A118 Forensic Fractography of Bone Using Computed Tomography (CT) Scans

Angi M. Christensen, PhD, FBI Laboratory, Quantico, VA 22135; Summer J. Decker, PhD, University of South Florida Department of Radiology, Morsani College of Medicine, Tampa, FL 33606*

Learning Overview: After attending this presentations, attendees will have learned how to apply principles of bone fractography to fracture surfaces reconstructed from CT scans. Attendees will have also gained a deeper understanding of how 3D models can contribute to skeletal trauma analysis, as well as certain limitations.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing additional information on a methodology that can assist in the analysis of fractures from CT scans. As the use of CT expands worldwide, medical examiners (as well as clinicians) will have additional tools for analyzing skeletal fractures using virtual 3D methods in a non-invasive manner.

Fractography is the science of fracture surface morphology and its relationship to crack propagation. This well-established and validated science can be used to assess a material's mechanical properties and determine the underlying mechanisms leading to material failure. Recent studies and case reports have demonstrated the utility of fractography in forensic anthropology for understanding the directionality of impact/force application and fracture propagation on broken bones by assessing features of the fracture surface. Specifically, the presence and orientation of fracture surface features, including bone mirror, arrest ridges, bone hackle, wake features, and cantilever curl, can be used to reliably determine the point of fracture initiation and the direction of crack propagation. However, these previous studies utilized processed bone and directly examined the fracture surface features visually and microscopically. Removal of soft tissue from complete or mostly complete remains may be impractical in some cases, and assessments may be expedited if fracture surfaces could be assessed without maceration.

This study investigated whether the science of fractography can be applied to reconstructed CT scans. As a test of the method, a series of clinical scans of individuals with traumatic lower extremity injuries from patients that presented to a Level 1 Trauma hospital for assessment were obtained under Institutional Review Board (IRB) approval. The scans were performed using a Philips Brilliance 64 slice CT scanner under a standard trauma scan protocol. Relevant images included thin slice data sets of the lower extremities, acquired using bone and soft tissue algorithms. The fracture surfaces were visualized as 3D computational models in the volume rendering software package Mimics® Innovation Suite version 22 and 3-Matics version 14 Materialise. The 3D models were then exported as 3D .pdfs for fractography assessment.

Using this approach, some fractographic surface features were apparent, including bone mirror, arrest ridges, and cantilever curl, which are indicative of crack propagation direction and therefore the direction of impact. Due to resolution limitations, the amount of fracture surface detail visible in the CT scans is notably less than using direct observation of the bone surface, but diagnostic features of crack propagation were still apparent in some cases. As noted in previous bone fractography studies, features were less often identified when cortical area was smaller, and comminuted fractures also made surface visualization and feature identification more challenging. The selection of 3D modeling software may also affect results. When fracture surface features can be visualized and evaluated on CT scans, this may eliminate the need for skeletal processing, and perhaps even be applied in clinical as well as forensic contexts.

Fractography, Skeletal Trauma Analysis, Crack Propagation