

A61 Variation in Bone Shrinkage Due to Thermal Exposure: A Patellar Case Study

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Learning Overview: After attending this presentation, attendees will see an example of thermal alteration within the same individual that is significantly higher than what is currently reported in the literature.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by highlighting the need to expand research conducted on the percentage of bone shrinkage from thermal exposure in humans.

Most literature on bone shrinkage from thermal alteration are experimental studies utilizing animal proxies, which suggests bone may shrink upward of 20% when burned. Current literature using human bone suggests much less shrinkage, with most studies finding less than a 5% decrease in original size.¹⁻³

This research presents a case study from a multiple individual (>1 Minimum Number of Individuals [MNI]) context involving burning. In this case, the patellae, later confirmed to be from the same individual, showed a high degree of bone shrinkage due to thermal exposure. Gross observation suggested that the shrinkage was considerably higher than the 5% documented in the literature for human bone, which initially led the analyst to consider an MNI of two rather than one. Specifically, this study analyzes differential burning between the left and right patella confirmed to be from the same individual to assess the degree of bone shrinkage in human bone and to illustrate the need to expand the research in this area.

Two observers recorded seven measurements from the posterior side of the left and right patellae: the maximum articulation width and height, width of the medial and lateral facet, volume of the entire articulation, volume of the medial and lateral facet. Measurement and observer error were assessed due to the small size of the bone and to ensure that deviations in size reflected actual bone shrinkage rather than error. Each of the measurements were collected three times per observer using Image J. The Technical Error of Measurement (TEM) was calculated for intra-observer error to verify the accuracy of repeated measurements. Absolute TEM was calculated, then transformed to relative TEM in order to obtain the error expressed as a percentage. Deviation percentages of less than 5% were considered acceptable.

The Relative TEM was under 5% for all seven measurements, with most under 2% for both observers and both patellae, suggesting low intra-observer error in measurements. The percent decrease in size (i.e., difference between patellae) was calculated using the difference in the average of the individual observer's three recordings for each of the seven measurements (left minus right side) divided by the larger size (left) for comparison. After calculating the percent decrease for the left and right patella, three measurements were consistent among both observers (<5% variation) and therefore retained for analysis of bone shrinkage: maximum articulation width and height and volume of the entire articulation.

The results show a high percentage of bone shrinkage in the right patella which was calcined (i.e., longer duration and/or higher temperature) compared to the left patella, which was only charred (i.e., less duration and/or lower temperature). The right patellar surfaces were considerably smaller than the left side from the same individual: maximum articular width was 21.7% smaller, maximum articular height 18.0% smaller, and volume of the entire articulation was 34.7% smaller. These results show a ~20% decrease in 2D metrics and a >30% decrease in volume metrics.

This case study shows that, within the same individual, thermal alteration can produce bone shrinkage that is significantly higher than what has been previously reported in the literature (5% versus 30%). This is important to consider when sorting and determining MNI in commingled contexts.

Reference(s):

1. Hermann, Bernhard. On Histological Investigations of Cremated Human Remains. *Journal of Human Evolution* 6, no. 2 (1977): 101-102.
2. Buikstra, Jane E., and Mark Swegle. Bone Modification Due to Burning: Experimental evidence. In *Bone Modification*, edited by Robson Bonnicksen and Marcella Sorg, 257-258. Orono, ME: Center for the Study of the First Americans, Institute of Quaternary Studies, University of Maine, 1989.
3. Castillo, Rafael, F., Douglas H. Ubelaker, Jose Antonio Lorente Acosta, Guillermo A. Canadas de la Duente. Effects of Temperature on Bone Tissue. Histological Study of the Changes in the Bone Matrix. *Forensic Science International* 226 (2013): 33-37.

Thermal Alteration, Bone Shrinkage, Patella