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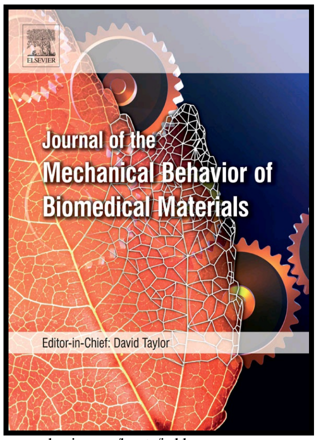

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Rate Dependent Anisotropic Constitutive Modeling of Brain Tissue Undergoing Large Deformation

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Abstract

This study aims constitutive modeling of rate dependent anisotropic viscoelastic brain tissue that experiences large deformation during accidental impact. Many experimental studies confirm that brain parenchyma mechanisms are strongly influenced by anisotropy, nonlinear viscoelasticity, rate dependent loading/unloading and tension-compression asymmetry of the soft brain tissues. We present a rigorous thermodynamically consistent phenomenological approach to capture these mechanisms in a single model. Model parameters are calibrated from the experiments, and mechanical responses are predicted for different loading conditions. We consider a 2-D fibrous circular tube geometry, an idealized form of a human head, to simulate shear stress distribution for a given boundary condition. Different orientations of the fibers are considered to investigate the influence of anisotropy on the shear stress. Finally, stretch rate dependency of stress responses for a particular fiber orientation is demonstrated.

Keywords: Finite strain, Anisotropic viscoelasticity, Constitutive responses, Parameter identification, Simulations and predictions

1. Introduction

Traumatic Brain Injury (TBI) due to violent head impact in motor vehicle accidents, falls, and sports injuries, causes internal tissue damage beyond the recoverable limit. Although the brain is capable of recovering from a concussion, the amount of force necessary to cause permanent brain damage is under study, and hence still unclear. One aspect to investigate TBI is to provide a mathematical model and a computational framework by identifying its underlying mechanisms. Another important aspect is to correlate injury mechanisms of the tissue damage with the mechanical parameters of impact phenomena. For example, one well-known injury criterion is the Head Injury Criterion (HIC), and a good model prediction can improve such a criterion.

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