

Reliability of panoramic radiography in chronological age estimation


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Introduction

Unquestionable forensic age investigations are based on the statistical models constructed on a sample containing subjects of identical origin as the examined individual.^[1] Chronological age is the actual age of an individual. However, the relationship between growth and chronological age is not linear and therefore the concept of “biological” age is used, which may be expressed as either skeletal age or dental age.

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Abstract

Introduction: There has been a strong relationship between the growth rate of bone and teeth, which can be utilized for the purpose of age identification of an individual. **Aims and Objective:** The present study was designed to determine the relationship between the dental age, the age from dental panoramic radiography, skeletal age, and chronological age. **Materials and Methods:** The study included 270 individuals, averaging between 17 years and 25 years of age from out-patient department of New Horizon Dental College and Hospital, Sakri, Bilaspur, Chhattisgarh, India, for third molar surgery. Panoramic and hand wrist radiographs were taken, the films were digitally processed for visualization of the wisdom teeth. The confirmations of ages were repeated again at an interval of 4 weeks by a radiologist. The extracted wisdom teeth were placed in 10% formalin and were examined by one dental surgeon to estimate the age on the basis of root formation. Student's *t*-test was adopted for statistical analysis and probability (*P* value) was calculated. **Conclusion:** Estimating the age of an individual was accurate by examining extracted third molar. Age estimation through panoramic radiography was highly accurate in upper right quadrant (mean = 0.72 and *P* = 0.077).

Key words: Dental age, forensic science, medico legal cases, panoramic radiograph, skeletal age

Kullman^[2] reported that documentation of birth is one of the most important factors determining chronological age in most developed countries. When the birth date is not known, there will be a strong need to estimate the biological age. The times of appearance and fusion of ossification centers and the size and morphology of different bones such as the neck and wrist are used for estimation of skeletal age. Dental methods for determining biological age are more acceptable than other methods and most of the researchers have used these methods for determining age. These methods have been based mostly on the subjective prediction of radiological stages of dental age.^[2]

Dental age may be expressed in terms of the time of emergence of teeth or the state of maturation of their mineralization.^[3-13]

Age estimation methods using the third molar has proved to play a very significant role in forensic field. Liversidge

and Marsden,^[5] Olze *et al.*,^[6] Schmelting *et al.*,^[7] had found third molar to be significant for estimation of age of an individual using Demirjian or Moorrees root stages and they found that results were associated with significant bias. Kullman *et al.*,^[8] showed that only wisdom teeth are useful for determining age as their maximum developmental age is only after 14 years of age. Eruption of the teeth and their stage of mineralization have been used in dental ageing. It is accepted that the process of mineralization is genetically determined, whereas eruption appears to be affected by systemic influences such as nutrition or local conditions.^[9] Zeng *et al.*,^[10] performed a study and showed significant relationship of Chronological age and third molar mineralization.

Grover *et al.*,^[11] demonstrated a high correlation co-efficient using Willems' method between both chronological and obtained dental age; thus, confirming their potential applicability in the clinical practice and forensic dentistry.

In dentistry, awareness about the growth potential of a patient is one of the most important factors determining the success of orthodontic treatment. In addition, occasionally, the legal system requires an assignment of age so that appropriate procedures may be observed, for example, where there is a legal age for criminal responsibility. In certain countries, criminals lacking birth certificates may be obliged to prove under-age status in order to avoid the death penalty.^[9]

Experience has shown that panoramic radiography is very important for certain diagnoses. It is also useful for determining the completion of the stages of teeth, viewing all the four regions of the jaw in a single radiograph and to know the position of the third molar teeth. The use of radiographs is based on the degree of formation of root and crown structures, the stage of eruption, and the intermixture of primary and adult dentitions.^[11,12] In our view, there are limits to the possibilities of radiographic diagnosis, which may produce errors in the frequency of agenesis and in the rate of third molar calcification; thus, increasing the magnitude of error in age estimation from dentition. Thorson and Powell^[13] indicated the value of completion of third mandibular molars in panoramic radiographs for determining age for young foreigners in Scotland whose exact birthdates were not known.

The present study aimed to identify the relationship between chronological age and biological age using hand wrist radiographs, panoramic radiographs, and examining extracted third molar teeth.

Materials and Methods

This study was conducted as a cross-sectional study and was approved by Ethical Committee of the respective university.

The sample consisted of 270 patients, randomly selected from patients of the age group of 17-25 years known chronological age, referring to a New Horizon Dental College and Research Institute, Sakri, Bilaspur (Chattishgarh) for third molar extraction. Chronologic age of an individual was calculated by subtracting the birth date (based on their official birth certificate) from the date on which the radiographs were exposed for that particular individual. The distribution of the samples in different age groups was as follows: 74 in 17-19 years, 104 in 20-22 years, 92 in 23-25 years.

An inclusion and exclusion criterion for selection of cases for the present study was as follows:

- a. Subjects were clinically free from any developmental, endocrine or nutritional disorder
- b. Subjects were clinically free from any past prolonged illness
- c. Subject should be clinically free from any special dental diseases such as dysplasia of enamel or dentine
- d. Those who had broken teeth during the surgery were excluded from the study
- e. Those who had uncleared radiographs were excluded
- f. Those who had missing third molars were excluded.

The patients' biological age was estimated by three methods:

1. Use of panoramic radiographs for all wisdom teeth seen in radiographs using Demirjian's method.^[14-16] (Demirjian, Goldstein and Tanner rated seven mandibular permanent teeth in the order of the second molar, first molar, second premolar, first premolar, canine, lateral incisors and central incisor and determined eight stages [A-H] of tooth mineralization together with stage zero for nonappearance)
2. Peterson's method is based upon growth and extent of root formation. Roots are approximately 50% formed by the age of 16 years. Usually, the roots are completely formed with an open apex by age 18 years. By the age of 24 years 95% of all third molars that will erupt have completed their eruption^[17]
3. Radiography of the hand (Greulich and Pyle classification consist of radiological examinations of the left hand and wrist of subjects at different stages of skeletal maturation).^[18]

All the panoramic radiographs were taken in New Horizon Dental College and hospital by one technician under similar conditions. After obtaining consent from the patients, the radiographs were taken using Orthophos XG5 Sirona digital machine (Sirona Dental Company, Bensheim, Germany) with 66-72 kvp 15 s 8 mA exposure parameters. The films were digitally processed for visualization of the wisdom teeth. Then the shape of the radiograph and the teeth was drawn with a B2 pencil on a size A4 tracing paper. Then an oral maxillofacial radiologist was calibrated for confirmation of age using these papers. These confirmations

of ages were repeated again at an interval of 4 weeks. To test the agreement for confirmation of age, the required test was performed and reliability (0.87) was confirmed.

The extracted wisdom teeth were placed in 10% formalin and were examined by one dental surgeon to estimate the age on the basis of root formation. A hand-wrist radiograph was taken after informed consent was obtained from patients. These radiographs were taken at the same hospital under similar conditions. Same machine was used with an exposure parameter of 50 kvp 1s 6 mA. Radiologist examined the radiography of the wrist and estimated the biological age based on his observation.

In all three methods, the age estimation was repeated by the same person (without the knowledge of the previous age estimate) at an interval of 10 days for 50 randomly chosen samples to test the reliability of these methods.

Results

The results were compared with actual chronological age to determine the best method for estimating age [Table 1]. Estimated age was lower among all methods compared to chronological age [Tables 1 and 2]. In panoramic radiographs, the least age difference between real and estimated age was found in upper right wisdom teeth ($P = 0.077$) followed by lower right wisdom teeth ($P = 0.053$).

Average difference between the chronological age and estimated age by different methods was calculated. The most unreliable method in the present study was by hand and wrist radiography [Table 3].

Multiple regression analysis showed that statistically significant predictors for age estimation were extracted third molar teeth followed by panoramic radiograph [Table 4].

Our results indicated that there is no significant difference in the age estimate by using age on the basis of visualization of any of the wisdom teeth. Finding the best method for estimation of age in panoramic radiography, different combination of images from wisdom teeth was required and was investigated.

Therefore, the age estimated from the right upper wisdom teeth is the best method used.

Discussion

Forensic method of age estimation is now popular worldwide. Dental identification is one of the accurate methods in the forensic field.^[19] It is commonly observed that for a given chronological age, dental age showed less variability compared to skeletal age. Dental development is less affected than bone by adverse environmental

Table 1: The results of the mean ages by different methods

Method	Details of patients	Number of patients	Mean of age (years)	Standard deviation
Chronological age	Birth certificate	270	20.97	3.330
Panoramic radiograph	Upper left	165	20.06	2.302
	Upper right	266	20.18	2.323
	Lower left	267	20.28	2.376
	Lower right	214	20.13	2.342
Extracted third molar teeth	Upper left	81	20.26	3.427
	Upper right	84	20.85	3.424
	Lower left	105	20.10	3.258
	Lower right	95	20.64	3.392
Hand and wrist radiograph		270	20.52	2.232

Table 2: Statistical analysis of co-relation between the chronological age and estimated age by different methods

Methods	Details	Number	Coefficient correlation	P value
Panoramic radiograph	Upper left	165	0.104	0.185*
	Upper right	266	0.120	0.048**
	Lower left	267	0.004	0.951
	Lower right	214	0.026	0.050
Extracted third molar teeth	Upper left	81	0.113	0.032
	Upper right	84	0.093	0.044
	Lower left	105	0.032	0.001***
Lower right	95	0.010	0.035	
Hand and wrist radiograph		270	0.235	0.021

*Not significant, **Significant, ***Highly significant

Table 3: The average difference between the chronological age and estimated age by different methods

Method	Details	Mean	Standard deviation	t value	P value
Panoramic radiograph	Upper left	0.99	3.723	2.429	0.051*
	Upper right	0.72	4.296	2.740	0.077
	Lower left	0.83	4.081	1.314	0.731
	Lower right	0.82	3.937	3.056	0.053
Extracted third molar teeth	Upper left	1.30	4.368	1.832	0.762
	Upper right	0.83	4.296	1.740	0.087
	Lower left	0.72	4.081	1.314	0.521
	Lower right	0.84	4.658	1.627	0.079
Hand and wrist radiograph		3.672	2.646	1.213	0.003**

*Not significant, **Significant

Table 4: Stepwise multiple regression analysis using age estimation as a dependent variable

Model	R	R square	F value	P value
Age estimation				
1	0.143 ^a	0.025	1.212	0.008**
2	0.165 ^b	0.086	2.142	0.041**
3	0.196 ^c	0.091	2.245	0.852*

^aPredictors: (Constant) extracted third molar teeth, ^bPredictors: (Constant) extracted third molar teeth, panoramic radiograph, ^cPredictors: (Constant) extracted third molar teeth, panoramic radiograph, hand wrist radiograph,

*Not significant, **Significant

circumstances such as nutrition and disturbances of endocrine function.^[20-22] The reasons of less variability in dental age are not fully understood. A possible reason is that the development of all the deciduous dentition and part of the permanent dentition takes place before birth in a protected environment, whereas skeletal growth and development, even though having a strong genetic basis, is exposed for an increasing length of time to external factors such as variations in nutrition, socio-economic status, and possibly climate.

An attempt to identify an individual is an important aspect for solving legal matters, as it helps in imprisoning the correct culprit. Estimation of accurate age also aids in appropriate diagnosis and treatment planning for orthodontic and surgical procedures.^[9]

Various areas of skeleton have been used for age estimation such as: Ankle, hip, elbow, hand wrist, cervical vertebrae.^[23] The hand-wrist radiograph is commonly used for skeletal developmental assessment. Most investigators have found a significant correlation among maturation stages derived from hand-wrist radiographs, changes in height during pubertal growth period, and facial growth.^[2,8,24]

Panoramic radiographs were used to assess dental maturity because they are routinely available in clinics, and the mandibular region is clearly visible. There are a number of standard scales for rating the tooth calcification stage.^[25]

In the present study, multiple stepwise regression analysis showed high accuracy of age estimation by dental method rather than skeletal method. Age estimation was found to be most accurate by extracted wisdom teeth method. However this method cannot be used in living individuals and also in cases where it is not acceptable to extract teeth for religious or scientific reasons. Furthermore, it's an invasive procedure and there may be an inter and intra observer variation. Thus, other methods were used for age estimation. Panoramic radiograph was found to be the most accurate method among these methods.

Our results are similar to the study conducted by Ardakani *et al.*^[9] They found that panoramic radiographs show the maximum percentage of similarity between the chronological age and estimated age from the upper right wisdom tooth (39.4%). In the present study, we also found the upper right wisdom teeth to be most significant ($P = 0.077$) for age estimation.

Grover *et al.*,^[11] Nik-Hussein *et al.*,^[14] and Bagherpour *et al.*,^[15] also demonstrated, accuracy of panoramic radiograph in estimating age in their studies using Demirjian and Willems methods. However, Lewis and Garn^[26] had found hand wrist radiographs to be most accurate in estimating age.

Conclusion

The findings of this study indicate that tooth calcification stages might be clinically used as a maturity indicator of the pubertal growth period.

However, because of the small size of samples in this study, we must be conservative in the interpretation of these results and therefore further studies are recommended in a larger sample size.

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