



Accuracy of methods of age estimation in predicting dental age of preadolescents in South Indian children



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ABSTRACT

Age estimation in forensic context is of prime importance for criminal, civil and administrative laws. The objective of this study is to test the accuracy of 3 methods of age estimation in South Indian children (preadolescents) aged between 7 and 15 years. It is a retrospective study of orthopantamograms (OPGs) of 150 children among which 79 were boys and 71 were girls. Cameriere's, Willems and Acharya's age estimation methods were used to predict chronological age. Paired *t*-test was used to compare all data and relationships between continuous variables were examined using Pearson's correlation coefficient. The Cameriere's method underestimated the real age by -0.62 years in boys and -0.54 years in girls. Both Willems and Acharya's methods overestimated age in both sexes by 0.41 , 0.18 years and 0.41 , 0.47 years respectively.

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1. Introduction

Age estimation in forensic context is of prime importance for criminal, civil and administrative laws. Its application is invaluable in medico-legal cases of judicial punishment such as rape, kidnapping, employment, attainment of majority, social benefits and marriage. The age discrimination in preadolescents to predict whether they are above or below 14 years of age is of legal pertinence, particularly for individuals who are unable to deliver documentary evidence about their birth date.¹ The anticipated developmental sequence of human dentition and the appreciation of these stages on radiographs seem to be more appropriate in the assessment of age.² There are various of age estimation methods are present in literature among which the most widely used methods are based on subjective assessment of crown and root formation stages.³ The objective of this study is to test the accuracy of 3 methods of age estimation in South Indian children (preadolescents) aged between 7 and 15 years.

2. Material and methods

2.1. Study design and sample

This study was a retrospective study of orthopantamograms (OPGs) of 150 children among which 79 were boys and 71 were girls. Age was ranged between 7 and 14.99 years. Age and sex distribution of the sample was listed in Table 1. The OPGs utilized in this retrospective study belongs to the healthy children who visited Panineeya Institute of Dental Sciences, Hyderabad. These radiographs were taken as a routine dental practice.

2.2. Age estimation methods used

Cameriere's method assessed dental maturity using the normalized measurements of seven left mandibular teeth, the sum of normalized open apices ($s = x_1 + x_2 + \dots + x_7$) and the number of teeth with completed root development (N_0). Subject's gender ($f = 0$, $m = 1$) was also used as a predictive variable and subsequently utilized in statistical analysis. The variables that had shown correlation with the chronological age and contributed significantly to the fit were included in the linear regression formula. This formula was applied to our study sample and statistical analysis was

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Table 1
Sample distribution.

Age group	Boys	Girls	Total
7–9.99	8	9	17
10–10.99	9	14	23
11–11.99	13	10	23
12–12.99	9	15	24
13–13.99	21	10	31
14–14.99	19	13	32
Total	79	71	150

done to measure the difference between dental age (DA) and chronological age (CA) among the age groups and both sexes.⁴

Willems method is a scoring system based on tooth developmental stages assuming that prediction of age is relatively accurate than depending the eruption process of the tooth. This method evaluated the dental age using Demirjian's method in children from Belgian Caucasian origin. According the developing criteria, maturity scores were given to all the seven mandibular teeth and then summed up. The obtained values after summing up all the maturity scores of the seven teeth provides the dental age of the individual. This method didn't provide any regression equation but had given maturity scores according to developmental stages for all teeth and both sexes.⁵

Indian specific formulae of Demirjian's method proposed by Acharya was utilized as the third method in this study. As the original formulae resulted in inferior age prediction in Indians, the author adapted new population specific formulae. Unlike cameriere's method, sex specific regression equations were present. According to the developmental stages, each tooth was assigned a maturity scores and at last these scores were summed up and substituted into the formulae which gives the dental age of the individual.⁶

2.3. Radiographic analysis and calculating accuracy

Analysis of the radiographs was carried out on X-ray viewer. To measure the parameters of the developing teeth, each radiograph was digitized on a scanner and the images were then stored on computer. These digitized images were later then processed with the help of computer aided drafting programme (Adobe photoshop 7).⁴ Chronological age (CA) of each individual was calculated using the date of birth and the date on which the x-ray was taken.⁷ CA was subtracted from obtained dental age (DA), the obtained positive value represents the over-estimation of the age, whereas the negative represents under-estimation.

2.4. Statistical analysis

Statistical analysis was performed using SPSS (Statistical Package for Social Sciences) software. The mean difference between dental age and chronological age was calculated for all age groups. The paired *t*-test was used to compare all data. Relationships between continuous variables were examined using Pearson's correlation coefficient. The confidence level of the study was kept at 95% and *p*-value of less than 0.05 was considered significant for all statistical data.

2.5. Reproducibility

To assess the reproducibility and intraobserver variability, 60 radiographs randomly selected and re-evaluated. Cohen's kappa was calculated for each age estimation method and the results obtained were compared.

3. Results

The Cameriere's method had shown slight underestimation of

Table 2

Median of residuals (in years), first and third quartiles and IQR for each method tested, for children aged 7–14.99 years.

	Gender	N	Median	Q1	Q3	IQR
Cameriere's Method	Boys	79	−0.510	−1.300	−0.050	−1.25
	Girls	71	−0.700	−1.300	0.000	1.30
	Both	150	−0.600	−1.300	0.032	1.33
Willems Method	Boys	79	0.260	−0.300	1.270	1.57
	Girls	71	0.040	−0.920	1.190	2.11
	Both	150	0.150	−0.742	1.240	1.982
Acharya's Method	Boys	79	0.200	−0.820	1.900	2.72
	Girls	71	0.000	−0.980	1.700	2.68
	Both	150	0.190	−0.877	1.800	2.677

age the individuals compared to the chronological age (Table 2). The median of the residuals for boys was −0.510 years (with Inter Quartile range, −1.25 years) and −0.700 years for girls (with Inter Quartile range, 1.30 years). The Willems method showed over-estimation of the real age for both boys and girls, with mean residual errors of 0.260 years and 0.040 years. The Acharya's method also overestimated the real ages for boys and girls with mean residual errors of 0.200 years and 0.000 years.

The paired difference of mean (SD) between the CA and DA using method 1 was 0.586 years (1.03), which is statistically significant and strong positive correlation of 0.833 (Table 3). Method 2 had mean (SD) difference of −0.305 (1.39), which is statistically significant and correlation value of 0.790. Method 3 had mean (SD) difference of −0.418 (1.92), which is statistically significant and correlation of 0.617.

The Cameriere's method had shown better mean prediction for boys than girls (Table 4). Even though the accuracy was better for boys than girls, the *p*-value is 0.604, implying that the difference in means is not statistically significant. No significant difference was found between the boys and girls in terms of mean prediction error using Willems method with *p*-value of 0.33. Demirjian's method overestimated the real ages (Tables 2 and 4) for both sexes, the mean prediction errors are not statistically significant for boys and girls with *p*-value of 0.95.

Cameriere's method produced 60% of absolute residuals (difference between chronological age and dental age) falls within the range of 1 year and 36% of absolute residuals falls within the range of 0.50 years (Table 5). Willems method produced results closer to the former with 54% of residuals within 1 year rang and 32.6% within 0.50 years. Demirjian's method yielded lesser residuals of 42% within 1 year range and 21% within 0.50 years.

Figs. 1–3, show the accuracy of each method for each age cohort and gender. When Cameriere's method was applied, 14–14.99 years age cohort was least accurate. Both boys and girls had shown underestimation of age, with boys slight edge over girls. The Willems method had shown slight overestimation of real ages among 11–13.99 ages, with slight overestimation in boys and near accurate to residual error in girls. The modification of Demirjian's method by Acharya mostly overestimated the real ages for all age groups. Fig. 4 demonstrated the box plot of difference between DA and CA by different methods, showed that Cameriere's method had shown underestimation of real ages, while other methods shown over-estimation with Willems method better than that of Demirjian's method. Cohen's Kappa measuring reproducibility yielded 0.86 for Cameriere's method, 0.82 for Willems method and 0.81 for Acharya's method of Demirjian's stages.

4. Discussion

The applicability of an age estimation method and its success in predicting DA in relation to CA depends on the accuracy and

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