CASE REPORT

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Case Involving Differentiation of Deer and Human Bone Fragments

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ABSTRACT: In a recent Louisiana forensic anthropology case, it was necessary to attempt species identification of six small bone fragments. The primary concern was whether or not they matched the fractured humerus of a woman killed by two shotgun blasts and then disposed of in the Mississippi River. These tiny fragments were recovered by law enforcement officers inside a jeep pickup and at the gas station where the vehicle had been cleaned. The police suspect claimed that these fragments were from a deer that he had recently killed. The small size of the pieces precluded positive recognition of human versus nonhuman origin based upon gross morphology and cortical thickness. Microscopic examination was possible. This analysis involved comparison of the unknown specimens to reference deer and human thin sections including bone recovered from the woman during autopsy. Examination of the jeep and gas station fragments revealed no plexiform bone, secondary (not primary) osteons, and variability in size and shape of the osteons and Haversian canals. These and other variables identified the bone fragments as human.

KEYWORDS: physical anthropology, musculoskeletal system, human identification

This article outlines the case history of a middle-aged white female found in a moderately severe state of decomposition on the Mississippi River bank in southeastern Louisiana. The specific focus concerns the forensic anthropological analysis involving histological identification of small bone fragments found in the vehicle owned by the suspect charged with murdering the woman and at the gas station where the vehicle was cleaned. The bone fragments were compared with nonhuman (deer) bone and bone recovered from the woman at autopsy to determine whether the microstructure and morphometry of the fragments showed features characteristic of human bone.

Autopsy Findings

The woman's body was recovered in a moderately severe putrefactive state and partly eviscerated. The remains were brought to the Forensic Anthropology Laboratory (LSU) for X-ray

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and autopsy. Positive identification was established by comparison of antemortem and postmortem dental X-rays. The autopsy was completed by a forensic pathologist. Forensic anthropologists and investigators from the State Police Crime Laboratory were present.

The autopsy provided evidence of at least two shotgun blasts, one to the left side of the head, and the other to the right side of the chest [*1*]. The head was partially decapitated by one blast and showed extensive fracture of the facial and cranial bones, which were covered by remnants of dura mater on the inner table and lacerated fragmented scalp on the outer. The other blast fractured the right humerus and caused destruction of the right mammary gland. The humerus was fractured near the midpoint and showed decomposition and destruction of soft tissues in this region. The middle third of the diaphysis was missing bone such that the proximal and distal segments could not be joined. Radiographic survey of the body had revealed two shotgun pellets in the subcutaneous tissue (submammary region) of the left anterior chest wall, and these were recovered.

The thorax and the abdomen had a midline incision extending between the sternal and pubic regions exposing the abdominal cavity. This anterior wound measured approximately 60 cm in length with the gap at mid-abdomen being 25 cm. Incisions were also present on the anterior thighs (approximately 40 cm on each side) and posteriorly in the lumbosacral region (40 cm in length). It was not possible to determine whether the incisions were made pre- or postmortem. Motivation for these incisions presumably was to maintain submersion in the river.

Upon completion of the autopsy, bones of the cranium, the cervical vertebrae, and the right humerus, radius, and ulna were removed for further analysis, including structural restoration of the skull and histological analysis.

Further Investigation

Investigators charged a suspect with the crime and searched a number of localities for evidence relating to this incident. The suspect was believed to have shot the woman in the passenger seat of his jeep pickup and to have disposed of the body in the Mississippi River at a nearby ferry landing. Later he washed the vehicle at a local gas station.

The searches recovered four small bone fragments in the cab of the vehicle along with blood and tissue. Two bone fragments were found at the gas station where a witness had observed the defendant cleaning out the cab. When questioned about the presence of blood and bone fragments in the vehicle, the suspect stated that he had poached a deer and, in order to avoid detection, had placed the animal in the cab.

The largest fragment recovered from the vehicle measured 19 mm in length by 11 mm in width. The others were considerably smaller. Inspection of the bone fragments using a low-power binocular microscope indicated general surface similarity to bone recovered from the right humerus at autopsy. Three fragments had recognizable periosteal and endosteal surfaces and were from a long bone. No cranial fragments were identified. Despite considerable effort, none of the pieces could be joined to the one fractured long bone, the right humerus. Cortical thickness of the fragments closely matched comparable measurements taken at several points on the humerus. Nevertheless, further verification of species identity seemed necessary. To accomplish this objective, a comparative histological analysis was initiated to resolve the following question: do the unidentified specimens match deer bone or the histological structure of human bone recovered after the autopsy? The results would help confirm or refute testimony.

Methods

The forelimb of a recently killed deer was acquired by investigators of the State Police Crime Laboratory for direct comparison. The deer humerus was cleaned, labeled to maintain anatomical orientation, and cross-sectioned to remove the midshaft section. Cortical thicknesses were measured with Helios dial calipers to 0.1 mm at the fracture edges (human) and transverse section edges (deer) of the proximal and distal humerus segments on the ventral, dorsal, medial, and lateral surfaces. Periosteal and endosteal surfaces were clearly defined on two bone fragments and these fragments were measured.

The thin-section analysis was completed in the Department of Anthropology, University of Massachusetts, by M. K. Keith, who had previous experience with histological analysis of both human and deer bone. Sections of autopsy and deer bone were taken using a standard band saw. An Isomet wafering saw was used to section one fragment of human bone taken at the point of fracture, the two larger fragments from the vehicle (labeled X and Y), and the two fragments found at the gas station (G_1 and G_2). Sections were mounted using standard laboratory procedures on labeled microscope slides and ground to approximately 50 to 100 μm using a polisher-grinder with descending grades (240 to 600) of carborundum paper and finished with a polishing cloth. Only one specimen was removed from its envelope at a time, to avoid the possibility of confusing fragments.

The sections were examined and photographed using a Nikon binocular microscope with camera attachment. A Zeiss integrating lens was inserted into the right lens to project a grid onto the section and the diaphragm was closed to a viewing field of 2.405 mm^2 for counting numbers of whole osteons and measuring diameters of the Haversian canals. Fragments X, Y, and G_2 allowed morphometric comparison. The fragment G_1 was excluded from further analysis because its fields were not strictly comparable.

Several areas on each slide were examined for primary and secondary osteons and osteon fragments. These areas included all sides (dorsal, ventral, medial, and lateral surfaces of human autospy and deer bone), and each general area was counted twice at slightly different locations. Average counts were determined for each specimen. Fields composed of plexiform bone without osteons (for example, ventral and medial fields in the deer slides) were excluded from counts used to calculate the average number of osteons. Canal diameters were measured with the ocular grid.

Results and Discussion

Cortical thickness measurements are presented in Table 1. Values for fragments recovered from the gas station and the vehicle corresponded with measurements taken from the woman's right humerus. They also fell within the range of values recorded for the deer.

Sections of deer bone consisted principally of plexiform bone, a primary bone tissue in which regular planes of longitudinal, radial, and circumferential primary canals form a symmetrical network of bone (Fig. 1). Where osteons were observed, they were primary (that is, remodeling had not occurred; Fig. 2). These primary osteons were uniform in shape and size, and were packed, having very little interstitial bone between osteons. Refer to Enlow [*2,3*] and Ortner

TABLE 1—*Cortical thickness of bone fragments relative to measurements taken on the human and deer humeri.*

Location	Human		Deer		Fragment X (Vehicle), mm	Fragment G (Gas Station), mm
	Proximal, mm	Distal, mm	Proximal, mm	Distal, mm		
Anterior-ventral	3.4	4.4	3.7	4.5	...	...
Posterior-dorsal	3.8	3.9	2.7	3.2	...	...
Medial	3.8	3.8	2.7	3.0	...	...
Lateral	3.5	3.5	3.3	3.1	...	...
Unknown	...	...	...	...	3.9	3.8
Mean	3.6	3.9	3.1	3.5	3.9	3.8

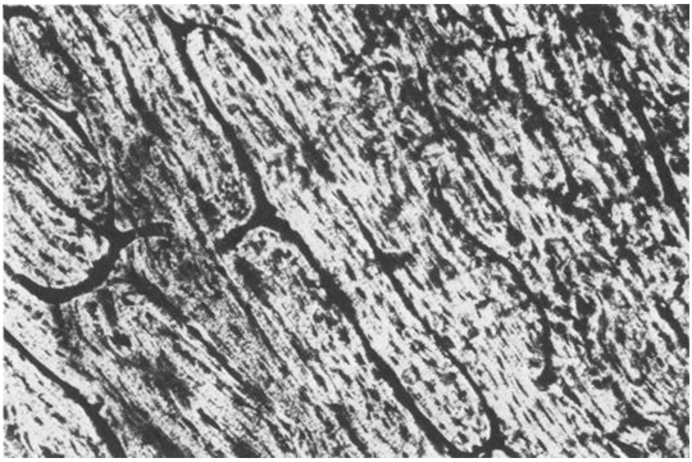

FIG. 1—*Histological section of a deer humerus showing plexiform bone (×100).*

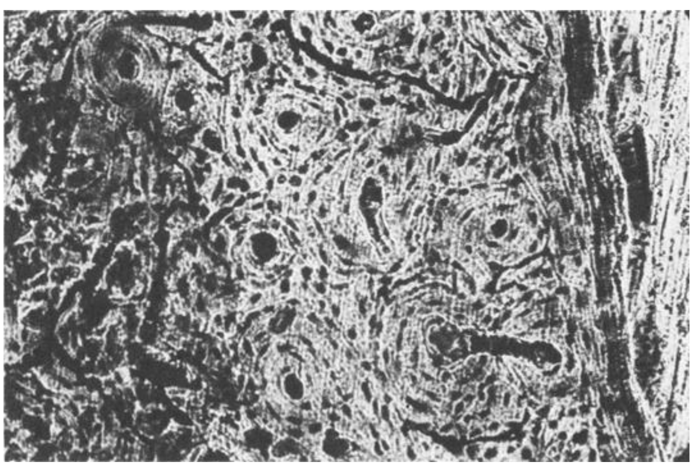

FIG. 2—*Histological section of a deer humerus showing osteons (×100).*

and Putschar [*4*] for descriptions and identifying characteristics of these and other bone structures (that is, plexiform bone, primary, and secondary osteons).

Diagnostic of the autopsy material was the presence of secondary osteons (that is, the product of the internal remodeling of primary compact bone; Fig. 3). These secondary osteons were variable in size and shape, and their canals were also less uniform in size than the primary osteons.

Examination of the vehicle and gas station fragments revealed no plexiform bone, secondary (not primary) osteons, and variability in size and shape of osteons and canals (Fig. 4). In addition, osteon fragments were present as expected in secondarily remodeled bone, but not in primary tissue. Average numbers of whole osteons per mm^2 in the unidentified fragments were similar to human autopsy values (Table 2). Considerably higher counts characterized the deer section. Haversian canal diameters also proved distinctive (Table 2). Autopsy values were larger (these calculations include osteons in the process of remodeling). The unidentified fragments were comparable to autopsy values. Thus, on several points, the histological structure of the

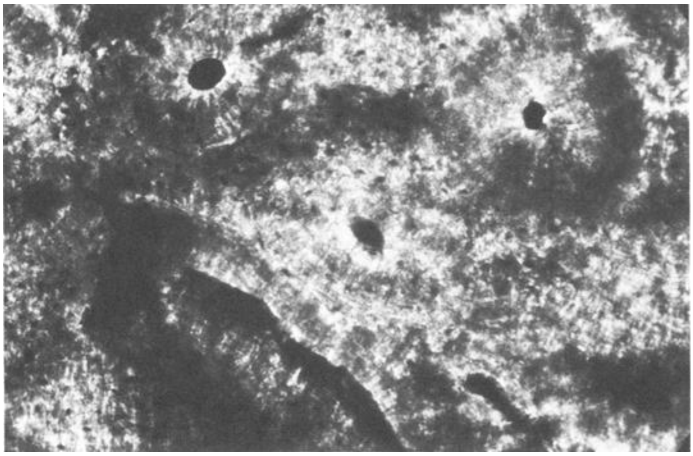

FIG. 3—*Histological section of the woman's humerus showing osteons and Haversian canals (×100).*

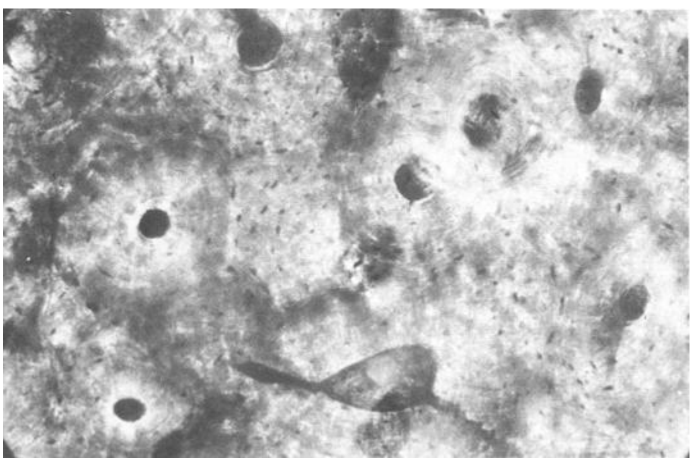

FIG. 4—*Histological section of a bone fragment found in the suspect's vehicle showing osteons and Haversian canals (×100).*

vehicle and gas station fragments more closely resembled the autopsy humerus than the deer sections.

Comparative studies of bone tissues of a number of animals have searched for features that permit species identification [*5-8*]. In general, their results indicate that it is difficult to identify human bone with certainty in all cases because some mammals have structural features that resemble human bone microanatomy (for example, other primates, bears, and cats). Enlow [*3*] notes that it is occasionally possible to show that a bone is not human. Moreover, bone tissues in many nonprimate forms have characteristics that distinguish them from human. "The bones of some forms, such as cow, deer, dog, turtle, any bird, etc., can usually be distinguished from human bone with little difficulty" [*3, p.* 102]. Presence or absence of plexiform bone, for instance, is useful for identification purposes. This type of bone occurs in some carnivores and infrequently in primates, including young monkeys and very young humans. It is the principal bone tissue in *Bovidae, Suidae*, and in *Cervidae*, which includes deer.

TABLE 2—*Mean number of osteons per mm² and range and mean diameter of Haversian canals in human and deer humeri and bone fragments.*

	Number of Osteons		Diameter of Haversian Canals			
Specimen	Count Areas	Mean, mm^2	*N*	Mean, mm	Minimum, mm	Maximum, mm
Deer humerus						
Section 1 (midshaft)	4[a]	5.53	...	...	...	...
Section 2 (midshaft)	3[a]	6.31	10	0.071	0.031	0.250
Human humerus (autopsy)						
Section 1 (proximal third)	7	0.65	10	0.175	0.063	0.312
Section 2 (at fracture site, midshaft)	3	1.46	...	...	...	...
Fragment X (vehicle)						
Section 1	3	1.59	5	0.192	0.083	0.333
Section 2	3	1.80	...	...	...	...
Fragment Y (vehicle)						
Section 1	2	1.32	5	0.175	0.083	0.250
Section 2	2	2.18	...	...	...	...
Fragment G_2 (gas station)						
Section 1	2	1.14	5	0.179	0.125	0.250

[a]Excludes fields comprised primarily of plexiform bone.

Conclusion

This paper has described a histological examination of bone fragments that helped determine their origin. Circumstances of the case required identification as deer or human. Bone fragments from a suspect's vehicle and from a gas station where the vehicle was cleaned were best identified as human bone. Following accumulation of this and other forensic science data, and shortly before the date scheduled for the trial, the suspect admitted murdering the woman.

Acknowledgments

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