Original article

Measurement of open apices in teeth for estimation of age in children

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Abstract

Background: Estimation of age has been a major factor in identification of an individual, either living or after death. **Objective:** To estimate and assess the dental age of children by measuring the open apices of the teeth using panoramic radiograph applying linear regression equation. **Methods:** This was a retrospective cross-sectional study conducted on 50 children (25 boys and 25 girls) aged between 5-15 years. The seven left permanent mandibular teeth were assessed using panoramic radiographs which were collected from Medical Record Department, Manipal University, taken during the course of diagnosis and treatment. The number of teeth with closed apical and with open apical end of roots were examined and measured. The values were tabulated and placed on the linear regression equation proposed by Cameriere et al for the estimation of dental age. **Result:** The result showed no significant difference between the dental age (10.13±1.69 years) and the chronological age (10.31±1.75 years) (p=0.26). The method underestimated the mean age by 0.11 years and 0.23 years for the boys and girls, respectively. The paired sample t- test showed no significant difference between dental age and chronological age for boys (p=0.546) as well as for girls (p=0.351) **Conclusion:** The estimated age of children by measuring the open apices of the teeth using panoramic radiograph linear regression equation used in the European subjects closely matches with the chronological age in Asian subjects also. Keeping in context to validate more accurately the significance of linear regression equation, there is a need of larger sample size belonging to variety of ethnic and socioeconomic background.

Keywords: age estimation, open apex, panoramic radiograph

Introduction

The use of teeth for determining the age has its origin more than 170 years ago when tooth eruption was first used for estimation of dental age in connection with child labor.[1] The first known attempts which used teeth as an indicator of age originated from England. In the early 19th century the determination of age was based mostly on the calculation of height.[2,3]

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Estimation of age is an important component of forensic sciences in the identification of an individual. Accurate estimation of age is essential from forensic odontology, pediatric issues, and orthodontic treatments to legal matters. During the growth of a person, the application of skeletal, odontological, anthropological and psychological methods allows an approximate assessment of age.[4]

Although, the skeletal methods are used in the estimation of age, variability of bone maturation is found to be influenced by several environmental factors. Age estimation in children based

on dental development is preferential as the calcification rate of tooth is controlled more by genes rather than environmental factors hence less variability. [5-7] Dental maturity has played an important role in estimating the chronological age of individuals because of the reported low variability of dental indicators. Various morphological and radiological techniques are applied for the estimation of chronological age using dental maturity as guidelines.

Tooth formation is less affected by malnutrition, endocrinopathies, and other pathological insults than other tissues. Cameriere et al conducted a study with 2 subsample of Peruvian school children (undernourished, well nourished) and found that nutrition does not affect the process of tooth growth.[8] One reason for this circumstance could be that teeth consist of bradytrophic tissues and do not undergo continuous remodeling process.

The most common method for age estimation was the method proposed by Demirjian (published in 1973), Goldstein and Tanner with subsequent modification. [9-11] With advancement and modification, several authors have developed alternative approaches based on the measurement of various tooth parameter, such as the degree of racemization of aspartic acid in tooth enamel[12-14] or crown height, apex width, root and pulp length of teeth observed in radiographs. [15-17]

In 2006, Cameriere et al presented a method of assessing the chronological age in children based on relationship between age and measurement of open apices in teeth in European population.[4] Their method has been reported to be more accurate than other methods.[18]

The aim of this study was to estimate the age and determine the accuracy of the Cameriere et al method for assessing the chronological age in children based on the relationship between age and measurement of open apices in teeth.

Methods

This was a retrospective study in which panoramic radiographs of 50 children (25 boys and 25 girls) aged between 5- 15 years were considered. Radiographs which were unclear, from patient with hypodontia, gross pathology of the jaw or with previous orthodontic treatment were excluded from the study. The radiographs were collected from the Medical Record Department of Manipal University, India after obtaining ethical clearance from the University Ethics Committee, Manipal. Radiographs were digitized using a scanner, and images were recorded on computer files, which were than processed using a computer programming tool, Adobe Photoshop 7.

Images of seven left permanent mandibular teeth were assessed. Number of teeth with complete root development and completely closed apices of the roots (N_0) were calculated. Also, teeth with incomplete root development and therefore with open apices were also examined.

For teeth with one root, distance (Ai, where i=1,2…5) between the inner side of the open apex were measured (Figure 1). For teeth with two roots, (Ai, where i=6 & 7) the sum of the distances between the inner sides of the two open apices were evaluated (Figure 2). In order to consider the effect of possible differences in magnification and angulations among the radiographs, measurements were normalized by dividing with tooth length (Li, i=1,2…,7).

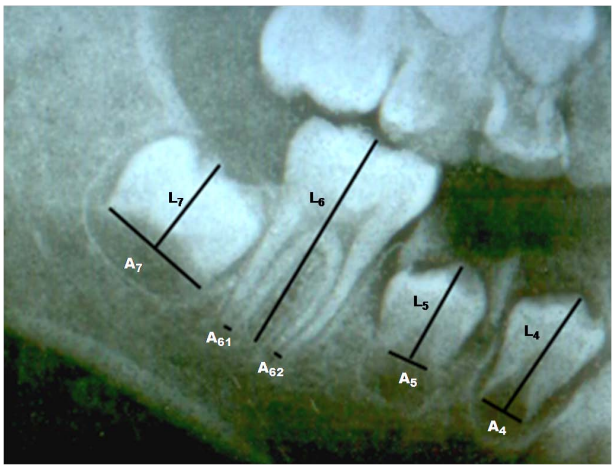

Figure 1: Measurement of tooth. Ai, i=1,2…,5 (teeth with one root), is the distance between the inner sides of the open apex; Ai, i=6,7 (teeth with two roots), is the sum of distances between the inner sides of the two open apices, Li, i=1,2,…,7 , is the length of the seven permanent teeth

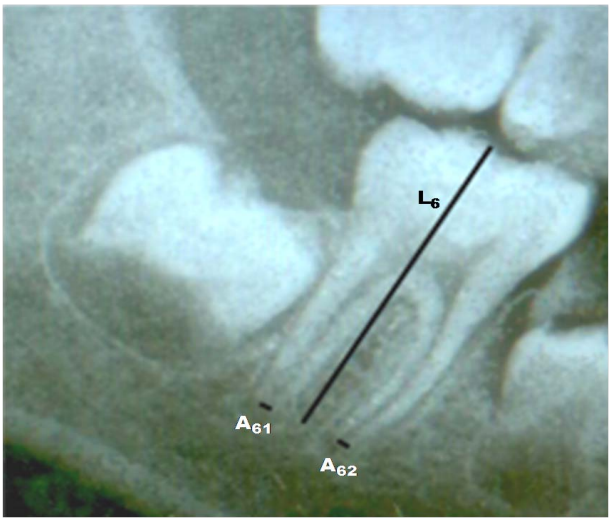

Figure 2: An example of measurement of a tooth with two roots. A_6, sum of the distances (A_6= A_{61}+A_{62}) between the inner sides of two open apices and L_6 is the length of second permanent molar.

Dental maturity was evaluated using the normalized measurements of the seven permanent left mandibular teeth (Xi=Ai/Li, where i=1,2….,7), the sum of the normalized open apices (s) and the number (N_0) of teeth with completed root development.

All measurements were carried out by the same observer. To test intra observer reproducibility, a random sample of 25 panoramic radiographs was re examined after an interval of at least 2 weeks.

All the morphological variables, Xi, s N_0 and gender were entered in an EXCEL work book. The values were kept in the linear regression equation formulated by Cameriere et al[4] on their study on European Population.

Dental Age =8.971 + 0.375g +1.631x_5 + 0.674N_0-1.034s- 0.176s.N_0

Where,

g = gender (1 for boys and 0 for girls), $x_5 = A_5/L_5$, s = sum of normalized open apices, N_0 = number of teeth with completed root development

The chronological age for each subject was calculated by subtracting date of radiograph taken from the date of birth.

Statistical analysis was performed with Statistical Package for the Social Sciences (SPSS) version 11.0 statistical program.

Result

There were no statistically significant intra observer differences between the paired sets of measurements, carried out on the re-examined panoramic radiographs. Comparison between the mean values of the calculated dental and chronological age, an underestimation of 0.18 years was calculated. Each for boys and girls population, an underestimation of 0.11 years and 0.23 years was observed, respectively (Figure 3).

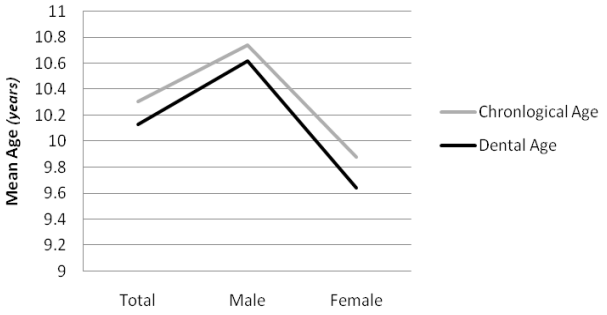

Figure 3: Comparison between the mean values of chronological and dental age (boys and girls), demonstrating an underestimation of age.

A mean age of 10.31 ± 1.75 years with a standard error of mean of 0.24 was calculated among the chronological age of the study population. Similarly, a mean age of 10.13 ±1.69 years with a standard error of mean of 0.23 was calculated among the dental age of the study population. Paired sample t test showed no significant difference between the calculated dental age and chronological age for boys (p=0.54) as well as for girls (0.35). There was no significant difference between the dental and the chronological age (p=0.26) (Table 1).

Table 1: Comparison of chronological age and dental age

	Mean Age (years)	Standard Deviation	Standard Error of Mean	p value
Chronological Age	10.31	± 1.75	0.24	0.26
Dental Age	10.13	± 1.69	0.23	

Paired t test (p<0.5 considered as significant)

Discussion

Age determination of individuals using all available scientific methods is a common part of forensic practice. Forensic dentistry

uses different clinical, morphological, and radiological methods on the teeth to determine the dental age on living persons and after death.[19] Dental age of children is commonly determined and recommended to use by radiological evaluation of development of crown and root of growing teeth. [20]

Tooth formation has been more widely used than tooth eruption for assessing dental maturation because it is a continuous and progressive process that can be followed radiographically and most teeth can be evaluated at each examination.[21] Several studies showed that morphological measurements can be reliably 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 angulations between x-ray beam and film.[4]

Dental x- ray methods have proved to be most accurate in childhood until the teeth have erupted and root development is completed (with the exception of wisdom teeth). However, in adolescence the validity of skeletal methods improves considerably. [22] So the use of dental x-ray as method of choice in the present study validates its reliability.

Estimation of age of living or deceased has become a very important tool, especially when concern for illegal immigrants, disaster victims, crime scene, individual with missing birth date, orphans and older individuals in retiring age without identification documents mentioning age and verification of chronological age in order to be entitled to civil rights and social benefits.

The result obtained in our study on boys and girls showed a high correlation between the chronological age and calculated dental age by Cameriere linear equation.[4]

In the present study, age estimation resulted in an average under estimation of age by 0.18 years (0.11 years in boys and 0.23 years in girls). Similar results were observed in European population [23-26] although a mean over estimation by 0.05 years for boys and 0.04 years for girls was estimated in the Indian population.[21] The difference in the chronological age and calculated dental age, despite of the method used can be attributed to numerous factors, such as accuracy of the method's applied, subjectivity, sample size and structure, nationality and social status. [27]

Based on the results of this research, it can be concluded that the European Formula using linear regression equation formulated by Cameriere et al is suitable for dental age estimation, although with a slight underestimation. This radiographic method can be recommended for practical application not only in clinical dentistry but also in forensic procedures and social issues in the population.

Conclusion

The estimated age of children by measuring the open apices of the teeth using panoramic radiograph linear regression equation used in the European subjects closely matches with the chronological age in Asian subjects also. Keeping in context to validate more accurately the significance of linear regression equation, there is a need of larger sample size belonging to variety of ethnic and socioeconomic background.

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