A33 Initiation and Propagation of Fractures in Blunt Impacts to Unconstrained Human Cadaver Heads

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After attending this presentation, attendees will be informed about cranial fracture initiation and propagation in blunt impacts to upright, unconstrained cadaver heads.

This presentation impacts the forensic science community by adding to their current understanding of the relationship between location of fracture production, propagation of fracture, and implement type in cases involving blunt cranial trauma.

Previously, this research group presented the results of blunt cranial impacts performed on entrapped human cadaver heads at the American Academy of Forensic Sciences meetings.[1,2] High-speed footage of these experiments support Gurdjian's predictions that: (1) cranial fracture can initiate either at or peripheral to the impact site; and, (2) variables, including implement shape and impact energy, influence the location of fracture initiation and propagation.[3] Fenton et al. and Isa et al. report that fractures tend to initiate peripherally in impacts with larger, broader implements and at the point of impact with smaller, more focused implements.[1,2] As these experiments were performed on heads fully constrained within a rigid medium (plaster of Paris), it remains unclear how fractures would initiate and propagate in impacts to more realistically constrained heads.

The current study investigated fracture initiation and propagation in blunt cranial impact experiments designed to simulate a blow to the head of an upright individual. Nineteen unembalmed male cadaver heads were impacted using a new, custom-built pneumatic impact system. Three aluminum impactors were selected for this study to approximate the shapes of objects commonly implicated in forensic cases: a brick (3" diameter flat), a bat (2.5" diameter cylinder), and a hammer (1" diameter flat). Twelve impact experiments (n=4 for each implement) were performed at a base energy level: 91.8J±18.7J for brick impacts, 112.1J±3.7J for bat impacts, and 105.3J±19.5J for hammer impacts. Seven impact experiments (n=2 brick; n=2 bat; n=3 hammer) were performed at approximately 1.6-1.8 times the base energy level (153.6J±50.0J for brick impacts, 137.1J±39.3J for bat impacts, and 172.0J±10.6J for hammer impacts).

Impacts were delivered at the mid-parietal, inferior to the parietal boss, on heads placed in an upright position. Prior to impact, specimens were secured at the C4 vertebra to a mounting plate using an adjustable clamping mechanism. Heads were positioned for impact via breakaway tethers attached to a collar fastened around the neck. A high-speed camera captured fracture initiation and propagation at 10,000fps.

A key result of the base energy-level experiments was the observation of peripheral fracture initiation in impacts with all three implements. These results indicate peripheral initiation is not just possible, but likely following a blunt impact to an unconstrained head. A second key finding was that for all three implements, at least one of four experiments generated fractures that initiated peripherally and did not propagate back to the impact site. As a result, 4/12 experiments (2/4 brick, 1/4 bat, and 1/4 hammer impacts) produced fractures concentrated somewhere other than the impact site (primarily in the temporal and sphenoid).

Initial results also indicate that both implement shape and impact energy influence the location of fracture initiation and propagation in unconstrained heads. At the base energy level, experiments with brick and bat implements tended to generate peripherally initiating linear fractures that propagated back toward and/or away from the impact site. At a higher energy, brick and bat implements produced linear fractures that initiated at the point of impact and propagated away. In contrast, high-energy hammer impacts produced peripherally initiating linear fractures that propagated back toward the impact site.

The present study sought to investigate the issue of fracture initiation and propagation in blunt impacts to unconstrained adult heads. High-speed photography revealed fractures initiating peripherally with all three implements impacted at the base energy level. In some cases, peripherally initiating fractures also traveled away from the point of impact, resulting in fractures located distant from the point of impact. Practitioners, therefore, should be advised that the location of linear fractures does not necessarily correspond with the location of impact.

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Reference(s):

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2. Isa M.I., Fenton T.W., Vaughan P.E., Haut R.C. Understanding the Role of Contact Area in Adult Cranial Fracture Variation. *Proceedings of the American Academy of Forensic Sciences*, 68th Annual Meeting, Las Vegas, NV. 2016: 131.
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Blunt Force Trauma, Cranial Fracture, Trauma Analysis