A32 Reevaluating the Use of Percentage of Bone for Histological Age Estimations

Mariah E. Moe, MA, New Braunfels, TX 78130; Timothy P. Gocha, PhD, Forensic Anthropology Center, San Marcos, TX 78666-4684*

Learning Overview: After attending this presentation, attendees will understand the potential for using the percentage of non-remodeled bone tissue in the histological analysis of cortical bone for the estimation of age at death from human skeletal remains.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating that the use of non-remodeled bone allows for easier training of histological methods and provides a more time-efficient means for age estimation when compared to the more commonly used histological measures such as Osteon Population Density (OPD). In addition, this presentation will show how ArcGIS® software can be used to maintain accuracy and precision of data collection while allowing for ease of access for future analyses. Finally, this presentation will highlight the benefits of histology as an objective and highly sensitive tool that can be used in cases in which other macroscopic methods have failed or are unavailable.

Traditional macroscopic methods for estimating age at death from human skeletal remains can be highly accurate when applied to younger decedents but are notoriously inadequate when aging individuals over the age of 50 years. Primary, or non-remodeled, bone is produced during normal growth and development. Throughout life, individuals undergo the lifelong process of remodeling wherein primary bone is replaced with microstructures known as secondary osteons. As individuals age, the amount of primary bone tends to decrease as the number of osteons increases. Skeletal histology as a means for age estimation has the potential to overcome the challenges encountered with macroscopic methods and more accurately estimate age in older individuals.

This study quantified the percentage of primary bone from the anterior femoral midshaft of 30 modern cadaveric samples (15 males and 15 females) ranging in age from 21 to 97 years. All femora were digitally subdivided circumferentially into octants, and radially into periosteal, middle, and endosteal thirds. Specifically, the periosteal third of the anterior octant was examined, and the percentage of non-remodeled bone was evaluated using static images and direct microscopic observation in linearly polarized light as well as brightfield illumination. Quantification of the non-remodeled bone was accomplished using Geographic Information Systems (GIS) software, specifically the polygon feature tool within the ArcMap® interface of ArcGIS®. Polarized light assisted with the quantification of the primary bone in that it highlighted the parallel structure of this bone, clearly delineating it from the more concentric remodeled bone tissue. Often, a reversal line (the defining feature separating the secondary osteons and fragments from the surrounding primary bone) could be better visualized with fine adjustments of the slide using brightfield microscopy.

All statistics were performed using SPSS version 24 and/or 25. Independent samples *t*-tests demonstrated no significant differences between males and females based on age distribution. Normality of the data was evaluated using a Shapiro-Wilk test due to small sample size (n=15) based on sex, where percentage of bone was the dependent variable and sex was the independent variable. The Shapiro-Wilk test revealed that the data were not normally distributed between the sexes nor with the sexes combined. The data were then transformed using the square root function in SPSS. Another Shapiro-Wilk test was performed and, as the test showed the transformed data to be normally distributed with maintenance of normality in the combined sex evaluations, all further analyses were conducted on the transformed percentage values with the sexes combined.

The data showed a statistically significant inverse relationship between percentage of non-remodeled (primary) bone and age at death. Regression analysis showed a linear relationship between the variables in the anterior, periosteal octant, accounting for 76% of the variability in age with a standard error of ±11.1 years.

These results were compared to previous research conducted by Maat et al. that investigated a smaller Region Of Interest (ROI) and showed that increasing ROI size significantly improves its predictive power.[1] These results were also compared to the most widely utilized histological predictor of age, Osteon Population Density (OPD). Linear regression analysis of OPD data previously obtained by Gocha revealed a strong correlation between OPD and age, explaining 83% of the variability in age with a standard error of ±9.2 years.[2] Quantification of the percentage of non-remodeled bone, however, requires less time and less training to implement than evaluating OPD and may be an adequate first step in histological analysis of age at death.

Reference(s):

1. Maat, G.J.R., Maes, A., Aarents, M., and Nagelkerke, N.J.D. (2006). Histological age prediction from the femur in a contemporary Dutch sample. *Journal of Forensic Sciences, 51*(2), 230-237.
2. Gocha, T.P. (2014). *Mapping spatial patterns in cortical remodeling from the femoral midshaft using geographic information systems software: Implications for age estimation from adult human skeletal remains.* Unpublished doctoral dissertation, The Ohio State University, Columbus, OH.

Histology, Age Estimation, Non-Remodeled Bone