H32 A Forensic Pathology Tool to Predict Pediatric Skull Fracture Patterns – Part 2: Fracture Quantification and Further Investigations on Infant Cranial Bone Fracture Properties

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The goal of this presentation is to inform attendees about further research on fracture propagation caused by impulsive loading of the parietal bone in a developing porcine (pig, Sus scrofa) model.

This presentation will impact the forensic community by describing directions and patterns of fracture propagation in the developing porcine model and demonstrate the GIS image-analysis method to quantify fracture patterns.

Pediatric deaths involving head injury with associated cranial fractures represent one of the greatest challenges to forensic professionals. The ability of the forensic investigator to establish the circumstances of death in these cases is severely hampered by the lack of skull fracture standards for infants and young children. In many of these situations the most likely cause of trauma is interpreted by examining the overall patterns of bone fracture and comparing them to descriptions of the incident, however these analyses are both qualitative and anecdotal, leaving the final interpretation up to a best guess by the experienced professional. This research aims to understand the basic principles behind infant cranial fractures in the porcine model which may then be used to guide later human research.

Previously findings were reported that identified multiple fracture initiation sites on the porcine cranium away from the impact site, and also demonstrated that a compliant interface caused relatively more fracture damage to the developing porcine cranium than did a rigid interface at equal energy levels (Fenton *et al.* 2009). The phenomenon of remote fracture initiation in the infant porcine specimen has also been documented using high-speed video. This next phase of research deals with fracture propagation at higher input energy levels. The generated porcine fracture patterns from both the previous low energy (initiation) and new high energy (propagation) impacts have been quantified using a GIS image-analysis model. In addition, fracture propagation and the relationship between input energy and fracture length has been explored through these higher energy impacts.

In order to examine higher energy fracture propagation, a gravity accelerated mass (GAM) drop-tower was employed. Only rigid impacts have been conducted to date. To produce more input energy for the impacts, the drop height of the mass was doubled. Based on a sample size of 34 porcine specimens aged under 28 days, the preliminary data of total damage to the cranium (both bony fracture and diastatic fractures) followed similar patterns as the previous rigid impacts but with four times more measured damage than documented in our earlier studies.

In an attempt to quantify these porcine fracture patterns, a GIS model was employed using an image-analysis approach, as previously described by Marean *et al.* (2001). Using this method, each fracture configuration was traced onto an individual outline of the porcine cranium. The GIS model then superimposes each cranial outline and sums the overlying fractures, generating an overall fracture pattern. Results indicate that more fracture damage occurred in the younger aged specimens, particularly more diastatic fractures. The fracture patterns for each corresponding age class were similar to the previous initiation impact fracture patterns. Interestingly, the higher energy impacts generated more fracture co-occurrence between specimens. This suggests that with more input energy, the tendency for repeated fracture configurations increases.

The location of fracture initiation has been in question due to conflicting viewpoints in the literature. Recently, Kroman (2007) documented fracture initiation beginning at the impact site for adult human cadaveric specimens. From gross observation of the current infant porcine model, fracture initiation appeared to occur at remote sites and radiate back toward the site of impact. Fracture initiation and propagation was then recorded using high-speed video on six drop-tower impacts to infant porcine crania of differing ages. Each impact was recorded at a speed of 8,000 frames per second with a resolution of 512x128 pixels. Results indicate that fracture initiation occurred at the surrounding bone-suture boundary and propagated back towards the point of impact. It is, however, currently unclear if this translates to infant human crania.

The opinions, findings, and conclusions or recommendations expressed in this presentation are those of the authors and do not necessarily reflect the views of the Department of Justice.

Child Abuse, Fracture Patterns, Bone Biomechanics