Original Research Paper

Age Estimation from Teeth with Critical Analysis of Gustafson's Method

[1]P.C.Sarmah, [2]Ashim Mishra, [3]Abhishek Das, [4]B.V. Subhramanyam

Abstract

In this era of evidence based medicine much of expertise in field of Forensic Odontology is drawn from basic research and experience. Teeth are better preserved than other material, so their use for identification of an individual's age at death is very important .Ever since its inception Gustafson's method for determination of age from permanent teeth is considered gold standard even though many workers have dealt with the topic extensively, and critically determined the error factors involved. The present study reveals that the central incisor is the best age indicator with a standard error of ±6.35 years, and in combination of canine and first molar gives age estimation within an error of ±5.35 years. The first molar alone being the first to erupt in permanent series is found less useful age indicator (error±8.15 years). In contradiction to many researchers and Gustafson himself, this study points that attrition constitutes the most reliable parameter.

Key Words: Gustafson's Method, Age, Central Incisor, Attrition

Introduction:

From time immemorial, a quest is there to determine age from various body parts. Out of these variables, teeth are very important owing to its less perishable nature. Age, race and sex determination together with dental identification and facial reconstruction on skeletal material are procedures that the Forensic Odontologist has to master. [1] Gustafson's criteria for age in adult life is based on the evaluation of ground sections of teeth where six age-related parameters are evaluated in the ground sections of teeth and are compared to a regression curve of age versus the age related changes. [2]

It comprises of six parameters, that are namely occlusal attrition of the tip of the tooth, secondary dentine deposition starting in apex of the pulp cavity, regression of the attachment of the periodontal membrane, increase in root transparency starting from below upwards, root resorption and accumulation of Cementum around the root.

Corresponding Author:

[3]Assistant Professor
Department of Forensic Medicine and Toxicology
Sikkim Manipal Institute of Medical Sciences,
Gangtok, Sikkim
E-mail: abhishek.das.forensic@gmail.com
[1]Prof & HOD
[2]Assistant Professor
[4]Former Prof & HOD, Dept. of FMT,
RIMS, Imphal
DOR: 07.11.2014 DOA: 04.04.2015
DOI: 10.5958/0974-0848.2015.00041.X

Even Gustafson himself gave more credit to root transparency and declared attrition as a highly erratic indicator of age. [3] The aging of the dentition when based on physiological attrition could correlate with age but factors such as bruxism, diet, environment and medication has limited the age estimation by examination of dental attrition. [4]

The present study done by the authors although done in recent past provides statistically significant regression co-efficient and correlation co-efficient with reasonable standard error in relation to central incisor, canine and first molar teeth, when the Gustafson's method has been applied, it shows that attrition constitutes the most reliable parameter in contrast to previous workers and pioneers in this field who have also researched extensively on confrontation of modification of Gustafson's method. [4, 5]

Newer modifications like Kilian's method uses subjective evaluation of six markers: the degree of attrition, the secondary dentine, the secondary cementum, the root resorption, the transparency of root and the position of epithelial attachment on neck of tooth where as Kashyap and Koteswara Rao attempted the quantitative evaluation of four markers: the attrition, the secondary dentine, the secondary cementum and the transparency. [1]

The author in his research work found out that the Gustafson's method is the gold standard for estimation of age from permanent teeth even though subjected to criticisms.

Material and Methods:

Our sample comprised of 73 freshly extracted permanent teeth collected from dead bodies of apparently healthy persons brought to Department of Forensic Medicine, Institute of Medical sciences, Varanasi for the autopsy. The teeth were extracted from both sides and also from upper and lower jaw randomly to exclude variation of focal aging changes depending on the chewing pattern/habit.

The exact age of the patient collected from the inquest reports and other records such as school certificates and horoscopes were noted. The teeth were first cleaned with pumice slurry and polishing brush in a slowly rotating hand piece and thoroughly washed under running water.

Each tooth was cut into longitudinal two halves using a carborandum disc rotating in high speed by electric motor. The sections were again rinsed under running water to clear them of debris and particles. Following grinding on hone up to 1mm thickness and after dehydration, tooth sections were placed on glass slide and covered with cover glass for microscopic observation.

The ground sections were evaluated by Gustafson's method using the light microscope with the possibility of image analysis. Individual changes were classified and noted. Score points of individual tooth are recorded first considering the degree of involvement of six criteria and then the average point values of two and also all three of them considered.

After completion of observations, the known age of each sample is compared. Point values of the samples are plotted and scatter diagrams obtained.

Statistical Analysis:

All the statistical analysis was performed using the Microsoft Excel. Equations for age prediction were derived using least squares regression analysis. Absolute mean error of estimation was counted from absolute values of residuals. The formula for age prediction was calculated from multiple regression analysis.

Correlation Co-efficient, r is calculated by using the following formula:

$$r = \sum \frac{\sum xy - (\sum x)(\sum y)/n}{\sqrt{[x2 - \sum \frac{x2}{n}]\,[\sum y2 - \sum y2/n]}}$$

Regression co-efficient, b is found out with the help of the formula

$$b = \sum \frac{\sum xy - (\sum x)(\sum y)/n}{\sqrt{[x2 - \sum \frac{x2}{n}]}}$$

Standard error of estimation of Regression co-efficient, S_{yx}

$$S_{yx} = \sum \frac{\left[\sum y2 - \frac{\sum y2}{n}\right] - b[\sum xy - (\sum x)(\sum y)/n}{[n-2]}$$

Here 'x' represents the score points recorded in observations, 'y' represents known age in years and 'n' is number of cases studied.

After finding out the value of r and b, $S_{y.x}$ is estimated by the help of regression equation, Y=bx + C, where 'Y' is the estimated age of the individual, 'b' is the regression co-efficient, 'x' is score points of specimen observed and C is the constant which indicates the theoretical value of Y when x equals to zero.

Results:

The average error in the present work when central incisor, canine and first molar were taken together is ±5.9 years. When central incisor and canine are taken together the error is ± 6.07; with canine and first molar it is ± 5.35; with central incisor and first molar taken together it is ± 6.35 years. The three teeth in combination give the estimated error of ±5.95 years. When plotted as a scatter diagram it is found that the dispersion of the points (scatter) is less in case of canine and first molar together while it is more in case of first molar alone.

First average point value of the teeth of 73 samples projects the correlation co-efficient r=0.87 and regression co-efficient, b=5.5, standard error of regression coefficient $S_{y.x}$=±7.02 and sample error (standard error of correlation co-efficient, S_b=±0.31, the test for significance, t=17.74.

The p value is less than 0.001 at 60 degrees of freedom, which is highly significant. The regression line equation is Y=5.5x-3.38; where Y is the estimated age, x is the score points and -3.38 is a constant which indicates the theoretical value of Y when x is zero.

The reliability of this estimate is found to be 76 per cent. The difference between the regression co-efficient of two sexes is found to be insignificant.

The present study although done in recent past provides statistically significant regression co-efficient and correlation co-efficient with reasonable standard error in relation to central incisor, canine and first molar teeth when the Gustafson's method has been applied, and shows that attrition constitute the most reliable parameter in contrast to many authors.

Discussion:

Gustafson's proposition regarding the utility of human teeth in age estimation have been re-examined time and again by many workers. [6-8]The present study was aimed at

finding out the utility of central incisor, canine and first molar individually and in combinations. The average error in the present work when central incisor, canine and first molar are taken together is ±5.9 years quite similar to Johanson study. [9]

While taken alone the central incisor has shown the standard error of ±6.35 years and with canine alone the value is ±7.48 and with the first molar it is ±8.15 years.

When central incisor and canine are taken together the error is ± 6.07; with canine and first molar it is ± 5.35; with central incisor and first molar taken together it is ± 6.35 years. It differs from Gustafson study where he gave an error limit of ±3.6 years in 33% cases and ± 7.3 years in 4.5% of cases while in 1% of cases the error limit was ± 9.1 years.

The present findings also differ from study of Sognanaes. [7] The findings are slightly higher than study by Rai *et al* results of age estimation which found absolute mean error of estimation 4.95 years.

Score points of observation are found to vary tooth wise even in the same sample and in some cases total points are found to be identical in two or in rare cases in three teeth. This variation in score points is not only limited to attrition and paradontosis but also to other age changes. [5]

Our study also states that the age changes are comparatively more advanced in the anterior teeth and also they are more uniform for which when considered alone, anterior tooth gives better results than the posterior one.

Age changes are also not same in teeth of the same individual even having uniform mastication (chewing habits). Central Incisor is the first permanent tooth replacing the deciduous tooth. It is the most frequently used teeth in biting and cutting habit, thus more prone to secondary changes.

Even Gustafson had been very categorical in refuting the importance of attrition. [3] A recent view even highlights the merits and demerits of attrition used as a sole indicator of age estimation. [4] While many authors have given more credence on the transparency of root as an important age indicator, it appears from the present study that attrition is more reliable and better indicator of age.

The point values obtained from central Incisor under attrition is found to be more consistent with age related changes, thus implying the reliability of correlation in case of attrition. The transparency of root itself is variable and not reliable especially in the case of bicuspid and molar teeth whether as a whole or in fragmentary state. It varies in a single tooth in between the different roots and even in the same roots.

However the transparency of root is found better in higher age groups (above 25 years).This finding in our study somehow contradicts with the opinion of Gustafson. [3]

Our study also points the accuracy of observations depends on thickness of the samples which were made to 1mm by grinding manually on hone. The conception of using less thick up to 0.25 mm does not yield better results. It is also proved by other researchers. [10]

Conclusion:

The work done was entirely manual except use of carborendum disc for longitudinal section of teeth. Although amenable to human errors, the observations here by obtained is within narrow limits or similar to various authors.

Thus the usefulness of manual work in Forensic investigation cannot be refuted even in this era of technology. Extensive research is an integral part in evaluation and researchers are always welcomed to further analyze the study.

References:

1. Lampe H**, Roetzscher K.** Forensic odontology: age determination from adult human teeth Med Law. 1994; 13 (7-8):623-8.
2. **Gustafson G.** Age determination on teeth. Journal of the American Dental Association 1950; 41: 45-54
3. **Gustafson G.** Forensic Odontology: London-Staples Press, 1966
4. Ball J**.** A critique of age estimation using attrition as the sole indicator. J Forensic Odontostomatol. 2002 Dec; 20(2):38-42.
5. **B. Rai, S Dhattarwal, S Anand.** Five Markers of Changes in Teeth: An Estimating of Age. The Internet Journal of Forensic Science. 2005; 1:2
6. **Miles A. E.W.** Dentition in the estimation of age. J. Dent. Res.1963; 42:255-63
7. **Sognanaes R. F.** Talking teeth: American Scientist 1976; July-Aug: 369-73
8. **Pillai P.S, Bhaskar G.R.** Age estimation from teeth using Gustafson's method –A study in India: Forensic science.1974; 3:135-141
9. **Johanson G., Lindenstam B.** Dental Evidence in Identification. Acta Odontologica Scandinavica. 1968; 25(6):834-38
10. **Metzger Z, Buchner A, Gorsky M.** Gustafson's method for age determination from teeth--a modification for the use of dentists in identification teams. J Forensic Sci. 1980 Oct; 25(4):742-9.

Table 1: Comparative Results in 73 Cases in Individual Tooth and In Combination

Sample	R	b	Sy. x	Sb	t value
I_1	0.87	4.52	6.35	0.31	14.58
C	0.81	4.55	7.48	0.39	11.67
M_1	0.77	4.75	8.15	0.47	10.11
I_1+C	0.88	4.98	6.07	0.32	15.56
C+M_1	0.91	5.72	5.35	0.31	18.45
I_1+M_1	0.87	5.12	6.35	0.35	14.63
I_1+C+M_1	0.88	5.39	5.95	0.34	15.85

p<0.001, r =correlation co-efficient, b=regression co-efficient, Sy. x=standard error of regression co-efficient, Sb=Standard error of correlation co-efficient, I_1=Central incisor, C=canine, M_1=first molar

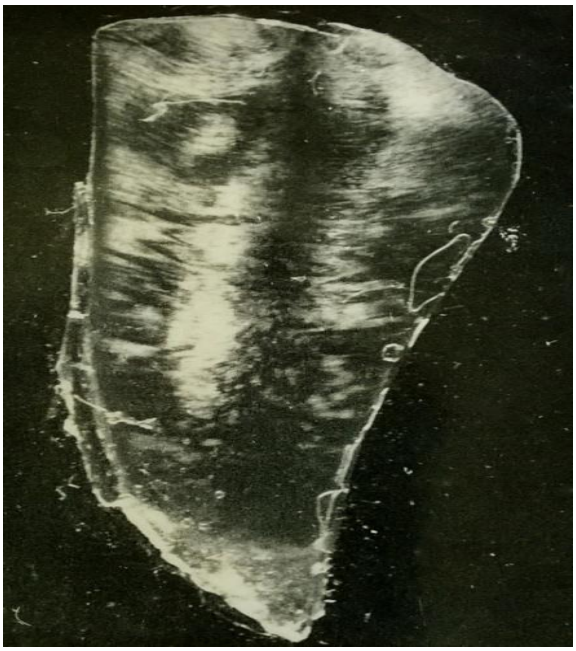
Table 3: Error Limits of Results Taking Average Points Values of I_1, C and M_1

Error limit (yrs ±)	Cases	Percentage
±1	7	9.58
±2	13	17.8
±3	8	10.95
±4	7	9.58
±5	9	12.32
±6	7	9.58
±7	7	9.58
±8	3	4.1
±9	1	1.36
±10	2	2.73
±12	5	6.84
±15	4	5.47
Total	73	100%

Fig.1: Ground section of Central incisor
A=2 P=2 S=0 C=1 R=0 T=1 Total score= 6

Known age= 30 years Estimated age= 35.8 years

Fig. 2: Ground Section of Canine
A=2 P=3 S=2 C=3 R=1 T=2 Total score= 13



Known age= 65 years Estimated age= 66.2 years

Table 2
Estimated Age in Different Age Groups in 73 Cases

Age (yrs)	No. of samples (%)	$C+M_1$		I_1+C+M_1	
		Average point values	Estimated age	Average point values	Estimated age
16-20	4(5.4)	4.06	19.31	4.33	19.7
21-25	8(10.9)	5.15	25.54	5.43	25.63
26-30	13(17.8)	5.86	29.6	6.16	29.57
31-35	15(20.5)	6.65	34.12	6.98	33.99
36-40	8(10.9)	8.12	42.53	8.37	41.48
41-45	7(9.5)	8.67	45.68	9.25	46.22
46-50	8(10.9)	9.0	47.57	9.37	46.87
51-55	3(4.1)	9.33	49.45	9.88	49.62
56-60	3(4.1)	9.33	49.45	9.88	49.62
61-65	2(2.7)	10.25	54.72	11.16	56.52
66-70	1(1.3)	9.5	50.43	10.66	53.82
71-75	1(1.3)	11.5	61.87	12.33	62.82