

Reliability of Age Estimation in Modi Nagar Children using Demirjian's Eight Teeth Method and Indian Specific Formula

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Citation: Jaiswal R, Kodirekkala AN, Kushwala A. Reliability of age estimation in Modinagar Children using demirjian's eight teeth method and indian specific formula. *Genesis J Surg Med.* 3(1):1-15.

Received: February 26, 2024 | **Published:** March 09, 2024.

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Abstract

Forensic odontology, historically underexplored in dentistry, plays a crucial role in medico-legal contexts, with age estimation being a vital sub-discipline. Accurate and user-friendly age estimation is imperative.

Keywords

Forensic; Odontology; OPGs; Age estimation; French maturity score; Radiograph.

Introduction

Anthropologists have extensively examined age systems, where age serves as a pivotal organizing principle encompassing formal age classes, age grades reflecting social and biological development, and relative age distinctions. Notably, the correlation between body development and chronological age is imperfect. Variances in developmental patterns lead to disparities between chronological and biological age. Consequently, parameters like dental age, bone age, mental age, and milestones such as menarche, voice change, height, and weight are utilized as proxy indicators for biological age and body development. Dental development stands out as a particularly reliable indicator, being less susceptible to influences from nutritional and endocrine factors, making it a pertinent measure of biological maturity in children [1].

Forensic odontology, historically underexplored in dentistry, plays a crucial role in medico-legal contexts, with age estimation being a vital sub-discipline. Accurate and user-friendly age estimation is imperative. Presently, many methods are invasive, time-consuming, and reliant on expensive tools and experienced pathologists, lacking in in-vivo applicability. Radiology emerges as a valuable tool, offering non-invasive insights into dental developmental stages, providing baseline data for precise age estimation in children and adolescents [2].

The universally utilized Demirjian method for age estimation, primarily involving seven left mandibular teeth, has demonstrated variations in estimates across different populations, including Indians. The original method excluded the third molar due to congenital absence and developmental variability. Despite this, the third molar remains a crucial predictor for assessing age in the 16–23 age group. Recognizing this, others have assessed this tooth using Demirjian's criteria, aiming to expand the method's applicability up to the age of 18 years [3].

The widely adapted Demirjian method has undergone numerous modifications, notably replacing centile maturity curves with regression formulas and integrating the third molar to enhance the method's scope and duration for age prediction. In this context, Acharya conducted a regression analysis, devising a formula that incorporates the third molar for age estimation within the Indian population [2].

It has been seen that there is wide range of variations in age estimates and thus a new India specific formula has been adapted by modifying the Demirjian's original formula by 8 teeth instead of 7 teeth method by including third molar given by Acharya, to use it on a wider range of population.

In this study we evaluated the accuracy of age estimation using Demirjian's 8 teeth method of age estimation combined with Acharya's India specific formula in Modinagar.

Aim

To evaluate the accuracy of age estimation using Demirjian's eight teeth approach, which incorporates an Indian formula in addition to the French maturity scores.

Objectives

1. Predicting age estimation accuracy using an India-specific formula.
2. To calculate the age estimation's reliability following the third molar's incorporation.

Inclusion and Exclusion Criteria

Inclusion criteria

1. Patients free of obvious developmental anomalies.
2. Orthopantomograms (OPG) without any distortions.
3. Radiographs of patients with the either seven or eight teeth in the mandibular left or right side.
4. Patient between the ages of 7 - 23 years.

Exclusion criteria

1. Radiographs of patients with developmental anomalies
2. Crowding and tooth distortion in cases when the teeth's root structures were not easily visible
3. Diagnosis and treatment of bilaterally absent teeth in the jawbone.
4. Displacement of root due to pathology, such as cyst or tumour.

Methods

Sixty OPGs, collected from 30 males and 30 females who visited the OPD of DJ Dental College, Modinagar were categorized into four groups based on age and sex. Group A comprised males aged 7–16 years, Group B involved males aged 16.1–23 years, Group C included females aged 7–16 years, and Group D consisted of females aged 16.1–23 years. The division by sex aimed to account for gender-specific tooth development rates. Each sex was further divided into subgroups to evaluate the reliability of the third molar for age estimation after 16 years, as it remains the only tooth still developing under normal conditions at this stage. Digital OPG images, acquired in JPEG format from a KODAK 8000 digital panoramic unit, were analyzed using a scoring criterion, yielding the total maturation score (S).

French maturity scores

The OPGs would be interpreted according to the French Maturity Scores given by A Demirjian, H. Goldstein, and M. Tanner in the year 1973 and each tooth is graded accordingly.

Dental Developmental Stages.

1. Tooth not yet calcified.
2. Crypt Stage: Bone crypts are visible without dental germ inside it.
3. In both uniradicular and multiradicular teeth, a beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.
4. Fusion of the calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface

- 5a. Enamel formation is complete at the occlusal surface. It can be seen extending and converging towards the cervical area
- 5b. The beginning of the dentinal deposit is seen.
- 5c. At the occlusal boundary, the pulp chamber's contour curvatures.
- 6a. Up to the cemento-enamel junction, the crown formation is finished.
- 6b. In uniradicular teeth, the pulp chamber's superior border is clearly curved and concave in the direction of the cervical area. If pulp horns are present, their protrusion creates an outline resembling the top of an umbrella. The pulp chamber of molars is trapezoidal in shape.
- 7. uniradicular teeth
 - a. The wall of the pulp chamber now forms straight lines, horn, which is larger than the previous stage
 - b. The crown height is greater than the length of the roots.

Molars

- a. The calcified origin of the bifurcation has developed further down from its semi-lunar
 - b. The length of the root equals or exceeds the crown height.
8. The walls of the root canal are now parallel, and its apical end is still partially open.
9. The root canal's apical end is entirely sealed.

The periodontal membrane has a uniform width around the root and the apex.

Using the scoring system:

1. The developmental stages for each tooth are then scored according to the Demirjian's individual maturity score of boys and girls (S).
2. The scores were summed up (S) and substituted in the Indian specific formulae.

India Specific Formula

1. Males: $\text{Age} = 27.4351 - (0.0097 \times S_2) + (0.000089 \times S_3)$
2. Females: $\text{Age} = 23.7288 - (0.0088 \times S_2) + (0.000085 \times S_3)$
3. The value so obtained was designated as age estimated.
4. The chronological ages of the children were obtained by subtracting their birthdates from the date of collecting the radiograph.
5. The further calculation of result and statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) Statistical Software.

Result

The data thus obtained was compiled systematically; master table was prepared. Inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean \pm SD and results on categorical measurements are presented in Numbers (%). Total 60 OPGs radiographs were collected from 30 males and 30 female subjects. The panoramic radiographs were divided into following four groups based on the age and sex of the subjects. Group A contains males in the age group of 7–16 years; Group B contains males in the age group of 16.1–23 years, Group C containing females in the age group of 7–16 years and Group D containing females in the age group of 16.1–23 years. Table 2 shows the correlation between the estimated age and actual age of all four groups showing the P-value of Group A = 0.124, Group B = 0.001, Group C = 0.001, Group D = 0.001 respectively and has an

overall p – value of 0.001 that is significant.

Discussion

Age estimation is crucial in medico-legal contexts, especially in civil and criminal litigation. Teeth, known for their durability and resistance to decay, fire, and chemicals, contribute significantly to personal identification and age assessment. In living individuals, dental age estimation relies on non-invasive methods that evaluate the timing and sequence of growth stages in developing dentition, as well as modifications in mature dentition and surrounding tissues [2].

The eruption of teeth is a conspicuous transformation in the dynamic progression from tooth formation to eventual shedding. The timing of tooth eruption remains relatively consistent, making the examination of teeth a widely accepted method for determining an individual's age [3].

Demirjian's method for age estimation has been proved adequate by some researchers in different populations [4, 12]. However, this method has shown inaccuracies with limitations such as overestimation and underestimation of dental age when compared to Willems, Haavikko and Nolla methods [13, 34].

initially classified tooth development into 8 stages, creating an age estimation method for the French population.⁴ Modified for various regions, this method was expanded by incorporating the third molar for broader age prediction [4]. Acharya introduced an India-specific formula, derived from a regression analysis using Demirjian's 8 teeth method, for age estimation in the Indian population [3].

This study utilized 60 panoramic radiographs (30 males and 30 females) from the Department of Oral Medicine and Radiology at Divya Jyoti College to assess the reliability of age estimation using Demirjian's 8 teeth method combined with Acharya's India-specific formula in the Modinagar population. Subjects were categorized into four groups: Group A (males, 7-16 years), Group B (males, 16.1-23 years), Group C (females, 7-16 years), and Group D (females, 16.1-23 years) (Table 1).

S. No.	Group	Criteria	No. of samples
1	Group A	Males in the age group of 7–16 years	12
2	Group B	Males in the age group of 16.1–23 years	18
3	Group C	Females in the age group of 7–16 years	17
4	Group D	Females in the age group of 16.1–23years	13

Table 1: Showing Group wise Distribution of Study samples.

In the present study, which comprises of 30 males and 30 females of age 7 to 23 years, mean of all the age have been calculated which was 12.08, 19.27, 13.11, 19.3 for actual age in GROUP A, B, C and D respectively and 13.96, 18.48, 13.14 and 17.99 for estimated age in GROUP A, B, C and D respectively (Table 2-5) then after mean values, correlation between estimated and actual age was calculated (Chart 1).

Group A [Males 7-16 Years]		
S. No.	Actual Age	Estimated age
1	15	14.6709
2	15	16.6927
3	12	10.3818
4	9	7.1613
5	15	13.58
6	14	12.4786
7	14	14.6708
8	12	11.2396
9	11	11.2396
10	11	12.4235
11	10	14.8911
12	7	19.7481
Mean	12.08	13.96

Table 2: Presenting the Mean of ages in Group A.

Group B (Males 16.1 – 23 Years)		
S. No	Actual age	Estimated age
1	16	17.3517
2	18	18.2697
3	16	16.692
4	18	18.2697
5	20	19.4351
6	21	19.4351
7	22	19.4351
8	21	19.5351
9	18	18.2697
10	20	18.2697
11	18	17.3516
12	20	18.549
13	19	19.4351
14	22	19.4351
15	17	16.692
16	20	19.4351
17	21	19.4351
18	20	17.35
Mean	19.27	18.48

Table 3: Presenting the Mean of ages in Group B.

Group C (Females 7 – 23 Years)		
S.NO	Actual age	Estimated age
1	15	16.5082
2	15	14.7728
3	15	14.7728
4	11	10.0753
5	13	10.5218
6	15	15.5807
7	18	17.8305
8	10	10.2062
9	15	15.1944
10	15	14.7728
11	11	10.5041
12	11	10.1819
13	12	9.7555
14	14	13.8294
15	10	13.4221
16	10	9.8674
17	13	15.652
Mean	13.11	13.14

Table 4: Presenting the Mean of Ages in Group C.

Group D (Females 16.1-23 Years)		
S. No.	Actual age	Estimated age
1	16	11.2096
2	19	17.8305
3	16	14.144
4	20	18.2628
5	21	17.8305
6	18	17.8305

7	18	16.3169
8	23	20.7288
9	18	18.5901
10	18	19.0708
11	21	20.72
12	22	20.7288
13	21	20.7288
Mean	19.31	17.99

Table 5: Presenting the Means of Ages in Group D.

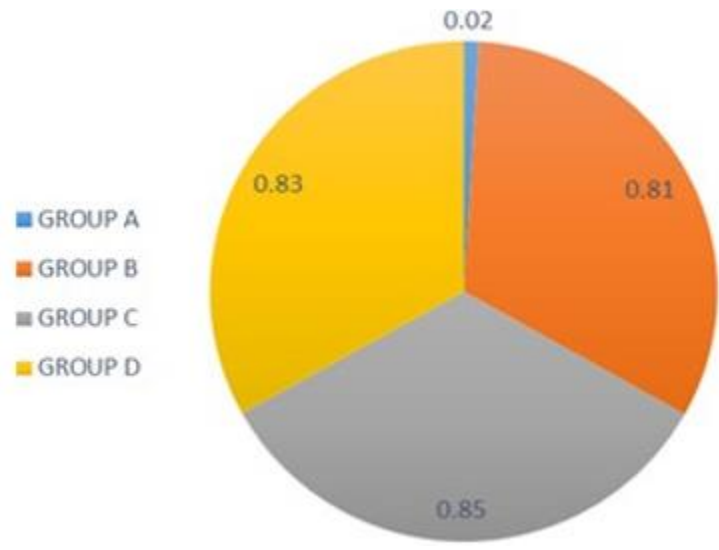
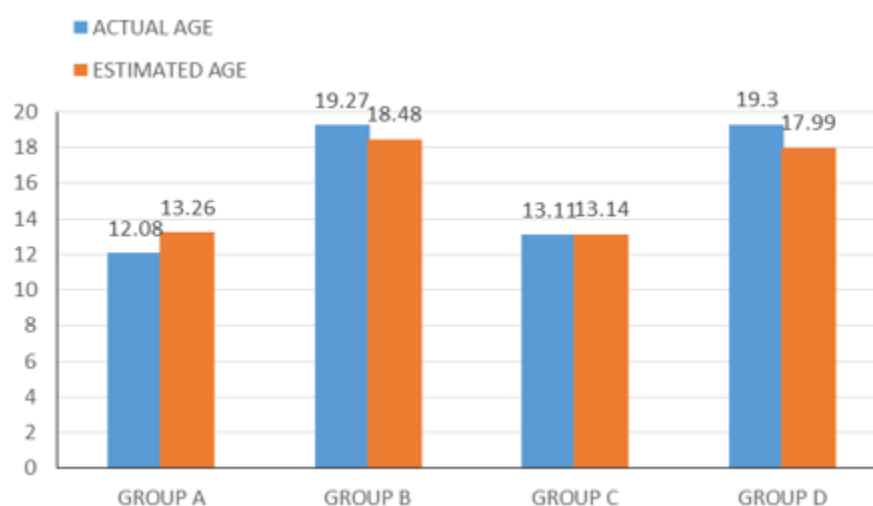


Chart 1: correlation Coefficient Between Estimated age and actual age.

Among the 60 samples, Group A (12 samples) exhibited a correlation coefficient of 0.024 and a non-significant p-value of 0.124, indicating an insignificant relationship between estimated age and actual age. Conversely, Group B (18 samples) demonstrated a significant correlation (coefficient: 0.807, p-value: 0.001), as did Group C (17 samples, coefficient: 0.845, p-value: 0.001) and Group D (13 samples, coefficient: 0.829, p-value: 0.001), signifying a meaningful correlation between estimated and actual age in these groups (Table 6, Graph 1).

	Actual age	Estimated age	Correlation Coefficient	Significance (p-value)
Group A	12.08±2.61	13.26±3.24	0.024	0.124 (non-significant)
Group B	19.27±1.87	18.48±1.02	0.807	0.001 (significant)
Group C	13.11±2.36	13.14±2.75	0.845	0.001 (significant)
Group D	19.30±2.21	17.99±2.81	0.829	0.001 (significant)
Overall	17.19±4.11	16.79±3.54	0.858	0.001 (significant)

Table 6: Correlation Coefficient between Estimated Age and Actual Age.



Graph 1: Correlation between estimated age and actual age.

Tandon et al, on comparing calculated age with estimated age using India specific formula, mean estimated age was found to be significantly higher than calculated age for overall as well as both the genders independently. The difference between the estimated age and calculated age was significant for all age groups except the age group 16-18 years. Hence it was in accordance with the present study [35].

Khorate et al, conducted a study on Goan population and concluded significant correlation between estimated age and actual age, they found Acharya's India specific formula is limited to an age group of 9-22 years in females which agrees with the criteria of present study [36].

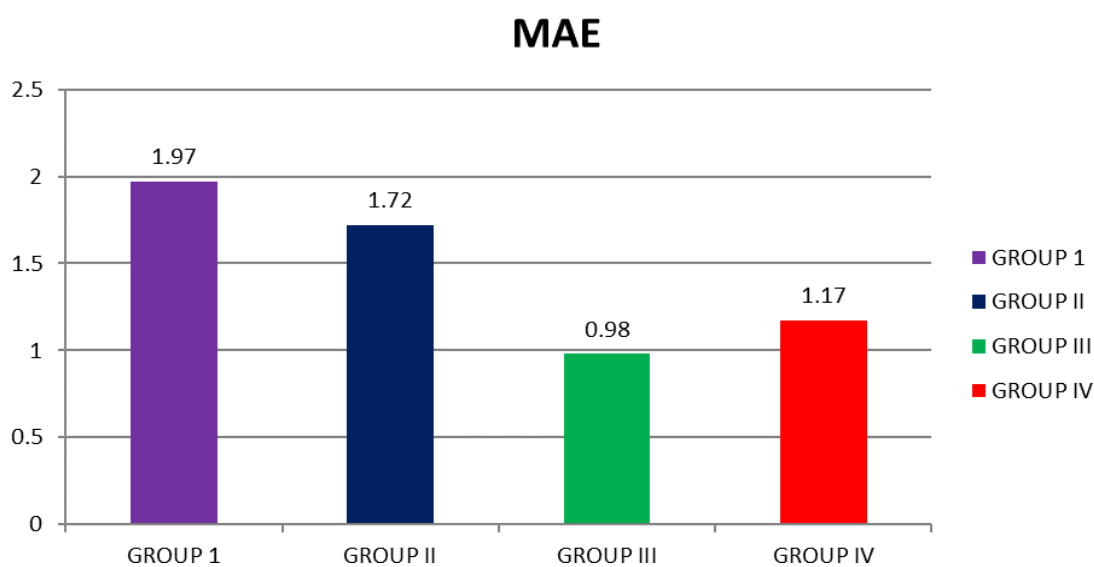
Gandhi et al, found that Indian formula was more reliable for age estimation with only slight underestimation (-0.65 years) in males and overestimation (0.68 years) in females of age group below 10 years. Males and females from 13 to 15 years showed that dental development was almost parallel; thus, this result was in accordance with current study [37].

In this study, mean accuracy error (MAE) was calculated in all the group of age estimation (Table 7). Out

of 18 samples the MAE was calculated to be 1.97 ± 2.90 which was statistically very high, Group B containing 32 samples shows a MAE of 1.72 ± 1.11 which was permissible. Hence the result obtained was significant. Group C contains 17 samples with MAE of 0.98 ± 1.06 . In Group D, 33 samples were present, and MAE calculated was 1.17 ± 0.97 ; hence the overall result was calculated to be 1.46 ± 1.57 which was statistically significant (Graph 2).

No. of samples	Male
Group A	12
Group B	18
Group C	17
Group D	13
Overall Total	60

Table 7: Error of Age Estimation in all the Groups during the Study.



Graph 2: Error of age estimation in all the groups during the study.

Kumar et al, assessed that the mean absolute error in males (7-16 years) was 1.2 years; in males (16.1-23 years) was 1.3 years; in females (7-16 years) was 0.95 years and in females was 1.16 years. Therefore, the overall result was statistically significant and was in accordance with present study [2].

Khorate et al, conducted a study on Goan population and mean absolute error calculated was -1.88 to +1.45 in case of female samples and that of male samples ranging from -1.55 to +1.29, so they found Acharya's India specific formula is reliable to an age group of 9-22 which agrees with the criteria of present study [36].

Rath et al, tested the accuracy of modified Demirjian's method and overall mean absolute error in the four subgroups were compared, the least MAE and therefore most accurate estimation was obtained in

Group B at 1.1 years followed by Group D at 1.3 years. Therefore, the results were in favour of present study [37].

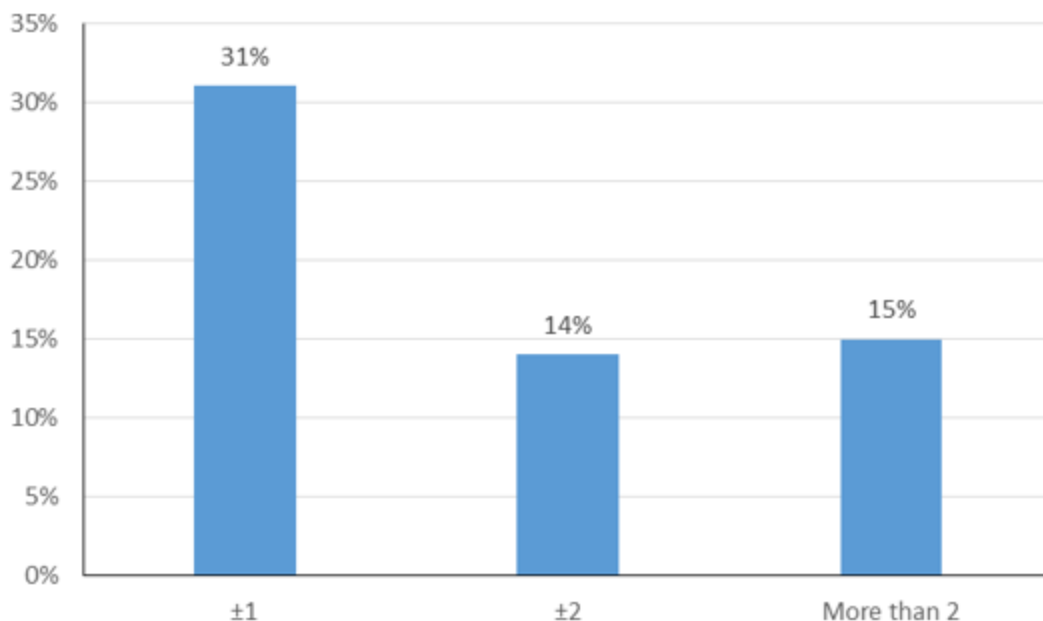
In this current study, percentage of subjects with different levels of accuracy in different groups has been calculated (Table 8) the difference obtained was divided in three groups (Table 9) i.e. within + 1 year, within 1.1-2 years & 2 years. In group A we found that 44.4% in +1, 33.3% within + 2 and contains 22.2% in >+ 2. This shows that there is not much correlation between the actual age and the calculated age. The difference obtained in group B was found to be 31.2% in +1, 28.1% within + 2 and contains 40.7% in >+ 2. This showed statistically good correlation between the actual age and the calculated age. The difference obtained in group C was found to be 70.6% in +1, 5.9% within + 2 and contains 23.5% in >+ 2. Hence this showed good correlation between the actual age and the calculated age. The difference in group D was calculated 48.5% in +1, 39.4% within + 2 and contains 12.1% in >+ 2. (Graph 3 and 4).

Level of accuracy	No. of samples	Percentage
±1	31	31%
±2	14	14%
More than 2	15	15%

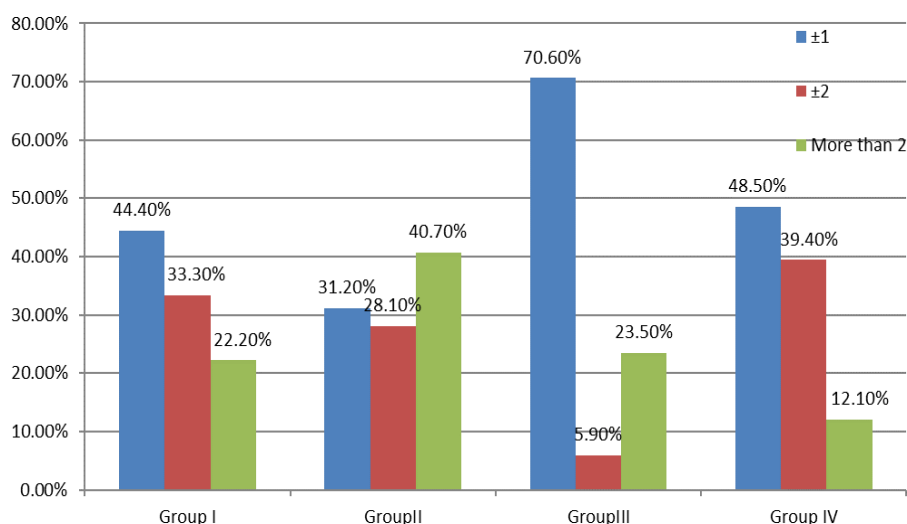
Table 8: Percentage of Subjects with Different Levels of Accuracy in the Age estimation.

Groups	Level of Accuracy		
	±1	±2	More than 2
Group A	6	3	3
	-44.40%	-33.33%	-22.22%
Group B	8	6	4
	31.20%	-28.10%	-40.70%
Group C	10	5	3
	70.60%	-5.90%	-23.50%
Group D	7	4	2
	48.50%	-39.40%	-12.10%

Table 9: Percentage of Subjects with Different Levels of Accuracy in Different Groups.



Graph 3: percentage age of subjects with different levels of accuracy in the age estimation.



Graph 4: Percentage of subjects with different levels of Accuracy in different Groups.

In Kumar, et al. Study the reliability of age estimation using Demirjian's 8 teeth method, and an India-specific formula yielded fairly reliable results, narrowing down the prediction error to just over 1 year. This improvement was noted compared to the original method in the Indian population. The incorporation of the third molar, as observed in our study, also contributed to reducing errors in age estimates [2].

Gandhi, et al, concluded that Demirjian's formula is less reliable as it gave a considerable difference in age, but Indian standard formula showed high reliability and accuracy, the males and females showed that level of accuracy was significantly high and thus gave a result in positive direction and on the same time in accordance with the current study [38].

Rath, et al. tested the accuracy of Indian standard formula in Orissa population and the result showed

that majority of the test patients, i.e. approximately 50% were estimated to be within ± 1 year while 26.4% age estimates fell within 1.1–2 years from the actual age. In 23.6% samples, age estimates fell outside the ± 2 year range, which agrees with the criteria of present study [37].

Based on the study's findings, we conclude that utilizing Demirjian's age estimation method with a modified Indian standard is suitable for estimating the age of individuals in the Modinagar vicinity. However, its accuracy is lower in males aged 7–16 years compared to females of the same age. This aligns with Gandhi et al.'s observations, indicating that dental maturity occurs earlier in females than in males. Nevertheless, for both males and females in the 16.1–23 age group, the modified Demirjian method proves to be reliable and accurate.

Conclusion

This study, conducted at the Department of Oral Medicine and Radiology in Modinagar, UP, aimed to assess the reliability of age estimation using the modified Demirjian's 8 teeth method and Acharya's India-specific formula. The research involved 60 subjects divided into two age groups (7-16 and 16.1-23 years) with soft copies of OPGs collected from archives. The study found a significant relationship between actual and estimated age ($P = 0.001$) with an overall permissible error of 1.46 ± 1.57 . The method proved reliable for age estimation in Modinagar females (7-23 years) and males (16.1-23 years) but not in males aged 7-16. Limitations include applicability only between ages 7-23 and dependence on sample size and radiograph clarity, warranting further studies for enhanced accuracy and reliability.

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