ORIGINAL ARTICLE

Age estimation and comparison by dental and skeletal maturity in the age range of 9-18 years in the Mumbai region

Hemlata Pandey, Vandana Tripathi[1], Harish Pathak, Sumit K. Choudhary[2], Manoj B. Parchake

Department of Forensic Medicine, Seth Gordhandas Sunderdas Medical College and King Edward Memorial Hospital, [1]Department of Pedodontics and Preventive Dentistry, Government Dental College, Mumbai, Maharashtra, [2]Department of Forensic Science, Raksha Shakti University, Ahmedabad, Gujarat, India

Address for correspondence:
Dr. Manoj B. Parchake, Department of Forensic Medicine, Seth Gordhandas Sunderdas Medical College and King Edward Memorial Hospital, Parel, Mumbai - 400 012, Maharashtra, India.
E-mail: manoj.parchake@kem.edu

Abstract

Background: Age estimation is crucial in the identification of juveniles in conflicts with law, survivor of sexual assault, sportsperson, and civil cases. **Aims:** To estimate and compare the age (9–18 years) by dental and skeletal maturity in the Mumbai region. **Settings and Design:** This was a cross-sectional study. **Materials and Methods:** A total of 70 cases from 9 to 18 years of age were studied in 1 year in the urban population of the Mumbai region. Among 70 cases, 45 were males and 25 were females. Orthopantomogram and elbow joint radiographs were taken to assess the dental age through modified Demirjian's method and the radiological age through Sangma *et al*. staging method, respectively. **Statistical Analysis:** Data were analyzed using SPSS Statistics Version 26; descriptive statistics and regression statistics were used in the study. **Results:** Dental age by Demirjian's method in males with standard deviation was 15.25 (2.17), with a mean difference of 1.08 and significant $P = 0.03$. However, in females, dental age by Demirjian's method with standard deviation was 14.30 (1.94) with a mean difference of 0.74 and insignificant $P = 0.07$. Interclass correlation coefficient of dental age with chronological age, in males and females, showed 0.85 and 0.87 correlation, respectively. Correlation between the skeletal maturity and the dental age was reflected by the association of Demirjian stage 9 in the second molar with radiological stage 5 in males and stage 4 in females. **Conclusions:** It was concluded that Demirjian's method shows a significant correlation and *P* value for the age estimation in males of the Mumbai region.

Key words: Age estimation, Demirjian, dental and skeletal maturity, Mumbai

Introduction

Age estimation or age verification is one among the most common requisitions sent to forensic medicine departments by investigating agencies. Although age estimation is carried out for biological profiling of unknown bodies, it is also required to be done in living persons for various reasons. Some of the most common queries for age

Access this article online	
Website: www.jfds.org	Quick Response Code
DOI: 10.4103/jfo.jfds_90_19	

Submitted: 26-Nov-19 **Accepted:** 10-Mar-20
Published: 03-Jun-20

How to cite this article: Pandey H, Tripathi V, Pathak H, Choudhary SK, Parchake MB. Age estimation and comparison by dental and skeletal maturity in the age range of 9–18 years in the Mumbai region. J Forensic Dent Sci 2019;11:142-6.

estimation involve legal aspects such as age of consent, age for criminal responsibility, abduction, trafficking, and victims or perpetrators of child abuse. Hand-wrist radiographs, elbow joint radiograph, pelvis, and shoulder joint are used often for skeletal age estimation in the age group of 10–18 years.

Previously, tooth emergence which is popularly known as eruption sequence was the technique employed for dental age estimation. Although this technique is considered to be convenient and less time-consuming as compared to other methods, radiographic methods studying tooth mineralization have been accepted to be a far superior technique in terms of accuracy, especially after 12 years of age. Since mineralization of the tooth is a continuous process, various stages of the development can be studied as it is done for the appearance of ossification centers and union. It has also been observed that although tooth emergence may be affected by external factors, the mineralization of the teeth is comparatively independent of external factors and hence a better evaluator. Age estimation reporting is a comprehensive process including assessment of bone ossification, dental development, physical maturity, and psychological maturity. Although physical maturity and psychological maturity are not as reliable as skeletal and dental age, they provide an overall assessment for comprehensive reporting. In India, age estimation is commonly required (1) to assess issues such as criminal responsibility, judicial punishment, kidnapping, sexual assault, medical termination of pregnancy, criminal abortion, and infanticide and (2) to determine competency as a witness, senior citizen concession, retirement disputes, and verification of any document for age proof.

Since there is a literature debate regarding the relationship between skeletal and dental maturation, the current study is focused on comparing the chronological, dental, and skeletal age in the range of 9–18 years. No such study has been previously done in the population of the Mumbai region. Hence, the present study aims to estimate and compare chronological, dental, and skeletal age in the Mumbai region.

Materials and Methods

Study design and setting

This cross-sectional study on age estimation was conducted from January 2017 to December 2017 at Seth Gordhandas Sunderdas Medical College and King Edward Memorial Hospital, Mumbai.

Study population and main selection criteria

Children and adolescents who came for age estimation for the purpose of playing sports during the study period in the age range of 9–18 years were included. Subjects without any congenital anomaly or bone lesion and no previous tooth extraction were selected.

Sample size

A total of 70 cases were included in the study. Of 70 cases, 45 cases were males and 25 were females.

Data collection procedure

Participants were selected as per the selection criteria and then sent for orthopantomogram (OPG) and elbow joint radiograph. Tooth calcification was assessed by modified Demirjian's method in which the mineralization was divided into 10 stages from 0 to 9.[1-3] Elbow joint was used to estimate the radiological staging and age through Sangma *et al*. staging method.[4] Demirjian stage of the left mandibular second molar was used to compare the stages of the left elbow joint. Measurements were made in a dimly lit room to improve the readings on both the radiographs. The elbow radiographs were assessed by forensic medicine experts, and dental radiographs were assessed by dental experts [Figures 1 and 2].

Tooth calcification was assessed by modified Demirjian's method:[1-3]

- Stage 0
  - Dental calcification has not yet begun.
- Stage 1
  - The bone crypt has formed, but no sign of the tooth germ.

Figure 1: Stage 3 radiograph of elbow joint

Figure 2: Panoramic radiograph (orthopantomogram)

- Stage 2
  - In both uniradicular and multiradicular teeth, a beginning of calcification is seen at the superior level of the crypt, in the form of inverted cone or cones. There is no fusion of these calcified points.
- Stage 3
  - Fusion of the calcified points forms one or several cusps, which unite to give a regularly outlined occlusal outline.
- Stage 4
  - Enamel formation is complete at the occlusal surface. Its extension and convergence toward the cervical region are seen
  - The beginning of dentinal deposit is seen
  - The outline of the pulp chamber has a curved shape at the occlusal border.
- Stage 5
  - The crown formation is completed down to the cementoenamel junction
  - The superior border of the pulp chamber in the uniradicular teeth has definite curved form, being concave toward the cervical region. The projection of the pulp horns, if present, gives an outline like an umbrella top. In molars, the pulp chamber has a trapezoidal form
  - Beginning of the root formation is seen in the form of a spicule.
- Stage 6
  - Uniradicular teeth
    - The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage
    - The root length reaches at least one-third of the crown height.
  - Multiradicular teeth
    - Initial formation of the radicular bifurcation is seen in the form of either a calcified point or semilunar shape
    - The root length reaches at least one-third of the crown height.
- Stage 7
  - Uniradicular teeth
    - The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape
    - The root length is equal to or greater than the crown height.
  - Multiradicular teeth
    - The calcified region of the bifurcation has developed further down from its semilunar stage to give roots a more definite and distinct outline, with funnel-shaped endings
    - The root length is equal to or greater than the crown height.
- Stage 8
  - The walls of the root canal are now parallel (distal root in molars)
  - The apical ends of the root canals are still partially open (distal root in molars).
- Stage 9
  - The apical end of the root canal is completely closed (distal root in molars)
  - The periodontal membrane has a uniform width around the root and apex.

Following ossification events were determined by Sangma *et al*. staging method:[4]

- Nonunion – When the epiphyseal cartilage did not begin to decrease in thickness
- Commence of union – When the thickness of epiphyseal cartilage was found to be reduced appreciably (one-fourth united)
- Incomplete union – When the epiphysis has begun to fuse with shaft and complete union was well underway (one-half united)
- Complete union by epiphyseal scar – When the epiphyseal cartilage was bony in architecture and its density indistinguishable from the epiphysis and diaphysis in its neighborhood, but an epiphyseal line called epiphyseal scar could still be distinguished
- Complete union without epiphyseal scar – With the absence of epiphyseal scar.

Reliability test

Intraobserver study

The two observers scored elbow joint radiographs almost identically with a gap of 60 days. One observer had two cases out of 30 where the age scored differed with an underestimation of 6 months and 1 year. Second observer had only one case out of 30 where the age scored differed with an overestimation of 1 year.

Dental radiographs were scored by observer 1, with differing score in three cases with underestimation by 4 and 7 months in two cases and overestimation of 6 months in one case. Second observer presented differing scores in two cases with overestimation by 4 and 6 months.

Interobserver study

The interobserver study was based on 20 scores recorded the first time during the intraobserver test.

There was no significant difference found between age estimation by elbow radiographs and dental radiographs between both the observers with $P = 0.076$ and $P = 0.071$, respectively.

Statistical analysis

Data were analyzed using IBM SPSS Version 26, USA statistics program; descriptive statistics and regression statistics were used in the study. The probability of significance was set at 5%.

Results

Of 70 cases, 45 were males and 25 were females [Table 1]. The mean and standard deviation with chronological age in males were 14.17 and 1.92, respectively, and in females were 13.56 and 1.72, respectively.

Table 2 shows that the mean with standard deviation of dental age by Demirjian's method in males was 15.25 (2.17) with a mean difference of 1.08 and significant $P = 0.03$. Similarly, in females, the mean dental age by Demirjian's method with standard deviation was 14.30 (1.94) with a mean difference of 0.74 and insignificant $P = 0.07$. As shown in Table 3, interclass correlation coefficient of dental age with chronological age in males and females showed 0.85 and 0.87 correlation, respectively.

According to Table 4, the distribution of skeletal maturity stage and Demirjian's stage in males showed 100% agreement of stage 5 of skeletal maturity with stage 9 of the second molar by Demirjian's staging. Further, stage 4 showed 90% correlation with stage 9 of the second molar by Demirjian's staging. Skeletal maturity stage 1 showed 50% agreement with stage 5 of the second molar. As shown in Table 5, the distribution of skeletal maturity and Demirjian stage in females showed 66.67% agreement of skeletal maturity stage 5 with stage 9 of the second molar; further, stage 4 showed 100% agreement with stage 9 of the second molar.

Discussion

Age estimation is critical for juveniles in conflicts with law in India. Majority of age estimation in India is carried out for juveniles in conflicts with law because of lack of birth proof or nonreliability on documents. Even though various methods for the age determination do exist, a universal system has not been developed due to the constantly changing differences in different ethnic population groups.[5] Demirjian's method of dental age estimation is the most extensively researched and applied technique, because of its easiness as well as radiographic and schematic pictures of the tooth development and accompanying description.[6] Skeletal age is frequently used as an investigative tool for the evaluation of endocrine, orthopedic, and various genetic disorders. As regards bone mineralization, the growth of numerous parts of the body and also the presence of ossification centers, size, morphology, and fusion can also be used for age estimation.[6]

In the present study, dental age estimation done using modified Demirjian's method showed high accuracy with an overestimation of 1.08 years in males and 0.74 years in females when applied to the population of 9–18 years of age group. Similar results were obtained from the studies conducted by Hegde and Sood,[7] Koshy and Tandon,[8] and Prabhakar *et al*.,[9] who recorded an overestimation of 3.04, 0.14, and 1.20 years for males and 0.04, 2.82, and 0.90 years for females, respectively, in different Indian populations.[7-9] This overestimation of dental age using Demirjian's method may be due to progressive secular trend in the growth and development, different socioeconomic status, nutritional and ethnic background, and standard tables developed for French–Canadian population.[10]

Table 1: The distribution of chronological mean age and standard deviation as per sex

Sex	*n*	Mean (SD)
Males	45	14.17 (1.92)
Females	25	13.56 (1.72)
Total	70	13.97 (1.86)

SD: Standard deviation

Table 2: The comparison between mean chronological age and dental age by modified Demirjian's method

Sex	Chronological mean age	Mean Demirjian age (SD)	Mean age difference	*P*
Males	14.17	15.25 (2.13)	1.08	0.03
Females	13.56	14.30 (1.94)	0.74	0.07

SD: Standard deviation

Table 3: The interclass correlation coefficient of dental age

Sex	ICC dental
Males	0.85
Females	0.87

ICC: Interclass correlation coefficient

Table 4: The association between Demirjian's stage of the mandibular second molar and skeletal maturity stage of elbow joint in males

Skeletal maturity of elbow joint	Demirjian stage of the mandibular second molar (%)			
	6	7	8	9
1	5 (55.55)	4 (44.44)	0	0
2	4 (44.44)	3 (33.33)	2 (22.22)	0
3	0	1 (100)	0	0
4	0	0	1 (10)	9 (90)
5	0	0	0	16 (100)

$P<0.05$

Table 5: The association between Demirjian's stage of the mandibular second molar and skeletal maturity stage of elbow joint in females

Skeletal maturity of elbow joint	Demirjian's stage of the mandibular second molar (%)			
	6	7	8	9
1	2 (66.66)	1 (33.33)	0	0
2	3 (42.86)	4 (57.14)	0	0
3	0	2 (50)	2 (50)	0
4	0	0	0	1 (100)
5	0	0	2 (33.33)	6 (66.67)

$P>0.05$

In the present study, a mean difference of 1.08 years in males and 0.74 in females between the estimated dental and chronological ages was found, but the age difference was found to be statistically significant in males and insignificant in females. Thus, in accordance with our study, Demirjian's method should be applied with caution to Indian females. This might be due to the fact female samples were less as compared to males. There are many studies that have used mandibular third molars for dental age assessment, but these have a few limitations.[11,12] The third molars are frequently found to be congenitally missing in human dentition, and it has been observed that development and eruption of third molars are variable.[13] Hence, these teeth are less reliable for age estimation.

In the present study, mandibular teeth from the left quadrant were used for age estimation as per the technique employed. The teeth absent on the left quadrant were observed on the right quadrant.[13] The assessment errors are less frequent in the mandibular molars than in the maxillary molars as maxillary molar roots usually overlap with anatomic structures, such as the zygomatic arch, maxillary sinus, or inferior border of zygomatic process, which makes the observation of roots difficult.[12,13]

The association between skeletal maturity of elbow joint and Demirjian's stage shows significant agreement between stage 5 of skeletal maturity and stage 9 of second molars in males. To the best of our knowledge, there was no study conducted in the Indian population comparing skeletal maturity of elbow joint and Demirjian's method in the Indian population. It is a well-known fact that elbow joint is commonly employed for age estimation in medicolegal cases in India. Various studies done by Galstaun,[14] Basu and Basu,[15] Hepworth,[16] Lal and Nat,[17] Pillai,[18] and Flecker and Franklin[19] showed elbow joint very useful in the estimation of age.

Conclusions

Demirjian's method shows a significant correlation and *P* value for the age estimation in males of the Mumbai region. In females, Demirjian's method was insignificant although with good correlation. Correlation between the skeletal maturity and the dental age was reflected by the association of Demirjian stage 9 for second molar with radiological stage 5 in males and stage 4 in females. Thus, to reduce the radiation exposure to children and adolescents, OPG and X-ray of the elbow joint can be used to estimate age with good accuracy. Since there was no significant difference found between intraobserver and interobserver readings, these techniques are scientifically reliable and can be substantial for forensic purposes.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Chaillet N, Demirjian A. Dental maturity in South France: A comparison between Demirjian's method and polynomial functions. J Forensic Sci 2004;49:1059-66.
2. Acharya AB. Age estimation in Indians using Demirjian's 8-teeth method. J Forensic Sci 2011;56:124-7.
3. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol 1973;45:211-27.
4. Sangma WB, Marak FK, Singh MS, Kharrubon B. A roentgenographic study for age determination in boys of North-Eastern region of India. J Indian Acad Forensic Med 2006;28:55-9.
5. Shilpa PH, Sunil RS, Sapna K, Kumar NC. Estimation and comparison of dental, skeletal and chronologic age in Bangalore South school going children. J Indian Soc Pedod Prev Dent 2013;31:63-8.
6. Bagherian A, Sadeghi M. Assessment of dental maturity of children aged 3.5 to 13.5 years using the Demirjian method in an Iranian population. J Oral Sci 2011;53:37-42.
7. Hegde RJ, Sood PB. Dental maturity as an indicator of chronological age: Radiographic evaluation of dental age in 6 to 13 years children of Belgaum using Demirjian methods. J Indian Soc Pedod Prev Dent 2002;20:132-8.
8. Koshy S, Tandon S. Dental age assessment: The applicability of Demirjian's method in south Indian children. Forensic Sci Int 1998;94:73-85.
9. Prabhakar AR, Panda AK, Raju OS. Applicability of Demirjian's method of age assessment in children of Davangere. J Indian Soc Pedod Prev Dent 2002;20:54-62.
10. Macha M, Lamba B, Avula JS, Muthineni S, Margana PG, Chitoori P. Estimation of correlation between chronological age, skeletal age and dental age in children: A cross-sectional study. J Clin Diagn Res 2017;11:ZC01-4.
11. Garn SM, Lewis AB, Bonne B. Third molar formation and its development course. Angle Orthod 1962;32:270-9.
12. Cho SM, Hwang CJ. Skeletal maturation evaluation using mandibular third molar development in adolescents. Korean J Orthod 2009;39:120-9.
13. Kumar S, Singla A, Sharma R, Virdi MS, Anupam A, Mittal B. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod 2012;82:501-6.
14. Galstaun G. A study of ossification as observed in Indian subjects. Ind J Med 1937;25:267-324.
15. Basu SK, Basu S. Medico-legal aspects of determination of age of Bengali girls. Ind Med Res 1938;58:97-100.
16. Hepworth SM. Determination of age in Indians from a study of ossification of ossification of the epiphysis of long bones. Ind Med Gaz 1939;74:614-6.
17. Lal R, Nat BS. Age of epiphyseal union at the elbow and wrist joints among Indians. Indian J Med Res 1934;21:683-9.
18. Pillai MJ. The study of epiphyseal union for determining the age of South Indians. Indian J Med Res 1936;23:1015-7.
19. Flecker H. Roentgenographic observations of the times of appearance of epiphyses and their fusion with the diaphyses. J Anat 1933;67:118-64.