H94 Interpreting the Injury Mechanisms of Blunt Force Trauma From Butterfly Fracture Patterns

Samantha L. Reber, BSc, 5 Webster St, Ashton Preston, Lancashire PR2 1BY, UNITED KINGDOM*

After attending this presentation, attendees will have a better understanding of: (1) which factors affect butterfly fracture formation; and, (2) how to interpret the direction of applied force from butterfly fracture patterns. The main goal of this research was to challenge previous assumptions made about the interpretation of blunt force injury mechanisms from butterfly fractures and to provide the forensic community with rigorously tested results on how and whether the direction of force can be accurately determined from butterfly fracture analysis.

This presentation will impact the forensic science community by demonstrating that the side and orientation of butterfly fracture fragments can be inconsistent and, therefore, inaccurate when used as the sole criterion for determining the direction of applied force; however, this study has also found that by analyzing the pattern of the fracture in its entirety for both complete and incomplete fractures, a specific blunt force fracture pattern can be observed and used to more accurately determine the direction of force.

The majority of current forensic literature suggests that the direction of applied force can be determined by analyzing the orientation of butterfly fracture patterns. More specifically, the side of the bone from which a butterfly-shaped fragment originates is thought to directly correspond to the direction of applied force.[1] The use of this method was recently cautioned by Thomas and Simmons after analyzing the controlled fractures of 94 sheep femora.[2] This study reported the formation of butterfly fractures to be highly inconsistent, observing butterfly fragment formation on both the impact and nonimpact side of bones. Another recent study by Fenton et al. analyzed the controlled fracturing of 15 dry human long bones.[3] This study reported that the direction of force could be determined in 14 out of 15 cases by analyzing the entire fracture pattern, including both gross and incomplete fracture lines, instead of focusing merely on the identification and orientation of butterfly fragments. These studies indicate that further controlled research is needed to corroborate, refute, or simply clarify the accurate interpretation of the direction of applied force from blunt force fracture pattern analysis.

In this study, 105 *Ovis aries* femora were broken using a customized pendulum impact apparatus made of a large wooden frame with a weighted base, a rigid metal pendulum, blunt anvil, and an adjustable bone stand with metal cup stabilizers. The bones were oriented in an upright position with the anterior mid-shaft surface facing the impact hammer. The bones were secured in place by adjustable metal cups that applied compressive forces in a fashion mimicking the intrinsic forces experienced by weight bearing.[4] The initiation and propagation of each fracture was captured with a high-speed camera at 1,000 frames per second.

According to the biomechanics of fracture production, the biomechanical response of a bone to applied extrinsic forces is highly dependent on its specific geometry; therefore, the following measurements and observations were recorded for statistical analysis: length; mid-shaft circumference; cortical thickness; moment of inertia; fracture classification; presence of butterfly fragment; fragment angle; fragment side; and overall fracture pattern and propagation.[4] In addition to this experiment's sample, the 94 sheep femora previously broken by Thomas and Simmons were re-analyzed with the intent of including both gross and incomplete fracture lines in the analysis of determining the direction of applied force.[2] Including this sample also allowed for a comparison between two different injury mechanisms; more specifically, between the fractures seen in bones held upright with compressive forces and bones held against a substrate.

Preliminary results suggest the wedge-shaped fragmentation traditionally described as a butterfly fracture pattern does, as reported by Thomas and Simmons, occur on both the impact and nonimpact side of the bone.[2] However, refocusing the analysis on the entire fracture pattern, as suggested by Fenton, reveals a specific pattern of gross and incomplete fractures in 76% of the sample.[3] Based on these observations, a new overall fracture pattern was defined. Subsequently, it was found that the direction of applied force could be determined accurately in 100% of specimens displaying a partial or complete variation of the identified pattern. At this time, no comparison has been made between the bones held upright with compression and the bones held against a substrate; however, this comparison will be addressed in the presentation.

In summary, this study demonstrates that the side and orientation of butterfly fracture fragments is indeed inconsistent and, therefore, inaccurate when used as the sole criterion for determining the direction of applied force. This study showed that through analyzing the pattern of the fracture in its entirety for both complete and incomplete fractures, a specific blunt force fracture pattern is observed and can be used to accurately determine the direction of force.

References:

1. Galloway A, editor. Broken bones: anthropological analysis of blunt force trauma. Springfield: Charles C. Thomas, 1999.
2. Thomas TS, Simmons, TL. The relationship between directionality of force and the formation of butterfly fractures. *Proceedings of the American Academy of Forensic Sciences*; Seattle, WA., 2010;16.
3. Fenton TW, Kendell, AE, Deland, TS, Haut, RC. Determination of impact direction based on fracture patterns in human long bones. *Proceedings of the American Academy of Forensic Sciences*; Atlanta, GA., 2012;18:398.

4. Hipp JA, Hayes WC. Biomechanics of fractures. In: Browner BD, Jupiter JB, Levine AM, Trafton PG editors. Skeletal trauma, basic science, management and reconstruction. Philadephia: Saunders, 2003;90-119.

Butterfly Fracture, Blunt Force Trauma, Injury Mechanisms

