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Computational Modelling of Human Head Injuries

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In spite of several preventive strategies, there has not been an important impact on the burden of head injury world-wide. Consequences of head injuries are not limited to the victim alone but have impact on the society as a whole through the large costs involved, not to mention the tragedies and the suffering. It should be noted that very little is understood about the true mechanisms associated with head injury, but many theories exist. At present, mainly a criterion based on the linear acceleration of the head, named the Head Injury Criterion (HIC), is used in the development of safety devices, where a rigid dummy head is launched towards specific locations in the car. However, the human head behaves in a more complex way. One of the advantages with the finite element (FE) method is the possibility to model the anatomy with great detail, thus it is possible to study the kinematics of the head as well as the stresses and strains in the Central Nervous System (CNS) tissues. This paper primarily focuses on summarizing current efforts, and to outline future strategies in human head injury modeling. Non-linear and viscoelastic models are derived for the CNS and meninges and their importance's for injury prediction is outlined. Multiple length scales are involved in the development of traumatic brain injury, where the global mechanics of the head level are responsible for local physiological impairment of brain cells. In a multi-scale approach, finite element models of the head and the axonal level are coupled, where it is observed that the maximum axonal strains do not always correlate directly with the brain tissue strain levels. The results indicate that cellular level heterogeneities have an important influence on the axonal strain, leading to an orientation and location-dependent sensitivity of the tissue to mechanical loads. It is concluded that constitutive modeling, skull-brain interface conditions, multi-scale modeling and authentic anatomical representation needs further investigation. However, using proper material characterization, correct boundary conditions and detailed geometric representation, a finite element model of the human head can provide us a powerful tool. Application of the FE head model to reconstructions of accidents and suspected abuse and homicide cases involving head traumas will also be discussed.