

# Assessment of Demirjian's 8-teeth technique of age estimation and Indian-specific formulas in an East Indian population: A cross-sectional study

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## Abstract

**Background:** The age of an individual can be assessed by a plethora of widely available tooth-based techniques, among which radiological methods prevail. The Demirjian's technique of age assessment based on tooth development stages has been extensively investigated in different populations of the world. **Aim:** The present study is to assess the applicability of Demirjian's modified 8-teeth technique in age estimation of population of East India (Odisha), utilizing Acharya's Indian-specific cubic functions. **Materials and Methods:** One hundred and six pretreatment orthodontic radiographs of patients in an age group of 7–23 years with representation from both genders were assessed for eight left mandibular teeth and scored as per the Demirjian's 9-stage criteria for teeth development stages. Age was calculated on the basis of Acharya's Indian formula. Statistical analysis was performed to compare the estimated and actual age. All data were analyzed using SPSS 20.0 (SPSS Inc., Chicago, Illinois, USA) and MS Excel Package. **Results:** The results revealed that the mean absolute error (MAE) in age estimation of the entire sample was 1.3 years with 50% of the cases having an error rate within  $\pm 1$  year. The MAE in males and females (7–16 years) was 1.8 and 1.5, respectively. Likewise, the MAE in males and females (16.1–23 years) was 1.1 and 1.3, respectively. **Conclusion:** The low error rate in estimating age justifies the application of this modified technique and Acharya's Indian formulas in the present East Indian population.

**Key words:** Age estimation, Demirjian's method, forensic odontology, Indian-specific formulas, tooth development stages

## Introduction

Age estimation forms a key subspecialty of forensic sciences and constitutes an essential duty of the


medicolegal officers.<sup>[1]</sup> It remains part of the fundamental triad leading to the reconstruction of a biological profile.<sup>[2]</sup> It is also of relevance in living individuals to settle the dispute

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over chronological age in an array of civil and criminal scenarios. Particularly, in children, adolescents, and young adults, age estimation is important to answer questions pertaining to criminal liability, employability (child labor), adoption, illegal immigration, attainment of majority status, eligibility for marriage, etc., if birth certificate is not available.<sup>[1,3]</sup> Among the various physiological parameters that aid in age estimation, dental age predictors are most suited vis-a-vis bone ossification, secondary sexual characters, and general body development, as teeth are resistant to physical, chemical, and mechanical impacts, and are minimally influenced by medical, nutritional, or environmental conditions.<sup>[4]</sup>

The techniques of dental age estimation may be subdivided into morphologic, radiologic, biochemical, and histological methods.<sup>[2,5]</sup> The radiological method has an advantage over others as it is a practical, simple, economic, nondestructive technique, and can be of use both in the living and the dead. Dental radiological methods of age assessment usually employ parameters such as tooth development stages, tooth eruption, open apices of teeth, and pulp-tooth ratio.<sup>[6]</sup> Development of tooth is comparably preferred over eruption as the latter can be influenced by exogenous factors, but formation is a continuous, cumulative, and progressive process.<sup>[7]</sup> In fact, Demirjian *et al.* devised a radiological age estimation method based on the scoring of seven mandibular teeth on the left side according to an eight-tier tooth development staging system.<sup>[8]</sup> Individual tooth scores were summated to derive a total maturity score, from which the dental age was calculated using an age conversion table. However, to overcome the demerits of assessing only a narrow age range of population, the third molar was incorporated in a modification by Chaillet and Demirjian.<sup>[9]</sup>

Demirjian's technique has found wide acceptance globally for age assessment in different populations as it is a simple, practical method with clearly defined stages, increased interobserver agreement, and reduced speculation, as found in other methods.<sup>[10,11]</sup> However, few authors have also reported an overestimation of age in regional population groups.<sup>[12,13]</sup> Few such studies have predicted age more accurately after improvising the Demirjian's method with population-specific revision and cubic functions.<sup>[3,7]</sup> A singular study in the Indian population has evaluated the reliability of Demirjian's 8-teeth method in age estimation along with Acharya's Indian-specific regression formulas, which resulted in superior age estimates.<sup>[14]</sup> The aim of the current paper was to test the reliability of Demirjian's revised method and Indian cubic functions in estimating age in an East Indian population of Odisha.

## Materials and Methods

A retrospective cross-sectional study was conducted on 106 archived digital orthopantomograms, which were principally

pretreatment orthodontic radiographs from patients in the age range of 7 to 23 years [Table 1]. The patients had visited our institution in the years 2010–2014. Informed consent for the study was sought from the patients or their parents if the patients were minor. Personal details and brief clinical findings were recorded on a standard pro forma.

Inclusion criteria for selection were as follows:

1. Written record of age
2. Acceptable quality of radiographs
3. Presence of full complement of teeth on mandibular left or right side.

Exclusion criteria were as follows:

1. Congenital/developmental anomalies
2. Any disease (systemic, nutritional, or endocrinal) that could affect general growth and development
3. Any distortion or crowding of teeth that could interfere with proper visualization on the radiographs.

A single-skilled examiner first analyzed the soft copy of the digital radiographs that were taken using a digital OPG machine (Planmeca ProOne, Planmeca Inc., USA) and scored the eight left mandibular teeth depending on their stage of calcification, as per Demirjian's modified criteria which have ten tooth development stages. Gender-specific French-weighted maturity scores (Chaillet and Demirjian's modification) were entered corresponding to the grade of individual tooth. Scores were summed up to generate the total maturity score, which was then substituted in the Indian-specific regression formula developed by Acharya as given below:

$$\text{Males: Age} = 27.4351 - (0.0097 \times S^2) + (0.000089 \times S^3)$$

$$\text{Females: Age} = 23.7288 - (0.0088 \times S^2) + (0.000085 \times S^3)$$

This was the calculated dental age. Calendric age of each patient was calculated in years by subtracting date of birth

**Table 1: Sample distribution across age groups and genders**

Age (in completed years)	Males	Females	Total
10	1	1	2
11	1	2	3
12	1	1	2
13	1	5	6
14	2	1	3
15	3	4	7
16	3	4	7
17	1	10	11
18	6	9	15
19	1	10	11
20	4	16	20
21	5	6	11
22	0	5	5
23	0	3	3
Total	29	77	106

in the dental record from the date on which the radiograph was taken. Representation of the scoring from one such radiograph used in the study is depicted [Figure 1].

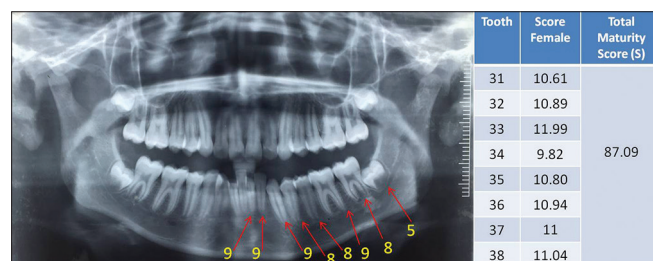
Intraobserver reproducibility was assessed, after re-evaluation of 25 randomly selected radiographs after 4 weeks by the same examiner, by using the Wilcoxon signed rank test. Likewise, a second examiner scored 30 randomly selected radiographs. There was no significant intra- or inter-observer variation.

The radiographs were divided into four subgroups, i.e., males and females into two age groups of 7–16 years and 16–23 years each. This was done due to known gender differences that exist in tooth development to assess the role of third molar in age prediction and to facilitate comparison with other studies.

All the data were analyzed using Microsoft Excel (MS office 2010 Microsoft Corp., Redmond, WA, USA) and statistical package SPSS version 20.0 (SPSS Inc., Chicago, Illinois, USA).

## Results

The majority of sample subjects were between 17 and 20 years. The sample had majority of females (77%) [Table 1]. Tests for inter and intra-observer bias did not show any statistically significant variation. When the sample was assessed for differences in estimated and actual ages between the group below 18 years of age and those above 18 years as depicted [Tables 2 and 3], 80% of the patients above 18 years were correctly identified while 78.43% of the patients below 18 years of age could be correctly evaluated. When the mean absolute error (MAE) in the four subgroups were compared [Table 4], the least MAE and therefore most accurate estimation was obtained in Group B (males, 16.1–23 years) at 1.1 years followed by Group D (females, 16.1–23 years) at 1.3 years. The error rates were slightly higher at 1.8 years in Group A (males, 7–16 years), followed by 1.5 in Group C (females, 7–16 years). The overall MAE was 1.3 years (standard deviation ±1). Majority of the test patients, i.e., 53 out of 106 (approximately 50%) were



**Figure 1:** Panoramic radiograph of a 13-year-old female, depicting different stages of tooth development of mandibular left side with corresponding tabulated Demirjian's scores that gave an estimated age of 13.13 years using Indian formulas

estimated to be within ±1 year while 28 (approximately 26.4%) age estimates fell within 1.1–2 years from the actual age. In 25 samples (approximately 23.6%), age estimates fell outside the ±2 year range.

## Discussion

Age of an unknown person can be assessed by correlating physical, skeletal, and dental maturity of an individual.<sup>[1,4]</sup> Dental development follows a specific timeline of formation, mineralization, and maturation, and therefore, has been extensively and exclusively studied as in the Demirjian's system of age estimation, which was first published in 1973.<sup>[8]</sup> Demirjian's original method assigned each of the seven mandibular teeth of the left side, an individual score based on their developmental stage. Individual scores were summed up to generate a total maturity score, which was interpreted using centile charts and curves. The dental maturity scores proposed by Demirjian *et al.*, which are derived from a French-Canadian population have been widely used as a reference dataset for the evaluation of age across population groups.<sup>[10,11]</sup> However, the applicability of Demirjian's method in various populations has remained a point of debate as it has led to vivid variations in age estimates. Overestimation of age has been a consistent observation when the Demirjian dataset was applied for other populations, and this has ranged from 0.20 to 3.04 years in boys and from 0.23 to 2.82 years in girls.<sup>[12,13,15]</sup>

**Table 2: Sample distribution across genders in age groups above and below 18 years of age**

Sex of participants	Estimated age (years)		Actual age (years)	
	<18	>18	<18	>18
Male	14	15	16	13
Female	37	40	35	42
Total	51	55	51	55

**Table 3: Number of individuals whose estimated age fell outside the 95% confidence interval in the groups above and below 18 years of age**

Estimated category	Actual category		Total
	<18	>18	
<18	40	11	51
>18	11	44	55
Total	51	55	106

**Table 4: Error of age estimation in the four subgroups during the study**

Groups	Gender and age group (years)	Number of samples	Mean absolute error
Group A	Males (7-16)	12	1.8
Group B	Males (16.1-23)	17	1.1
Group C	Females (7-16)	18	1.5
Group D	Females (16.1-23)	59	1.3

Indian studies have shown overestimation ranging from 2 months to over 3 years.<sup>[11,12,16]</sup> In contrast, underestimation of age was reported only in a Venezuelan population.<sup>[17]</sup> A meta-analysis of 12 studies by Jayaraman *et al.*, which employed the Demirjian's method, found an average overestimation of age of patients by more than 6 months and suggested that this dataset should be used with caution in global populations.<sup>[18]</sup> Consequently, the method's adaptation to the local population was considered essential for optimal age prediction.<sup>[3,9,12]</sup>

Even within the same country, some authors deemed specific standards for valid age estimation, placing emphasis on geographic region instead of country boundaries to generate standards.<sup>[3,7,18]</sup> Gilbert *et al.*'s study in a mixed Canadian population of Sudbury estimated age better when Sudbury-specific cubic functions and equations (model) were used that gave 95% confidence interval of just over 2.5 years compared to 3–4 years with Demirjian's method in this population.<sup>[7]</sup> Genetic influences, socioeconomic status, nutritional conditions, and dietary habits have been reported as the possible reasons for variations in skeletal and dental maturity among different populations and ethnic groups and different groups within the same population.<sup>[4,7,15]</sup>

A later modification of this method by Chaillet and Demirjian incorporated the third molar to broaden the applicability of aforesaid technique up to 18 years. They also developed regression formulas based on cubic functions which gave good reliability after inclusion of the third molar into the study.<sup>[9]</sup> Although a great variation exists in its position, morphology, and time of formation, the single compelling reason to rely on third molar formation to estimate chronological age is that very few alternative methods subsist during the interval roughly between the middle teens and early 20s.<sup>[4,5]</sup> However, surprisingly, this modified 8-teeth method has been tested only in limited studies.<sup>[3,14]</sup>

Acharya's original comparative study in the Indian population employing Demirjian's formulas resulted in an overall underestimation of age while incorporation of Indian formulas in Demirjian's 8-teeth method gave no such discrepancy and were better age predictors in the said population with the MAE deduced as being only 1.43 years.<sup>[3]</sup> In fact, a recent study by Kumar and Gopal that estimated the age in a South-Eastern Indian population by employing Demirjian's 8-teeth method and Indian-specific formulas resulted in still lower MAE of 1.18 years.<sup>[14]</sup> In the present study, the overall MAE was 1.3 years, which was slightly better than Acharya's original study. However, the higher error rate of 1.8 and 1.5 years in males and females, respectively, in the age group of 7–16 years compared to that of 16.1–23 years age group was contrary to the observations in the other studies where age prediction has been found to be better in the younger age group. This may have been

due to the paucity of samples in that group in our study. In fact, slightly, more numbers of age estimates were correctly identified in the group above 18 years (80%) compared to those below 18 years (78.43%). The higher accuracy of prediction in the latter age group in our study (MAE of 1.1 and 1.3 in males and females in 16.1–23 years, respectively) may be due to the fact that third molar enhances the age correlation of dental development, and most of the patients in this group were within 20 years of age. Suboptimal estimates begin to occur once the age goes beyond 20 years as the third molar development is complete by then.<sup>[3]</sup>

## Conclusion

The reasonably good results obtained in the present study assert the use of Demirjian's 8-teeth method with Indian cubic functions in our East Indian population. It is a worthwhile exercise to apply the Indian formulas locally within specific regions, albeit in large samples and also test the method on population-specific samples in actual forensic scenarios where panoramic radiographs are accessible. This would in future lead to the development of regional database in various populations.

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## Conflicts of interest

There are no conflicts of interest.

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