D43 The Use of Finite Element Head Models to Predict Skull Base Fracture

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After attending this presentation, attendees will be presented with the finite element method, its principles and its applications in forensic sciences focusing on a skull base fracture case, showing the possible interest in some forensic cases of the use of this method.

This presentation will impact the forensic science community by understanding the use of finite element models, their possible application in practice, and also, through the particular case reported, to be careful when a body is found floating in a river without external evidence of injury, not to conclude too fast on the cause of death.

It can be a fundamental problem in forensic investigations to establish whether a head injury is the consequence of an accident or an assault. Close examination of the wounds may help to understand the mechanism of injury, but sometimes doubt remains and it may be particularly difficult to differentiate the consequence of a fall from the consequence of a blow. During the second half of the 20th-century, engineers have tried to develop mathematical models using fundamental Newtonian principles and experimental observations to predict the mechanisms of head injury for a given scenario. Yet, inaccuracies can arise from these models in which tolerance to impact originates from various sources, including experiments on animals, human cadavers, anthropomorphic dummies, and human volunteers. A proposed alternative method for assessing the consequence of a given head impact scenario is the use of finite-element models of the human head. Computer models are increasingly proving to be an alternative to complicated, practically unfeasible, or unethical (human or animal) experiments. The finite-element method, which is a mathematical method for solving complex physical problems on domains with complicated geometries, is commonly used in constructing such computer models. The finite-element modeling technique offers the advantage of being able to model structures with intricate shapes and indirectly quantify their complex mechanical behavior at any theoretical point. Because the finite-element method uses the theories of elasticity and static equilibrium, the effects of multiple external forces acting on a system can be assessed as physical events in terms of deformations, stresses, or strains. A finite element model of the human head has been developed in Strasbourg University to predict skull fractures and brain injuries. The geometry of the inner and outer surfaces of the skull was digitized from a human adult male skull. The main anatomical features modeled were the skull, falx, tentorium, subarachnoid space, scalp, cerebrum, cerebellum, and brainstem. For the CSF, a Lagrangian formulation was selected and the brain–skull interface was modeled by an elastic material validated against the *in-vivo* vibration analysis. The scalp was modeled by a layer of brick elements and surrounds the skull and facial bone. Globally, the model consists of over 13,000 elements. Its total mass is 4.7kg. Tolerance limits were identified relative to DAI, subdural hematoma, and skull fracture with a risk of occurrence of 50%. The complex geometry of the skull, including the evolution of the skull thickness throughout the skull, and the reinforced beams which play an important role in its dynamical response to impact have been taken into account. Previous published papers have dealt with the use of this finite element head model in forensic sciences for falls and gun injuries. This paper illustrates its possible use for predicting skull base fractures through the report of the case of a woman who was found floating in a river near Strasbourg, next to the boat where she used to live. External examination showed no particular injury. Autopsy showed a right low parietal head impact and a transverse fracture of the skull base with traumatic dilacerations of the two internal carotid arteries. Death was due to “drowning” by the victim’s own blood which had obliterated the trachea passing through the skull base fracture into the pharynx. A finite element method reconstruction of the fall and the head impact on the dock where the ship had stopped was made, showing how the victim could have fallen to create her skull base fracture, thus confirming the possibility of an accidental death.

Finite Element Model, Skull Fracture, Drowning

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