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Original communication

Age estimation by measuring open apices of lower erupted teeth in 12–16 years olds by radiographic evaluation

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ABSTRACT

The purpose of this study was to estimate chronological age from panoramic radiographs by measuring open apices of seven right or left mandibular teeth in children of South Indian origin. A total of 101 male and female patients aged between 12 and 16 years were selected. The panoramic radiographs of the patient were indirectly digitised. The variables *N*0, *x*3, *x*4, *x*5, *x*6, *x*7 and *s* were measured using a computer-aided drafting program. Statistical analysis was performed to derive a regression equation for estimation of age. Two variables *x*3 and *x*7 contributed significantly to the fit, yielding the following linear regression formula: Age = 16.025−9.445 (*x*7) + 1.620 (*x*3). Statistical analysis indicated that the regression equation explained 97.5% of total variance (R^2 = 0.975). The median of the residuals was −0.0348 years with an interquartile range (IQR) of 0.2520 years. The derived regression equations from these variables can serve as an invaluable tool in estimating the age of children between 12 and 16 years of South Indian origin.

1. Introduction

Forensic odontology is a vital and integral part of forensic science that is most widely used for identification of the living and deceased persons.[1]

In recent years estimation of age of living persons plays a pivotal role in establishing the identity of the person. Age estimation is imperative in both forensic and clinical work. For forensic purposes, the problem of age estimation concerns how close the actual age is to the minimum age for criminal responsibility in various countries. From a legal perspective, age estimates are carried out to determine whether a suspect without valid identification documents has reached the age of criminal responsibility and whether general criminal law in force for adults is applicable in the particular case. In many countries, the age thresholds of relevance to criminal prosecution lie between 14 and 18 years.[2]

In India the issues of concern are high rate of child marriages, large numbers of child labourers and children trafficked for commercial and sexual exploitation. Most children are forced into these activities and the age estimation in such individuals is therefore crucial.[3] Age estimation also plays an important role in paediatric endocrinology, archaeology and clinical dentistry in orthodontics diagnosis and treatment planning and in developmental disorders.[4]

During the growth of a person, the application of skeletal, odontological, anthropological and psychological methods allows an approximate assessment of age.[5] Among the methods most frequently used for skeletal maturity are those concerning the left hand-wrist area (e.g., Tanner–Whitehouse[6] and FELS[7] methods), which can produce estimates up to the age of 16 years, at which time wrist maturation is completed in 90% of subjects. However, these skeletal methods present some drawbacks in view of the important variability of bone maturation, which is influenced by environmental factors and higher radiation dose. An alternative approach based on dental development is suitable for age determination in children because the calcification rate is controlled more by genes than by environmental factors, and therefore yields lower variability.[8–10] In 2001 and recently in 2008, the Study Group on Forensic Age Diagnostics stressed the study of the dental and skeletal areas as fundamental for age estimation.[11]

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Teeth are most frequently analysed for age estimation. The high number of teeth and the continuous modification of both crown and root in children mean that several methods of age estimation can be applied.[12] In 1973, Demirjian et al.[13] studied one method of age estimation based on dental maturation of third molars on children of French–Canadian origin. Their data were later compared with other sample groups from several nationalities. Most of the results revealed the fact that the standards of dental maturation described by Demirjian et al. are not always suitable for other countries.[14,15] Although these studies validated the method, they also highlighted the need to apply a particular regression model to each country.[12]

In 2006, Cameriere et al.[5] presented a method for assessing chronological age in children based on the relationship between age and measurement of open apices in teeth, which gave reliable estimates of the ages of 455 Italian Caucasian children. The present study was undertaken to assess the chronological age in children aged between 12 and 16 years based on the relationship between age and measurement of open apices of teeth on panoramic radiographs. The purpose of the present research is to derive a specific formula for Indian children based on Cameriere's method.

2. Materials and methods

A total number of 101 patients, 52 males and 49 females, aged between 12 and 16 years (Table 1) were selected from the Dental Outpatient Department of Oral Medicine and Radiology, M. S. Ramaiah Dental College and Hospital, Bangalore. Approval from the ethical committee of the institution was obtained regarding the study. Informed consent was taken from all the parents of the patients explaining the aim and methodology of the study. The patients were subjected to panoramic radiographs as a part of routine diagnostic procedure for their orthodontic treatment between 2008 and 2010.

Individuals with the following conditions were included in the present study. All teeth on the right/left lower jaw should be present, appropriate for the age group of 12–16 years, and either the right or the left lower side of the jaw was considered for study. Individuals should be of ethnic origin from South India (history confirmed up to two generations). Individuals with the following conditions were excluded from the present study: Third molars, radiographs that were unclear showing any pathology on the concerned side of the lower jaw, ex-developmental abnormalities, grossly decayed teeth, tooth fractures, cysts or tumours and patients with previous history of orthodontic treatment.

The radiographs were then digitised using a flatbed scanner (EPSON Perfection V 700 PHOTO), and the images were recorded on computer files.

Table 1
Distribution of study samples by age groups and gender.

Age	Gender		Total
	Male	Female	
12	16	12	28
	57.1%	42.9%	100.0%
13	12	12	24
	50.0%	50.0%	100.0%
14	12	7	19
	63.2%	36.8%	100.0%
15	10	12	22
	45.5%	54.5%	100.0%
16	2	6	8
	25.0%	75.0%	100.0%
Total	52	49	101
	51.5%	48.5%	100.0%

For each individual, the following parameters were considered. The chronologic age of an individual was calculated by subtracting the birth date from the date on which the radiographs were exposed for that particular individual after converting both to a decimal age by the method of Eveleth and Tanner.[16] 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.

The images were processed using a computer-aided drafting program, Adobe Photoshop 7. With the help of Adobe Photoshop 7 the following parameters were calculated with the measure tool. The measure tool is present on the drop down column on the left hand side of the Adobe Photoshop. It was used to measure the length of the tooth and the distance between the open apices. The number of right or left permanent mandibular teeth with root development complete, apical ends of the roots completely closed, was calculated and denoted as (*N*0). In teeth with incomplete root development, and therefore with open apices, the distance between the inner sides of the open apex was measured. For teeth with one root, the distance between the inner sides of the open apex was measured and denoted as *Ai*, where $i = 1, 2, 3, 4, 5$ (1, central incisor; 2, lateral incisor; 3, canine; 4, first premolar; 5, second premolar) (Fig. 1). For teeth with two roots, the sum of the distances between the inner sides of the two open apices is calculated and denoted as *Ai* where, $i = 6, 7$ (6, first molar; 7, second molar) (Fig. 1).

Due to the possible differences in magnification and angulations among X-rays, measurements (*Ai*) were normalised by dividing (*Ai*) by tooth length. Tooth length is measured from the point of highest cusp to the root apex and is denoted as (*Li*) (Fig. 1).

Dental maturity was evaluated using the normalised measurements of the seven right or left mandibular teeth ($xi = Ai/Li$, $I = 1,\ldots, 7$). Therefore, the sum of the normalised open apices is, $S = (x1 + x2 + x3 + x4 + x5 + x6 + x7)$.

Fig. 1. An example of tooth measurement. *Ai*, $i = 1,\ldots, 5$ (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 the distances between the inner sides of the two open apices; and *Li*, $i = 1,\ldots, 7$, is the length of the seven teeth.