H9 A SEM-EDS Trace Elemental Analysis of Sharp Force Trauma on Bone

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The goal of this presentation is to apply the scanning electron microscope, with energy dispersive spectroscopy (SEM-EDS) to trace elemental analysis of sharp force trauma on bone.

This presentation will impact the forensic community by expanding the use of the SEM beyond that of cutmark analysis and to apply EDS to sharp-force injuries specifically. This study furthermore aims to provide another method for identifying tools used to inflict trauma.

The study of cutmarks on bone, as evidence of sharp forces, has a long history in anthropological studies. Forensic anthropologists have a particular interest when medico-legal questions are raised concerning the presence of cutmarks along with circumstances surrounding death. The unifying goal of these studies is to match diagnostic features of the tool with unique impressions left in the resulting cut.[1] It is crucial that forensic practitioners become familiar with recent technological innovations which could potentially meet these goals.

The scanning electron microscope (SEM) is a high-powered visualization tool typically applied to engineering, microbiological, and material sciences. Energy Dispersive Spectroscopy (EDS) is an additional technique that may be used concurrently with the SEM to identify the elemental composition of scanned materials by collecting the fluorescent X-rays generated in the SEM process. While SEM has been used extensively for cutmark analysis, few studies have applied EDS for the principles of forensic anthropology in published literature. EDS has determined the presence and chemical ratio of elements present in dental restorative resins,[2,3] and has additionally been used to authenticate or eliminate a possible set of human cremains.[4,5] In 2007 Berryman et al. identified several elements characteristic of gunshot residue on bones which had been impacted by gunshot trauma.[6] However, research has not yet applied SEM-EDS to additional forms of trauma on bone, particularly sharp force trauma.

Most contemporary metallic instruments are composed of steel or a similar alloy, which will rust upon exposure to aquatic environments. External layers of rust can easily be shed through contact, as well superficial metallic particles that deteriorate through the corrosion process. Sharp force trauma was preferentially selected for this analysis because the incision often resembles a trough, in which trace particles are more likely to become imbedded and preserved in the bone matrix. Even when a sufficient amount of force is used, sharp instruments rarely obliterate or completely destroy point of contact.

Osteological material was provided by the University of Tennessee Zooarchaeological Laboratory. One *Bos taurus* limb (humerus, radius, ulna, and metapodials) was disarticulated and flesh was removed, leaving periosteum intact. Eight sharp tools of known metallic composition, with various shapes, sizes, and level of rust development, were selected to induce sharp force trauma to samples. Each tool was used to strike a single area of bone, leaving cut marks relatively perpendicular to the shaft. Samples were either fully processed by boiling and removing residual tissue, or minimally process by removing periosteum only. Samples were then dried, and vacuum-pumped for 72 hours prior to scanning. SEM was performed using a [Hitachi VP-SEM S-3400N microscope] and elemental analysis was performed using the [Oxford INCA Energy 200 Dispersive X-Ray Spectroscope.]

The SEM successfully imaged the cutmarks on bone at magnifications 200x – 500x. EDS found organic compounds (Ca, C, O, P, Na) in the control samples at generally expected ratios. Inorganic elements (Fe, Ni, Mn, Cr) were determined in samples cut with metallic hand-axes, and the highest amount of iron (Fe) and elevated oxygen (together creating corrosive rust compounds) were seen in the samples where a rusty instrument was used. The presence of inorganic elements was greatly reduced by the full processing method. Future research will include comparisons of various corroded tools to potentially individualize a source, and investigation of other metallic substances in addition to steel.

Results suggest that EDS may successfully be used to identify inorganic elements resulting from sharp force trauma. This methodology will lend to class-level identification, or negate alternative explanations for bone pathology. This work may potentially support other corroborating evidence when attempting to identify an instrument used in forensic contexts.

References:

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Sharp Force Trauma, Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS)