J Forensic Sci, Mar. 2003, Vol. 48, No. 2
Paper ID JFS2002174_482
Available online at: www.astm.org

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Model of Age Estimation Based on Dental Factors of Unknown Cadavers Among Iranians

ABSTRACT: Two hundred and ten cadavers ranging in age from 25 to 60 were studied. Thirty subjects from each five-year interval were selected, and data were collected using the mandibular anterior and premolar teeth after extraction. Sections ranging from 0.5 to 1.0 mm were measured by a stereo microscope with a precision of 0.1 mm. The following factors were determined: attrition, periodontosis, root resorption, secondary dentine apposition, cementum apposition, and translucency of the root. Statistical analysis used the sum of ranks of the dental factors as an independent variable in a linear regression model to estimate the age of the cadaver. Among the different mandibular teeth, the sum of ranks of the first premolar factors had the best correlation coefficient with age. The sum of the dental factors presented a better model than each of the factors alone. The first premolar is recommended as the first step in the estimation of age.

KEYWORDS: forensic science, age estimation, Gustafson's method, dental factors, human, identification, forensic dentistry

Estimation of age in unknown cadavers is an important method for their identification. Different methods have been used for age estimation in different ranges of age. The most common method in adults older than 25 is using dental parameters used by Gustafson in 1947 (1). In 1950, he presented his models based on microscopic and macroscopic features of teeth, including attrition, periodontosis, root resorption, secondary dentine apposition, cementum apposition, and translucency of the root. These parameters were ranked from 0 to 3 and used in linear regression models to estimate age with precision of $\pm$3.6 years (2).

In 1971, Johanson tried to present a more accurate model based on ranking above factors from 0 to 6 (3). The precision of his model for age estimation was $\pm$5.1 years. Pillai et al. (4) showed in India that Gustafson's method is under influence of external factors such as race and culture. Lucy et al. (5) minimized the defects of Gustafson's method by presenting new formulas in 1995.

Gustafson's method was used by Rahimian (6), Sabaghian (7), and Savabi (8) in Iran. The correlation coefficients between observed and estimated ages were 0.80 and 0.95 by the later two researches, respectively. However, the models were never calculated. In Iran, age is estimated by formulas that were designed for Swedish people. Therefore, it is necessary to present appropriate models for domestic use. In this study the six factors will be used for modeling to estimate age based on 210 teeth for the range of 25 to 60 years.

Materials and Methods

This study is a cross-sectional study. The samples were selected from Iranian cadavers referred to the Forensic Medicine Organization of the Isfahan province. Their age ranged from 25 to 60 years. This range was classified into five-year age groups. Thirty cases were selected for each group. The dental parameters are independent variables, and age is dependent. The inclusion criteria were presence in at least one single-root tooth on a mandible, including either a premolar, canine, or incisor. The tooth should not be crowned or be used in a fixed or removable partial denture. It should not be under onlay or cusp capping procedures. Our priority in tooth selection was based on Solheim's (9) study and included right 2nd premolar, left 2nd premolar, right 1st premolar, left 1st premolar, right canine, left canine, right lateral, left lateral, right incisor, and left incisor in descending order.

After getting the needed permits, the cases were selected during nine months. Their age was determined based on the data of their identification card. After tooth selection, the distance between sulcus of gingiva and cervix of tooth (CEJ) in medial aspect of buccal surface was measured with a probe in millimeters. This is measured to calculate the periodontosis factor. Upon presence of trauma or laceration of gingiva, the distance between junctional epithelium on root and CEJ was measured after extraction of the tooth. Tooth extraction was based on rotational technique using lower jaw forceps. Upon fracture of a tooth due to severe curvature of the root, the tooth was disregarded and the next tooth was selected based on the above-mentioned priority.

After extraction, the teeth were cleaned and put in tubes containing alcohol and xylene. Alcohol and xylene show a better presentation by dehydration of translucent area of root.

For each case, variables such as name and surname, age, type of tooth, and periodontosis factor (mm) were gathered. A non-stop Bego device was used to make longitudinal sections ranging from 0.5 to 1.0 mm, and smoothing was achieved by sand-blast. Three teeth were deleted from the study due to previous endodontics treatments on their root. Microscopic studies were done by stereo microscope with a precision of 0.1 mm. The factors and their classifications are defined as follows:

Periodontosis factor (P) is the ratio of distance between sulcus of gingiva and cervix of tooth (CEJ) to the root length. P0 = no periodontosis. P1 = beginning of periodontosis. P2 = periodontosis

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Received 21 May 2002; accepted 19 July 2002; published 3 Feb. 2003.

more than one third of root coronally. P3 = periodontosis more than two thirds of the root coronally.

Attrition factor (A) is the extent of destruction of crown. A0 = no attrition. A1 = attrition up to enamel level. A2 = attrition up to dentin level. A3 = attrition up to pulp. Secondary dentine apposition factor (S) is the ratio of secondary generated dentin to the total volume of pulp cavity. S0 = no secondary dentin. S1 = secondary dentin up to upper part of pulp cavity. S2 = secondary dentin up to half of pulp. S3 = diffuse calcification of the entire pulp.

Root resorption factor (R) is the extent of destruction of root due to resorption. R0 = no resorption. R1 = spotted like resorption. R2 = root resorption at the level of cementum. R3 = extensive resorption of cementum and dentin.

Cementum apposition factor (C) is the extent of increment of cementum. C0 = normal thickness (undetectable). C1 = thickness more than normal (detectable). C2 = generation of thick cementum. C3 = hypercementosis thickness.

Translucency of the root factor (T) is the ratio of height of translucency area to the length of root. T0 = no translucency. T1 = beginning of translucency of root. T2 = translucency more than one third of apical root. T3 = translucency more than two thirds of apical root.

Statistical analysis of this study is based on linear regression analysis using sum of the ranks of the factors (SR) as a predictor of age. Statistical analyses were done by PSS.

Results

The total number of 210 cadavers including 185 (88.1%) males and 25 (11.9%) females were selected. Frequency distribution of the six factors, including attrition, periodontosis, root resorption, secondary dentine apposition, cementum apposition, and translucency of the root, are shown in Table 1. Mean and standard deviation (*SD*) of SR is 6.72 (1.81). Correlation coefficients of age with attrition, periodontosis, root resorption, secondary dentine apposition, cementum apposition, and translucency of the root are 0.394 ($P < 0.001$), 0.384 ($P < 0.001$), 0.169 ($P = 0.014$), 0.522 ($P < 0.001$), 0.251 ($P < 0.001$), and 0.344 ($P < 0.001$), respectively. Coefficients of the regression line regardless of the tooth type are calculated as the following [P(constant) < 0.001, P(SR) < 0.001, $R = 0.641$]:

$$\text{Age} = 16.948 + 3.697(\text{SR})$$

Upon calculation, the quartiles of error, regardless of tooth type, were less than 2.5, 5.7, and 9.2 years in 25, 50, and 75% of the subjects, respectively. Similarly, quartiles of error based on the 1st premolar model were 2.6, 4.7, and 7.1 years in 25, 50, and 75% of the subjects, respectively. Table 2 shows coefficients of the regression line by tooth classification. Mean error upon estimation of age by type of tooth appeared to be 6.4, 7.0, 6.7, 5.2, and 6.2 years for regression lines of central, lateral, canine, 1st and 2nd premolar teeth, respectively.

TABLE 1—*Frequency distribution of different levels of the factors.*

Factors	0 *n* (%)	1 *n* (%)	2 *n* (%)	3 *n* (%)
Periodontosis	0 (0.0)	151 (71.9)	55 (26.2)	4 (1.9)
Attrition	0 (0.0)	114 (54.3)	87 (41.4)	9 (4.3)
Root resorption	76 (36.2)	93 (44.3)	36 (14.1)	5 (2.4)
Secondary dentine apposition	55 (26.6)	123 (59.4)	24 (11.6)	5 (2.4)
Cementum apposition	5 (2.4)	180 (85.7)	25 (11.9)	0 (0.0)
Translucency of root	9 (4.3)	177 (84.3)	20 (9.5)	4 (1.9)

Discussion

There have been two major series of methods for age estimation based on dental parameters, including single and multiple factor methods. In 1979, Helm and Prydso used the severity of attrition of molar teeth to estimate age of medieval Danes (10). These findings showed that attrition factor had a medium accuracy for age estimation. Lovejoy showed that, upon using a high sample size, a correlation coefficient of 0.96 could be found between the attrition factor and the age of a group of American Indians (11). In 1991, Kambe et al. have found a correlation coefficient of 0.93 between attrition and age using computer-assisted image analyzer (12). In 1993, Tomaru et al. showed that the correlation coefficient between incisors of lower jaw and age was 0.607 based on their findings (13). However, Santini et al. showed that the attrition factor of molar teeth based on Mile's method was not useful for age estimation (14).

Translucency of dentine can also be used for age estimation as another possible single factor method (15). Bang and Ramm have shown mean error of estimation to be ±4.7 years in 58% of cases and ±10 years in 79% of the subjects (16). In Wegner and Albrecht's study, correlation coefficient between root dentin transparency and age was 0.67, and the best range of age was 30 to 60 years using the translucency factor (17). On the other hand, Hopp and Blick used length of translucency zone so that the mean error of estimation was ±5 years with 90% reliability (18). In 1989, Sol-

TABLE 2—*Coefficients of the regression lines by tooth type.**

Tooth Kind		UC *B*	UC *P* value	*R* square	*n*
Central	(Constant)	24.421	0.028	0.380	10.0
	SR	2.307	0.056		
Lateral	(Constant)	20.281	0.006	0.359	21.0
	SR	2.738	0.004		
Canine	(Constant)	13.183	0.035	0.545	25.0
	SR	4.401	0.000		
1st Premolar	(Constant)	7.545	0.077	0.608	49.0
	SR	5.136	0.000		
2nd Premolar	(Constant)	14.767	0.000	0.394	105.0
	SR	4.165	0.000		

*Dependent variable = age; UC = unstandardized coefficients; *SR* = sum of ranks.

heim et al. showed that correlation coefficients between translucency factor and age were 0.68 to 0.86 in different methods of measurements and 0.57 to 0.83 in different teeth (8,19). Drusini has mentioned that mean error of estimation was ±5 years just in 21.1% of the subjects by applying the Bang and Ramm equation and using the translucency factor (20).

In 1982, age was estimated based on calculation of cementum annulations by Stott (21). In another study in 1986, the correlation coefficient between number of cementum annulations and age was 0.78. Mean error of estimation was ±6 years (22). However, Miller found no relationship between these two variables (23). In 1990, Solheim showed the highest correlation coefficient between age and cementum thickness in the lower third of root (24). It ranged from 0.40 to 0.67 by different methods of measurements. Stein et al. showed the number of cementum annulations to be an accurate factor for age estimation with a correlation coefficient of 0.93 (25).

The multiple factor method was first used by Gustafson in 1950 using attrition, periodontosis, root resorption, secondary dentine apposition, cementum apposition, and translucency of the root (2). The mean error of estimation in his study was ±3.63 years. In 1962, Dalitz disregarded cementum apposition and root resorption (26). He presented his model by classifying the factor into five categories. Maples has used secondary dentine and translucency of root of the second molar teeth (27). His method was suggested for use as a complementary method along with other methods. In another study, translucency of root and secondary dentine were presented as more accurate factors for age estimation (28). Mean error of Gustafson's method was shown to be ±4.6 years by Haertig's study in France (29). Sabaghian (7) and Savabi (8) had also used Gustafson's linear regression without new modeling with a lower sample size in a group of Iranians.

These studies show different results with different accuracies based on dental factors that may be due to different methodologies, race, and environmental factors. In our study, the correlation coefficients of age with each of six single factors are less than the coefficient of age with the sum of factors so that the best estimation is achieved by combination of all six dental factors. Furthermore, our results show that the best estimation is earned when the first premolar is used. Mean error of estimation is ±6.4 years, regardless of tooth type. In this study, 25% of the subjects had an error of less than 2.5 years, 50% had error of less than 5.7 years, and 75% were estimated with an error of less than 9.2 years, regardless of tooth type. When the 1st premolar was used, these values were 2.6, 4.7, and 7.1 years in 25, 50, and 75% of the subjects, respectively. So, it seems that the 1st premolar should be used in the 1st step among Iranians when Gustafson's method is used for age estimation. Furthermore, this method can be used either before or in conjunction with other accurate methods, such as amino acid analysis of *D*/*L* ratio of aspartic acid crystals in dentine (30) among Iranians.

The reason for errors of Gustafson's method for age estimation of Iranians is low variability of dental factors in different ages. It can be due to congenital and environmental patterns, including eating habits, which seems to be a determinant of dental factors (4). Furthermore, measuring the factors on dried teeth rather than fresh teeth may be another source of measurement error in this study. Despite these problems, the model is a cheaper, easier, and more practical method and should be used in the first step before more sophisticated methods of age estimation in unknown cadavers.

Acknowledgment

The authors would like to appreciate the Forensic Medicine Organization of Esfahan for their sincere consideration.

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J Forensic Sci, July 2003, Vol. 48, No. 4
Paper ID JFS2003erratum_484
Available online at: www.astm.org

ERRATA

Erratum/Correction of Monzavi BF, et al. Model of Age Estimation Based on Dental Factors of Unknown Cadavers Among Iranians. J Forensic Sci 2003 Mar;48(2):379–381.

It has come to the attention of the Journal that one of the co-author's name, Dr. Asghar Karimi, was inadvertently omitted.

The Journal regrets this error. Note: Any and all future citations of the above-referenced paper should read Monzavi BF, et al. Model of Age Estimation Based on Dental Factors of Unknown Cadavers Among Iranians. [published erratum appears in J Forensic Sci 2003 July;48(4)] J Forensic Sci 2003 Mar.;48(2):379–381.

Erratum/Correction of Thali MJ, et al. Virtopsy, a New Imaging Horizon in Forensic Pathology: Virtual Autopsy by Postmortem Multislice Computed Tomography (MSCT) and Magnetic Resonance Imaging (MRI)—a Feasibility Study. J Forensic Sci 2003 Mar.;(48)(2):386–403.

On page 387, at the bottom of the left column, "or Flaiv sequences" should be "or Flair sequences"

On page 388, Table 1,

case 033, in the first line, there are "1" instead of "+".
case 025 "arhythmia" must not be printed in boldface.
case 029 "hypoxia" must not be printed in boldface and italicized.

The Journal regrets this error. Note: Any and all future citations of the above-referenced paper should read: Thali MJ, et al. Virtopsy, a New Imaging Horizon in Forensic Pathology: Virtual Autopsy by Postmortem Multislice Computed Tomography (MSCT) and Magnetic Resonance Imaging (MRI)—a Feasibility Study. [published erratum appears in J Forensic Sci 2003 July;48(4)] J Forensic Sci 2003, 48(3):386–403.