to the high number of unknown parameters. Then the model is scaled up to fit the real structure of the collateral ligaments and simulated under realistic boundary conditions. Predications have been successful in describing the observed transient response of the collateral ligaments during tensile test under pre- and post-damage loading conditions. Collateral ligaments maximum stresses and strengths were observed near to the femoral insertions, a results that is in good agreement with experimental investigations. Also for the first time, damage initiation and propagation were documented with this model as a function of the cross-link density between tropocollagen molecules.

Keywords : multiscale model, tropocollagen, fibrils, ligaments commas
Conference Title : ICBSE 2018 : International Conference on Biomedical Science and Engineering
Conference Location : Paris, France
Conference Dates : September 20-21, 2018