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Dental age estimation by using cameriere's method in mangalorean children: a pilot study

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ABSTRACT

Introduction: Age estimation by means of teeth is one of the interesting applications of Forensic Odontology as they survive post-mortem destruction and hence considered to be better suited for age estimation. Among several methods used radiographic age estimation rely on developmental stages of individual teeth especially in children.

Aim: To formulate a regression model for dental age estimation in Indian children population using Cameriere's method and to correlate the efficacy of chronological and dental age by using this formula.

Materials and Method: The present study comprised of 40 subjects ranging from 7-16 years. Dental age was assessed by using Cameriere method based on 7 permanent right mandibular teeth on panoramic radiographs.

Results: Pearson's correlation coefficients between age and morphological variables showed that all of them were significantly correlated with age. The variable x4 was statistically noteworthy and hence it was used to derive the linear regression formula: Age=13.868-6.400(x4) -2.054

Conclusion: The present study indicated that, Cameriere method was reliable for age estimation in our sample. Age of subjects can therefore be estimated with a good degree of accuracy using this specific formula.

KEYWORDS Dental Age, camereire, Forensic Dentistry, Panoramic Radiograph

INTRODUCTION:

The age of an individual as such has a significant role in clinical, medico-legal, forensic and anthropological applications. In instances where the chronological age is unknown, un documented or missing, several other growth parameters based on skeletal indicators such as hand-wrist bone ossification, fusion of cranial sutures, maturation of dentition, changes in pubic symphysis and somatic indicators can be utilized for probable age estimation.[1] However, most of these indicators show considerable variation, which is influenced by environmental and genetic factors. Unlike these, the dental maturation serves to be the reliable and most accurate means, especially because of its unique nature of incremental formation and periodic mineralization which can be well defined. This pattern of growth and progressive calcification of the developing tooth is independent of the local and environmental influences, as well as from the somatic growth[2]. Hence teeth are counted as the least variable bio-indicator for assessment of age. This is further reassured by the sustainability of dental hard tissues against various environmental insults[3].

For dental age estimation various methods were proposed by Demirjian, Nolla, Willems and Haavikko for growing individuals[4-7]. In the above methods, radiographs were used as an evidence to analyse the progressive sequence of teeth development and each stage of development was coded and given a score. These scores were hence manipulated to derive the dental age of an individual, relative with the chronological age, with acceptable error limits. However, all these methods dated back a few decades and the change in the growth trend of the current generation posed a need for formulating a newer method of dental age assessment[8].

In 2006, Cameriere *et al*. published a new concept of estimating chronological age in children by measuring the open apices in seven mandibular teeth on radiographs, which gave reliable estimates of age in 455 Italian Caucasian children[9]. However the reliability of Cameriere's method was evaluated on several sample groups from different nationalities, which revealed that the original regression model formulated by Cameriere is not always suitable for other countries as tooth development differed among populations and exhibited variation among different ethnic groups and regional locations[10]. Although such studies helped in validating Cameriere's regression model, they also insisted on the need for developing a discrete regression model for the study samples of each country. Thus, in this study we attempted to formulate a regression model for the growing children of South Indian mangalorean population.

Materials and Methods

The study was conducted in the Department of Oral medicine and Radiology at Yenepoya Dental College, Mangalore, Karnataka. Panoramic radiographs of 40 South Indian children aged between

7-16 years from the archives of the department were analysed. Radiographs that were unclear, with any gross pathology, tooth fractures, hypodontia of permanent teeth or having history of orthodontic treatment were excluded. 40 radiographs with satisfiable criteria were included in the study. Table 1 shows the distribution of panoramic radiographs by gender and age. All the radiographs were digitalized using Agfa CR X digitizer and the images were recorded on computer files and processed by a computer aided drafting program (Agfa nx software).

Age_group * Sex Cross tabulation

			Sex		
			F	M	Total
Age_gro	7-10	Count	2	4	6
		% within Age_grp	33.3%	66.7%	100.0%
	10-13	Count	8	11	19
		% within Age_grp	42.1%	57.9%	100.0%
	13-16	Count	7	8	15
		% within Age_grp	46.7%	53.3%	100.0%
Total		Count	17	23	40
		% within Age_grp	42.5%	57.5%	100.0%

Table 1 - Distribution of panoramic radiographs in the study samples

All the 40 radiographs were evaluated in accordance with Cameriere's *et al.,* [9] for dental age estimation. For each individual the chronologic age was calculated by subtracting the birth date from the date on which the radiographs were taken for that particular individual and both were converted to a decimal age by the method of Eveleth and Tanner.[11] Decimal age was taken for simplicity of statistical calculation and age was estimated on a yearly basis, for example, 12 years 9 months as 12.75 years and was considered in the 12 years' age group.

In brief, the radiographs of 7 left permanent mandibular teeth were assessed. Teeth which were formed completely, with closed apical ends, were designated as N_0. The teeth with incomplete root formation and hence with open apex were evaluated in the following order. For teeth with single root, Ai; where I = tooth 1.,5, the distance between the inner side of the open apex was measured. For teeth with two roots, A_{im}, A_{id}; where I = tooth 6, 7 and m = mesial root, d = distal root, the sum of the distances between the inner sides of the two open apices were measured as depicted in Figure 1 and both were added. In order to manipulate the accountable differences in magnification and angulations during radiographic imaging, measurements were normalized by dividing by the tooth length (Li, where I = tooth 1,….,7). Finally, dental maturity was evaluated using normalized measurements of all the seven permanent left mandibular teeth (xi = Ai/Li, I = tooth 1,…,7), the sum of normalized open apices (s) and the number (N_0) of teeth with complete root development. Tooth length is measured from the point of highest cusp to the root apex and is denoted as (Li) (Fig. 1). Dental maturity was thus evaluated using the normalised measurements of the seven right or left mandibular teeth (xi = Ai/Li, I = 1,., 7). Therefore, the sum of the normalised open apices is, S = (x1 + x2 + x3 + x4 + x5 + x6 + x7). Measurements were carried out by two different observers and inter and intra-observer reliability was checked on 10 independent panoramic radiograph samples**.**

Figure 1
Cameriere's method of measurement for the teeth with open apices

Statistical analysis

For each individual, all the morphological variables N0, s, xi, where I = tooth 1…7 were entered in an EXCEL file to be used as predictive variables for age estimation in sequential statistical analysis. Chronological age of the radiograph from the archives was also recorded. The interobserver reliability of the sum of normalised open apices (s) was studied by means of the concordance correlation coefficient, and kappa statistics were used to measure the intraobserver reliability of the number of the seven right permanent mandibular teeth with root development complete (N0). Furthermore, correlation coefficients were evaluated between age and predictive variables. To obtain an estimate of age as a function of the morphological variables and subjects' gender, a multiple linear regression model was developed with first order interactions by selecting those variables that contributed significantly to age estimations using the stepwise selection method. Statistical analysis was performed with Statistical Package for Social Sciences (SPSS) version 22.0% statistical program. The significance threshold was set at 5%.

Results

There were no statistically significant interobserver and intraobserver differences between the paired sets of measurements carried out on the re-examined panoramic radiographs. Pearson's correlation coefficients between age and morphological variables showed that all of them were significantly correlated with age. When all the variables were entered in the EXCEL file for statistical analysis, it was found that out of the variables x1, x2, x3, x4, x5, x6, x7, S, N0, the variables x3, x4 and x7 contributed significantly to the fit (Table 2). Among these three variables, variable x4 was statistically noteworthy and hence it was used to derive the linear regression formula:

Age=13.868-6.400(x4) -2.054 (1)

Descriptive Statistics

	Mean	Std. Deviation	N
Age	12.5500	2.12374	40
X3	.1160	.13266	40
X4	.1103	.15537	40
X5	.1735	.29448	40
x7	.2980	.40734	40

Table 2

The derived variable (x4), calculated from the panoramic radiographs of different children, was applied on the regression equation and the adjusted age/predicted age was calculated. When the adjusted age was compared to the chronological age it was found that the regression equation with selected variables explained 66.1% of total variance (R2 ¼ 0.661). The standard error of estimate is 1.252 (Table 3).

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.813a	.661	.652	1.25203	.661	74.212	1	38	.000
2	.835b	.697	.681	1.19923	.036	4.419	1	37	.042

Table 3

The graph (Fig. 2) is an observed versus predicted plot. The values of the observed age are plotted against the predicted values from the regression model. The plot shows that the values are equally distributed; hence, the regression model fits the trend of the data reasonably well.

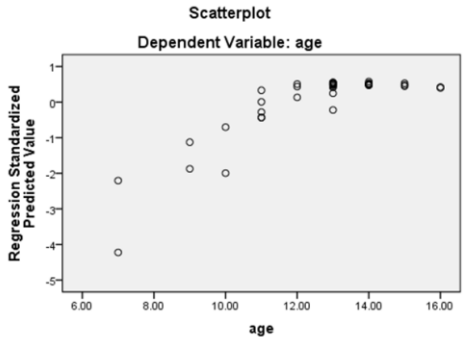

Figure 2: Observed vs predicted plot

The residual plot (Fig. 3) shows the adjusted age or predicted values from the derived regression equation plotted against the residual that is, observed minus predicted age. The residual plot did not show any obvious pattern with only three possible outliers. Hence, both diagnostic plots support our chosen regression model to estimate age.

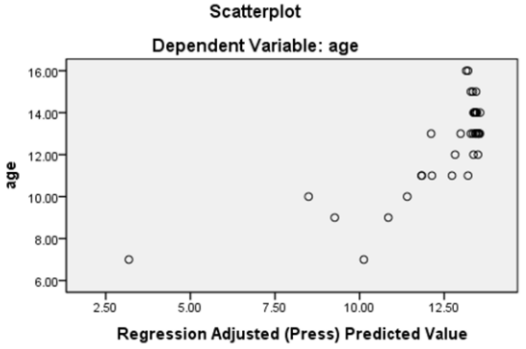

Figure 2: Residual plot

DISCUSSION

Age estimation plays an important role in various disciplines such as forensic medicine, pediatric endocrinology, archaeology and clinical dentistry. With respect to the dead and the relative requirement for biological profiles from a forensic perspective, assigning an age to a living child of unknown identity may be necessary when the child is suspected of a crime, in illegal immigrations, or when there is no valid documentation of age. In such cases, it is prudent to use non-invasive methods with higher accuracy and precision, because of specific legal requirements12. Teeth are most frequently used for age estimation. The high number of teeth and the continuous modification of both crown and root in children helps in several age estimation methods. The aim of the present study is to estimate chronological and dental age in individuals from Mangalore between 7-16 years of age. The age range from 7-16 years remains the most critical with regard to estimating a child's dental age and consequently to determine the proper timing for orthodontic therapy. The maxillary teeth were not included as the apices of maxillary teeth are often obscured by superimposition from anatomical landmarks or errors from the radiographic procedures.

The panoramic radiograph is considered the best tool for age estimation in children owing to the reason that intraoral radiography is difficult to obtain in children without image distortion. Panoramic radiographs are ideal screening tools as they are inexpensive, readily available, provide an unobstructed view of the entire dental arch and have comparatively less radiation exposure. When open apices were measured on digitised panoramic images of mandibular teeth, it was shown that there were no significant intra- and interobserver differences. Based on this, we concluded that this technique could produce reliable and reproducible intra- and interobserver measurements.

Our study showed no statistical differences in dental age estimation between male and female samples, which showed that gender did not show significant influence on age estimation and was therefore excluded as a factor in the model equations.

A study was done by Cameriere L et al on Italian population of children aged between 5-15 years. Study based on seven mandibular left healthy permanent teeth for assessing dental age by measurement of open apices in teeth. Statistical analysis showed a significant correlation with chronological age, morphological variables explain 83.6% (R2=0.836)9. In our study, statistical analysis indicated that gender does not have a significant influence on age estimation. (R2= 0.66)

Another study was carried out by Rai B et al on a large sample of Indian children aged between 4-16years. Results showed correlation coefficient between dental age and chronological ages were highly significant13. The present study showed the accuracy of Cameriere method and it's not influenced by any factors.

A study was conducted by Cameriere, L et al to determine the accuracy of the Cameriere method for assessing chronological age in children based on the relationship between age and measurement of open apices in teeth and to compare with widely used Demirjian and Willems method14. In Cameriere method, the difference between two mean prediction errors was not statistically significant. Demirjian method was significantly less accurate ($p = 0.024$). Willems method was better than that of Demirjian but was significantly less accurate than that of Cameriere ($p < 0.001$). However in present sample Cameriere method showed highly significant ($p = 0.000$).

In a study conducted in Haryana sub-population by the same author Kaur J et al Panoramic radiographs of healthy children aged between 5-15 years were selected and Cameriere's regression equation was applied. Authors observed underestimation of age in boys and overestimation in girls as compared to their chronological age15. But in present study showed, gender does not have a significant influence on age estimation.

In the present study only the variable 'second premolar' contributed significantly to the fit and were therefore included in the regression equation. This is in contrast to a study conducted in a sample of South Indian population by Deepa et al where 'canine' and 'second molar' contributed significantly to the fit16.

A similar study was performed in a sample of North Indian and South Indian (Kerala) children by Balwant Rai et al13. The results showed that the variables 'gender' and 'second premolar' contributed significantly to the fit which is similar to our study.

The limitations of the study are that the derived regression equation is same for both the male and female gender and does not differentiate between a fast- or slow-maturing children.

CONCLUSION:

The present research has confirmed that there is significant correlation between age and measurement of open apices. This method can be used for assessing age in forensic as well as legal contexts and based on these variables chronological age can be determined in the South Indian population. Since our study has a small sample size we were not able to give the exact value of variation between each age group that the chronological and dental method assessed. The present Regression equation is derived for age estimation from Indian children. This equation can be applied in various condition of Indian judiciary till Indian Population specific studies are developed.

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