A23 Making Up for Missing Pieces: Scanning Electron Microscopy With Energy-Dispersive X-Ray Spectroscopy (SEM/EDX) Gunshot Residue (GSR) Analysis of the Human Cranial Bone

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After attending this presentation, attendees will understand the utility of nanotechnology for detecting GSR in bone. A forensic case will be presented to illustrate how the combined use of SEM and X-ray elemental microanalysis (in the form of EDX) demonstrates the presence of signature inorganic compounds found in GSR.

This presentation will impact the forensic science community by demonstrating the application of a rarely used technique that practitioners can employ to distinguish gunshot trauma from other forms of skeletal trauma when diagnostic fracture patterns or wound signatures are absent.

Cranial gunshot wounds are easily detected even in the absence of soft tissue by examining bony traumatic defects for characteristic attributes (e.g., internal or external beveling); however, these features may be absent in partial or fragmentary remains. In these instances, the forensic anthropologist cannot reliably distinguish between fractures caused by gunshot versus blunt force trauma.

Research by Berryman et al. found that SEM/EDX analysis was able to detect trace amounts of lead, barium, and antimony — components of bullet primer — in experimentally shot fleshed pig bones.[1] GSR is a combination of primer and gunpowder particles (burnt and unburnt) derived from the bullet cartridge. Ignited primer and gunpowder exit as a gaseous plume from open surfaces of the gun. Primer mixtures often comprise three inorganic compounds: (1) lead styphnate (initiator); (2) antimony sulfide (fuel); and, (3) barium nitrate (oxidizer). Sulfur, charcoal, and potassium nitrate are common organic compounds in GSR derived from the gaseous plume. SEM reveals GSR morphology, while EDX yields quantitative elemental analysis of the inorganic compounds (primer).

Partially skeletal remains were found in a shallow hole and scattered in the surrounding wooded area by animal activity. Fragments of women's clothing were also recovered. At pathological examination, the remains had areas of residual intact skin, which were devoid of injury. Residual internal organs were severely decomposed. The skull was fragmented and incomplete due to trauma.

The anthropological analysis revealed a nearly complete skeleton and partial skull. The occipital bone was absent, and the right parietal, left and right temporal, and vomer were partially absent. Four linear fractures consistent with peri-mortem trauma were present on the right parietal, and a small linear fracture was visible on the right hard palate. The etiology of these fractures could not be ascertained with scientific certainty, but the pathologist and anthropologist strongly suspected gunshot trauma.

In order to determine if the cranial fractures were caused by gunshot trauma, four cranial fragments and a control specimen of a thoracic vertebral spinous process were analyzed with SEM/EDX for elemental components of GSR. The cranial fragments were cut from the lateral and posterior aspects of the right parietal, the posterior portion of the left parietal, and the left temporal. Fragments were sputter coated prior to analyses of the inorganic

residue components. Trace amounts of barium, antimony, and lead were detected on the cranial fragments, but not on the control specimen, indicating the likelihood of GSR in the skull.

A missing person fitting the biological profile provided by the anthropologist was found, and identity was confirmed via dental comparison. The cause of death was certified as disruptive head trauma and, given the circumstances of the case, the manner of death was certified as homicide. The investigation of the case is ongoing.

Forensic pathologists and anthropologists frequently work together to ensure a thorough analysis of skeletal trauma, but some cases present circumstances that require additional experts. Nanotechnology such as SEM/EDX provides a useful tool for detecting GSR in cases in which fracture patterns are atypical or remains are too fragmentary to conduct macro-morphological analyses with scientific certainty. This technique can also provide an additional line of evidentiary support, even in cases in which gunshot trauma is easily recognizable.

Reference(s):

1. Berryman H.E., Kutyla A.K., Davis II J.R. 2010. Detection of gunshot primer residue on bone in an experimental setting: An unexpected finding. *J Forensic Sci.* 55:488-91.

Gunshot Residue, Skeletal Trauma, EDX