Computational Modeling of Axonal Injury using The Embedded Element Approach

Harsha T. Garimella*, Reuben H. Kraft†

* The Penn State Computational Biomechanics Group, Department of Mechanical and Nuclear Engineering, 341 Leonhard Building, The Pennsylvania State University, State College, Pennsylvania, USA-16802. E-mail: vsg111@psu.edu

† The Penn State Computational Biomechanics Group, Department of Mechanical and Nuclear Engineering, 341 Leonhard Building, The Pennsylvania State University, State College, Pennsylvania, USA-16802. E-mail: reuben.kraft@psu.edu

ABSTRACT

Brain injury is a major public health problem in United States that is estimated to occur in 1.6-3.8 million people. This is a particularly common problem in contact sports like football, hockey, boxing and soccer as well as in military due to blasts. Despite its significance and growing concerns about the potential long-term consequences of head injury, its biomechanical mechanisms are not fully understood. Since 1970s computational head modeling has proven to be an indispensable tool for the establishment of head injury criteria and these models are often used to study traumatic brain injury. But the fidelity of such models depends vastly on the efficient incorporation of appropriate structural detail, the accurate representation of material behaviour and the appropriate measure of injury [1]. In this study, a approach called the embedded element method has been used to incorporate the axonal fiber structure into the computational finite element model of human head. This approach answers the problem of implementing the accurate axonal orientation information into the human head finite element model. This method also eliminates the usual mathematical complexity usually involved in defining the anisotropic materials with more than one fiber direction [2]. The confidence in the human head finite element models has been achieved by validating the model to Nahum et al. [3] and Hardy et al. [4] experimental results. Here the finite element models of the axonal fiber structure are developed from the diffusion tensor imaging (DTI)/diffusion spectrum imaging (DSI) tractography models. An axonal strain criterion of 18% is used as the injury criterion for the onset of brain injury as diffuse axonal injury (axonal elongation) is considered as the most common phenomenon during a traumatic brain injury [1]. The corresponding axonal strain information has been used to determine the location as well as the extent of damage during the traumatic brain injury under impact loading conditions.

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