H79 Experimental Study of Fracture Propagation in the Human Skull: A Re-Testing of Popular Theories

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This presentation outlines the results of a study examining fracture propagation in the human skull and demonstrates the biomechanical forces behind blunt force trauma.

This research will impact the forensic community by demonstrating that highly regarded and cited fracture pattern theories regarding blunt force trauma and the human skull are incorrect and unsupported by experimental testing.

Trauma analysis is an ever growing area of forensic anthropology. In many cases, accurate interpretation of fractures in bone may be the only objective means of determining cause and manner of death (Berryman and Symes 1998). Postmortem trauma assessment is an essential tool for identifying the location of impact sites, sequencing blows, and establishing the characteristics of the object responsible for injury (Berryman and Symes 1998). In anthropological trauma analysis, one of the most complicated and confusing areas is blunt force trauma.

One of the key researchers to contribute to area of blunt force trauma interpretation was E.S. Gurdjian. Gurdjian and colleagues conducted research on cranial fractures, and extensively published on the topic. Today his work is still considered a standard reference for the fields of forensic anthropology and forensic pathology. However, recent evaluation of his predictions of fracture propagation patterns in the skull has led to questioning.

The theories of Gurdjian and colleagues (1945, 1947, 1950a, 1950b) describe how the cranial vault responds to blunt force impact. They state that when the cranium is impacted, an area of inbending is created at the point of force application, with an area of outbending occurring in other remote areas of the skull. Fracture propagation then begins in these areas of outbending (even on the opposite side of the cranium), then radiate back towards the point of impact, sometimes never reaching it (1947, 1950a, 1950b). This notion that fracture initiation begins *away* from the point of impact is heavily cited in both anthropology and pathology (Berryman and Symes 1998, Galloway 1999, DiMaio and DiMaio 2001, Knight 1996), and has led anthropologist to identify points of impact in locations other than the central area of fractures. Recent sentiments among practicing forensic anthropologists and pathologists working in the area of trauma analysis have expressed a strong concern that Gurdjian's theories are leading anthropologists astray (Symes 1989). Observed cases of blunt force trauma indicate that fracture initiation begins at the point of impact, not at a location remote to it. The conflicting opinions regarding the theories of Gurdjian and fracture propagation in the skull, has led to the need for further research.

Most of the current bone trauma research is taken from forensic specimens that are examined in a postmortem setting. While this type of research is crucial to the field, it is always after the fact. This study attempted to evaluate the theories of Gurdjian in a controlled, experimental setting. A study design was developed that would utilize new technology in the fields of industrial and biomedical engineering, while keeping with the needs of anthropology. Because of the unique biomechanical properties of the human skull, it was decided that a non-human substitute was not an option. Instead, five fully fleshed, un-embalmed cadaver heads were used. An engineering drop tower system was constructed to delivered calibrated, fully monitored blows to the left parietal region in each specimen. Five data acquisition load cells monitored the biomechanical response of the skulls for compressive and shear stress in the X, Y, and Z moments in millisecond intervals. With the data from the load cells, the forces through out the impact and fracture propagation were charted and analyzed. To help solve the question of how and where fracture propagation occurs in relation to the point of impact, a high speed film system was also designed. By filming at a speed faster than the fracture can travel through bone, it allowed the entire fracture event to be viewed and analyzed. After testing, each specimen was examined, with fractures charted and photographed. The experimental design allowed for complete monitoring throughout the impact event, and provided extensive data on how the cranium responds to blunt force trauma and fracture occur. The high speed filming allowed for the fractures to be observed as they traveled. The data from the test specimens was then compared to the original results from the Gurdjian studies and to known blunt trauma forensic cases.

The results from data analysis, high speed film, and examination of fracture patterns in the test subjects clearly show that fracture propagation initiates at the point of impact in the skull, then radiates out. High speed film clearly captured the fractures traveling from the point of impact in the parietal, posterior to the occipital. No fractures were observed to originate in locations other than the point of impact. These results are contrary to the theories of Gurdjian and colleagues, and substantiate recent claims from practicing forensic anthropologists and pathologists.

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