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Improving Accuracy, Precision, and Efficiency in Analysis of Osteon Cross-sectional Shape

C.S. Mears, S.M. Litton, C.M. Phippen, T.D. Langston, K.E. Keenan, J.G. Skedros

Variations in secondary osteon (SO) cross-sectional shapes help determine species affiliations, estimate age, and decipher load history. SO cross-sectional shape is expressed as "circularity index" [CI=4π(area/perimeter^2); 1.0=perfect circle] and can be measured in various ways. But which method is the most accurate and efficient? Sixty osteons (5 osteons/image; 8 deer calcanei and 4 human femora; backscattered electron images) and 9 virtual osteons (created using Photoshop) were traced/measured. Each trace followed a predetermined cement line made by: (1)opening each image in Photoshop, (2)selecting the osteon using quick select tool, and (3)outlining the SO periphery with black and filling with white. Using ImageJ, methods included: (1)wand tracing tool followed by smoothing (fit spline vs. interpolate), (2)manual tracing with stylus on a Windows-based tablet (ASUS M80T) using freehand selections tool, and (3)manual tracing with the polygon selections tool (minimum 20 points). Data from virtual osteons suggest that fit spline could be problematic by over smoothing when crenulations are present, although not by much (mean CI difference =0.032 vs. interpolate). Although when using the wand tool, fit spline or interpolation can significantly affect perimeter (hence CI); but SO *area* measurements are not significantly affected. Therefore, the two best methods are: (1) Windows tablet running ImageJ/freehand tool, without the fit spline or interpolation functions, and (2) wand trace tool with interpolation function. Mean CI difference of these two methods =0.007 and their traces closely follow the cement line. Windows-based tablet also bypasses the need to first paint the SO in Photoshop, which enhances efficiency.