World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:11, No:03, 2017

Development of a Paediatric Head Model for the Computational Analysis of Head Impact Interactions

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Abstract : Head injury in childhood is a common cause of death or permanent disability from injury. However, despite its frequency and significance, there is little understanding of how a child’s head responds during injurious loading. Whilst Infant Post Mortem Human Subject (PMHS) experimentation is a logical approach to understand injury biomechanics, it is the authors’ opinion that a lack of subject availability is hindering potential progress. Computer modelling adds great value when considering adult populations; however, its potential remains largely untapped for infant surrogates. The complexities of child growth and development, which result in age dependent changes in anatomy, geometry and physical response characteristics, present new challenges for computational simulation. Further geometric challenges are presented by the intricate infant cranial bones, which are separated by sutures and fontanelles and demonstrate a visible fibre orientation. This study presents an FE model of a newborn infant’s head, developed from high-resolution computer tomography scans, informed by published tissue material properties. To mimic the fibre orientation of immature cranial bone, anisotropic properties were applied to the FE cranial bone model, with elastic moduli representing the bone response both parallel and perpendicular to the fibre orientation. Biofiedility of the computational model was confirmed by global validation against published PMHS data, by replicating experimental impact tests with a series of computational simulations, in terms of head kinematic responses. Numerical results confirm that the FE head model’s mechanical response is in favourable agreement with the PMHS drop test results.

Keywords : finite element analysis, impact simulation, infant head trauma, material properties, post mortem human subjects
Conference Title : ICCMAS 2017 : International Conference on Computational Modeling, Analysis and Simulation
Conference Location : London, United Kingdom
Conference Dates : March 14-15, 2017