TECHNICAL NOTE

H. Lamendin,[1] D.D.S., Ph.D., E. Baccino,[2] M.D., J. F. Humbert,[1] Ph.D., J. C. Tavernier,[3] D.D.S., R. M. Nossintchouk,[3] D.D.S., Ph.D., and A. Zerilli,[2] D.D.S.

A Simple Technique for Age Estimation in Adult Corpses: The Two Criteria Dental Method

REFERENCE: Lamendin, H., Baccino, E., Humbert, J. F., Tavernier, J. C., Nossintchouk, R. M., and Zerilli, A., **"A Simple Technique for Age Estimation in Adult Corpses: The Two Criteria Dental Method,"** *Journal of Forensic Sciences,* JFSCA, Vol. 37, No. 5, Sept. 1992, pp. 1373–1379.

ABSTRACT: A method for age determination of adults from single rooted teeth is presented. It is based on the measurement of two dental features: periodontosis height times 100/root height (P) and transparency of the root height times 100/root height (T). These measurements are made on the labial surface of the entire tooth without section and do not require special equipment or training. The application of multiple regression analysis to a working sample of 306 teeth of known age, sex and race provided the following equation: Age (years) = $0.18 \times P + 0.42 \times T + 25.53$. The mean error between the actual and estimated age was $\pm$ 10 years on the working sample and $\pm$ 8.4 years on a control sample made of 45 forensic science cases. Upper incisors showed a better precision than the other single rooted teeth and accuracy was not sex related. A comparison of the Gustafson and Lamendin methods on a control sample of 39 teeth resulted in an advantage of the latter considering the mean error on the estimation (14.2 $\pm$ 3.4 years for Gustafson versus 8.9 $\pm$ 2.2 for Lamendin). The Lamendin method can be of practical interest for any forensic pathologist or dentist as it is fast, easy to use, and reasonably accurate except for cases of individuals under age 40 where other methods must be preferred.

KEYWORDS: odontology, age estimation, adults, dental method, transparency of the root, periodontosis

Since its publication in 1947 [*1*] and despite the criticisms it raised (sample size, subjective scoring, poor statistics and replicability) [*2,3*] the Gustafson method, which uses six features of dental microstructure, is still considered by most forensic science textbooks as the reference dental method of determining age at death in adults [*4,5*]. Several authors proposed significant improvements to the original technique, including a reduction in the number of variables [*2,6–9*], the use of multiple regression analysis [*2*] and index values based on actual physical measurements [*6*]. Unfortunately, major drawbacks still remain.

[1]Associate professor of biology and research assistant, Laboratoire de Biologie Cellulaire et Animale, Faculté des Sciences, Orleans.

[2]Professor of forensic sciences and research assistant of forensic odontology, Unité de Médecine Légale, Service Sebileau, CHRU A. Morvan, Brest Cedex.

[3]Professor of forensic odontology and research assistant, Laboratoire d'Odontologie Légale (Sous Section 56-03), Faculté de Chirurgie Dentaire, Paris.

The microscopical examination of longitudinal thin sections requires the expertise of a well-trained dental histologist [5]; moreover it results in the destruction of the tooth, making re-examination by other methods impossible.

To overcome these disadvantages, we focused on two dental features: 1) translucency of the root (T); and 2) periodontosis (P), which can be easily observed on the entire tooth, measured and expressed as an index value by relating the measure to a fixed measurement on the tooth (that is, height of the root (R). Multiple regression analysis was applied to these variables and in order to test the accuracy of this simplified dental method, the resulting equation for age determination was tested on a forensic sample and compared to the original Gustafson method.

The working sample was made of 306 single rooted teeth, free of restoration, collected from 208 individuals of known age (22 to 90 years), sex (135 men and 73 women) and race (198 whites, 10 blacks). The patients were either hospital or private office cases coming from urban and rural areas in equal number.

Dental Features and Measurements

See Figs. 1 and 2.

Periodontosis (gingival regression)

Due to the degeneration of the soft tissues surrounding the tooth, it progresses from the neck to the apex of the root. It appears as a smooth and yellowish area below the enamel and darker than it but clearer than the rest of the root; tartric deposits are often seen at its level. On the labial surface of the tooth, the maximum distance between the cementoenamel junction and the line of soft tissues attachment was measured.

Transparency of the Root

This physiologic feature never appears before the age of 20 and is due to the deposit, within dentin tubuli, of crystals of hydroxyapatite. T can be observed on the entire tooth

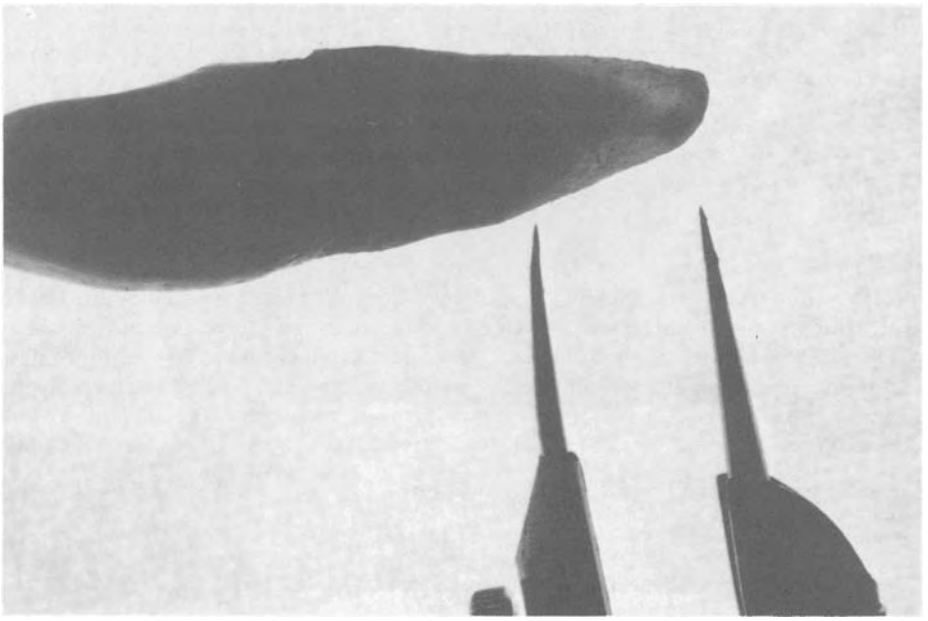

FIG. 1—*Upper central incisor: measurement of transparency of the root.*

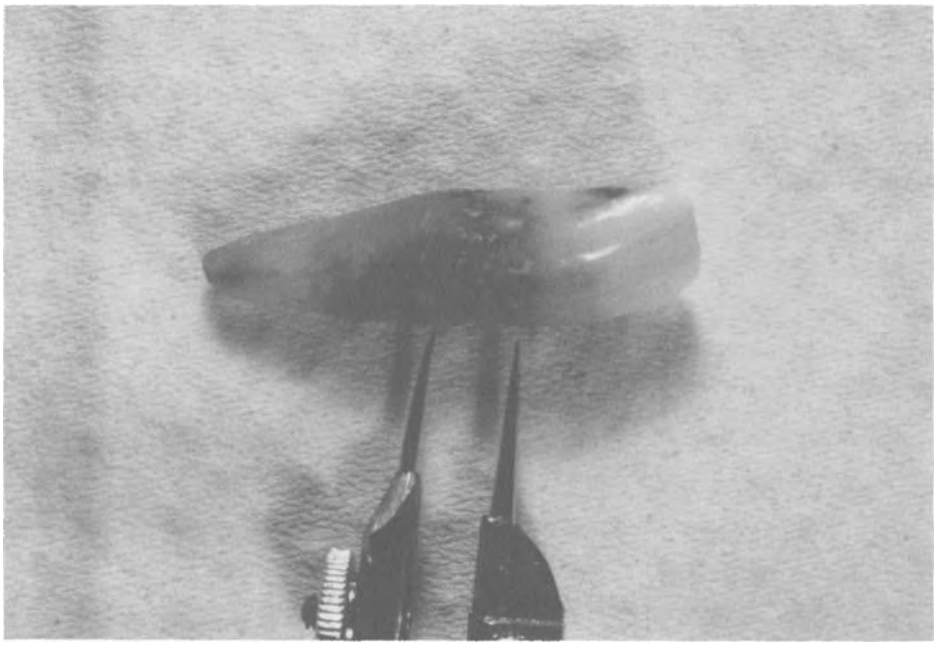

FIG. 2—*Upper central incisor: measurement of periodontosis.*

with the help of a negatoscope (Power 16 watts). From the apex of the root the maximum height of T is measured on the labial surface of the tooth. Among all the tooth surfaces the labial surface was chosen as it is the one where T is usually the highest and where P is less susceptible to be influenced by pathologic factors such as infections.

Root's Height

This is the distance between the apex of the root and the cementoenamel junction.

For each dental feature, the maximum height has been measured using a calliper square and a millimetric ruler; the precision of the measure is ± 1 mm.

Multiple regression analysis was used to establish an equation for age determination based on the measurement of the dental variables; the Mann-Whitney U Test was used for comparison of means.

Results

The following equation was obtained:

$$A = (0.18 \times P) + (0.42 \times \%) + 25.53$$

where

A = Age;
P = (Periodontosis height × 100)/root height; and
T = (Transparency height × 100)/root height.

The correlation coefficient of multiple regression (r^2) is 0.33; the partial correlation coefficients are 0.247 and 0.487 for variables P and T respectively.

The value (25.33) of the constant of the equation makes the latter useless for individuals under 25 years of age and, interestingly, is equivalent to the age at which transparency of the root usually appears.

For each tooth of the sample the age was estimated using the equation and the mean error (ME) between actual and estimated age calculated for the whole sample as well as for each decade (see Table 1).

On subgroups of the total sample the influence of various physiological and methodological factors was assessed by calculating the ME.

Interobservers Study

On a sample of 30 teeth the ME for 2 independent observers was 9 ± 1.8 and 10 ± 2 years respectively ($P > 0.05$).

Sex

Age was estimated for 174 teeth of the men and 92 teeth of the women with a ME of 10.1 ± 1.1 and 9.4 ± 1.4 years respectively ($P > 0.05$).

Comparison between sexes "decade by decade" also failed to show any significant difference.

Type of Tooth

On a sample of 69 upper incisors, 66 lower incisors, 28 upper canines, 26 lower canines and 45 premolars the ME were 8.5 ± 1.8; 12.1 ± 2; 10.6 ± 3; 10.1 ± 3.8, and 12.5 ± 2 years respectively. No particular type of tooth was superior when considering the whole sample; however, for decades 40 to 49, 59 to 59, and 60 to 69, the upper incisors provided a significantly better age estimation ($P < 0.05$) especially when using the central incisors.

Number of Teeth

The number of individuals with more than one tooth extracted was not large enough to assess whether age estimation is more accurate from one tooth or by using the average measurements from several teeth; therefore, on the control samples we used to test our method, the age estimate was given from a single tooth for each individual; when several teeth were present the choice was made accordingly with the results reported in the paragraph "type of tooth" (central upper incisors first, then lateral upper incisors, lower incisors, lower canines, upper canines, and premolars).

In order to test the accuracy of our (Lamendin) method we used two control samples.

Application of the Lamendin's Method to Forensic Cases

A total of 45 teeth coming from 24 forensic cases (mean actual age 44.4 ± 11.1 years, none under 25 years of age, 20 men and 4 women were evaluated. As Table 2 shows the

TABLE 1—*Mean error (ME) between actual and estimated age using the two criteria dental method.*

Age intervals (years)	26–29	30–39	40–49	50–59	60–69	70–79	80–89	Total
Number of teeth	5	42	39	90	65	46	19	306
ME (years)	24.8	15.5	9.9	7.3	6.3	11.6	18.9	10

TABLE 2—*Application of the two criteria dental method to a forensic sample; the mean error (ME) is the average difference between actual and estimated age.*

Age intervals (years)	30–39	40–49	50–59	60–69	Total
Number of teeth	22	13	8	2	45
ME (years)	13.1	6.3	3.3	9.8	8.4

ME by decade were similar to these of the working sample and the global ME even slightly lower in the forensic sample (8.4 versus 10 years).

It is worth noting that in individuals under 40 years of age 46% of cases had an actual age included within the interval determined by the estimated age ± the ME of considered decade while 90% accuracy was achieved for individuals over 40 years of age, confirming that the Lamendin method is not useful in young adults.

Comparison of the Lamendin and Gustafson Methods

On a sample of 39 individuals (42 to 79 years of age), the ME using the Lamendin method was significantly lower than with the method of Gustafson (8.9 ± 2.2 versus 14.2 ± 3.4) ($P < 0.05$), moreover as illustrated in Fig. 3 the Lamendin method gives more errors which are smaller than 10 years (60% for Lamendin versus 36% for Gus-

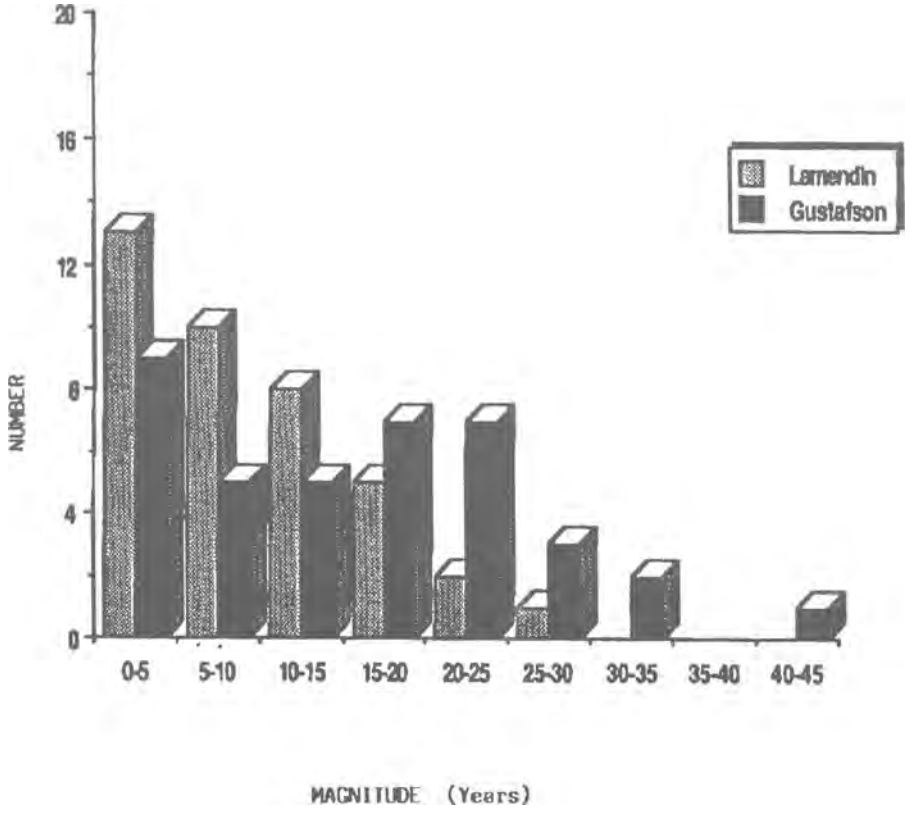

FIG. 3—*Comparison of the Lamendin and Gustafson's methods: magnitude of errors (n = 39 individuals).*

tafson). Eventually the larger error for one individual was 20 years for Lamendin versus 41 years for Gustafson.

Discussion

As is the case for other researchers who have used Gustafson's regression [*2,10,11,12*] our study shows that the actual ME of age estimation is larger than the "error of estimation" claimed by this author (± 3.63 years) [*1*]. The reasons for this discrepancy have been extensively reviewed by Maples [*2*] who also gave some clues to improve the accuracy of the Gustafson method [*3*]: the use of multiple regression analysis, reduction in dental variables and the use of objective measurements; more recently, Kashyat [*6*] based a modified Gustafson method on index values that represent the ratio between the measurement of a dental feature and a fixed measurement of the tooth [*6*]. Our method takes into account all of these suggestions but, in contradiction to Maples who supports the evaluation of secondary dentin (D) plus T as being the most accurate combination for age estimation [*3*], we choose the couple T + P. The first reason for this choice is that, without X-ray equipment, D evaluation is impossible on the entire tooth [*13*]. The second reason was derived from one of our previous studies [*14*] where we demonstrated that using multivariate analysis D was not statistically correlated to age but rather to P, and that the combination of T plus P gave a better age estimation than T alone. These modifications explain the better accuracy of the Lamendin method over Gustafson's and provide precision which is comparable to those of other published dental techniques [*3,15*] except for Kashyat who claimed an average error in age estimation as low as ± 1.59 years on a sample of 25 individuals [*9*]. Our goal was not to propose another improved or modified Gustafson method but rather to present a really simplified one. Considering that no tooth preparation or special training or equipment are needed for our method, we believe that we have achieved this goal. Of course some limitations must be underlined as large errors can be found in some individuals, mainly when they are either under 40 or over 80 years of age. Currently there are no other satisfactory solutions for a better age estimation in older cases. On the other hand, anthropologic methods such as those based on macroscopical observation of the pubic bone [*16*] and the fourth rib [*17*] have shown to be more accurate in younger individuals. The results of a preliminary study on 26 forensic-science cases combining the Lamendin dental method and the Suchey Brooks system for age determination from the pubic bone supports the complementarity of these methods [*18*].

References

[*1*] Gustafson, G., "Age Determination on Teeth," *The Journal of the American Dental Association*, Vol. 41, July 1950, pp. 45–54.

[*2*] Maples, W. R. and Rice, P. M., "Some Difficulties in the Gustafson Dental Age Estimations," *Journal of Forensic Sciences*, Vol. 24, No. 1, Jan. 1979, pp. 168–172.

[*3*] Maples, W. R., "An Improved Technique Using Dental Histology for Estimation of Adult Age," *Journal of Forensic Sciences*, Vol. 23, No. 4, Oct. 1978, pp. 764–770.

[*4*] Knight, B., Forensic Pathology, Edward Arnold, 1991, pp. 479–485.

[*5*] Spitz, W. U. and Fisher, R. S., Medicolegal Investigation of Death, Charles C Thomas, Springfield Ill, 1980, pp. 71–87.

[*6*] Miles, A. E. W., "The Dentition in the Assessment of Individual Age in Skeletal Material; Dental Anthropology," (Symposia of the Society for the Study of Human Biology), D. R. Brothwell (Ed), Pergamon Press, Vol. V, 1963, pp. 191–209.

[*7*] Bang, G. and Ramm, E., "Determination of Age in Humans from Root Dentin Transparency," *Acta Odontologica Scandinavica*, Vol. 28, 1970, pp. 3–35.

[*8*] Wegener, R. and Albrecht, H., "Estimation of Age from Root Dentine Transparency," *Zeitschrif für Rechtsmedizine*, Vol. 87, 1980, pp. 29–34.

[9] Kashyat, V. K. and Kuteswara Rao, N. R., "A Modified Gustafson Method of Age Estimation from Teeth," Forensic Science International, Vol. 47, 1990, pp. 237–247.
[10] Dalitz, C. G., "Age Estimation of Adult Human Remains by Teeth Examination," *Journal of Forensic Science Society*, Vol. 3, 1462, pp. 11–21.
[11] Johanson, G., "Age Determination from Human Teeth," *Odontologisk Revy*, Vol. 22 (suppl. 21), 1971, pp. 40–126.
[12] Haertig, A. and Durigon, M., "Identification Dentaire. Comparaison des Méthodes de Gustafson et de Shiro-Ito (modifiée). A propos de 156 cas," *Bulletin Médecine Légale, Toxicologie*, Vol. 21, No. 5, 1978, pp. 603–608.
[13] Lamendin, H., "Appréciation d'âge par la Méthode de Gustafson Simplifiée," *Le Chirurgien Dentiste de France*, No. 427, May 1988, pp. 43–47.
[14] Lamendin, H., Humbert, J. F., Tavernier, J. C., Brunel, G., and Nossintchouk, R., "Estimation d'âge par une Méthode à Deux Critères Dentaires," *Le Chirurgien Dentiste de France*, No. 539, 1990, pp. 93–96.
[15] Solheim, T. and Sundnes, P. K., "Dental Age Estimation of Norvegian Adults. A Comparison of Different Methods," *Forensic Science International*, Vol. 16, 1980, pp. 7–17.
[16] Brooks and Suchey, J. M., "Skeletal Age Determination Based on the Os Pubis: A Comparison of the Acocidi-Nemeskeri and Suchey-Brooks Methods," Vol. 5, No. 3, 1990, pp. 227–238.
[17] Ican, M. Y., Loth, S. R., and Wright, R. K., "Racial Variation in the Sternal Extremity of the Rib and its Effect on Age Determination," *Journal of Forensic Sciences*, Vol. 32, No. 2, March 1987, pp. 452–466.
[18] Baccino, E., Tavernier, J. C., Lamendin, H., Framery, D., Nossintchouk, R., and Humbert, J. F., "Recherche d'une Méthode Multifactorielle Simple Pour la Détermination de l'Âge des Cadavres Adultes," *Journal de Médecine Légale, Droit Médical*, Vol. 34, No. 1, 1991, pp. 77–83.

Address requests for reprints or additional information to
Professor E. Baccino
Service Sebileau
CHRU A. Morvan
29609 Brest Cedex
France