A99 A Forensic Pathology Tool to Predict Pediatric Skull Fracture Patterns: Part V — Controlled Head Drops Onto Shaped Impact Surfaces

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After attending this presentation, attendees will better understand the effects of various shaped impacters on both the biomechanics and pattern of cranial fracturing generated during controlled head-drop experiments using a developing porcine model.

This presentation will impact the forensic science community by providing baseline data regarding some of the effects of cranial impacts against various shaped surfaces and comparisons to impacts against flat surfaces presented in previous studies.

Most current literature on the analysis of blunt force trauma to the cranium cites Gurdjian et al.'s works on fracturing mechanics. Although their experimental work focused on flat surface head drops, they noted that such variables as the size, shape, and energy of the impacting object have an effect on fracturing. They also stated that "a slowly moving object, fairly sharp or pointed in contour, may cause an area of depression more or less patterned after the shape of the object;" however, fatal injuries do not always result in characteristic wounds and systematic studies regarding the morphology and mechanics of injuries resulting from non-flat surface impacts are limited.[1] Thus, there is currently little more than conjecture and anecdotal data regarding the assessment of cranial fractures resulting from impacts with shaped objects. The current study was conducted to understand some of the basic biomechanical mechanisms and cranial fracture patterns from shaped surface impacts using a porcine model.

The hypotheses of the study were: (1) heads dropped against surfaces with a large contact area would have fractures that mimic flat surface experiments with peripherally initiated linear fractures; (2) as the contact area decreased, depressed fracturing would occur; (3) at some intermediate contact size and shape, there would be a combination of depressed and linear fractures; and, (4) the energy and resulting contact force necessary to cause fracture initiation would decrease with the area of the impacting interface.

To document the cranial fracture biomechanics and fracture patterns for various shaped interfaces, heads from pigs between one and 20 days old (n=64) were dropped under controlled conditions onto 14 rigid, shaped impact surfaces.[2] Four impacters which simulated such objects as a table corner, hammer, etc. were chosen for closer analysis. Biomechanical data were collected during each experiment; thereafter, the heads were visually inspected for fractures, photographed, and the fracture patterns were diagrammed using previously described methods.[2]

The four impacters were: (1) 2" hemisphere (n=8); (2) 1/16" edge (n=9); (3) $^{5}/_{8}$" ball bearing (n=7); and, (4) ¼" flattop peg (n=8). Peripheral linear fractures were present on 97% of the specimens analyzed (31/32). The 2" hemisphere most resembled results seen in earlier flat surface studies and seems to represent the transition between flat and focalized surfaces as five specimens expressed both peripheral linear and area of impact fractures. As predicted, as the contact area decreased, the presence of depressed fractures increased. Depressed fractures first appeared with the $^{5}/_{8}$" ball bearing and the impacter shape also started to become discernible. The 1/16" edge generated linear fractures that extended along the impacter's contact surface and caused creasing of the bone. The ¼" peg produced punctures through the bone and had the highest frequency of depressed fractures at 88% (7/8).

The peak forces generated at fracture for the four impacters were: (1) 1/16" edge 424±149N; (2) 2" hemisphere 378±148N; (3) 5/8" ball bearing 186±70N; and, (4) ¼" peg 151±69N. Those in the flat surface studies were 967±350N. These data indicate that the peak force causing cranial fracture decreased with contact area and interface shape. Importantly, the kinetic energy needed to cause fracture followed a similar pattern.

This study using the infant porcine model demonstrated that impact surface shape had an effect on fracture type and pattern. Additionally, it shows the energy and forces causing cranial fracture decrease significantly for impacts against shaped surfaces which reduce area of contact. Such basic biomechanical data may have direct relevance to human pediatric victims as forensic scientists attempt to opine injury causation in cases not involving flat impact surface conditions.

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References:

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2. Powell BJ, Passalacqua NV, Fenton TW, Haut RC. 2013. Fracture Characteristics of Entrapped Head Impacts Versus Controlled Head Drops in Infant Porcine Specimens. *Journal of Forensic Sciences* 58: 678–683.

Shaped Impacters, Cranial Fracture Patterns, Bone Biomechanics