H33 Fracture Initiation and Propagation in Pediatric Blunt Cranial Trauma

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After attending this presentation, attendees will gain awareness of: (1) fracture initiation and propagation in pediatric blunt cranial trauma; (2) the applicability of a porcine study as an explanatory model for human forensic cases; and, (3) the implications of this study for the medicolegal interpretation of cranial fracture.

This presentation will impact the forensic science community by addressing misconceptions in current literature regarding the mechanism of cranial fracture that may hinder the forensic investigator's assessment of pediatric cranial injuries.

An accurate interpretation of blunt cranial injury patterns depends on a clear understanding of the mechanism by which cranial fracture is produced. Adult cadaver studies by Gurdjian et al. demonstrated that initiation and propagation of cranial fracture depends on impact conditions, namely the shape and kinetic energy of the impacting object[1]. Those studies outlined six distinct impact conditions that influence injury outcomes including type of fracture sustained and the location of fracture initiation either directly at or peripheral to the impact site.

While Gurdjian demonstrated the effect of impact conditions on adult cranial fracture, similar data had not been systematically collected for immature crania. This study utilized an infant porcine model to develop an understanding of the relationship between impact conditions and patterns of pediatric cranial fracture. Single blunt impacts were delivered to fleshed infant pig heads under known conditions. Fracture number, location, and length were assessed for each cranium to characterize the overall injury pattern.

The results of the porcine study revealed peripheral fracture initiation occurring in 100% of 64 impacts involving drops onto a flat, rigid interface. Impacts to the center of the right parietal produced fractures extending from all adjacent sutures both toward and in the opposite direction of the impact site. The effect of this mechanism of fracture initiation was the frequent occurrence of multiple, separately initiating fractures (87.5% of 64 drop experiments), including fractures in bones adjacent to the impacted right parietal (82.8% of 64 drop experiments).

The patterns of injury described in the porcine model have also been observed in several human cases that emerged as part of the Pediatric Cranial Fracture Registry, a National Institute of Justice (NIJ) - funded multidisciplinary effort to establish a national database of pediatric deaths involving blunt force cranial fracture. Of 57 homicides studied, 12 cases exhibited cranial fracture patterns nearly identical to those observed in the porcine model: multiple, separately initiating fractures with involvement of multiple cranial bones. The striking similarities between these cases and the porcine experiments provides support that: (1) the porcine model has applicability for human forensic cases; (2) peripheral initiation also occurs

in human infants; and, (3) the injuries present in these human cases may have been caused by single blows with flat impact surfaces resulting in peripheral initiation.

These results are consistent with Gurdjian's predictions for impacts involving lower energies and flat interfaces. According to Gurdjian, compression of the skull under these conditions produces outward bending in areas peripheral to the point of impact. Because bone is more resistant to compression than tension, fractures initiate at these out-bended areas of tensile stress rather than the impact site. Recent studies by Kroman and others have attempted to discredit peripheral initiation altogether, instead demonstrating initiation at the impact site in adult cadavers[2]. The current study's results indicate that such a dismissal is premature and misleading, particularly in regard to immature crania.

The understanding of fracture initiation presented by this study has significant implications for the medicolegal interpretation of pediatric cranial injuries. The presence of multiple fractures is generally considered a strong indicator of abuse. If it is assumed that initiation occurs exclusively at the point of impact, it follows that multiple, non-intersecting cranial fractures indicate multiple impacts. However, this study has demonstrated that multiple, nonintersecting cranial fractures may result from a single impact due to fracture initiation occurring peripherally from the impact site. Therefore, the forensic investigator must execute caution when using such injury patterns to determine abuse in pediatric cases.

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References:

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Cranial Fractures, Blunt Force Trauma, Pediatric