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A Digital Orthopantomograph Study for Age Estimation by Measuring Open Apices of Permanent Teeth among 6-10 Years Old in Rohilkhand Region

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ABSTRACT

Background:To calculate maturity and predict age, teeth formation is commonly used tool in dentistry. This evidence assists in diagnosis and treatment planning in clinical as well as in forensic dentistry. Dental age estimation is based on morphological, histological, biochemical and radiological measurement of teeth. The developmental stages of teeth in growing children can be utilized for radiographic age estimation. This method makes utilization of radiographs for age estimation; a practical method in living as well as in deceased. The aim was to estimate the chronological age in children of Rohilkhand region population by using Cameriere's method. **Materials and Methods:** A retrospective observational study included - a total of 96 panoramic radiographs of patients aged 6 - 10 years. The mean length of teeth and width of open apices of seven right or left mandibular teeth were calculated using radiovisiography and adobe photoshop software. **Results:** The linear regression equation derived for estimation of age, from the variables X1, X2, X3, X4, X5, X6, X7, s & N, was $10.145 - 0.703S + 0.208S.N - 0.600X5$. **Conclusion:** Cameriere's method can be used for age assessment in children in case of forensic as well as legal contexts and based on these variables a reliable age estimation equation was proposed specifically for Rohilkhand region population.

Keywords: Cameriere Method, Regression Equation, Forensic Dentistry, Panoramic Radiograph.

INTRODUCTION

Assessment of age in children is the elementary query in forensic medicine, paediatric and in orthodontic treatment. Age is defined as a period of human life, measured by years from birth; it is an important religious, social, and cultural phenomenon. Forensic dentistry plays a vital role in the implementing dental knowledge to those criminal and civil laws that are captured by police agencies in a criminal justice system.¹ In judiciary forensic dentistry plays a vital role in implementing dental knowledge on criminals captured by police agencies. It is more relevant in our country, where significant number of children and adolescents don't own any identification entity.^{2,3}

In a growing individual, to estimate the age - skeletal, odontological, anthropological and psychological methods are used. The commonly used for skeletal maturity are those concerning the left hand-wrist area (e.g. Tanner-Whitehouse⁴ and FELS⁵ methods), which can estimate the age up to 16 years, at which time wrist maturation is complete in 90% of subjects.³

Among the various system developed to determine dental age, Demirjian⁶ system has gained wide acceptance. Earlier, Koshy S et al., and Anand K et al., checked the applicability of this method in Indian population and found an overestimation of age, it was summarized that it's not applicable for Indian children.^{7,8} In 2006, Cameriere et al developed a novel approach to determine chronological age in children based on the relationship between age and measurement of open apices in

teeth.⁹ Bagh T et al., conducted a study by using the aforementioned method and a Cameriere’s formula specific for Indian children was established.¹⁰ But due to its rich culture variability & mixed ethnicity, in India there is need for region specific formula. Hence the present study was designed to evaluate the viability of Cameriere’s specific formula for India population at Rohilkhand region of Bareilly district.

Table 1: Distribution of study subjects in age and gender

Age (years)	Male	Female	Total
6	14	14	28
7	13	7	20
8	13	3	16
9	6	7	13
10	13	6	19
Total	59	37	96

RESEARCH HYPOTHESIS

There will be association between the age calculated by measuring the open apices of teeth and the chronological age of the patient.

MATERIALS AND METHODS

A total of 96 Orthopantomographs (OPGs) of age groups 6 - 10 years comprising both sexes were selected from the Department of Pedodontics and Preventive Dentistry.

Inclusion Criteria:

- Healthy children of Rohilkhand, Bareilly origin in the age group of 6-10 years.
- All teeth on the right or left lower jaw should be present.
- Accurate Orthopantomograph showing full complement of teeth without any pathologies.¹¹

Exclusion Criteria¹¹:

- Children with any medically compromised conditions.
- Un-cooperative children.
- Patients undergoing radio/chemotherapy for head and neck malignancies.
- Radiographs that are unclear and show any pathology on the concerned side of the lower jaw like developmental abnormalities, grossly decayed teeth, tooth fractures, cysts or tumors.

PROCEDURE:

As per indication, OPG were taken as a part of routine investigation. The study pattern was fabricated according to the revised Helsinki declaration (2013) and was approved from the ethical committee of the institution. After elaborate case history taking for each individual, date of birth

was cross confirmed with the appropriate certificate. Each subject's chronological age was calculated by subtracting the birth date from the date on which radiograph was exposed. The images were processed using a computer-aided drafting program, Adobe Photoshop Software (version 7.0) and the following parameters were calculated with the measuring tool present on the drop-down column on the left-hand side of the screen.

Table 2: Regression analysis predicting Chronological age for Rohilkhand region

Regression Analysis	t value	P
Intercept	70.797	<0.001
Gender	1.240	0.218
Dental maturity of second premolar (X5)	-1.945	0.055
Sum of normalized open apices (S)	-12.918	<0.001
Number of teeth with complete root development (N)	-0.021	0.983
Interaction between S and N	1.644	0.104

Images of seven left or right permanent mandibular teeth were assessed. Number of teeth with complete root development open apices and completely closed apices of the roots (N) were calculated. For teeth with one root, distance A_i , where ($i = 1, 2, 3, 4, 5$): 1 – central incisor, 2 – lateral incisor, 3 – canine, 4 – first premolar, 5 – second premolar. For teeth with two roots, the sum of distance between inner sides of two open apices was calculated and denoted as A_i ($i = 6, 7$); 6 – first molar¹², 7 – second molar. (Figure 1)

In the present study, two observers had estimated and calculated the open apices of all the seven left or right permanent mandibular teeth.

Due to potential difference in magnification and angulation among X-ray measurements, A_i was normalized by dividing it with tooth length. Tooth length was measured from point of highest cusp to the root apex and was denoted as L_i . Dental maturity was evaluated using normalized measurements of seven right or left mandibular teeth as $X_i = A_i/L_i$; $i = 1$ to 7 .¹² Therefore, sum of normalized open apices was calculated as $S = X_1 + X_2 + X_3 + \dots + X_7$.

STATISTICAL ANALYSIS

To assess age as a function of the morphological variables and subject’s gender, a multiple linear regression model with first-order interactions was developed by selecting those variables that contributed significantly to age estimations using the stepwise selection method. To determine possible interactions between significant morphological variables and gender Analysis of covariance was applied. Statistical analysis was performed with S-PLUS 6 statistical programs (S-PLUS 6.1 for

Windows). The significance threshold was set at 5%.

Table 3: Stepwise Regression analysis for predicting chronological age for Rohilkhand region		
Stepwise Regression Analysis	t value	P
Intercept	95.265	<0.001
Sum of normalized open apices (S)	-13.046	<0.001
Interaction between s and N	5.268	<0.001
Dental maturity of second premolar (X5)	-2.092	0.039

RESULTS

A total of 96 Orthopantomographs (OPGs) of age groups 6 to 10 years comprising both sexes were selected. (Table 1)

There was no statistically significant intra-observer differences between the paired sets of measurements carried out on the re-examined panoramic radiographs. All correlation coefficients between age and morphological variables were significant and negative. (Table 2) Subject's age was modelled as a function of the morphological variables (predictors), and to optimize the model, a stepwise regression procedure was applied.

The results (Table 3) show that the variables X5 (second premolar), S, N and the first order interaction between S and N contributed significantly to the fit. Thus, only these variables were included in the regression model, yielding the following linear regression formula:

$$\text{Age} = 10.145 - 0.703 S + 0.208 S.N - 0.600 X5$$

The residual plot (Figure 2) shows no obvious pattern, and Scatter Plot of Observed cumulative probability Value and expected cumulative probability value showing that regression model fits the trend of data very well.

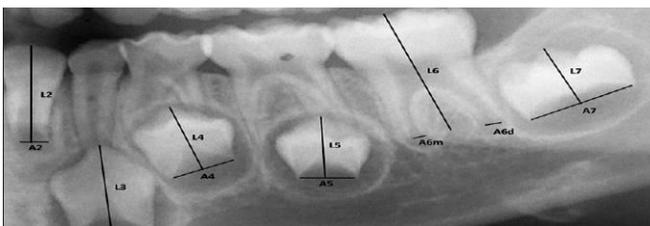


Figure 1: An example of tooth measurement in Adobe Photoshop. A_i , $i = 1, \dots, 5$ (teeth with one root), is distance between inner sides of open apex; A_i , $i = 6$ and 7 (teeth with two roots), is sum of distances between inner sides of two open apices; and L_i , $i = 1, \dots, 7$, is length of seven teeth.

The Scatter Plot (Figure 3) of fitted value and observed value again showing that regression model fits the trend of data reasonably well and Scatter Plot (Figure 4) of Residuals against fitted value showing no obvious pattern.

DISCUSSION

The growth of child is affected by various factors (ethnic,

nutritional, socioeconomic status etc.). Nevertheless, the different methods of age estimation based on teeth do not provide a common formula for the whole world.¹⁰

Eruption of tooth is influenced by many factors such as space in the dental arch, extraction of deciduous predecessors tipping or impaction of teeth. It is commonly seen during the developmental stages particularly in root formation, a distinguish difference exist between sexes; females being ahead when equated with males. Literature shows the dental age estimation using developmental stages of teeth in this age group is satisfactory as it is less influenced by environmental factors.¹³

The estimation of age for human identification, both for the living individuals and deceased is a vital issue.¹⁴ It is important from a forensic perspective as well and useful in establishing the difference between the juvenile and the adult states of an individual in law suits. To estimate an age of child with unidentified identity may be of prime importance when the child is the victim of a crime, alleged of a crime, or when the child is a migrant of uncertain age, as well as in circumstances where the individuals do not have valid documentation of age. In these cases, it is relevant to employ non-invasive methods with advanced accuracy and meticulous, because of specific legal requirements.²

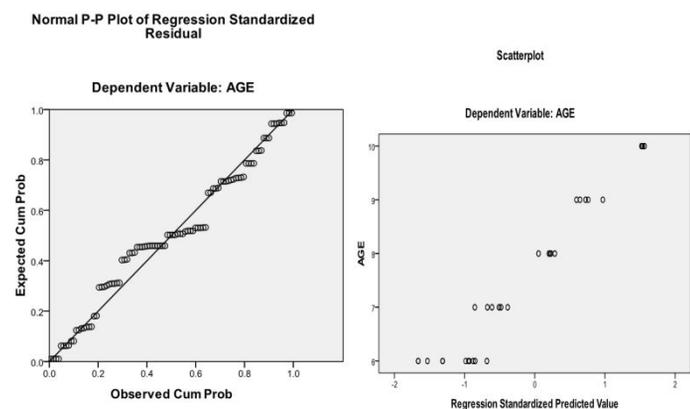


Figure 2 & 3: Plots of expected cum probability against observed cum probability, and age against regression standardized predicted value respectively.

Several studies show that morphological measurements can be consistently made in panoramic radiography, provided that some corrections are made to take into account the individual variability of tooth size and the differences in magnification of radiographs and angulation between x-ray beam and film.³

In Rohilkhand region, the India-specific formula cannot be applied. Hence in current study OPGs have taken for the individual belonging to Rohilkhand itself.

The radiological method is amongst one of the most reliable method available for age estimation which is extensively used for both dental and skeletal method.^{15,16,17} In the current study

dental age had been assessed by using Panoramic radiograph, following the method described by Cameriere, which is widely accepted and has been studied extensively on various population by many authors.^{3,10}

Scatterplot

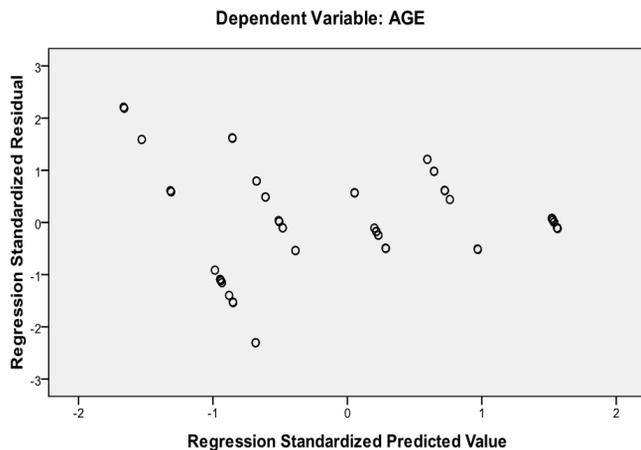


Figure4: Plots of regression standardized residuals against regression standardized predicted value.

Study was done by Cameriere L et al on Italian population of children aged between 5-15 years. In our study, statistical analysis indicated that gender does not have a significant influence on age estimation. ($R^2=0.956$) this finding is dissimilar to previous study by Cameriere R.³

Cameriere L et al had derived a common formula for children from European background. Their results showed that the median of the absolute value of residual errors were 0.035 years.¹⁸ In the present study, results showed that the median residual errors were 0.0024 years.

In parallel to the current study in which gender did not have a significant influence on age estimation. ($R^2= 0.956$), Rai B et al showed a significant correlation with chronological age except gender and second premolar, these morphological variables explain 89.7 % ($R^2= 0.897$) variations in estimated dental age¹⁰ by using modified Cameriere's European formula.

By using Cameriere's regression equation on the age group of 5-15 years, in Haryana sub-population Kaur J et al detected underestimation of age in boys and overestimation in girls as related to their chronological age.¹⁹ But in present study, gender did not have a significant influence on age estimation.

Results of the current study showed that not all the variables used for the European and Indian models were significant predictors of age estimation in the Rohilkhand sample. The results found in this work, indicates more attention should be focused on the possible differences between children of different origins.

CONCLUSION

In the present study we evaluated remarkable correlation between the Chronologic and dental age. 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 Rohilkhand region, children.

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