



A15 A Revision of the Histological Age Estimation Formula From Stout for Sternal Rib Ends

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After attending this presentation, attendees will understand how forensic anthropologists use histological methods to estimate age at death and how the accuracy of these methods may be improved.

This presentation will impact the forensic science community by providing a revised regression equation to improve the accuracy of histological estimation of age at death from cross sections of sternal rib ends.

Given the lack of macroscopic features in highly fragmentary skeletal remains, histological methods may be employed to estimate age at death if complete skeletal elements are not available. These methods are based on the assumption that bone remodeling events accumulate throughout one's lifetime, meaning the bones of older individuals generally contain more osteons, the result of remodeling, than those of younger individuals.

Previous research by Stout and colleagues described a formula for histological age estimation based on Osteon Population Density (OPD) for cross sections of the sternal end of the fourth rib from an autopsy sample of 60 individuals (mean age=39.2 years, age range=11-88 years).¹ Though the original publication reported that age estimates produced by the histological prediction equation differed from known age at death by 8.8 ± 0.98 years, reexamination of the original equation using individuals from the same collection revealed that age estimates differed from known age at death by 22.54 ± 2.30 years.¹

This current work seeks to revise the original formula, taking into consideration osteon area and osteon circularity in addition to OPD to create more accurate age estimates. OPD, defined by Stout and colleagues as the number of osteons per unit area, was calculated with the aid of a Merz counting reticle.¹ Osteon area is defined as the amount of bone in the boundary of an intact osteon in millimeters and osteon circularity is the quantification of how similar an osteon's shape is to a true circle, ranging from 0 to 1.^{2,3} Osteon area and circularity were measured using ImageJ software to trace the cement line, or outside boundary, of each osteon. Data on OPD, osteon area, and osteon circularity were collected from the entire cross section of the rib. Given that information on known age at death for 14 individuals had been misplaced since the original publication, a subsample of the original autopsy sample was used to develop the revised equation, including 46 individuals (17 females, 29 males) of known age (mean age=43.3 years, age range=15-83 years). The formula was generated using multiple regression analysis in which the dependent variable was age and the independent variables were OPD, osteon area, and osteon circularity. OPD and osteon area were found to make statistically significant contributions to the age estimation formula ($p < 0.05$). Osteon circularity did not significantly contribute to the age estimates, and the final formula was developed using only OPD and osteon area as independent variables.

Age estimates produced by the revised equation differed from known age at death by 10.18 ± 1.25 years, indicating that the revised formula was more accurate for estimating age than was the original formula. To test the accuracy of the revised equation, a "test set" approach was used in which a subset of individuals ($N=16$) was removed and the equation was calculated from those individuals who remained ($N=30$). Age at death was estimated for those individuals removed from the sample, and results revealed that age estimates produced by the "test set" equation differed from known age at death by 10.99 ± 2.48 years, indicating accuracy comparable to the equation generated from all 46 individuals. Therefore, it is recommended that the revised formula be used for histological age estimation of rib cross sections in place of the previously described formula.

Reference(s):

1. Stout S.D., Dietze W.H., Işcan M.Y., Loth S.R. Estimation of age at death using cortical histomorphometry of the sternal end of the fourth rib. *J Forensic Sci.* 1994;39(3):778-784.
2. Pinto D.C., Pace E.D. A silver-stain modification of standard histological slide preparation for use in anthropology analyses. *J Forensic Sci.* 2015;60(2):391-398.
3. Goliath J.R., Stewart M.C., Stout S.D. Variation in osteon histomorphometrics and their impact on age-at-death estimation in older individuals. *Forensic Sci Int.* 2016;262:282.e1-282.e6.

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