Forensic Science International, 47 (1990) 237–247
Elsevier Scientific Publishers Ireland Ltd.

A MODIFIED GUSTAFSON METHOD OF AGE ESTIMATION FROM TEETH

V.K. KASHYAP and N.R. KOTESWARA RAO

Department of Biology, Central Forensic Science Laboratory, Bureau of Police Research and Development (MHA), Government of India, Ramanthapur, Hyderabad 500 013, (A.P.) (India)

(Received June, 1989)
(Revision received March, 1990)
(Accepted June, 1990)

Summary

Modifications to the Gustafson method of age estimation from teeth are described. They are designed to minimise the subjective nature of the scoring technique and to quantify the regressive changes in the enamel, dentine and cementum.

Randomly selected teeth from 25 Indians were examined by the Gustafson method and by our own modification. It was shown that our modified method resulted in more accurate and reproducible age estimations than did the original method.

Key words: Gustafson method; Modifications; Teeth; Age Estimation

Introduction

Age estimation from the teeth may be the only useful method especially when the skull constitutes the only skeletal specimen. The first attempt was based on the degree of attrition of the enamel and dentine [1] and later Gustafson [2] proposed a unique method of age estimation based on certain regressive changes in the hard tissues of the anterior teeth. His method has been critically tested and reviewed by several workers [3–9] and the method has been questioned in relation to old individuals [10] because of the problems of quantifying the extent of migration of the periodontal attachment and the degree of root translucency.

Mathematical formulae for assessing the ratio of pulpal to dentine dimensions have been devised [11] and applied to the height and width of the pulp chamber and the dimensions of the dentine in molar tooth sections.

Our proposed modification to the Gustafson method is intended to minimise the inherent difficulties in quantifying regressive changes in attrition, secondary dentine, root translucency and cementum apposition, by using index values based on actual physical measurements.

0379-0738/90/$03.50

Materials and Methods

Twenty-five teeth were collected from cadavers received for autopsy at mortuaries in Gandhi and Osmania Hospitals, Hyderabad. Only those cases in which age, sex and habitats of the deceased were known were included in the study so that the estimated ages from our modified and the original Gustafson method could be compared with the known age at death. Extracted teeth were stored in water prior to grinding. One millimetre sections were prepared through the central axis of each tooth using carborundum powders (Nos. 80 and 300). Following dehydration, tooth sections were mounted in canadabalsam for microscopic observations. Regressive changes in attrition of the crown, formation of secondary dentine, translucency of root and cementum formation were observed at low magnification using a micrometer for accurate measurements.

Principles

Each index value of the various parameters undergoing regressive changes was calculated by relating the measured change to a fixed measurement on the tooth. The attrition index was calculated as the width of attritted area measured in relation to the width of the teeth at the cervical margin. The dentine index represented the extent of dentine deposition in the pulp cavity measured in relation to the entire length of the pulp cavity. The translucency index was the length of the translucent region of the root measured in relation to the entire length of the tooth and the cementum apposition index was the thickening of the cementum at the thickest point on either side of the tooth measured in relation to the width of the tooth at the point where cementum was thickest. The regressive changes in the various parameters is a function of age and the index values would be expected to remain unaltered during pathological changes which would have a similar impact on the regressive changes and their respective constant parameters we have used in our calculations.

Measurement of parameters

The formulae of the various index values for each parameter were as follows:

(I) Attrition: (A) Incisor, canine, premolar and molar tooth index values were dealt with separately due to a single attritted area in the former two compared with two attritted facet areas (buccal and lingual sides) in the latter.

(a) Incisor and canine attrition index values:

$$(A) = \frac{a}{A} \times 100$$

where 'a' is the width in mm of the attritted teeth; 'A' is the width in mm of the teeth at the cervical margin (Fig. 1)

(b) Premolar and molar attrition index values:

$$(A) = \frac{a_1 + a_2}{A_1} \times 100$$

where a_1 and a_2 are the width in mm of the attritted tip of buccal and lingual sides; 'A' is the width of teeth in mm at the cervical margin (Fig. 2)

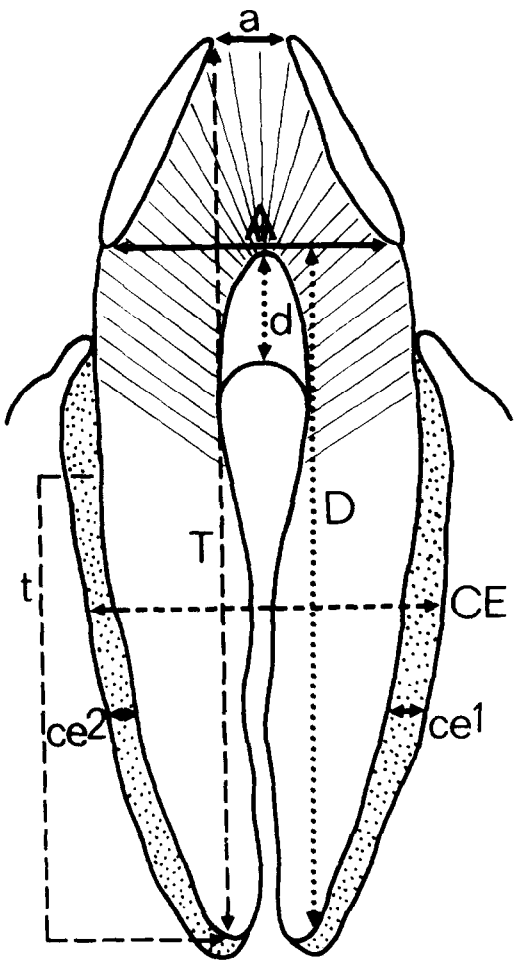

Fig. 1. Parameters of incisor teeth for estimation of age.

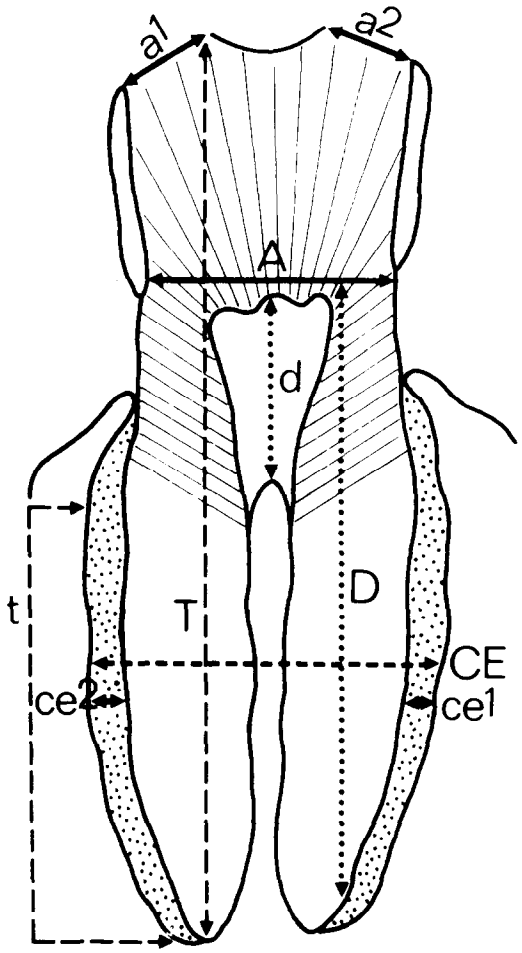

Fig. 2. Parameters of molar teeth for estimation of age.

(II) Secondary dentine: (D) The dentine index was measured in terms of percentile value of secondary dentine deposited and total length of the pulp cavity according to the following formula:

$$(D) = \frac{d}{D} = 100$$

where '*d*' is the length in mm of the secondary dentine deposition in the pulp cavity and '*D*' is the length of the entire pulp cavity of the tooth (Figs. 1–2).

(III) Translucency of the root: (T) Translucency index of the root was calculated for each tooth by the following formula:

$$(T) = \frac{t}{T} \times 100$$

where 't' is the length in mm of the region of the tooth and 'T' is the length in mm of the entire tooth (Figs. 1—2).

(IV) Cementum apposition: (CE) The cementum apposition index was measured in terms of percentile values of cementum thickness on either side of the tooth in relation to the total width of the tooth at the point of thickest cementum deposition.

$$(C) = \frac{ce_1 + ce_2}{CE} \times 100$$

where ce_1 and ce_2 are the thickenings of cementum in mm at the thickest point on either side of the tooth and 'CE' is the width in mm of teeth with cementum at the thickest point (Figs. 1—2).

The index values for attrition, secondary dentine, translucency of root and cementum apposition were independently plotted against the known age of the teeth and multiplication factors for each index value were determined (Fig. 3).

The ages of individuals were also calculated from applying the Gustafson formula (1950) to each section.

Statistical calculation

The efficacy of the proposed methods in relation to Gustafson's method and the actual age was assessed by computing mean, S.E.M.'t' values and Spearman's rank coefficient of correlation as the following formula [12].

$$\text{Coefficient of correlation} = 1 - \frac{\Sigma 6d^2}{N(N^1 - 1)}$$

where 'd' is the difference in values of estimated age between two methods and 'N' denotes the number of cases studied.

Results and Discussion

In the present study the regressive changes in the teeth were scored as index values. Attrition, secondary dentine, root translucency and cementum

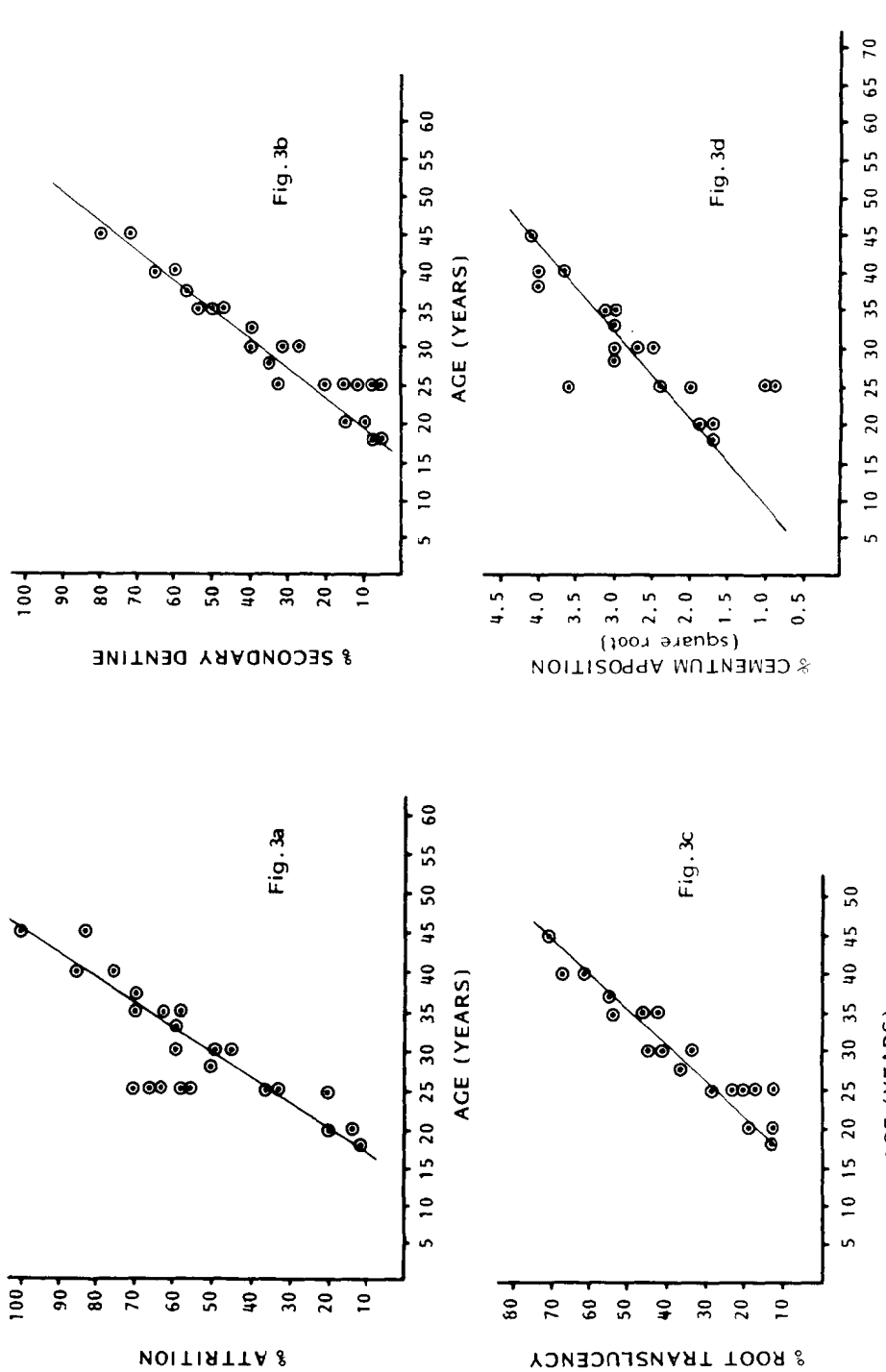

Fig. 3. Scattergram and regression line derived from indices of: (a) attrition; (b) secondary dentine; (c) root translucency and (d) cementum apposition.

TABLE 1

MEASUREMENTS OF VARIOUS POINTS AND THEIR PERCENTILE VALUES/UNDER ROOT TRANSFORMATION

S.No.	*Type of tooth*	*Age in years*	*Root Translucency*			*Secondary dentine*			*Attrition*			*Cementum apposition*			
			t	*T*	*Total*	*s*	*S*	*(S)*	*a*	*A*	*(A) %*	$c_1 + c_2$	*C*	*%*	*(C)*
					(T) % value			*% S*			*value A*			*value (C)*	
1	C	45	14.2	20	71.0	14.4	18	80	8.0	8	100	0.50	3	16.81	4.1
2	C	45	12.0	17	71.0	10.0	14	72	6.3	10	63	0.50	3	16.01	4.1
3	I	40	8.5	14	61.0	9.1	14	65	6.0	8	76	0.41	3	13.69	3.7
4	I	40	8.5	14	61.0	8.4	14	60	6.5	10	65	0.48	3	16.0	4.0
5	C	37	9.3	17	55.0	8.4	15	56	5.6	8	70	0.64	4	16.0	4.0
6	I	35	7.1	17	42.0	7.0	15	47	5.2	9	58	0.34	3	11.56	3.4
7	P	35	7.8	17	46.0	9.0	15	60	6.2	10	62	0.38	4	9.61	3.1
8	C	35	9.1	17	54.0	10.0	16	63	5.6	8	70	0.36	3	12.25	3.5
9	C	33	7.5	14	54.0	6.0	15	40	4.7	8	59	0.27	3	9.00	3.0
10	P	30	5.1	15	34.0	4.1	16	26	3.2	7	46	0.25	4	6.25	2.5
11	I	30	6.1	15	41.0	4.9	16	31	3.43	7	49	0.29	4	7.29	2.7
12	C	30	6.7	15	45.0	6.0	15	40	4.32	8	54	0.27	3	9.00	3.0
13	C	28	5.1	14	37.0	6.6	19	35	3.43	7	49	0.23	3	7.04	2.8
14	I	25	2.4	19	13.0	6.2	19	33	0.8	4	20	0.09	5	1.80	1.34
15	P	25	3.4	19	18.0	38	19	20	1.98	6	33	0.09	6	1.00	1.0
16	C	25	3.9	19	21.0	2.5	17	15	2.88	8	36	0.16	4	4.00	2.0
17	C	25	3.7	17	22.0	2.1	18	12	5.6	10	56	0.23	4	5.76	2.4
18	M	25	4.1	18	23.0	1.0	17	6	4.56	8	57	0.51	4	12.96	3.6
19	I	25	4.6	16	29.0	1.1	16	7	1.09	3	63	0.23	4	5.76	2.4
20	P	25	8.6	17	51.0	1.1	16	7	3.30	5	66	0.20	5	4.00	2.0
21	C	25	10.4	20	52.0	1.1	17	7	6.3	9	70	0.16	4	4.00	2.0
22	I	20	2.3	18	13.0	1.0	18	10	1.26	9	14	0.11	4	2.89	1.7
23	C	20	3.4	18	19.0	2.4	16	15	1.6	8	20	0.08	5	3.61	1.9
24	C	18	2.0	16	13.0	1.0	17	6	0.96	8	12	0.02	6	2.89	1.7
25	C	45	14.3	20	71.0	10.4	18	80	8.0	8	100	0.50	3	16.81	4.1

apposition of 25 tooth sections were calculated as per our formulae. Changes in level of periodontal attachment resorption do not show linear relationships with age and were not included in this study [10]. From the curves plotted for age, versus index values of regressive parameters (Figs. 3a,b,c,d), it was shown that the index values of attrition, dentine formation and translucency followed a linear relationship with the actual age of the teeth. In the case of cementum apposition (Fig. 3d) square root transformation of the index value showed linear relationship with age. From these curves the regression formulae and multiplication factor for each parameter was derived for establishment of the age of the individuals. For attrition this multiple was 1.66; for secondary dentine 1.23; for root translucency 1.26 and for cementum apposition 0.093. The age of an individual can therefore be estimated by multiplying index values of *(A)*, *(S)*, *(T)* and *(C)*.

TABLE 2

ESTIMATED AGE BY GUSTAFSON AND MODIFIED METHODS

S.No.	*Type of tooth*	*Reported age in years (A)*	*Estimated age by Gustafson Method in years (B)*	*Estimated age by Modified Method in years (C)*	*Difference in age by different methods*		
					Reported and Gustafson method age (A—B)	*Reported and Modified Gustafson (A—C)*	*Gustafson and Modified Gustafson (B—C)*
1.	C	45	40	44	5	1	−4
2.	C	45	41	44	4	1	−3
3.	I	40	35	38	5	2	−3
4.	I	40	35	39	5	1	−4
5.	C	37	30	35	7	2	−5
6.	I	35	30	33	5	2	−3
7.	P	35	29	33	6	2	−4
8.	C	35	29	34	6	1	−5
9.	C	33	28	32	5	1	−5
10.	P	30	24	28	6	2	−4
11.	I	30	25	29	5	1	−4
12.	C	30	24	28	6	2	−4
13.	C	28	22	27	6	1	−5
14.	I	25	19	24	6	1	−5
15.	P	25	18	24	7	1	−6
16.	C	25	19	23	6	2	−4
17.	C	25	19	24	6	1	−5
18.	M	25	18	24	7	1	−6
19.	I	25	18	24	7	1	−6
20.	P	25	19	23	6	2	−4
21.	C	25	18	24	7	1	−6
22.	I	20	15	19	5	1	−4
23.	C	20	14	19	6	1	−5
24.	C	18	12	17	6	1	−5
25.	C	45	38	44	7	1	−6

TABLE 3

MEAN ± STANDARD ERROR OF AGE (YEARS) ESTIMATED BY VARIOUS METHODS

Statistical Parameter	*Methods*			*Difference in values of various methods*		
	Reported (A)	*Gustafson (B)*	*Modified Gustafson (C)*	*A—B*	*A—C*	*B—C*
No. of data	25	25	25	147	33	−115
Mean ± S.E.	30.64 ± 1.603	24.76 ± 1.674	29.32 ± 1.596	5.88 ± 0.17	1.32 ± 0.10	4.56 ± 0.19
'*t*'	—	—	—	34.6*	13.86*	24.02*

*Significance at 0.1% level.

The average age calculated from different index values was more than the age calculated independently from various parameters.

Average age can be estimated as:

$$\text{Age} = \frac{(A) + (D) + (T) + (CE)}{4}$$

Index values of attrition were found to range from 12 (minimum) to 100 (maximum) for individuals between 18 and 45 years. Values for secondary dentine ranged between 6–80; for root translucency ranged between 12–71 and for cementum apposition range between 1.34 to 4.1 (Table 1). From these values it is clear that the method is most effective for estimation of age for those individuals between 18–45 years.

According to the Gustafson method the average error in estimation of age was found to be ± 3.63 years whereas for an Indian population it was ± 8.13 years [9]. When age is estimated following our modified method the error minimised to ± 1.59 years (Table 2). Application of the Spearman Rank correlation coefficient to the different methods (Table 3 and 4), indicated that our modified method provided more accurate results. Value of the Spearman coefficient was 0.998.

The modifications proposed in our study do not contradict the Gustafson method but complement it because the parameters are based on actual physical measurements and are not scored in an arbitrary manner. Regressive changes are measured more precisely and the results are reproducible when our technique is adopted in scoring the changes. The most advantageous feature of our method is the expansion of the scale for scoring the changes which makes the method more accurate, reliable and reproducible. These findings were corroborated when age was estimated by both techniques and compared.

Various pathological conditions and the quality of oral hygiene influence adversely the different dental features which may effect the scoring of

TABLE 4

SPEARMAN RANK CORRELATION COEFFICIENT BETWEEN VARIOUS METHODS OF ESTIMATION OF AGE BY TEETH

S.No.	*Between Methods*	*Rank correlations*
1.	Reported and Gustafson	0.9957
2.	Reported and Modified Gustafson	0.9982
3.	Gustafson and Modified Gustafson	0.9942

changes. In the Gustafson method no consideration is given to changes in teeth due to pathological conditions whereas in the present method, scoring of index values depends upon the ratio of two parameters. The influence of pathological changes are minimised due to similar influences on parameters and their respective constants with which they are composed. Accordingly the estimation of age is not signficantly influenced by oral pathology.

Acknowledgement

Acknowledgements are due to Sri M. Varaprasad of this Laboratory for extending photographic assistance.

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