Finite element analysis of brain contusion: an indirect impact study

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Abstract

The mechanism of brain contusion has been investigated using a series of three-dimensional (3D) finite element analyses. A head injury model was used to simulate forward and backward rotation around the upper cervical vertebra. Intracranial pressure and shear stress responses were calculated and compared. The results obtained with this model support the predictions of cavitation theory that a pressure gradient develops in the brain during indirect impact. Contrecoup pressure-time histories in the parasagittal plane demonstrated that an indirect impact induced a smaller intracranial pressure (-53.7 kPa for backward rotation, and -65.5 kPa for forward rotation) than that caused by a direct impact. In addition, negative pressures induced by indirect impact to the head were not high enough to form cavitation bubbles, which can damage the brain tissue. Simulations predicted that a decrease in skull deformation had a large effect in reducing the intracranial pressure. However, the areas of high shear stress concentration were consistent with those of clinical observations. The findings of this study suggest that shear strain theory appears to better account for the clinical findings in head injury when the head is subjected to an indirect impact.material.