ORIGINAL RESEARCH

A Comparison of the Accuracy of Maples and Rice and Newly Derived Formula for Age Estimation: A Forensic Study

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ABSTRACT

Aims and objectives: The aim of the study was to study the physiological changes of teeth according to the Gustafson's criteria by obtaining a new linear regression formula and compare it with Maples and Rice formula for age estimation.

Materials and methods: Total of 70 cases who visited the department of oral and maxillofacial surgery for extraction were taken in the study for teeth collection and the age of the patients was noted. The following dental parameters were studied in each case; attrition, periodontal disease, cementum apposition, secondary dentine deposition, root translucency and root resorption. Total scores of different parameters were plotted against the total score were plotted and regression formula obtained and by the use of this formula ages were estimated. Maples and Rice formula was also applied in the same scores and ages estimated.

Results: On comparing the means of both the calculated age and the actual age, it was observed that the difference between them was statistically significant except in the age group of > 70 years age group. On calculating the age mean error was found to be ± 4.52 and for Maples and Rice it was ± 6.43.

Keywords: Age estimation, Maples and Rice formula, Forensic odontology, Newly derived formula.

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INTRODUCTION

Age estimation is a subdiscipline of the forensic sciences and should be an important part of every identification process, especially when information relating to the deceased is unavailable. The estimation should be as accurate as possible, since it narrows down the search within the police missing persons files and enables a more efficient and time saving approach.[1] Age estimation is of broader importance in forensic science, not only for the identification purposes of the deceased victims, but also in connection with crimes and accidents. In addition, chronological age is important in most societies for school attendance, social benefits, employment and marriages.[2]

Many variables have been used as age determinants and even dental histological techniques can contribute to age determination (Sengupta et al, 1999).[3] The choice to use teeth for age determination is well accepted due to their longevity ability of being resilient to change (Drusini A et al).[4]

Estimation of human age is a procedure adopted by anthropologist, archeologist and forensic scientist. The estimation of age at the time of death is often an important step in identification of human remains. If the age can be accurately estimated, it will significantly narrow the field of possible identities that will have to be compared to the remains in order to establish a positive identification.[5]

Review of Morphological Age Estimation Studies

Gustafson (1950)[6] was first to note the morphological changes in the structure of teeth. These were attrition, periodontosis, secondary dentition, cementum apposition, root translucency and root resorption. He awarded a score of 0 to 3 based upon visual severity of changes and estimated age. He calculated age using the regression formula derived from his observation: Y = 3.52 X + 8.88 (X = total score and Y = estimated age). Gustafson established that the difference between calculated age and real age would not exceed ±3.6 years in 33% of cases, ±7.3 years in 4.5% cases, ±9.1 years in 1% of cases and ±10.9 years in 0.3% cases.

Later Bang and Ramm (1970)[7] used root dentine transparency in their study and recorded that this change with the age can be used for age estimation. They found a mean error of estimation of ± 4.7 years in 58% cases and ± 10 years in 79% of subjects.

Johanson (1970)[8] also used same six criteria as used by Gustafson but instead of 0 to 3 he used seven bands to each factor and found that error was less as compared to other study.

Pillai and Bhaskar (1974)[9] studied 83 anterior teeth collected from 59 cases (36 males and 23 females) and recorded physiological changes in tooth with age and comparison of these changes in males to that in females. Of the 63 mandibular teeth collected (76% of the total), 51 were medial incisors and 11 lateral incisors; there was one canine. The maxillary teeth collection comprised 14 medial incisors and six lateral incisors, a total of 20 samples. Single tooth was studied in from 38 cases whereas two teeth from each of 18 cases and three teeth from each of three cases. Teeth were grinded using two carborundum, rough and other smooth. Score was calculated and they plotted graph of

known age *vs* score and regression equation was deduced Y = 5.34 X – 4.08. They also found that the six factors used by Gustafson were age related variable but there was no significant relation with the sex of the person. They found that chewing habits exposed the teeth and surrounding tissue for degenerative changes thus, giving rise to higher point value. Dark stains due to pan and tobacco tended to be more on gingival surface stimulating degenerative changes earlier although study proved that whether vegetarian or non-vegetarian does not seem to influence the age changes in and around teeth.

Maples (1978)[10] improved multiple regression analysis in improvement of age estimation from adult human teeth. He found that not only the estimates were more precise but also involving fewer variables, decreasing the probability of observer error. There was consistent evidence that the second molar was the best to use for histological aging techniques. The reduction in variables to just secondary dentine and root transparency has also resulted in technique that can be used with some confidence in populations other than the one sampled. Thus, dental aging can be used in the same way as epiphyseal fusion, osteon aging, cranial sutures and changes in the public symphysis that have been used with other contemporary and prehistoric populations.

Nowell in 1978[11] used miles system of ageing, based upon analysis of the rate of molar wear, to evaluate the available sample from Tepe Hissar, Iran. The independently estimated ages for the mandibles and maxillae of the same individuals were found highly correlated ($r = 0.87$, $p < 0.001$). Ages of the subsample of the dentitions were compared with skeletal ages for the same individuals estimated from pubic symphyseal faces and found to be significantly correlated ($r = 0.82$, $p < 0.005$) with no significant differences in mean ages.

Maples and Rice in 1979[12] found that although Gustafson's method was a significant contribution to forensic identification but many statistical errors were present in the published articles. It was improved and new formula was found using multiple regression techniques. Formula derived was Y = 4.26 X + 13.45 (X = total score and Y = estimated age), ($r = 0.912$).

So, the present study was conducted to study the physiological changes of teeth according to the Gustafson's criteria by obtaining a new linear regression formula and compare it with Maples and Rice formula for age estimation.

MATERIALS AND METHODS

The present study was carried out in the Department of Oral Pathology of Jaipur Dental College; Jaipur. Total of 70 cases who visited the department of oral and maxillofacial surgery for extraction were taken in the study for teeth collection and the age of the patients was noted. The ethical clearance and consents of the patients were taken prior to the study. The design of the study was retrospective cross-sectional. The following dental parameters were studied in each case; attrition, periodontal disease, cementum apposition, secondary dentine deposition, root translucency and root resorption.

The armamentarium used in the study is composed of electric lathe, carborundum stone (rough and smooth), alcohol and xylene, formalin, microscope and slides. The extent of periodontal disease was recorded before the extraction of the tooth. Ground section was prepared by hand grinding which was done first with lathe and then with rough carborundum stone until a section of 1 mm was obtained and at this thickness, the root translucency was noted. Grinding was further done using fine stone until the section of 0.25 mm thickness is left. Finally, cleaned and dried section was mounted on slide and viewed under microscope for secondary dentine, cementum apposition and root resorption. Normal healthy teeth with class 1 occlusion were included in this study. The order of preference was premolar – canines – incisors. While third molar, patients with medical and drug history, trauma from occlusion, abnormal oral habits, congenital anomalies of teeth, pathologies affecting teeth were excluded. The scores obtained were tabulated. Linear regression analysis was applied by plotting actual age on one side and the calculated score on the other side then the regression formula obtained[13] (Graph 1) by a software available on internet (http://www.wessa.net)[14] by using this linear regression formula age estimation was done, deviation of estimated age from actual age noted and results were subjected for statistical analysis by using SPSS software (version 11.5).

Four points allotment system as per Gustafson's method as follows:[6]

Attrition (A)

A0—no attrition
A1—attrition limited to enamel level
A2—attrition limited to dentine level
A3—attrition up to pulp cavity

Periodontal Disease (P)

P0—no obvious periodontal disease
P1—beginning of periodontal disease but no bone loss
P2—periodontal disease more than 1/3rd of the root
P3—periodontal disease more than 2/3rd of the root

Secondary Dentin (S)

S0—no secondary dentin formation
S1—secondary dentin up to upper part of pulp cavity

S2—secondary dentin up to 2/3rd of the pulp cavity
S3—diffuse calcification of entire pulp cavity

Root Translucency (T)

T0—no translucency
T1—beginning of translucency
T2—translucency more than 1/3rd of the apical root
T3—translucency more than 2/3rd of the apical root

Cementum Apposition (C)

C0—normal cementum
C1—thickness of cementum more normal
C2—abnormal thickness of cementum near the apex of the root
C3—generalized abnormal thickness of cementum throughout the apex of the root

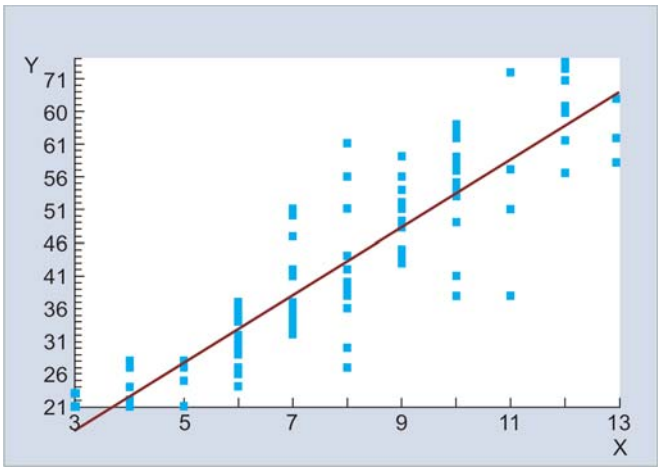
RESULTS

Total of 70 cases were taken in a study and divided in six age groups (21-30, 31-40, 41-50, 51-60, 61-70 and >70 years) with maximum number of cases were belonged to the age group of 31 to 40 with 19 cases and least number of cases were belonged to >71 years with four cases (Graph 2). Six physiological factors recorded according to Gustafson's criteria. Total scores of all six factors from 70 patients were plotted against the actual age and a regression line obtained (Graph 1) and regression formula Y = 2.91 + 5(x) {Y = estimated age, X = total score} obtained. The formula which was given by Maples and Rice, Y = 4.26(x) + 13.45 {Y = estimated age, X = total score} was also applied in the previously recorded total scores and the age estimated. By using newly derived formula and Maples and Rice formula, ages were calculated with the mean error of ±4.52 and ±6.43 respectively. It was also noted that by using Chi-square test estimated ages were found to be significant except the age group of >70 years (Table 1).

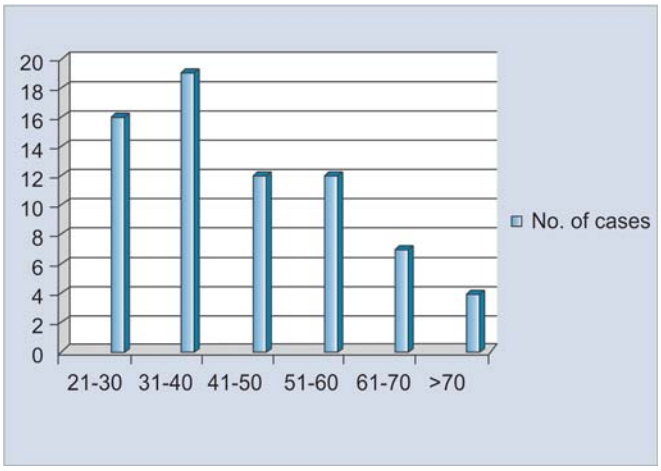
DISCUSSION

The concept of the age and time had come into the mind of the human being for centuries, possibly millennia. One can also measure life span of a person as well as ones age from the moment of conception. Age estimation can prove critical part in victim identification process. Physiological changes in order to estimate the age were first utilized by Gustafson in 1950; later this method was modified by number of researchers for the improvement of accuracy.

In present study, six physiological changes were used in order to estimate the age by using linear regression formula and ages were estimated with the mean error of ± 4.52 which was contrary to the finding of Gustafson[6] who found the mean age difference of ±3.63 but it was lesser



Graph 1: Linear regression line shows positive correlation between age and scores (Wessa P 2011)



Graph 2: Distribution of cases according to the age groups

Table 1: Correlation and significance of age groups with estimated age by both formulas

Age group (in years)	*Mean + SD*		*p-value*	*Significance*
	Newly derived formula	*Maples and Rice*		
21-30	26.55 ± 2.40	30.44 ± 4.40	<0.001	Sig
31-40	36.25 ± 1.73	42.59 ± 2.56	<0.001	Sig
41-50	42.85 ± 4.32	47.91 ± 2.82	<0.001	NS
51-60	51.70 ± 3.41	53.68 ± 2.09	<0.001	Sig
61-70	59.29 ± 3.63	61.71 ± 3.43	<0.001	Sig
>75	67.54 ± 3.37	63.05 ± 2.10	>0.5	NS

SD: Standard deviation; Sig: Significant; NS: Nonsignificant

than the mean error of Maples and Rice[12] (± 7.03) and Singh and Mukherji[15](± 4.9) but greater then Singh et al[16] who found the mean error of ± 2.16. It was observed that the total score increased with the increasing age and the increase was statistically analyzed and was found to be significant similar with the findings of Pillai and Bhaskar (1974).[9]

Maples and Rice[12] found some errors in Gustafson's formula, in order to improve the method they introduced a new formula Y = 4.26(x) + 13.45 which was obtained by multiple regression analysis. In their own study they found the mean error of ± 7.03.

The same formula was applied on the Indian population for the same study sample and ages were calculated with the mean error of ± 6.43. On comparing the means of both the calculated age and the actual age, it was observed that the difference between them was statistically significant except in the age group of >70 years group for both formulas.

On the comparison of newly derived formula and Maples and Rice formula it was noted that newer formula gives better results in Indian population. It was also found that Maples and Rice formula gives better results in Indian population which could be due to the different oral hygienic conditions and habits of Indians.

CONCLUSION

Age estimation from human teeth is well established. Different techniques and numerous studies have been published for age estimation, each one shows different accuracy and reliability. Error is present in every approach; to minimize the error one should perform repetitive measurements and calculations in order to reach a reliable conclusion. Physiological changes like attrition, periodontal disease, secondary dentin formation, root translucency, cementum apposition and root resorption noted in this study that could help in the age estimation. It was noted that the age estimation formulae give different accuracy rate in different population samples. It was also observed that the total score increased with the increasing age.

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