Revisions in the Microscopic Method of Estimating Age at Death in Human Cortical Bone

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ABSTRACT Problems recently discovered in the Kerley method of estimating age at death from cortical microstructure are discussed. Kerley's original data have been re-analyzed to produce new regression equations and to document the original field size.

In 1965, the first author (E. R. Kerley) described a method for the estimation of age at death from the microscopic examination of human cortical bone. This method involves the counting of osteones, fragments of old osteones and non — haversian canals and estimating the percentage of circumferential lamellar bone remaining in four circular visual fields located at the periosteal margin of the cortex. Modifications of the method have been offered by Ahlqvist and Damsten ('69) and Singh and Gunberg ('70). The method and/or the modifications have been used extensively in forensic identification and in estimating age at death of archeologically recovered human remains (Ubelaker, '74).

While gathering data for a recent study comparing the accuracy of the original Kerley method with that of the Ahlqvist-Damsten modifications (Bouvier and Ubelaker, '77), the second author detected several apparent problems in the original 1965 publication. The technique calls for a microscope equipped with a "ten-power objective lens combined with ten-power, wide-field oculars" which produce a circular visual field "1.25 mm in diameter." A survey of microscopes in Smithsonian laboratories with that combination of objective lens and oculars revealed that field size ranged from 1.2-2.0 mm, depending upon the structure of the microscope. When the sections used in the original study were re-examined with a field size of 1.25 mm, the resulting estimated ages were considerably lower than the actual ages. Thus the field size employed in the original study must have been greater than the published 1.25 mm. The microscope used originally is no longer available for measurement. In addition, regression formulae for tibial fragments and fibular osteones contain apparent errors, which result in unreasonable estimates.

MATERIALS AND METHODS

To resolve the problem of field size, the authors of this paper re-examined with a calibrated field size the sections used in the original study. All counts were then compared with the original counts. The comparison suggests that the original field size was about 1.62 mm, not the published 1.25 mm.

To improve the regression formulae, the second author (D. H. Ubelaker) obtained the original data sheets used in calculating the formulae by the Statistical Branch of the Armed Forces Institute of Pathology. As in the original study data from sections showing pathological alterations were excluded. Since the resulting sample is the same as that in the original study, details on sample composition are not repeated here.

The data were analyzed using the polynomial regression program BMD P5R allowing for up to cubic terms (Dixon, '75). The best curve fits are presented in the regression equation in table 1. These curve fits were checked by using the multiple linear regression program BMD P1R.

TABLE 1

Regression formulae for calculating age at death (Y) from cortical microstructure

Factor	Regression	s [1]
Femoral osteones	$Y = 2.278 + 0.187X + 0.00226X^2$	9.19
Femoral fragments	$Y = 5.241 + 0.509X + 0.017X^2 - 0.00015X^3$	6.98
Femoral lamellar	$Y = 75.017 - 1.790X + 0.0114X^2$	12.52
Femoral non-haversian	$Y = 58.390 - 3.184X + 0.0628X^2 - 0.00036X^3$	12.12
Tibial osteones	$Y = -13.4218 + 0.660X$	10.53
Tibial fragments	$Y = -26.997 + 2.501X - 0.014X^2$	8.42
Tibial lamellar	$Y = 80.934 - 2.281X + 0.019X^2$	14.28
Tibial non-haversian	$Y = 67.872 - 9.070X + 0.440X^2 - 0.0062X^3$	10.19
Fibular osteones	$Y = -23.59 + 0.74511X$	8.33
Fibular fragments	$Y = -9.89 + 1.064X$	3.66
Fibular lamellar	$Y = 124.09 - 10.92X + 0.3723X^2 - 0.00412X^3$	10.74
Fibular non-haversian	$Y = 62.33 - 9.776X + 0.5502X - 0.00704X^3$	14.62

[1] Square root of the mean square residual.

SUMMARY AND CONCLUSIONS

In using the Kerley method, investigators should be aware of the variance in field diameters with different microscopes and should adjust the data to a field diameter of 1.62 mm. The area (πr^2) of the 100 × field of the microscope used must be calculated using a stage micrometer and that field size divided into 2.06 mm^2 (area of a field diameter of 1.62 mm) to determine the relationship between the original field size and the field size of the individual microscope being used. All counts of osteons, fragments or non-haversian canals should then be multiplied by that factor. The estimate of percentage of lamellar bone is not affected. Age at death should then be calculated using the profile chart in the original publication or using the regression equations presented here in table 1.

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