Original Article

AGE ESTIMATION IN INDIAN POPULATION BY KVAAL'S METHOD USING MAXILLARY CANINE

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Abstract

Introduction: Age estimation in adults is advantageous in forensic odontology. With increase in age, dental pulp volume gets reduced due to secondary dentine formation. Kvaal et al. formulated a method for chronological age estimation based on pulp size by periapical dental radiographs. **Aim and objective**: Testing the Kvaal's method for chronological age estimation in Indian population using patients' intraoral periapical radiographs of maxillary canine. **Materials and methods**: This study included total of 100 subjects out of which 48 were females and 52 were males of age group 21-70 years. The ratios A1, A2, A3, A4 were calculated – pulp to root length, pulp to tooth length, tooth to root length, pulp to root width at three different levels respectively to avoid any discrepancy in magnification and angulation ofx-ray. Measurements were done using Kvaal's method and was analyzed for regression analysis and regression equations were obtained and checked for the results. **Results**: PCC indicated that among the ratiosA1, A2, A4 were less statistically significant compared toA3 which was more significant individually. **Conclusion**: Ratio A3 is a good indicator and thus linear regression was derived by this variable and all variables together as well. A1, A2, A4 were not good indicators individually for age estimation.

Keywords: Age estimation, Intraoral periapical radiograph, Canine, Secondary dentin

Introduction:

Age is the important factor to identify a person and it can be estimated by chronological, dental and skeletal age. In forensic sciences teeth are considered as an important indicator for age. Developmental and regressive

changes of the tooth have been related to chronological age of adult population. Dental age can be estimated using morphological, biochemical, histological and radiological evaluation. (1)

Dental Age Estimation Methods:
A. According to the state of development of the dentition:
- Methods applied to the forming dentition
- Methods for the adult fully formed dentition.
B. According to the method of investigation:
- Clinical or visual
- Radiographic
- Histological
- Physical and chemical analysis (2)

Invasive methods like tooth extraction are not indicated compared to non-invasive methods for age estimation. As Kvaal et al. in 1995 established a method using degenerative changes of pulp cavity on dental radiographs. (3)

Since secondary dentin deposition is a continuous process, it can be utilized as aindicator for age estimation for even above 21 years of age.(4)The period of the secondary dentin formation is stated by a curved line rather than a straight line with relative chronological changes. Therefore, there is a need for research to provide sufficient data for age estimation.(5) Canines are preferred for such measurements due to single root morphology, large pulp canals and relatively long-lasting tooth in older individuals. (6)

This study was thus planned on the basis of maxillary canine intraoral periapical radiography for evaluating Kvaal's method by analysing various measurements of tooth and dental pulp ratios in Indian population.

Materials and Method:

Kvaal et al. in 1995had a method that helps age estimation based on the morphological measurements of conventional radiographs by features of individual teeth. (7) The measurements comprise evaluation of pulp length / tooth length (A1), pulp length /root length (A2), pulp width /root widths at three defined levels (A3) and tooth length/ root length (A4). This study of age estimation was on the concept as given by Kvaal et al., although a few alterations in the study were made to assess whether the accuracy of age estimation can be influenced by individual parameters or combined parameters.

Total 100 patients, age 21-70 years old with 48 females and 52 males with known chronological age, were randomly selected and were divided in age groups of proper intervals. [Table 1]. Maxillary canine (right and/or left) was selected for each patient.

Inclusion criteria:

Tooth in function, Age range 21-70 years, Permanent maxillary canines

Exclusion criteria:

Tooth with pathology in periapical area, trauma, tooth with restorations or fillings, deciduous tooth, rotated tooth

All the radiographs were taken prior by GOMAX DGT-10 dental x-ray machine and was manually processed for proper image contrast and quality of the intraoral periapical radiographic films.[figure 1]

All radiographs were obtained, dried properly and manual measurements were made with single observer on an interval basis to avoid discrepancies. The following measurements were then made from the radiographs using simple measurement ruler and pointer on all radiographs from each patient: [Figure 2]

• The maximum tooth length (T)
• The pulp length (P)
• The root length on the mesial surface (R),
• The root and pulp width at three levels; at the CEJ (W1), at the midroot level (W2), and the apex of the root (W3)

After obtaining mean value of each measurements these ratios wereobtained;
-The ratio between the lengths of the pulp and the tooth (A1)

-The ratio between the lengths of the pulp and the root (A2)

-The ratio between the mean widths of the pulp and the root (A3)

-The ratio between the lengths of the tooth and the root (A4)

In this analysis the ratios of measurements were used rather than the measurements direct in order to reduce the effect of a variation between the angulations and magnifications of the radiographs. (8)

All the ratios A1, A2, A3, and A4 were utilized as variables for age estimation in the statistical analysis. The Pearson product moment correlation coefficient (PCC) was evaluated between chronological age and the predictive variables of the patient. Multiple regression analysis was then made, using age as the dependent variable and the independent variables as predictive variables. Besides evaluating the age using measurements from all parameters, we evaluated individual parameters as well.

Figure 1: Shows maxillary canine intraoral periapical radiograph

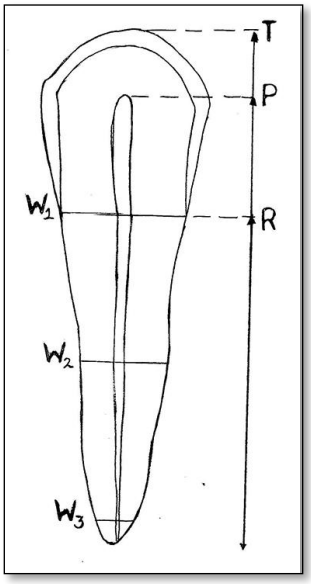

Figure 2: Shows measurements T-tooth length, P-pulp length, R-root length, W1-root and pulp width at CEJ, W2-Root and pulp width midway between CEJ and apex, W3-Root and pulp width at apex

Results: Patients were from the age group of 21-70 years, with a mean age of 38.1 years. The patients included 52 males and 48 females [Table 1].

PCC between age and the morphological variables was significant for A3[Table 2].

From the calculated mean values, standard deviation (SD) between the chronological age and the predicted age were determined, as presented.[Table 3] The relationship between these variables and the dependent variable could be expressed as;

$Y = X + B1A1 + B2A2 + B3A\ 3+B4A4$

Where Y = predictive dependent variable value

X = Value of Y when all A are zero

A1, A2, A3,A4 = Independent variables

B = Coefficients corresponding to the independent variables

The predictive variables A1, A2,A3, A4were used as an input dataset in the multiple regression analysis, having the following regression formulas. [Table 4]

Equation 1: When all parameters were considered together

Age=550.573+ (-640.379) *(A1) +(400.067) *(A2) +(109.239) *(A3) +(-331.777) *(A4) Where A1, A2, A3, A4 are the mean values. The coefficient of determination (R2) was 0.063, with a standard error of estimate of 13.28 Analysis was done for individual parameter and the regression equation obtained was as follows:

Equation 2: Age = 24.617 +(80.203) *(A3)

Where A3 is the mean value. The coefficient of determination (R2) for A3 was 0.023, with a standard error of estimate of 13.35. A higher correlation coefficient was obtained when all the parameters were included in equation. The age group 31-40 showed higher correlation for prediction of age than other groups by these formulas.

Table 1 - Age and gender distribution for study sample

Age group (years)	Males	Females	Total
21-30	16	14	30
31-40	14	22	36
41-50	04	06	10
51-60	16	06	22
61-70	02	00	02
Total	52	48	100

Table 2 - Pearson product-moment correlation coefficient

Dependent	N	P
A1	100	-0.069
A2	100	-0.060
A3	100	0.152
A4	100	-0.049

Table 3 - Descriptive statistics

	Mean	SD	N
Age	38.10	13.44	100
A1	0.83	0.03	100
A2	1.30	0.21	100
A3	0.17	0.02	100

A4	1.56	0.23	100

Table 4 - Multiple regression analysis

	R^2	Adjusted R^2	Std. Error
ALL	0.063	0.024	13.28
A1	0.005	-0.005	13.48
A2	0.004	-0.007	13.48
A3	0.023	0.013	13.35
A4	0.002	-0.008	13.49

Discussion:

Dental age estimation needs the utilization of morphologic, histological, radiographic and biochemical methods to calculate age dependent changes in teeth. Different methods are available for age estimation, invasive methods using extracted teeth cannot be used in individuals. are some non-invasive ways to determine age are like radiological examination of bone and structures, assessment of skeletal maturation, radiographical and clinical examination of dentition as well. (7) Dental age estimation can be done by different properties of the dentition. Age estimation methods employ various forms of tooth alterations, including tooth wear, (9)(10) root dentin transparency, (11) (12) and apposition of secondary dentin. (8) (13)

Gottlieb was the first to correlate changes in dentition with the increasing age. (14)In 1925, Bodecker established that the apposition of the secondary dentin was significant with the age. (15)The secondary dentin is laid down with the help of the odontoblasts throughout a individual's life, causing a decrease in the size of the dental pulp cavity. (16)as secondary dentin deposition was mentioned for age estimation by Gustafson, so it was one of the parameters in addition to attrition, cementum apposition, periodontal recession, apical translucency, external root resorption. (17)

Currently, there is no evidence that the process of secondary dentin formation occurs in a constant or gradual manner, or that each age group requires the exact time span to present itself with a specific amount of secondary dentin. (7) However, linear regression is widely used in forensics to provide the estimate of the measurement, for instance the age at death or the living stature, it should always kept in mind that human growth is not a linear process though. (18) The nature of secondary dentin deposition is also affected by factors like race, ethnicity, diet, and lifestyle. Some authors have requested the need for population-specific formulas due to differences in ethnicity to achieve accurate results.(19)(20)(21)

A study by radiographs of teeth is a non-destructive simple method to acquire information and is a method used daily in individual dental practice.

This study was based on the concept established by Kvaal et al. (8) by reviewing the literature, one can state that age estimation using Kvaal's method has varied results, some underestimating the exact age by approximately 30 years, whereas some were as close as 8-9 years(18) Hence we took only maxillary canines for this study in which, the pulp root width was measured at three different levels, namely at the CEJ, at the midroot

level, and at the apex. Correlation coefficients for A1, A2, A3, A4were statistically poorly significant, compared to A3 which was more significant.

However, the correlation coefficient for A1, A2,A4 was poor for teeth, showing less significance. Whereas correlation coefficient for A3 was good which is overall width of pulp/root ratio.

Statistically significant values were noted when all parameters were used. As in other studies, a higher correlation coefficient was obtained when multiple teeth were included, leading that the more the data gained from the patient, the greater are the chances of an accurate age estimation; in addition, it may also reduce the effect of various anatomy of any single tooth.

In the present study all parameters together showed the strongest correlation compared to the length ratios or individual ratios which was not significant as depicted in the study conducted by Kvaal et al. (8)

The accuracy of age estimation in this study was ± 11.32 years when all parameters were included. The better accuracy may be because of the exclusion of multirooted teeth. however, we used the bisecting technique, which may have angulation discrepancy and technique errors.

Some authors (18) have showed less relevance of the regression equations of Kvaal et al.(9) and Palevsky et al.(13)in younger individuals. Our results, however, differ, as we could estimate the age in a population ranging 21-70 years old with an overall accuracy of ± 11.32 years. From this study, we have calculated regression equations for age estimation in the Indian population.

Conclusion:

We conclude that all ratios together and the ratio A3are good indicators of age, while individual A1, A2, A4are not correlated with age estimation in this population. According to the authors, the results of this study suggest that Kvaal's method is a reliable one to estimate age in both young and older individuals. With a few alterations of Kvaal's method, we could estimate age with a standard error of estimate of ± 11.32 years in a sample of the Indian population, which was more applicable in age group 31-40 years. Only few conclusions can be drawn from a single study. However, more studies should be done using this method for various teeth as we have used only canines here.

Conflict of Interest Declaration: We declare that there is no conflict of interest between the authors.

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