

Equations for Predicting Age from Crown Height Measurements

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As part of our tooth wear research we have developed a series of equations for predicting age from crown height measurements (Table 1). These equations are based on measurements of modern North American blacks and whites of known age whose remains are in the Terry Collection at the National Museum of Natural History.

We have found these equations to be useful in forensic investigations of highly fragmentary modern skeletal remains. When isolated teeth, or jaws are discovered, dental anthropologists are often asked to provide a rough estimate the person's age based on tooth wear. The equations in Table 1 provide a statistical basis for making such estimates for people whose wear rates are comparable to those of the Terry collection (Figure 1).

To use the equations, measure the crown height from the cemento-enamel junction to the occlusal surface with the calipers held perpendicular to the occlusal plane. For the incisor, canine, and premolar equations make a single crown height measurement on the side of the tooth along its mid-sagittal plane. For the molars, the total crown height measurement used in the equations is the sum of the heights of each quadrant of the tooth (see Walker et al. 1991: figure 1). The age estimate is then the average of the estimated ages obtained for all the measured teeth of an individual.

Table 1: Equations for Estimating Age from Measurements of Crown Heights in Millimeters.

Mandibular Teeth

$$\begin{aligned}\text{Estimated Age} &= (\text{I1 Crown Height} \times -4.890) + 75.800 \\ \text{Estimated Age} &= (\text{I2 Crown Height} \times -5.555) + 84.288 \\ \text{Estimated Age} &= (\text{C Crown Height} \times -4.200) + 79.017 \\ \text{Estimated Age} &= (\text{P3 Crown Height} \times -3.960) + 68.582 \\ \text{Estimated Age} &= (\text{P4 Crown Height} \times -4.204) + 67.754 \\ \text{Estimated Age} &= (\text{M1 Total Crown Height} \times -1.658) + 76.955 \\ \text{Estimated Age} &= (\text{M2 Total Crown Height} \times -1.885) + 85.044 \\ \text{Estimated Age} &= (\text{M3 Total Crown Height} \times -1.535) + 74.175\end{aligned}$$

Maxillary Teeth

$$\begin{aligned}\text{Estimated Age} &= (\text{I1 Crown Height} \times -4.061) + 82.147 \\ \text{Estimated Age} &= (\text{I2 Crown Height} \times -4.715) + 85.079 \\ \text{Estimated Age} &= (\text{C Crown Height} \times -2.597) + 66.706 \\ \text{Estimated Age} &= (\text{P3 Crown Height} \times -5.213) + 82.222 \\ \text{Estimated Age} &= (\text{P4 Crown Height} \times -5.392) + 81.627 \\ \text{Estimated Age} &= (\text{M1 Total Crown Height} \times -1.423) + 77.240 \\ \text{Estimated Age} &= (\text{M2 Total Crown Height} \times -1.059) + 68.524 \\ \text{Estimated Age} &= (\text{M3 Total Crown Height} \times -1.054) + 66.284\end{aligned}$$

$$\text{Age Estimate: } \bar{x} = \frac{\sum \text{Estimated Ages}}{\text{Number of Teeth Aged}}$$

Age Prediction from Crown Height Measurements (cont'd)

We have used a "jackknife" procedure to test the equations. An individual was dropped from the sample and the regression line fitted to the remaining observations. This person's age was then predicted using the resulting equation. This was done for every person in the sample. These age estimates were then used to calculate the average inaccuracy (absolute difference between the estimated age and known age) and average bias (difference between the estimated age and known age) equations (Table 2).

Table 2: Average Inaccuracy and Bias In Years of Age Estimates
Derived from Crown Height Measurements

Tooth	<u>Mandible</u>			<u>Maxilla</u>		
	N	Inaccuracy	Bias	N	Inaccuracy	Bias
I1	93	9.79	-0.07	28	10.19	-0.24
I2	104	8.71	-0.01	43	10.46	-0.07
C	109	10.40	-0.03	51	10.17	0.06
P3	114	9.05	-0.02	47	10.57	0.01
P4	111	10.07	-0.01	47	10.33	0.02
M1	107	9.99	-0.02	45	9.90	-0.08
M2	116	10.36	0.01	46	9.58	0.03
M3	92	12.05	0.00	38	9.83	-0.16

N= number of individuals

Inaccuracy (years) = average absolute value of (estimated age) - (actual age)

Bias (years) = average value of (estimated age) - (actual age)

We found that the error of the estimate was lowest when the average of the age estimates obtained for each tooth of an individual was used as that person's estimated age (Table 3). This procedure resulted in an average inaccuracy in the age estimate of 9.36 years and an average bias of -0.25 years. These average values are comparable to those obtained by Lovejoy and co-workers (1985:7) in their analysis of age estimates based on several commonly used skeletal age indicators.

Table 3: Inaccuracy and Bias of Average
Crown Height Age Estimates

Actual Age (years)	N	Inaccuracy	Bias
18-29	35	13.65	-13.65
30-39	35	4.22	-2.2
40-49	20	4.52	2.31
50-59	27	10.21	9.63
>60	12	18.08	18.08
<u>All Ages</u>	<u>129</u>	<u>9.36</u>	<u>-0.25</u>

N= number of individuals

Inaccuracy (years) = average absolute value of (estimated age) - (actual age)

Bias (years) = average value of (estimated age) - (actual age)

Table 4: Correlations Between Crown
Heights and Crown Areas for Unworn Teeth

Tooth	<u>Mandible</u>		<u>Maxilla</u>	
	n	r	n	r
I1	16	-0.08	--	---
I2	18	0.31	4	-0.43
C	19	0.69	6	0.77
P3	19	0.32	6	0.18
P4	20	0.01	6	0.38
M1	21	0.30	6	-0.78
M2	22	0.04	6	-0.68
M3	18	0.03	6	-0.31

n = number of unworn teeth in sample

r = Pearson's r

Age Prediction from Crown Height Measurements (cont'd)

These average error values, however, are misleading. Although the equations perform quite well when used to age middle aged people, they have a strong tendency to underestimate the ages of elderly people and overestimate the ages of young adults (Table 3; Figure 2).

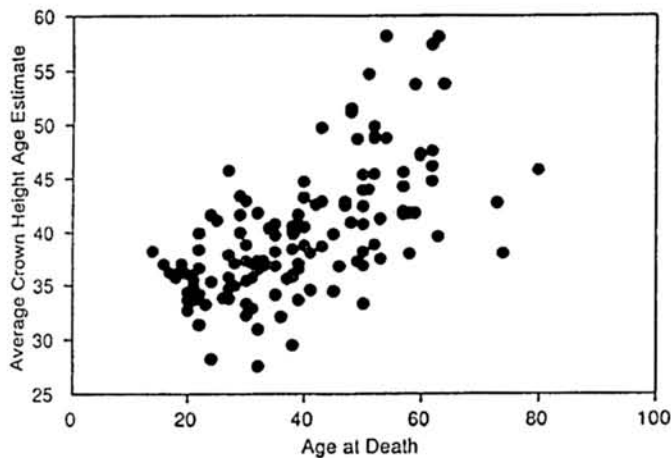


Figure 1. Age estimates based on the equations in Table 1 plotted against the actual age at death. The age estimates are the average of the age estimates obtained for all of the measurable teeth of an individual.

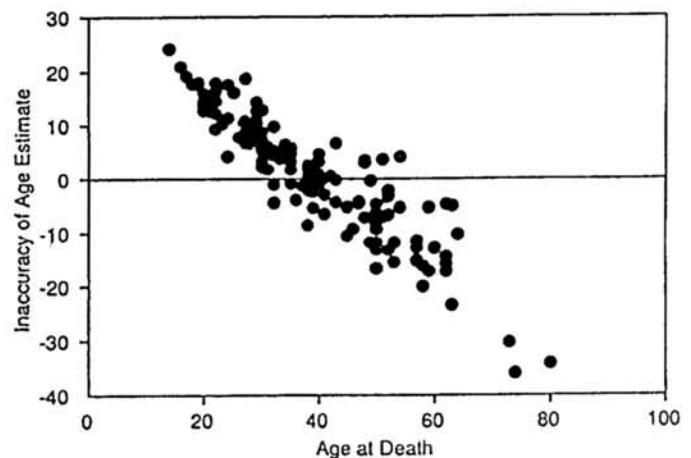


Figure 2. Inaccuracy of age estimates (estimated age) - (actual age) based on the equations in Table 1 plotted against the actual age at death.

We have attempted to improve the performance of these equations in a variety of ways. Variation in tooth size is a major source of error inherent in the use of crown heights to predict age. People with large unworn crown heights are underaged and people with smaller initial crown heights are overaged by these equations. To correct for this problem we standardized our crown height measurements by dividing them by crown area (buccolingual diameter x mesiodistal diameter) and then used this standardized dimension as an age predictor. Instead of improving our age estimates, this size standardization increased the inaccuracy of our age estimates. The explanation of this surprising finding is simple; for most teeth there is an unexpectedly weak correlation between crown area and unworn crown height (Table 4).

We have also explored the use of multiple regression models that include information on race, sex, and data on the crown heights of more than one tooth. These more complicated models only produced a small improvement in age prediction.

References

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