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ORIGINAL ARTICLE

Third Molar Development Reliability for Radiographic Age Estimation (Demirjian's Method)

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ABSTRACT

Background: The determination of age after a person has died is a potential stage in the postmortem profiling process that leads to definitive identification. Demirjian's method, designed for use with children, establishes maturity scores as a function of age using eight developmental stages and polynomial functions to estimate age as a function of the score.

Aim: This study's purpose was to examine the accuracy of age estimate by employing Demirjian's eight teeth approach following French maturity scores & an Indian-specific formula generated from third molar growth phases by use of orthopantomograms.

Materials and Methods: 30 participants, each with a known chronological age and gender, had dental panoramic tomograms taken, which were then assessed using Demirjian's standards. The Indian method and the Demirjian formula were used to calculate ages. The P values obtained from the statistical analysis, which included the Chi-square test and the ANOVA test, were statistically significant.

Results: Both Indian and Demirjian's formulations had an average underestimate of age. Since the Indian method had a reduced mean absolute error, it may be used to estimate ages Additionally, females complete dental development sooner than boys do since they were faster to reach dental maturity.

Conclusion: If population-specific formulae are developed using regression analysis and ethnic and environmental variance is taken into account, more accuracy may be attained.

Keywords: chronological age, dental maturity, panoramic, radiographs, third molar,

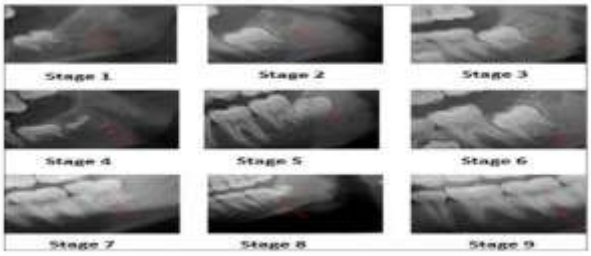
INTRODUCTION

It is possible to estimate the age of a person whose age is unknown by using either stomatological or osteological procedures based on the analysis of body remains. It was essential to utilize a person's teeth to determine their age after death since teeth are more likely to be maintained than other types of identification. The process of dental aging has generated a significant amount of interest in the fields of dental anthropology and forensic medicine. Gustafson was the first to establish a microscopic method for measuring age utilizing a 0-3 point scale and histological analysis of pulverized thin slices of teeth. Dental age assessment techniques are especially beneficial since teeth are very resistant to mechanical, chemical, and physical attacks as well as time. Furthermore, an individual's dietary, medical, environmental, and lifestyle characteristics have a minimal influence on dental age projections. There are three types of dental age-related factors: developmental, morphological, and biochemical changes in the teeth. (1)

As the body matures, height, weight, bone ossification, tooth eruption, and secondary sex traits appear. Many of these changes (height and weight) are too unpredictable to be used to determine age, but others are constant and have been used by medico-legal professionals. During this stage, teeth (primary and secondary), bones ossify, and secondary sex traits emerge. Before age 20, the age estimate is far more accurate. After this age, age estimates become less accurate. (2)

Teeth are the strongest parts of the human body, making them resistant to external effects such as severe temperatures, and other extreme circumstances, enabling them to be utilized after death for extended periods. Furthermore, teeth may be used to determine a person's age. These two factors enable us to determine age using human teeth in forensic investigations. The production, mineralization, and maturation of children's teeth occur following a predetermined schedule that has been the subject of much investigation throughout human history. (3)

In this context, Demirjian et al. divided tooth development into eight stages [Table/Fig-1] and developed an age prediction approach [Table/Fig-2,,3] (4) Demirjian devised a grading system based on tooth development [Table/Fig-1]. This approach is dependable since it does not rely on tooth eruption. Tooth eruption as an estimate of dental age has limits. Tooth eruption is significantly impacted by environmental variables such as dental arch space, deciduous antecedent removal, tooth tilting or impaction, etc. Instead, estimating dental age based on tooth development is more accurate since extrinsic factors have less effect on tooth growth. Teeth grow in stages.



The stages of growth of the mandibular third molar are seen in this radiograph.

Chronology of tooth development

Maxillary (Upper) Teeth					
Primary teeth	Central incisor	Lateral incisor	Canine	First molar	Second molar
Initial calcification	14 wk	16 wk	17 wk	15.5wk	19wk
Crown completed	1.5mo	2.5mo	9mo	6mo	11mo
Root completed	1.5 yr	2 yr	3.25 yr	2.5yr	3 yr
Mandibular (Lower) Teeth					
Initial calcification	14 wk	16 wk	17 wk	15.5wk	18wk
Crown completed	2.5 mo	3mo	9mo	5.5mo	10mo
Root completed	1.5yr	2 yr	3.25 yr	2.5yr	3 yr

Figure/table 3

Maxillary (Upper) Teeth								
Permanent	Central incisor	Lateral incisor	Canine	First premolar	Second premolar	First molar	Second molar	Third molar
teeth	3-4mo	10-12mo	4-5mo	1.5-1.75yr	2-2.25yr	At birth	2.5-3 yr	7-9yr
Initial calcification	4-5yr	4-5yr	6-7yr	5-6yr	6-7yr	2.5-3yr	7-8yr	12-16yr
Crown completed	10 yr	11yr	13-15yr	12-13yr	12-14yr	9-10yr	14-16yr	18-25yr
Mandibular (Lower) Teeth								
Initial calcification	3-4mo	3-4mo	4-5mo	1.5-2 yrs	2-2.25yr	At birth	2.5-3 yr	8-10yrs
Crown completed	4-5yr	4-5yr	6-7yr	5-6yr	6-7yr	2.5-3yr	7-8yr	12-16yr
Root completed	9yr	10yr	12-14yr	12-13yr	13-14yr	9-10yr	14-15yr	18-25yr

Age estimation is an important feature in practically all medico-legal forensic science investigations. Dental data may be utilized to identify disaster victims, anthropological identification, sexual assault cases, weddings, rape cases, consumer complaints, etc.

The goal of this research was to see how important radiographic examination of third molar growth is in determining age and to use Demirjian's technique to link chronological age with dental age.

METHODOLOGY

Dental panoramic tomograms from 30 orthodontic patients whose ages and sexes were known were collected for this study from the department of orthodontics. The individuals were separated into five age groups according to their age, which ranged from 10 to 30 years old: 10 to 15, 15 to 20, 20 to 25, and 25 to 30.

Because men and women had distinct development rates, each tooth's maturity score was gender-specific. Because of this, the orthodontic sample was divided depending on the genders of the people who participated in the study. The sample of each gender was divided into four subgroups to examine the accuracy of the third molar age estimation. This is because the third molar is the only one that is presently developing regularly.

The use of panoramic radiographs was made possible by the fact that they need less radiation than full mouth radiographs and are simpler to take in young or apprehensive children than intraoral radiographs. They create a somewhat distorted image of the mandibular area, but this is not a major problem because our grading method is based on relative values and form criteria rather than on exact lengths. (4)

Healthy children and teens aged 10 to 30 with all teeth on the left or right mandible were included. Mandibular hypodontia, poor radiological quality, image abnormalities that distorted the third molar, and crowding were exclusion criteria. These illnesses might affect the development and presence of wisdom teeth. (5)

Stage A: Although have not solidified, cusp tips are mineralized.

Stage B: The integrated mineralized cusps provide for a characterized mature coronal morphology.

Stage C: The pulp chamber is evident, the crown is around halfway complete, and dentinal deposition is taking place.

Stage D: To the junction of the dentine and enamel, crown formation is complete. The pulp chamber is trapezoidal, and the crown is about halfway developed.

Stage E: The first stages of the inter-radicular bifurcation have been initiated. The length of the root is less than the length of the crown.

Stage F: Root length is at least as great as crown length. Roots have funnel-shaped endings.

Stage G: Root walls are parallel, but apices remain open.

Stage H: The periodontal membrane has a consistent width around the root, and the apical ends of the roots are closed.

The eight phases of calcification used in the original Demirjian's approach indicate the calcification of the seven left permanent mandibular teeth's crown and roots up to the point of apex closure. The third molar was included in the improved approach, increasing the capability of prediction to 18 years and beyond. Therefore, Demirjian's modified approach was used in the current investigation. According to Demirjian et al., orthopantomograms (OPGs) were used to assess the developmental phases of all eight teeth located in the mandibular left quadrant, from A to H. The stage was assigned to each tooth using the modified Demirjian approach. To create mathematical models, Demirjian et al. gave physiologically weighted scores for each of the eight tooth phases. (6) Demirjian et al. predict that tooth development patterns will be comparable across populations, hence maturity ratings will be similar (1973). Demirjian et al. that their maturity score technique is used widely. Disparities are only apparent when converted to dental ages using regression analysis for each group. (4) Demirjian's maturity ratings were therefore employed in the current research for the various phases of eight teeth independently for boys and girls. Dental maturity scores are rescaled linearly to 100 based on the total of the scores for each tooth. (7)

Demirjian advised replacing a lost tooth on the left side with a tooth that is homologous to it or on the opposite side. However, Demirjian's approach cannot determine age or a maturity score if a tooth is absent bilaterally.

The following are the formulae employed in the current study: The formula by Demirjian

Males: Age = (0.000055 × S3) – (0.0095 × S2) + (0.6479 × S) – 8.4583

Females: Age = (0.0000615 × S3) – (0.0106 × S2) + (0.6997 × S) – 9.3178

Indian-specific formula (Acharya):

Males: Age = 27.4351 – (0.0097 × S2) + (0.000089 × S3)

Females: Age = 23.7288 – (0.0088 × S2) + (0.000085 × S3)

An ordinal scale was used to examine different development phases. Polynomial regression analysis was utilized in this work to compute ages using Equation 1, developed by Demirjian et al. for the French population, and Equation 2, developed by Acharya et al. for the Indian population. Estimates of ages, as well as discrepancies between them and their respective means and standard deviations, were included in the data that was produced. The analysis of variance (ANOVA), Pearson's correlation coefficient, and the Chi-square test were used to compare the estimated ages produced by the two formulae, as well as differences between the sexes. P 0.05 was decided to be the appropriate threshold of statistical significance. In the current population, the reliability and accuracy of different age estimate approaches were compared. The average discrepancies between the true and forecasted ages demonstrate accuracy. SPSS 12.0 statistical software was used for all statistical analyses.

RESULTS

30 participants made up the study group, with 7 (23.33%) men and 23 (76.66%) women. The age ranges of the subjects were from 10 to 15 years old, with 1 (10%) male and 9 (90%) females; from 15 to 20 years old, with 5 (27.78%) men and 13 (72.22%) females; and from 20 to 25 years old and 2 to 30 years old, respectively [Table 1].

Table 1: Subject's distribution according to sex and age

Age group	Females	Males	Total
10.1-15	9	1	10
15.1-20	13	5	18
20.1-25	1	0	1
25.1-30	0	1	1

The MAE for the age groups using the Indian method was 1.10, 0.44, -1.18, and -6.73, which was statistically significant (P 0.0001). Demirjian's approach produced MAEs of –0.55, –2.58, –4.99, and –9.84. (P 0.0001). [Table 2] illustrates the Indian formula's mean error (0.37 vs. -2.22).

Table 2: By using the Indian and demirjian formula, compare the chronological and estimated age in orthodontic group

Age group	Subject	Mean chronologic age	Indian method for the median estimated age	Mean age as determined by the Demerjian formula	Indian method for the difference between estimated and chronological age	Demirjian method for the difference between estimated and chronological age
10-15	10	13.20	14.31	12.66	1.10	-0.55
15-20	18	17.12	17.56	14.45	0.44	-2.58
20-25	1	20.25	19.07	15.26	-1.18	-4.99
25-30	1	26.17	19.44	16.33	-6.73	-9.84
p-values			<0.0001	<0.001	<0.001	<0.001

As a result, both the Indian and Demirjian formulae may be used to estimate age in the 10–20 years age range, with the Indian method being more successful than the Demirjian model.

When the error in predicting age using the Indian formula and the Demirjian formula were compared for men and females, the MAE for the Indian formula was found to be –0.65 for males and 0.68 for females. The Demirjian method, on the other hand, had an MAE that was 0.68 1±.189. According to Demirjian's calculation, the MAE was determined to be –2.90 ±3.205 for males and –2.02 1.519 for women, and the difference between the two was statistically significant (P = 0.011) [Table 3].

Table 3: Errors in determining age in the orthodontic group's men and females using the Indian and Demirjian formulas

3rd molar's developmental stage	NO	Males Mean age	No	females Mean age
C	1	13.57	6	13.39
D	1	15.15	10	14.99
E	4	17.5	1	18.46
F	0		3	18.50
G	0		2	19.51
H	1	26.7	1	19.42

With just a little underestimate (-0.65 years) in men and an overestimation (0.68 years) in females, the Indian formula was thus more accurate in estimating age (P = 0.071). Demirjian's method is less trustworthy since it underestimated ages in both men and females by around 2-3 years and provided a significant age disparity.

Men and females' third molars mineralized at about identical rates between the ages of 13 and 15, according to the mean chronological age and standard deviation for both sexes. Stage H was obtained sooner in females, indicating that third molar development in females was complete earlier than in males [Table 4].

Table 4: Men and women in the orthodontic group's average and standard deviation for the phases of mandibular third molar mineralization

Gender	Subject	Chronological age	Mean age as determined by the Demerjian formula	Using the Demerjian formula, the mean absolute error
Males	7	17.84	14.94	-2.90
Females	23	15.72	13.71	-2.02
p-values			0.021	0.011

DISCUSSION

The formation of a tooth is a continuous and progressive process that may be investigated radiographically at any step, beginning with the crypt stage and continuing until the root apex. When a tooth has reached its last stage of mineralization and has emerged from the gums, it transforms into a solid entity that is resistant to destruction even after death. In forensic and archaeological settings, it may be used to make age determinations for both adults and children. (8)

The development of the third molar occurs continuously over a longer length of time and continues until a later age than the development of the other teeth, providing it a specific advantage over the other types of tooth development in this respect. It is possible to estimate a child's age at the prenatal, neonatal, and early postnatal stages using histological (up to 12 weeks in utero) and radiological procedures, respectively (which indicate mineralization patterns). The legal repercussions of feticide and infanticide are significantly altered as a consequence of this factor. (9) The age of children and teenagers is determined by tooth emergence and dental calcification. These are two of the procedure's most crucial elements. To establish age, both morphological and radiographic approaches have been instrumented. The Demirjian technique is by far the most popular of them. having a significant influence on the interpretation and application of juvenile law. (10)

Forensic dentistry for newborns and teenagers is based on an analysis of eight stages of tooth calcification, developed by Demirjian et al. (1973) in the 1970s. It involves analyzing the seven left permanent mandibular teeth to reveal crown and root calcification from crown opening to apex closure. (11, 12) The third molar was excluded from the research conducted by Demirjian and Goldstein (1973) because it is often extracted and has the greatest amount of diversity in both its development and its eruption. However, to determine an individual's age, only the third molar can offer an accurate projection beyond the age of 16; other factors used to determine age are not as reliable. (13)Due to its propensity to be congenitally absent and the great diversity in its development, the previous approach had the disadvantage of excluding the third molar. (4) Although it is one of the few predictors for the age range of 16-23 years, the third molar was included in the original method so that it could be used up to 18-23 years. However, it is still mostly used for determining age between 16 and 23 years. The development of the root of the third molar is one indicator that a person is at least 18 years old. This approach cannot be used to estimate age in higher age groups since the growth of a person's third molar is complete by the time they are 24 to 25 years old.

Demirjian et al radiography's approach was utilized to determine age between 10 and 30 years. Using Indian-specific polynomial formulae, ages were calculated. Results were compared to the original formula ages. The original formulas were utilized to compute ages since this approach is population-specific. The MAE, determined as the difference between the expected age and actual age at exposure, highlights age prediction accuracy. Age at exposure determines this difference. The MAE is a typical metric for evaluating age estimation approaches in research. MAE decreases accuracy. (13) An estimate of the accuracy may be obtained by calculating the proportion of radiographic age guesses that fell within the error categories of one year, between one and two years, and more than two years. Because several authors, including S. Ritz-Timme and H. Mornstad, have referred to errors of 1 as "good results," for the sake of this inquiry, estimates with such errors have been labeled as "accurate." (11) In the field of forensic age prediction of young persons, errors of more than two years have been labeled as "inaccurate" because they are deemed unacceptable. There were a total of 30 participants in the orthodontic study, ranging in age from 10 to 30 years old, with 23 (or 76.66 percent) girls and 7 (or 23.33 percent) men. The completion of the third molar at this age was the foundation for the age limitation that was placed on the child.

The Indian method may be used to calculate age in the present population of 10-20 years, with a 6-12 (1 year) month "acceptable" overestimation. Current research verified this by

comparing chronological age and estimated age in the orthodontic group using Indian and Demirjian's methods. 60% (18 out of 30) of this group's members were within one year of their real age, 36% (11 out of 30) were within two years, and 4% were older than two years. Due to demographic differences in the Indian subcontinent, dental development in males and girls ends around 20 and 21 years, respectively. If the sample population was under 22, the error may be lower. According to Acharya and Kumar, the MAEs were lower in the younger age group, suggesting that third teeth are only present in people between the ages of 16.1 and 23. This leads to a higher error in age estimate. Beyond the age of 21, the MAE had furthermore increased significantly to 5–6 years with just two samples. The lack of samples and the conclusion of third molar development are cited as the causes. This conclusion agreed with that made by Kumar and Gopal (2011). (5) When Demirjian's method was used, the age was often understated. According to Acharya, this was the case (2011). In contrast to other research (Prabhakar 2002 (14) conducted on the Indian population, where an average overestimation was noted, our results showed an underrepresentation of the population. Environmental variables, such as socioeconomic level, nutrition, and dietary habits that differ across various demographic groups, might be to blame for this discrepancy. (15-17) the dental and skeletal maturation might suffer from starvation, according to Warhekar et al. (2011). (18) When Demirjian's algorithm was used, age underestimates were more common. The variation in racial makeup and/or the length of time between two studies on the dental development of these kids may be used to explain why the estimated dental ages of French-Canadian children and the general population are different.

The Indian method may be used to estimate age in the current population, but population-specific formulas must be constructed to correct the inaccuracy, according to a comparison of the MAEs of the two formulas. To do this, regression analysis must be performed using the correlation coefficient as the dependent variable and each person's overall maturity score as the independent variable. (19)

Men in the orthodontic group were better at guessing age using the Indian formula than women, with an MAE of 0.65 in men and 0.7 in women. This matched Acharya's sword's positions (7)

The orthodontic group analyzed the mineralization stages of the third molars in males and females and found that it took males longer on average to reach stages C and D than it did for females. This finding indicated that girls in younger age ranges (ranging from 10 to 20 years) were more mature in their teeth than males At stage E, the females showed a statistically insignificant delay (P = 0.823). According to the findings of studies that were carried out by a variety of authors on populations of a variety of different ethnic origins, the average age at which stage C was reached were 14.8 years for males and 14.7 years for women. Men reached stage D at an average age of 15.5 years, while women did so at 15.4 years. They then moved on to stage E at an average age of 16.0 years, stage F at an average age of 18.9 years, stage G at an average age of 19.84 years, and stage H at an average age of 21.97 years. Our results are consistent with those of Karatas et al., who proposed the concept that females complete tooth growth before males do. (20) Females completed root development (stage H) before males did, suggesting sexual dimorphism during the mineralization of mandibular third molars. This was consistent with the findings that Sisman et al. and other researchers who carried out a study on populations of Germany, Spain, South Africa, and Turkey. (21)

According to the study, the third molar is a indicator of age in those under 30. The third molar is the sole biological component that may be used to determine a person's age in their late teens or early twenties. Because of prior research. Due to the broad range of variability in the third molar, it can only be suggestive without better data, as Darji et al. indicated. (22) Children of the same chronological age grow differently biologically. Developing age estimation methods should aim to reduce these differences. Biological variation caused the disparities in chronological and estimated ages identified in this investigation. Similar findings from the reference studies and short sample size may be issues There are variations in children's overall dental maturity both within nations with essentially homogenous populations and across countries with generally homogenous populations, according to Nystrom et al.(23)

CONCLUSION

Both the Indian method and Demirjian's formula underestimated the average age of the current population, with the Demirjian's formula underestimating it more. Both formulae revealed that both men and females had an average underestimate of age, although the Indian calculation had a lower inaccuracy. The fact that girls reached dental maturity sooner than males suggests that females reach third molar development complete earlier.

Thus, the Indian formula may be used to estimate age, but if population-specific formulae taking into account ethnic and environmental diversity are constructed using regression analysis, higher accuracy can be gained.

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