H140 Imaging Impact: Can Computed Tomography Fractography Determine Direction of Fracture Propagation?

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Learning Overview: Fractography is the study of the surface features of a fracture. After attending this presentation, attendees will understand how fractography techniques derived from materials science can be applied to the study of bone. Evidence will be presented to demonstrate that Computed Tomography (CT) fractography can determine the point of impact of a bending force sufficient to fracture a bone and the direction of fracture propagation. The primary aim of this study was to assess whether CT fractography can determine impact site with a similar degree of accuracy to the direct examination of bone. A worked example of how CT fractography can be performed and utilized in a case of fatal pedestrian vs. vehicle trauma will be presented.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by showing attendees the theory and evidence behind CT fractography and by using illustrative examples, see how it can be used in routine forensic practice to improve the accuracy of fracture analysis.

Background: Bending forces are the most commonly accounted mechanism of injury leading to lower limb fracture in both clinical and forensic practice. The direction of force application required to fracture the long bones of the leg via three-point bending has traditionally been interpreted using the Messerer or wedge fracture. As bones are weaker in tension than in compression, the side of the bone in tension, opposite the impacting force, fractures first. The fracture propagates across the bone along two lines of cleavage to create a wedge. Early opinion suggested that the broad base of this wedge occurred on the side of impact. However, multiple studies have cast doubt on this theory, reflecting that in "real life" the fracture pattern is not predictable. In recent years, researchers have sought to improve the accuracy of bone trauma interpretation. In 2018, Christensen et al. applied fractography techniques to long bones; a team of materials scientists and forensic anthropologists were able to successfully determine the direction of fracture propagation by assessing the fracture surface in human femora.[1] A limited number of case studies suggest that volume-rendered reconstructions derived from CT scans can demonstrate fractography features, but to date there is no published comparison of CT and direct bone visualization.[2,3]

Method: Fifteen porcine femora were broken using a three-point bending test with axial loading to simulate external trauma, creating 30 fractured bone samples. These were scanned using CT and macerated. The CT images were analyzed for the presence or absence of five fractography features described by Cristensen et al. (bone mirror, bone hackle, wake features, arrest ridges, and cantilever curl) by a radiologist and findings compared to forensic examination of the bone by an anthropologist. Both assessors were asked to comment on the side of impact.

Results: Porcine bones demonstrated fractography features on CT. The radiologist and the anthropologist showed complete agreement for the presence of "arrest ridges" caused by compressive force. Although there was no significant agreement as to the presence or absence of the other four fractography features, both assessors correctly inferred the side of impact for all specimens.

Conclusion: Postmortem CT is a recognized and well-regarded technique in the investigation of fatal trauma and has been used as both an adjunct and an alternative to autopsy. CT fractography demonstrates arrest ridges on fractured bone surfaces, and, therefore, the detection of this feature could be used to determine the side of force impact, for example, in lower limb trauma in road traffic collisions. This novel technique may facilitate a more accurate and non-invasive interpretation of fracture patterns and add value to standard imaging techniques.

Reference(s):

1. Christensen A.M., Hefner J.T., Smith M.A., Blakely Web J., Bottrell M.C., Fenton T.W. Forensic Fractography of Bone: A new approach to skeletal trauma analysis. *Forensic anthropology*. 2018; 1: 32-51.
2. Christensen A.M. and Hatch G.M. Forensic fractography of bone using computed tomography (CT) scans. *Journal of forensic radiology and imaging.* 2019; 18: 37-39.
3. Schiers S., Cos M., McGlynn H., et al. Visualization and documentation of perimortem trains in long bone fractures using computed tomography. *Forensic Science, Medicine and Pathology*. 2020; 16: 281-286.

Computed Tomography, Blunt Force Trauma, Fractography

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