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Computational Study on Traumatic Brain Injury Using Magnetic Resonance Imaging-Based 3D Viscoelastic Model

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Abstract : Head is the most vulnerable part of human body and may cause severe life threatening injuries. As the in vivo brain response cannot be recorded during injury, computational investigation of the head model could be really helpful to understand the injury mechanism. Majority of the physical damage to living tissues are caused by relative motion within the tissue due to tensile and shearing structural failures. The present Finite Element study focuses on investigating intracranial pressure and stress/strain distributions resulting from impact loads on various sites of human head. This is performed by the development of the 3D model of a human head with major segments like cerebrum, cerebellum, brain stem, CSF (cerebrospinal fluid), and skull from patient specific MRI (magnetic resonance imaging). The semi-automatic segmentation of head is performed using AMIRA software to extract finer grooves of the brain. To maintain the accuracy high number of mesh elements are required followed by high computational time. Therefore, the mesh optimization has also been performed using tetrahedral elements. In addition, model validation with experimental literature is performed as well. Hard tissues like skull is modeled as elastic whereas soft tissues like brain is modeled with viscoelastic prony series material model. This paper intends to obtain insights into the severity of brain injury by analyzing impacts on frontal, top, back, and temporal sites of the head. Yield stress (based on von Mises stress criterion for tissues) and intracranial pressure distribution due to impact on different sites (frontal, parietal, etc.) are compared and the extent of damage to cerebral tissues is discussed in detail. This paper finds that how the back impact is more injurious to overall head than the other. The present work would be helpful to understand the injury mechanism of traumatic brain injury more effectively.

Keywords : dynamic impact analysis, finite element analysis, intracranial pressure, MRI, traumatic brain injury, von Misses stress
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