TECHNICAL NOTE

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Use of the Cranial Base in the Identification of Fire Victims

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ABSTRACT: Techniques exist for using the cranial base to estimate the race and sex of skeletalized individuals in forensic science cases. The applicability of these techniques to remains of fire victims has been uncertain because of possible cranial-base shrinkage that may result from burning. To determine the amount of shrinkage resulting from low-temperature burning (<800°C), the cranial bases of eight dissecting room cadavers were measured, the bones then burned, and the cranial fragments remeasured. The wet-bone measurements were compared to the burned-bone measurements, and the percentage of shrinkage was calculated. The average change from wet to burned bone is less than 1.00%, a figure in agreement with other published studies. Since a change of 1.00% is less than intraobserver error, it is argued that low-temperature burning—such as an average house fire—does not significantly impair the accuracy of the identification techniques. Therefore, the techniques should be applicable to many fire victims.

KEYWORDS: physical anthropology, musculoskeletal system, human identification, fires, crania, race determination, sex determination

Previous work by the author [*1,2*] illustrates the value of the cranial base in estimating the sex and race (that is, white or black) of skeletalized individuals. The skull's base, especially the area of the occipital condyles and foramen magnum, may be particularly useful when the cranium is fragmented such as in the case of fire victims (where the skull may literally "explode" from the heat).

Since the techniques presented previously [*1,2*] use measurements taken from the cranial base, the applicability of the techniques to fire victims has been uncertain because of the possibility that the bone may shrink during cremation. This paper presents the results of an experiment to determine the degree to which the cranial base is subject to shrinkage.

Methods

Previous studies (for example, Ref *3*) of skeletal elements other than the cranial base suggest that bone burned at temperatures of less than 800°C undergoes minimal shrinkage. This is fortuitous given the fact that most house fires averages less than 800°C [*4*]. To deter-

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mine the amount of shrinkage that occurs in the cranial base as the result of low-temperature burning (here defined as less than 800°C), eight dissecting room cadavers were obtained from the Department of Anatomy, University of Missouri-Columbia. A circular section of bone approximately 6 cm in diameter containing the occipital condyles and foramen magnum was removed from each cranium. Two specimens were degreased in solutions of acetone and denatured alcohol and allowed to air-dry. The remaining six fragments had varying amounts of soft tissue attached. Seven measurements were taken from each cranial section. Each measurement was made three times, separated by three and six days, to test for intraobserver error. The average error was less than 2.00%. After measurement, each bone fragment was burned. Six specimens were immersed in 0.25 L of flammable liquid and ignited, and two fragments were carbonized in a kiln (Table 1).

Following cremation, the fragments were collected and the measurements retaken. The specimens ranged in color from brown to black. In some cases, minor reconstruction was required to obtain a particular measurement. As with the wet-bone samples, each burned sample was measured three times. The average percent of change from wet to burned bone is shown in Table 2.

TABLE 1—*Method of cremation.*

Specimen	Agent
2221	gasoline
2222	gasoline
2223	kerosene
2226	naptha
2228	acetone
2230	alcohol
2232	kiln (400°C)[a]
2233	kiln (500°C)

[a]Specimens were fired in the kiln for 15 min.

TABLE 2—*Average percent of shrinkage.*

Measurement[a]	Percent Change
MLC	1.06
MWC	0.19
MLFM	1.56
MWFM	0.11
MnD	0.25
MxD	2.21
MxID	1.49

[a]MLC = maximum length of condyle, MWC = maximum width of condyle, MLFM = maximum length of foramen magnum, MWFM = maximum width of foramen magnum, MnD = minimum distance between condyles, MxD = maximum distance between condyles, and MxID = maximum internal distance between condyles; see Holland [*1*, *2*] for complete description of measurements.

Results

As Table 2 illustrates, the amount of shrinkage that results from burning is minimal—averaging under 2.25% for all measurements and under 1.00% combined. These figures are in agreement with previous studies [*3*] that show little or no shrinkage in bone burned at temperatures of less than 800°C (though temperatures in excess of 800°C may bring about marked changes). Maximum distance between condyles shows the greatest change—2.21%—while the maximum width of the foramen magnum exhibits the least—0.11%. The different firing agents produced no pattern to the shrinkage. Likewise, the degreased specimens show no increased or decreased shrinkage when compared to green bone samples.

Summary

The average change from wet to burned bone was under 2.25% for all measurements and less than 1.00% combined. Thus the cranial base, when burned at temperatures of less than 800°C, reacts in much the same fashion as other skeletal elements [*3*]. Shrinkage induced by low-temperature burning is less than the intraobserver error produced by remeasuring the wet-bone samples over a six-day period. Since most house fires average less than 800°C [*4*], the existing techniques [*1,2*] should be applicable to the fragmentary remains of many fire victims. If firing temperatures in excess of 800°C are suspected, or if the bone fragments are completely calcined (appearing grey or white in color), then caution should be exercised.

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References

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