H38 A Forensic Pathology Tool to Predict Pediatric Skull Fracture Patterns - Part 1: Investigations on Infant Cranial Bone Fracture Initiation and Interface Dependent Fracture Patterns

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The goal of this presentation is to inform attendees about the initial findings of fracture pattern analysis studies caused by impulsive loading of the parietal bone in a developing porcine (pig, *Sus scrofa*) model of the human.

This presentation will impact the forensic community by describing the expected fracture patterns and sites of fracture initiation in the developing porcine model. It will also serve as a prototype for future skull fracture modeling efforts for the pediatric human victim.

In fatal cases of violence against infants and young children, it is the job of the forensic specialist to determine the true cause and manner of death. While this is sometimes possible by establishing a "history of abuse," in other instances the ability to determine child abuse from accidental injury may be difficult. Because there is a lack of skull fracture standards for infants and young children, pediatric deaths involving single event head injuries with associated cranial fractures represent one of the greatest challenges to forensic pathologists and anthropologists.

The ultimate goal of this multiphase, interdisciplinary research project is to develop and validate a computational human head model that will predict skull fracture patterns in the human pediatric skull for a variety of impact interface conditions. Such data may be gathered from witnesses, defendants, and investigators in any given crime scene setting. Unfortunately, the ability to produce experimental skull fracture data is limited by ethical considerations surrounding experimentation on human pediatric cadavers, even if available tissue were to exist. Thus, the porcine head is being used to develop a computer-based technology that may ultimately help predict various skull fracture patterns in human infants and young children as a function of age, impact velocity, energy, and interface condition.

Using an experimental facility in which an impact mass is dropped from a specified height onto the parietal bone with different interface conditions, fracture patterns and sites of initiation have been collected on more than 80 porcine specimens. In order to understand the mechanisms of skull fracture to be incorporated in the computational model, it is important to first document sites of fracture initiation. All specimens were impacted in the central parietal region at an energy level that caused the initiation of a linear fracture. The locations of initial fracture (in the order of decreasing frequency) were: on the parietal bone at, and perpendicular to, the lambdoidal suture; on the parietal bone at, and perpendicular to, the coronal suture; on the frontal bone at, and perpendicular to, the coronal suture; and on the frontal bone at the superior orbit and parallel to the coronal suture. The results of this study showed that in the porcine model all major fractures on the cranium initiate away from the point of impact at the parietal suture margins, and radiate back toward the center of the parietal. This phenomenon has occurred with regularity regardless of the type of interface (rigid or compliant).

The fracture patterns caused by the different interfaces (rigid and compliant) were different and varied with animal age. On the skulls of animals aged under seven days there is significantly more suture damage caused by the compliant interface than by the rigid interface, which may be a function of the suture and bone properties in these young specimens. Another significant finding at this point in the study seems to be that there is more overall skull damage being generated in impacts from the same height with a compliant surface (carpeting, sod, etc.) versus a rigid interface (concrete, wood floor, etc.).

These results identified multiple fracture initiation sites on the porcine skull away from the impact site and showed that the compliant interfaces caused relatively more fracture damage to the developing porcine skull than did rigid interfaces. The next phase of the project will be to elaborate on these results, specifically investigating energy dependent fracture propagation, and developing a scaling scheme to compare anatomical growth patterns in the human skull and the porcine model.

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