Can Sharp Force Trauma To Bone Be Recognized After Fire Modification? An Experiment Using *Odocoileus virginianus* (White-Tailed Deer) Ribs

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INTRODUCTION

During the course of their analyses, forensic anthropologists routinely face the task of identifying and interpreting taphonomic events surrounding the death of an individual. At times they are called upon to analyze remains that have been exposed to, and modified by, fire. Intense heat modification to bone results in fragmentation, color changes, shrinkage, and warpage, which can make a forensic osteological analysis (including the determination of basic biological parameters) more difficult. This is especially disruptive to the analysis of bone trauma. This is particularly true when attempting to separate fragmentation patterns resulting from perimortem trauma (i.e., blunt force, projectile impact, etc.) from those resulting from postmortem heat and fire modification. Recent research has suggested that careful analysis may reveal diagnostic patterns that may be used to successfully differentiate perimortem from postmortem trauma (Symes et al. 2001). However, one area of skeletal trauma analysis which has not been thoroughly studied is the potential modification of sharp force trauma (SFT) evidence during the burning process.

Considering that sharp force trauma evidence is typically exhibited in the form of subtle marks left on the bone that even experienced analysts may have difficulty identifying, it is assumed that exposure to fire results in complete loss of those details. As such, evidence of SFT may be even more likely to remain undiscovered. To test these assumptions, an experimental model for assessing the visibility and identifiability of perimortem sharp force wound characteristics *after* exposure to fire was designed and implemented using *Odocoileus virginianus* (white-tailed deer) ribs. Grossly, *Odocoileus virginianus* ribs are similar in size and morphology to human ribs, and therefore represent a valid model for anthropological research.

CATEGORIES OF SHARP FORCE TRAUMA

Sharp force trauma is manifested in bone in a variety of morphologies, and can be inflicted by numerous tools—ranging from knives and screwdrivers to lawnmower blades and industrial machinery. It is also worth noting that various manifestations of SFT evidence in skeletal remains can result from the same instrument (i.e., a knife can cause puncture and notching-type incised wounds in a single event). Because SFT evidence varies according to the instrument used, angle

of impact and degree of applied force, most of the wound morphologies may be described categorically. With this in mind, the current study was interested in the following manifestations of SFT.

1. **Cutmarks**: In the anthropological literature cutmarks are perhaps the most researched and documented category of SFT (Owsley et al. 1977; Raemsch 1993; Shipman 1981;Walker and Long 1977; White 1992; White and Toth 1989). Typically, cutmarks are defined by shallow, linear striations (V-shaped in cross section) in the outer surface bone, made by a sharp edged tool (Figure 1).

2. **Shaved**: Shaved wounds are characterized by thin, flat sections of bone that are removed when the blade is drawn nearly parallel with the surface of the bone (Figure 1).

3. **Notching**: Notching wounds exhibit large V- shaped sections of missing bone and result from forces directed more perpendicular to the bone surface (Figure 1).

4. **Transection**: Transection wounds result in complete or partial severing of the bone element in which the wound displays straight, clean bone surface anomalies (Figure 1).

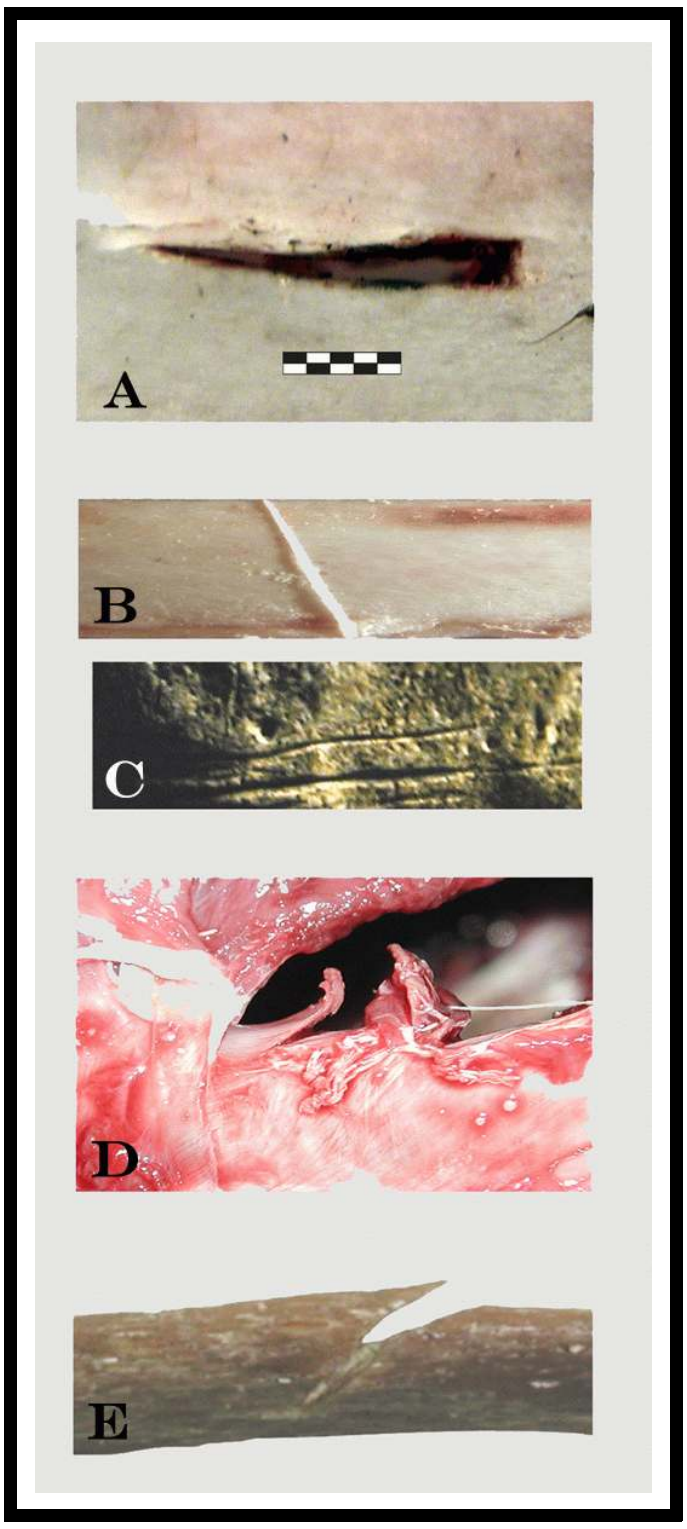

Figure 1. Various manifestations of sharp force trauma in bone. (A) Puncture wound; (B) cutmark; (C) cutmarks on temporal bone; (D) curling, and; (E) partial severing.

MATERIALS AND METHODS

In an effort to inflict several varieties of SFT to a single torso, a recently deceased (post-mortem interval of less than 12 hrs.) adult deer was stabbed multiple times at a variety of angles using both a large, non-serrated chef's knife and a smaller, non-serrated paring knife (Figure 2). Force was not calculated, though an attempt was made to inflict wounds with varying degrees of force.

Each rib exhibiting SFT defects were subsequently dissected out of the torso, and adhering soft tissue removed manually. The traumatic lesions were comprehensively described according to the precise anatomical location of the SFT and the type of SFT inflicted. Each element was then thoroughly documented using digital photography (*Olympus* 3030Z). Next, the ribs were burned in a semi-controlled, outdoor wood fire. The fire was ignited in a shallow pit, the floor of which was comprised of a sandy soil. The ribs were placed on top of a bed of small-to-medium sticks which provided the main source of fuel for the fire. Additional sticks were occasionally added on top of the bone as the fire progressed and the fuel was consumed. Firewood was added until most of the bone was partially calcined; a process which typically required approximately 30

Figure 2. One of the authors (JTH) inflicting SFT to a deer torso. The inset depicts the knives used during the study.

Figure 3. The burn pile where the dissected ribs were burned until smoked and partially calcined.

Figure 4. Cutmark after burning (black arrows). Note the heat induced fractures (red arrows). Their jagged morphology is not easily confused with SFT.

characterized by jagged, irregular defect walls (Figure 4). In some cases, SFT was rendered even more visible by thermal alteration. Figure 4 displays a cutmark which was turned white during the burning process, contrasting with the rest of the bone surface. This is interesting considering color contrast is usually used to distinguish perimortem from postmortem alterations (Sauer 1998).

In some instances the trauma evidence appeared to have been completely destroyed by the fire. However, careful laboratory reconstruction of the bone resulted in identification of the trauma. Still other evidence may be completely lost following exposure to fire. For example, wounds that completely transect the bone, or result in the significant removal of bone (such as shaving or notching type events), are often subjected to further separation, fragmentation and warping during the course of the burning process (Figure 5). This is tentatively suggested to be a result of the minutes. The remains were then carefully excavated from the fire pit, the fragments conjoined, and observations made concerning the survival and modification of the SFT wound characteristics.

RESULTS

Diagnostic perimortem SFT characteristics were found to remain visible after being subjected to an intense fire. Relatively shallow cutmarks, for example, persist even on the calcined cortical surfaces and can be differentiated (both macroscopically and under low-power magnification) from transverse and longitudinal fractures created during the burning process. Cutmarks on these burned elements were still identifiable via V-shaped cross sections and occasional uplifting of a thin layer of cortical bone adjacent to the groove. This evidence is distinguished from fractures created by heat alteration which were

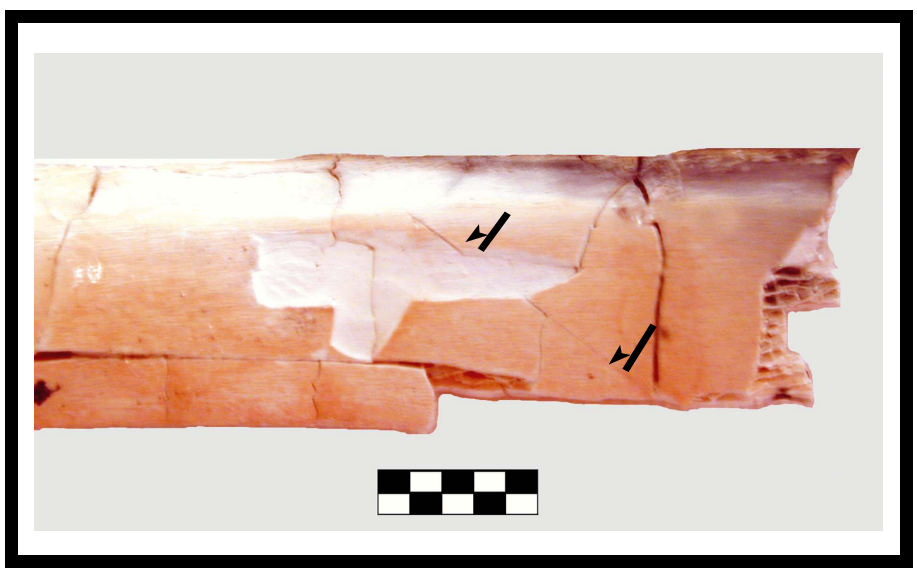

Figure 5. Cutmark after burning (black arrows). Note that if more cortical bone had flaked off, all evidence of SFT would have been destroyed.

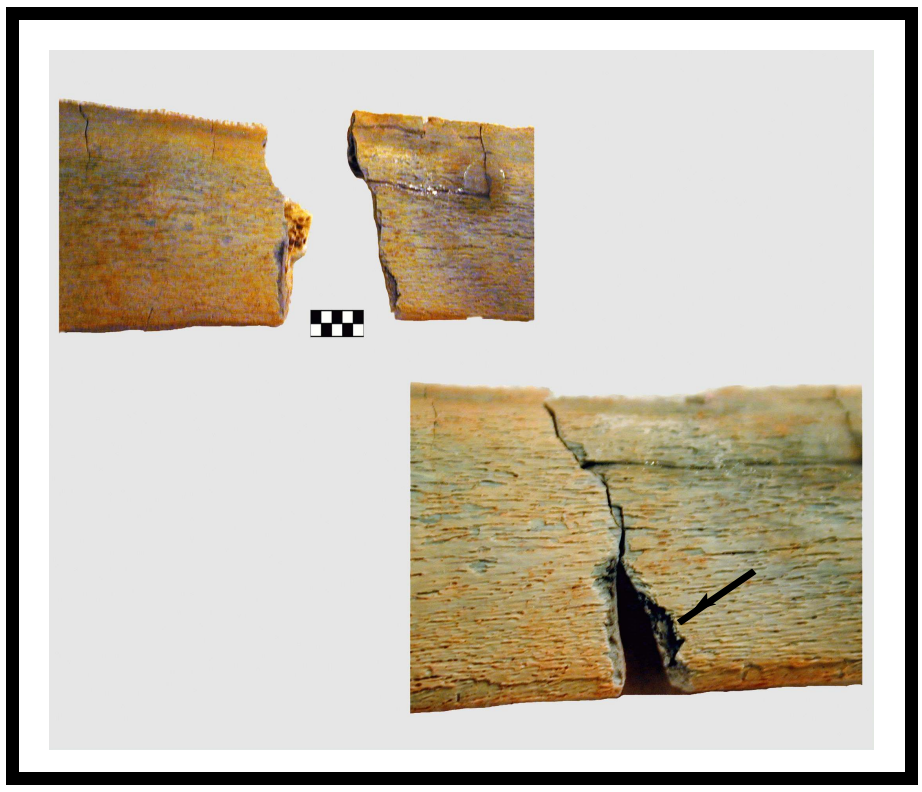

Figure 6. Rib fractured during the burning process. When the two fragments are joined a notching type SFT wound can be seen (arrow).

Figure 7. Puncture wound before (A) and after (B) burning episode. Note that some of the weapon class characteristics are still evident on the burned specimen.

breakdown of the biomechanical integrity of the bone, resulting in the propagation of fractures at those locations. (Figure 6).

SUMMARY

This study suggests that most evidence of sharp force trauma is preserved following heat-alteration and exposure to fire. Evidence of these wounds are, however, extremely transient and easily destroyed or overlooked if proper documentation, recovery, and curation efforts are not maintained.

Excavation methodologies for the recovery of fire altered remains have been described by several authors. The goal of any excavation is the comprehensive collection of contextual data. In the case of burned remains, contextual data relates to the *in situ* position of the remains. In order to preserve potential evidence of this nature, careful recovery, documentation and curation techniques must be employed (Dirkmaat, 2001). When remains are extremely fragmentary, the bone (and any additional evidence) should be collected from smaller subunits within each unit. A traditional 1 by 1 meter unit may be demarcated into 10cm by 10cm units, enabling more exact provenience data to be collected for each fragment, facilitating subsequent conjoining efforts.

Actualistic research is one of the primary sources for expanding taphonomic theory and analysis. The current project lends itself to a variety of follow-up studies. This research illustrates that it is of the utmost importance that the recovery of human remains from fire contexts be carried out by individuals with extensive training in osteology, taphonomy, and archeological methods.

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