H96 A Method for Standardization of Anatomical Axes and ROIs in Femoral Thin Sections of Unknown Orientations

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After attending this presentation, attendees will learn how midshaft cortical distribution observable via microscopic slides can be utilized to standardize femoral anatomical axes and histological regions of interest (ROIs) when skeletal orientation is unknown.

This presentation will impact the forensic science community by extending a technique for standardizing thin section anatomical axes and histological regions of interest, which may ultimately help identify areas of the femur most suitable for age-at-death estimation.

Different regions of the femur are in contact with separate lower limb muscle groups and subject to differential biomechanical demands. As both periosteal loads and far-field intracortical stresses influence remodeling—and, hence, osteons, the basic structures forensic histomorphologists quantify for an age estimate—it is imperative for correct anatomical orientation of investigated microscopic slides to be known. When working with fragmentary remains and thin sections removed from dissecting room cadavers, exact determination of anatomical axes locations becomes problematic if the samples are not expressly marked at the time of extraction. While anterior and posterior surfaces are easily identified through the presence of the femoral linea aspera, medial and lateral anatomical locations are not easily distinguishable.

To address this issue, Goldman and colleagues suggest using Sharpey's fiber insertion direction, and White (2000) suggests the lateral posterior femoral surface is usually more concave than the medial posterior surface. The accuracy of these techniques has yet to be demonstrated.[1,2] Nobel and colleagues extended a metric solution to the problem of identifying medial and lateral femoral cortices.[3] Seeking to identify the best placement for femoral midshaft medical implants, they measured 80 adult femora at their anatomical axes via radiographs. The authors found that the posterior cortical thickness on average was thickest (7.7mm), followed by the lateral cortex (7.6mm), the medial cortex (7.2mm), and finally the anterior cortex (5.1mm). Corroborating these findings, Stephenson and Seedhom (1999) measured 16 adult femoral midshaft and found anterior cortical thickness to be the thinnest, the posterior cortex the thickest, and medial and lateral cortices similar, but with the lateral side slightly thicker on average.[4]

To test the reliability of these observations, 200 femoral midshafts of known orientation were harvested from GWU Medical School Dissecting Room cadavers and processed for histological assessment. A 1200 dpi resolution image of each of the thin sections was obtained using an HP 4850 Scanner. ImageJ (version 1.44) and MomentMacroJ (version 1.2) were used to draw the principle axes of maximum and minimum bending rigidity on each femoral image. To standardize anatomical axes and histological ROI locations when a complete femur is not present for analysis, the A-P anatomical axis was consistently determined by drawing a vertical line, and the M-L anatomical axis by drawing a horizontal line, through the mathematically determined centroid of the section. To distinguish between medial and lateral cortices, each femoral cross-sectional image analyzed by ImageJ with observable axes was additionally placed over a background that standardized cortical width measurement every 22.5°. Analysis of this data suggests cortical width at the 292.5° lateral location is consistently thicker than at 112.5°, the medial location on the axis 180° across. These measurements were determined to be significantly different from each other using a paired comparison test and can therefore be used to distinguish medial and lateral cortices when femoral anatomical orientation is unknown.

Here, a method is extended for standardization of anatomical axes and histological ROIs in femoral thin sections with unknown skeletal orientations, with an additional technique for distinguishing between medial and lateral femoral cortices. While a useful technique when confronted with unlabeled femoral thin sections, standardized ROIs can also help to improve repeatability and reduce operator subjectivity in the field of histomorphology. Further research is underway that utilizes these techniques in an effort to uncover patterns in histomorphometric variation in biomechanical versus anatomical sampling locations in midshaft femoral cortical bones. Discovery of such patterns will be of great assistance to forensic anthropologists who use histomorphometric techniques by suggesting ROIs most suitable for age-at-death estimation.

References:

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Standardization, Histomorphology, Regions of Interest