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# AGE ESTIMATION BY MEASURING OPEN APICES OF LOWER ERUPTED AND NON-ERUPTED PERMANENT TEETH AMONG 5-15 YEARS OLD - A DIGITAL ORTHOPANTOMOGRAPH STUDY

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**Abstract**

**Background:** Age is one of the essential factor in establishing the individuality and identity of a person in this world and it refers to a period of human life, measured by years from birth. The use of dental factor like radiographs which is simple, non-invasive and non-destructive method which actually can be employed for the estimation of the age.

**Aim:** To evaluate applicability of Cameriere's method for assessing chronological age in children based on the relationship between age and measurement of open apices in tooth roots in an Indian sample.

**Objectives:**

1) Assessment of chronological age of children by measuring the open apices of either the right or left lower erupted and non-erupted teeth in children of Indian population

2) Assessment of correlation between chronological age and estimated dental age using cameriere's formula.

**Material and Methods:**

The study group comprised of 100 children of age ranging between 5-15 years, which included 50 boys and 50 girls subjected for digital panoramic radiographic technique and the images were recorded on computer files, which were processed using computer Digora compatible software DfW 2.6.All measurements were carried out by the same observer using cameriere et al formula.

**Results:**

After a thorough statistical analysis, the results showed that there was no significance difference between estimated age and the actual age of the patient.

**Conclusion:**

The results of the study suggested the feasibility of the cameriere s method for age estimation on Indian population in a set sample.

**Keywords: Age Estimation, Children, Orthopantomographs.**

**Introduction:**

Age refers to a period of human life, measured by years from birth; it is an important religious, social, and cultural phenomenon. Different stages of life which are considered significant mile stones like first birthday, time for school and voting right. To achieve the chronological age of a person a correct date of birth is required, which can be confirmed by the birth certificate which actually represents the starting point of identification and safety of every child s right to identity and existence.

The need to determine the age of living individuals is a problem of increasing interest in our community, due to the progressively higher number of persons not in possession of any document of identity/ whose birth certificate may be suspected to be wrong or who have immigrated illegally or committed crimes especially in a country as large as India, several tangible factors, such as climate, nutrition, socioeconomic levels and urbanization may all influence children maturation rates and especially in a city like Bangalore due to the great influence of people of different origin and other immigrants who also arrived to the city for work and study, Also in cases of adoption, it is sometimes important to assess age when no birth certificate is available. In the last few years, therefore, forensic medicine has shown increasing interest in this problem [1–5].

Forensic dentistry plays a very important role in the application of dental knowledge to those criminal and civil laws that are enforced by police agencies in a criminal justice system. Forensic dentists are involved in assisting investigative agencies to identify recovered human remains in addition to the identification of whole or fragmented bodies; forensic dentists may also be asked to assist in determining age, race, occupation, previous dental history and socioeconomic status of unidentified human beings. Identification is done by the comparison of ante mortem and post mortem dental records and using the unique features visible on dental radiographs. [9]

In children age estimation is a problem of interest and assumes importance from a forensic medicine, pediatric endocrinology, orthodontic treatment and medico-legal point of view including status of majority and criminal liability. It is particularly important in our country as a higher number of children and adolescents are not in possession of any identity [1, 2].

Various methods are utilized for determination of age from dentition. These may be described in four categories namely, clinical, radiographic, histological, physical and chemical analysis. The Factors used for the age determination using dentition are the appearance of tooth germs, earliest detectable trace of mineralization, Degree of completion of the non-erupted tooth, rate of formation of enamel and formation of the neonatal line, clinical eruption, degree of completion of roots of erupted teeth, degree of resorption of deciduous teeth, Attrition of the crown, Formation of physiologic secondary dentin, formation of cementum, transparency of root dentin, gingival recession, root surface resorption, discoloration and staining of teeth, Changes in the chemical composition of teeth.[10]

The most common method for age estimation with teeth was published in 1973 by Demirjian, Goldstein and Tanner, In 2006 Cameriere et al developed a new method for assessing chronological age in children, based on the relationship between age and measurement of open apices in tooth roots and recently, it has been reported that Cameriere's method is more accurate than other methods for estimating the age of children in age groups 6-13 years. [1]

The forensic implication of this investigation was to present a method for

assessing chronological age in children. However no study have been conducted in Indian children and adolescents in the age group of 5-15 years old to assess the applicability of Cameriere s formula, so this study was conducted to emphasize and enlighten that if this formula turns out to be unsuitable then the data from the present study could be used for derivation of a specific formula in age estimation of Indian children.

**Materials and Methods:-**

**Source of the data:**

Out Patient aged between 5-15 years visiting the Department of Oral Medicine and Radiology of Dr. Syamala Reddy Dental College, Hospital and Research centre, Bangalore

**Inclusion Criteria:**

- Healthy children of Indian origin in the age group of 5-15 years
- All teeth on the right or left lower jaw should present, appropriate for the age group of 5-15 years were included
- Accurate orthopantomograph showing full complement of teeth without any pathologies.

**Exclusion criteria:**

- Age group above 15 years of age.
- Children with any systemic diseases, hereditary diseases affecting the dentofacial complex, congenital anomalies and presenting with any syndromes and under any medication which affect development.
- Patients with history of or currently on orthodontic, restorative, endodontic treatment involving the teeth of interest.
- Children uncooperative for radiographic procedures.
- 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.
- Third molars were excluded.

**Sample size:**

The study group consists of randomly selected 100 samples of 50 males and 50 female's patients, within the age group of 5-15 years

**Method of collection of data:**

Permission was approved from the ethical committee of the institution before starting the study for examining patients and to carry out the radiographic examination.

Patients consulting the Department of Oral Medicine and Radiology, Dr Syamala Reddy Dental College, Hospital, and Research centre, aged between 5-15 years were be subjected for panoramic radiograph & appropriate candidates were considered for the study after obtaining their consent.

The patients were made to seat on a dental chair and examination was carried out using mouth mirror and a straight probe. The examination was necessary to confirm that the teeth under radiographic examination were present, and if present, they were neither carious nor restored. After recording the demographic details digital opg was taken and measured.

**Armamentarium:**

1) Extra oral Digora PCT film cassette and SOREDEX photostimulable phosphor (PSP) sensor imaging plate; (15×30 cm).
2) Extra oral X-ray machine: Soredex cranex excel ceph (Tuusula, Finland)
3) PSP scanner DIGORA PCT (Soredex) Tuusula, Finland
4) Disposable bite block barrier envelopes
5) Reusable imaging plates
6) X-ray cassette.
7) DIGORA compatible software DfW 2.6
8) Lead apron
9) Sterile gloves

Exposure Parameters: 55-65 Kvp; 6 or 10 mA

**For Digital Image Acquistion and Calibration**

- Digital imaging plate(DIGORA soredex, Tuusula, Finland)
- Application Software: DFW 2.6(Digora, Soredex)
- Personal Computer Configuration
- A Pentium (R) Dual core processor, 2.7GHZ, 0.99 GB RAM
- computer monitor 19 inches wide with resolution of 1024 X 768 pixels and 32 bit color depth

**Method of Study:**

Detailed case history was taken for each patient on a standard proforma and ages were confirmed with birth certificates. The Digital panoramic radiographs will be taken using SOREDEX CRANEX EXCEL CEPH and SOREDEX PSP Digital extra oral system phosphor imaging plate (15×30cm), In vivo imaging was performed using standardized technique. The phosphor plate was scanned using DIGORA PCT digital imaging scanner. The radiographic images were recorded on computer files, which were processed using computer Digora compatible software DfW 2.6.All measurements were carried out by the same observer.

**Image Calibration**

Using software built in with contrast enhancement tools each digital radiograph thus obtained was modified for contrast and resolution.

Using the calibration tool which is in built software was evaluated for the measurement of open apices of erupted and non-erupted teeth as described by Camerier et al. (2006)

The parameters which were considered for each individual were

- Chronological age of each child were calculated by subtracting the date of the x-ray from the day of birth, and converting both in decimal form for ease and for statistical calculation and on yearly basis age was estimated.
- The seven right or left permanent mandibular teeth were valued. The number of teeth with root development complete, apical ends of the root completely closed was calculated as (N0), Furthermore, the teeth with incomplete root development, i.e. with open apices, were considered and the distance (Ai, i = 1, . . ., 7) between the inner side of the open apex was measured, for the tooth with multiple roots, the sum of the distances between the inner sides of the two open apices was evaluated.
- In order to take into account the effect of possible differences among X-ray in magnification and angulations, measurements were normalized by dividing by the tooth length (Li, i = 1, . . ., 7).

**Figure 1:** Image in which measurement done

Finally, dental maturity was evaluated using the normalized measurements of the seven left permanent mandibular teeth (xi = Ai/Li, i = 1 . . . 7), the sum of the
Normalized open apices (s) and the number (N0) of teeth with complete root development.
Therefore the sum of the normalized open apices was represented as **S**

- Age is calculated by using the formula

Age =8.971 + 0.375 g +1.631 x5 + 0.674 N0 – 1.034 s – 0.176 s .N0
{This regression equation is proposed by Camerier et al. (2006)}
Where g is a variable equal to 1 for boys and 0 for girls
**X5:** sum of normalized open apices of second premolar
N0**:** (Number of erupted permanent teeth with closed apices)
**s :** (Sum of normalized open apices)
The calculated age was then correlated with the chronological age of the patient. A new regression formula specific to the population was also be derived and difference between the age obtained by cameriere's formula and new formula was statistically evaluated.

**Statistical analysis:**

The obtained results were tabulated and analyzed using Microsoft Excel 2013 and SPSS software (version 13.0) and following tests were applied
1) Correlation coefficient between open apices and chronological age were analyzed.
2) Student t-test was done to assess the correlation for statistical evaluation.

**Results:-**

This study included 100 subjects of either sex between age group of 5 to 15 years for assessment of age out of which 50 were males and 50 were females (FIGURE 2). Mean age range subjects in this group was 9.55 years for males and 9.73 years for females (Table 1).
For these subjects, age was assessed using Roberto Cameriere et al formula (Age =8.971 + 0.375 g +1.631 x5 + 0.674 $N_0$ – 1.034 s – 0.176 s .$N_0$).

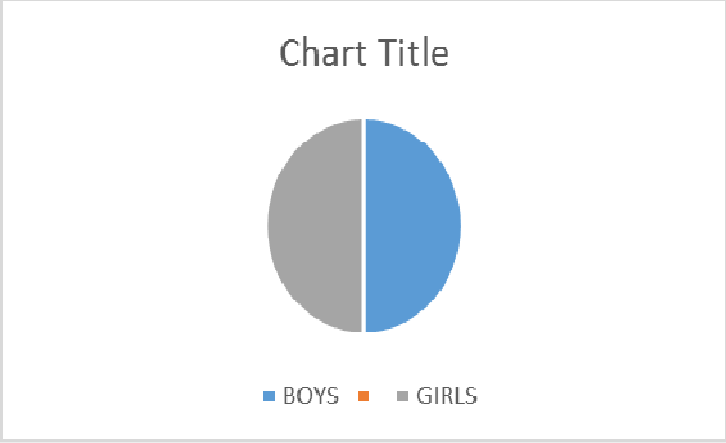



**Figure 2**: gender wise distribution of the study sample

Comparison of male and females was done with chronological age and estimated age of the patient by using t test and the results are tabulated as shown in Table 1, the mean chronological age of 9.55 in males and 9.73 in females and mean estimated age of 8.98 in males and 9.58 in females with p value of 0.7013 in chronological age and 0.0758 in estimated age.

Correlation between chronological and estimated age by Karl Pearson's correlation coefficient method in total, male and female samples was done and the values were tabulated

**Table: 1** showing mean age of estimated and chronological age

| Age | Male | | Female | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | | |
| Chronological age | 9.55 | 2.36 | 9.73 | 2.32 | -0.3847 | 0.7013 |
| Estimated age | 8.78 | 2.20 | 9.58 | 2.28 | -1.7949 | 0.0758 |

as shown in Table 2 and estimated age was taken as a variable and compared with chronological age in both male and female and the values were statistically significant ($P<0.05$) in both groups and also in total.

**Table: 2**

| | Variables | Correlation between chronological age | | |
|---|---|---|---|---|
| | | r-value | t-value | p-value |
| Total | Estimated age | 0.9087 | 15.0854 | 0.00001* |
| Male | Estimated age | 0.9063 | 14.8574 | 0.00001* |
| Female | Estimated age | 0.9087 | 15.0854 | 0.00001* |

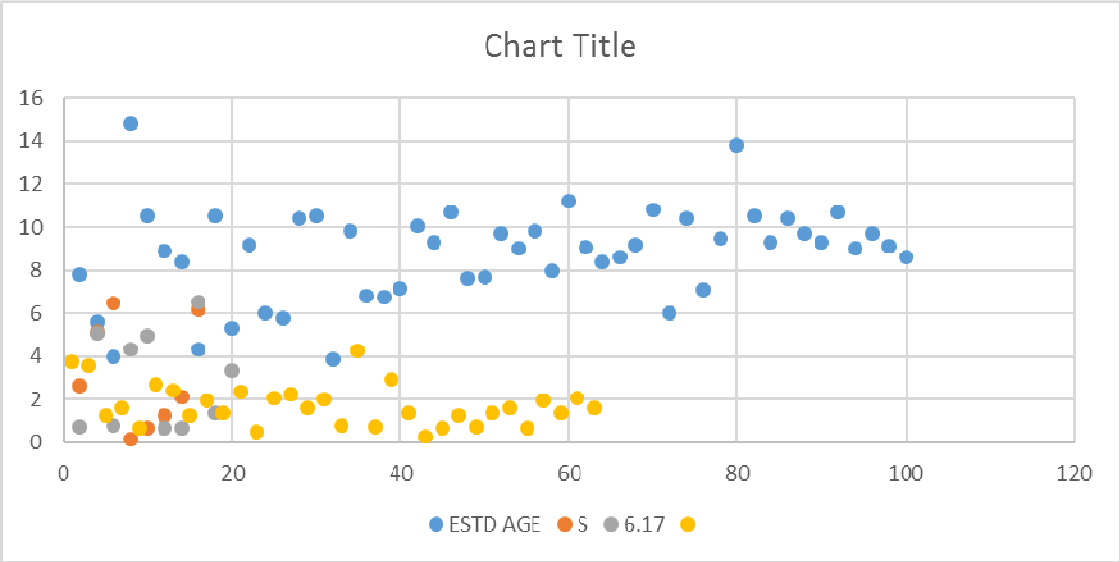
*p<0.05

Multiple regression analysis of age was done by $X_{1-7}$ and S as different variables and the values were tabulated as shown in Table 3.The independent variable intercept showed statistically significant($P<0.05$) value with the standard error of estimate was 1.166.

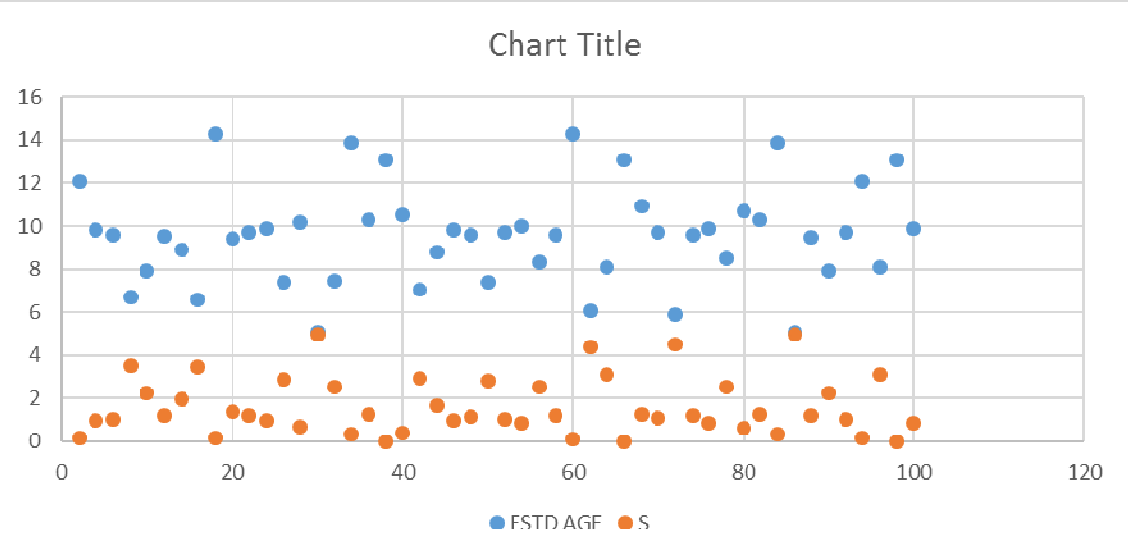
**Table: 3**

| Independent variables | Regression coefficient | SE of regression coefficient | t-value | p-level |
|---|---|---|---|---|
| Intercept | 12.5031 | 0.2715 | 46.0593 | 0.00001* |
| X1 | 1.6174 | 2.1154 | 0.7646 | 0.4465 |
| X2 | 1.3498 | 2.2573 | 0.5980 | 0.5513 |
| X3 | 0.9894 | 1.9293 | 0.5128 | 0.6093 |
| X4 | 2.1929 | 2.0783 | 1.0551 | 0.2942 |
| X5 | 0.4236 | 1.7288 | 0.2450 | 0.8070 |
| X6 | 1.6174 | 1.9638 | 0.8236 | 0.4123 |
| X7 | -0.4170 | 1.1868 | -0.3514 | 0.7261 |
| S | -2.1816 | 1.2740 | -1.7124 | 0.0902 |
| $R= 0.87729386$ $R^2= 0.76964452$ Adjusted $R^2= 0.74939349$, $F(8,91)=38.005$ $p<0.000018$* Std. Error of estimate: 1.1660 | | | | |

*p<0.05




**Graph 1**: showing s variable according to the distribution of estimated age in males.




**Graph 2**: showing s variable according to the distribution of estimated age in females.

**Discussion:-**

Age estimation plays an important role in forensic medicine, pediatric endocrinology, archaeology and clinical dentistry. In forensic contexts, with respect to the dead and the relative requirement for biological profiles, assigning an age to a living child of unknown identity may be necessary when the child is suspected of a crime when penal codes differentiate law and punishment for children of different ages, or when the child is a refugee of uncertain age. In these cases, it is necessary to use non-invasive methods and higher accuracy and precision, because of specific legal requirements[1].

The aim of an ideal age estimation technique is to arrive at an age as close to the chronological age as possible. In children somatic development such as skeletal maturity, height menarche etc., have been used to assess the age of a child, when unknown. Dental age estimation has got

acceptance as it is less variable when it is compared to other skeletal and sexual maturity indicators

Demirjian found a method for age estimation by considering calcification of teeth and developed a scoring system as the main base of his study which had minimum applicability up to the age of 21 years.

Gustafson, probably gave the first scientific method of estimating age which was based on the histological and morphological changes of the teeth. The study employed the six individual age related changes but it did not include the color difference from any of the tooth structure.

Although Gustafson s parameters are considered to have forensic value, a major disadvantage is that majority require extraction of teeth and this rules out its application in living adult people as well as in jurisdictions that do not permit post-mortem tooth extraction for a variety of legal and cultural reasons. Therefore, techniques that circumvent this limitation have been developed, most prominent among which are radiographic methods, which can be applied both in living and deceased.

One such non-destructive method for estimating chronological age in living children by examining the relationship between age and open apices of erupted and un erupted teeth on orthopantomogram was proposed by Cameriere et al in 2006.Recently, it has been reported that Cameriere method is more accurate than other methods for estimating the age of children in age groups 6–13 years. Hence the present study was carried out for age estimation by measuring open apices of erupted and non-erupted mandibular lower right or left seven teeth using digital radiographic technique.

Open apices of teeth was chosen for age estimation by Cameriere et al, who had concluded that this technique is suitable on Mexican children for dental age estimation. He also said that future research should aim at verifying whether the regional background, gender, chronological age distribution of the sample, and statistical procedures represent major factors controlling accuracy and reliability in sub adult dental age assessment.

This study included 100 subjects of either sex between age group of 5 to 15 years for assessment of age out of which 50 were males and 50 were females. The age of the subjects were estimated by Cameriere et al method by using digital orthopantomographs. In the present study the seven teeth that were selected from the lower jaw either right or left side and measurement of open apices was done to check whether Cameriere's formula can predict age accurately or whether population-specific equations can improve age assessment. In a country as large as India, several tangible factors, such as climate, nutrition, socioeconomic levels and urbanization may all influence children maturation rates and especially in a city like Bangalore due to the great influence of people of different origin and other immigrants who also arrived to the city for work and study. This probably explains the high correlation between estimated age by Cameriere's method and chronological age in the studied Indian sample.

Results indicate that Cameriere's formula, yielding under estimated values which yielded mean of 0.77 years in boys and 0.15 years in girls for an Indian sample, can also be applied to both male and female sample and it showed that more accuracy was seen in females than males when it comes to age estimation.

A similar study was done by Rai et al. he tested Cameriere's European formula in a sample of 480 orthopantomograms (OPGs) of Indian children. It yielded a mean overestimation of 0.05 years for boys and

0.04 years for girls. Which led the above authors to propose a specific formula for Indians.

Conversely, the relationship between chronological and estimated dental ages was evaluated for each gender, as well as for the total sample by analysis of means and standard deviation. The mean prediction error (ME) was 0.15 years for girls and 0.77 years for boys. Cameriere et al. also compared the ME for three methods, those of Willems et al, Cameriere et al. and Demirjian et al. Cameriere's method provided 0.48 years for girls and 0.50 years for boys, which is higher to the above achieved results in case of girls and lesser in case of boys when compared with the European formula in Mexican children. Using Cameriere's method, Galic´ et al. found ME of 0.53 years for girls and 0.55 years for boys.

The latter researchers studied a sample of 1089 Bosnian–Herzegovian children aged between 6 and 13 years. For girls, the mean DA was overestimated by 0.10 years according to Cameriere method by the range of differences of -0.80 to 0.60 years for all age groups. For boys, the mean DA was underestimated for -0.02 according to Cameriere's method by the mean of differences of -0.60 to 0.09 years for the 10-, 11-, 12- and 13-year-old groups, whereas it was overestimated by the mean of differences of 0.09 to 0.45 years for the 6-, 7-, 8- and 9-year-old groups. In Egyptian children, Cameriere's method showed an average underestimation of -0.29 - 1.04 years for the total sample, -0.26 -1.21 years for girls and -0.49 -1.03 years for boys. In an Indian sample of 480 children between 3 and 15 years, Cameriere's method yielded a mean overestimation of 0.05 years for boys and 0.04 years for girls

In our study it showed that gender has a significant influence on age estimation as the mean difference in female children was 0.15 years which was similar to previous study done by Cameriere et al in 2006 on Italian children, in which ANCOVA showed that gender had a significant influence on age estimation and was therefore they included gender as a factor in the model equation. All the normalized open apices had a significant correlation with age, but only x5 contributed significantly to the fit, while the other teeth in their study entered the model equation through the sum of the normalized open apices (s). Since dental development does not follow a linear progression, in the forensic context, some authors employed curvilinear functions to relate chronological and dental age. In particular, when dental maturity was evaluated using Demirjian's maturity score, third degree polynomial functions were used.

Cameriere s method, based on the normalized open apices of the seven left permanent mandibular teeth, employed a second degree polynomial function, which showed a median of the absolute value of residual error of less than 0.04 years (median=−0.035 years, IQR=1.18 years) and a standard of estimate of 0.93 years in his study which is similar to present study n which we got standard error of estimate through multiple regression analysis of different variables $N_0$ and $A_{1-7}$ is 1.12, $L_{1-7}$ is 1.59 and $X_{1-7,}$ S is 1.16 which is closer to the previous study done by cameriere et al. It is therefore comparable with other age estimation methods in children and is reasonably efficient and accurate.

According to previous study done by cameriere et al in 2006 tells that age in younger children can be more accurately predicted than in older children using the Cameriere method, the least accurately estimated age, for both boys and girls, was the 15-year-old cohort (ME = 1.14 years for girls, 1.036 years for boys) was found. The significant decrease in accuracy in the oldest

age cohort depends on many variables, but may particularly be attributed to the almost complete maturation of the teeth in this age cohort. More than 90% of the absolute value of residual errors obtained using the Cameriere method was less than 1 year which is similar to the present study.

The variance obtained in results could be explained on the basis of the fact that the software used for measurement in Cameriere method on conventional orthopantomographs was Adobe Photoshop (version 7.0) but in the present study, we used dfw2.6 software as the measurement tool on the digital orthopantomographs. Also considering the study sample selection, our study was based on Indian population.

This highlights the fact that Cameriere's technique is accurate and represents a useful method for age assessment in children of this age group (5–15 years). The accuracy of age estimation indicates how well chronological age can be predicted, and greater accuracy can be obtained by choosing the method which shows the least variability with age thus there was no need for deriving new formula for population studied.

**Conclusion:-**

This is a baseline study was carried out during the period of 2013 to 2014, for assessment of age using cameriere method for estimating age using digital orthopantomographs and comparing this estimated age with the actual age of the subjects.

The results of the study however inference for the feasibility of this technique in the Indian population on digital orthopantomographs.

As regards the first aim of this study, the results highlighted the accuracy and significance of developing teeth for more accurate estimation of age. According to the results of this research, it may be concluded that Cameriere's method is suitable for dental age estimation in Indian children.

Regarding the meaningfulness and usefulness of these results in the legal sphere, this accuracy indicates that Cameriere method is a powerful tool for forensic anthropologists and odontologists in age estimation in asylum and criminal proceedings. Nowadays, this formula can be used in all cases of crimes involving Indian children, especially illegal immigration, juvenile prostitution or trafficking in children for sexual purposes. This set of problems has emerged as significant both within and outside the Asia, mainly from developing countries such as India.

Further this study encourages for future studies on a large sample size with adequate representation of samples and also Future research should aim at verifying whether the regional background, gender, chronological age distribution of the sample, and statistical procedures represent major factors controlling accuracy and reliability in children dental age assessment.

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