H82 A Forensic Pathology Tool to Predict Pediatric Skull Fracture Patterns - Part 3: Entrapped Porcine Head Impacts vs. Controlled Head Drops

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The goal of this presentation is to inform attendees about research on fracture initiation and propagation caused by controlled head drop experiments onto the parietal bone in a developing porcine (*Sus scrofa*) model.

This presentation will impact the forensic science community by describing comparisons between controlled head drops and the previous data presented using an entrapped head impacted by a gravity-dropped mass with compliant and rigid interfaces.

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. This research aims to understand the basic principles behind infant cranial fractures in the porcine model which may then be used to help guide future human research.

Previously, findings were reported from a porcine head model entrapped in a bed of epoxy that was used for constraint during impact onto the parietal bone using a dropped mass impact interface. Fenton et al. showed multiple fracture initiation sites on the porcine cranium away from the impact site, and more recently Passalacqua et al showed that when the impact energy was doubled, there was extensive fracture propagation in both the parietal bone and into adjacent frontal and occipital bones.[1,2] The phenomenon of remote fracture initiation in this infant porcine model has also been documented using high-speed video (Passalacqua).[2]

Because forensic cases often involve situations in which free fall head drops are suspected, this next phase of research dealt with fracture initiation and propagation in controlled head drop experiments onto a rigid interface at energy levels comparable to the previous study of Powell et al. using the entrapped head model.[3]

In order to compare head drops versus the entrapped impacts, 31 porcine specimens aged 2-17 days were used. To produce the necessary impact energy, the head was attached to a drop tower trolley, which was raised to the necessary drop height. In the experiments a solenoid disengaged, allowing the trolley to fall freely. Upon impact, the head was disengaged from the trolley allowing it to impact a rigid aluminum interface once, by using an electromagnetic solenoid to catch the head after impact. The impact energy levels for various aged specimens in the current study were matched to the energy levels documented in Powell et al. for the entrapped heads. The fracture patterns were compared between experiments using a GIS image-analysis approach, as previously described by Marean *et al*.[3,4]

Results from these controlled head drop experiments demonstrated that the impact duration was significantly shorter than for the entrapped head experiments of Powell et al. ($p\text{-value} < 0.001$), however the peak impact force data was not different at each specimen.[3] There was significantly less skull fracture at each age for the free fall experiments than for the entrapped heads ($p\text{-value} < 0.001$). GIS fracture pattern results demonstrated that fracture initiation was located primarily along the anterior parietal bone in all free fall specimens. A simplified, theoretical model analysis of each experiment, using the finite element approach, showed that large tensile stresses develop around the periphery of the entrapped head, near the epoxy constraint, that likely produced extensive fractures remote to the site of impact. The tensile stresses in the head model were lower and located more near the impact site in free fall experiments.

While further research is necessary in order to define any potential relationships between the infant porcine model and the infant human, these results showed that head entrapment provides a significant stress riser that enhances the potential for cranial bone fracture compared to an equal amount of energy to a freely falling head impacting a rigid surface.

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References:

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