H31 Rethinking Bone Trauma: A New Biomechanical Continuum Based Approach

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After attending this presentation, attendees will have an improved understanding of the biomechanics of bone trauma and gain exposure to a new biomechanically based way of analyzing bone trauma.

This presentation will impact the forensic community by proposing a shift in the way that forensic practitioners think and examine skeletal trauma.

Anthropologists are now commonly tasked with integrating trauma analysis into the biological profile of age, ancestry, sex, stature, and pathology. Past approaches have focused primarily on which category (i.e., blunt, sharp, ballistic) is present. Anthropologists often run into trouble when there are characteristics of multiple types of trauma, i.e., an incised wound (indicator of sharp trauma) with a radiating fracture (indicator of blunt trauma). The categorical mindset sets the stage for errors when the analysis is focused around identifying a weapon, rather than looking at basic biomechanics of the injury.

The alternative mode of thinking views trauma as a continuum rather than discrete categories. The fracture patterns are influenced by three primary extrinsic variables of force, surface area of impacting interface, and acceleration/deceleration. This new way of thinking was tested through a series of experimental studies and injury data analyses on over 500 specimens. The studies include fracture patterns in the skull, thorax/upper body trauma, human phalanges, an lower limb fractures. The results show the importance of the variables (“engineering inputs”); force, surface area, and acceleration/deceleration, on the fracture patterns (“anatomical outputs”) of the human body.

Force: The human body is subjected to a variety of forces in everyday activities; however, injury occurs when these forces exceed the tolerance levels for the tissues of the body. The amount of force influences the severity of fracture. In the cranial base, the impact force determined extent of fracturing. In forensic anthropology, clues to the amount of force may be seen in the extent of the fractures. In the vault, fracture patterns with numerous radiating and concentric fractures may be indicative of higher force than a single linear fracture. However, anthropologists must keep in mind that it is not always a one to one comparison. The intrinsic properties of the bone (such as geometry, location, quality of bone) come into play and can explain differences in fracture patterns caused by equal force.

Surface Area of Impacting Interface: The variable of surface area between the impacting object and the bone is crucial in fracture analysis. This variable explains the differences between blunt and sharp trauma. An impact to the skull of 12 lbs, but a large surface area may cause a typical blunt trauma fracture pattern with a point of impact, radiating, and concentric fractures. However, an impact to the skull with an identical force of 12 lbs, but a very small surface area (i.e., the edge of a knife or axe) will create an incising type wound with straight margins. While the force remains the same, a change to the surface area of the impact interface alters the pounds per square inch (psi) influencing the bone. As frequently and aptly noted, sharp trauma is simply a beating with a sharp object (Symes et al 1989, Symes et al 2002). The variable that dictates the difference between a sharp trauma wound and a blunt trauma wound is simply surface area. It is possible to have sharp trauma wounds that also contain characteristics of blunt trauma. In testing, this variable played an important role in understanding the mechanics of impacts to the thorax.

Acceleration/Deceleration: The variables of acceleration or deceleration are important for understanding how a change in velocity over time can influence how bone responds to trauma. Since bone is a viscoelastic material, it has different mechanical properties dependant on the rate of loading (acceleration/deceleration). Anthropologists are accustom to looking for plastic deformation to indicate blunt trauma, and an absence of deformation to indicate ballistic trauma. These differences are created by the differences in acceleration/deceleration rates between the two. Instead of viewing these categories as independent, they can be visualized as a continuum; influenced by how the deceleration of the impacting object influences the fracture mechanics of the bone. When conceptualized in this manner, it is easy to understand how a bullet can create plastic deformation and “blunt trauma” when it has slowed down (i.e., reached terminal velocity) to an acceleration/deceleration rate consistent with blunt trauma.

In conclusion, there is a need for a “rethinking” in regards to trauma, with a shift in focus from a categorical weapons based approach to a biomechanically based continuum.

Fracture Biomechanics, Bone Trauma, Blunt Trauma

 ** Presenting Author*