

## Accuracy of Dental Age Estimation Using Demirjian's Eight-Teeth Method And Acharya's Indian Formula In Central Kerala Population

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### Abstract

#### Background

Age estimation is made possible by a variety of dental techniques, amongst which the radiological methods are more popular. The Demirjian's technique of age assessment based on tooth development stages has been extensively investigated in different population groups. However, several studies among the Indian population, using these formulas yielded under age estimation, which lead to the recent development of India-specific regression formula.

#### Objectives

To estimate the age of children and adolescents using Demirjian's 8-Teeth Method, Demirjian's formula and Acharya's Indian formula, among Central Kerala Population and compare the effectiveness of Demirjian's formula with that of Acharya's Indian formula.

#### Method

The study was conducted using 100 archived digital panoramic radiographs, 50 male and 50 female, aged between 6 to 18 years, which were predominantly pretreatment orthodontic radiographs of patients without any obvious developmental anomalies. The radiographs were interpreted using Demirjian's 8-teeth method and the dental age calculated using Demirjian's formula and

Acharya's Indian formula. Both formulas were compared using paired 't' test (SPSS Statistics 16).

#### Results

Demirjian's method underestimated the dental age by 1.45 years in males and 1.71 years in females and average 1.58 years in total. Acharya's method overestimated the dental age by 0.51 years in males and 0.76 years in females and average 0.63 years in total. However, there was no statistically significant difference between chronological age and dental age in Acharya's method ( $P > 0.05$ ).

#### Conclusion

As the absolute accuracy was better for Acharya's method compared with Demirjian method, we suggest Acharya's Indian formula is more effective in evaluating the dental age in Central Kerala population.

**Keywords:** Age estimation, Demirjian method, Acharya's formulae, Panoramic radiographs, forensic odontology, Central Kerala.

#### Introduction

The application of forensic odontology is expanding as the science develops. Teeth and bones are most commonly used for identification of an unknown individual and for age determination. Age estimation constitutes an essential duty of the medicolegal officers. It remains part of the fundamental triad leading to the reconstruction of a

biological profile. It is also of relevance in living individuals to settle the dispute 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 maturity status, eligibility for marriage, etc., if birth certificate is not available.

The techniques of dental age estimation may be subdivided into morphologic, radiologic, biochemical, and histological methods. The radiological method has an advantage over others as it is a practical, simple, economic, non-destructive 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. 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.

Demirjian *et al.* method of age assessment utilizes seven mandibular teeth on left side<sup>1</sup>, which has been widely used in all populations, but revealed variations in age estimates in Indians. As only seven teeth were included, it limits the use of this method in individuals above 16 years and also found to be inaccurate in some previous studies. To overcome this, Chaillet and Demirjian added the third molar for an assessment of age in French children and derived regression formulas for age assessment.<sup>2</sup> Another major modification made in this study was that two additional stages were included to staging of teeth for easier calculation and to develop cubic equations with good reliability. Radiographic analysis including third molar development expands the years of age estimation to 9–23 years as crown and root development can be studied independent of eruption. This revised method was tested

by Acharya on an Indian sample which showed recognizable differences and led to the development of India-specific formulas to accurately predict the age in Indians.<sup>3</sup> As yet no studies have tested these Demirjian's and India-specific formulas on Kerala population using Demirjian's 8 teeth method, this study aims to evaluate the accuracy of Demirjian's and Acharya's formulas for age estimation on Central Kerala population.

### **Aim of the Study**

To estimate the accuracy of dental age in children aged 6–18 years, using the original regression formulas by Chaillet and Demirjian (2004), and India-specific regression formulas by Acharya (2011), among the Central Kerala population.

### **Objectives**

- i) To estimate the dental age using original regression formulas by Chaillet and Demirjian from digital orthopantomographs
- ii) To estimate the dental age using India-specific regression formula by Acharya with the same OPGs.
- iii) To compare the age estimated using Acharya's and Demirjian method with the chronological age of the patients.

### **Materials and Methods**

This is a cross-sectional study which deals with the digital panoramic radiographs of normal healthy Central Kerala children and adolescents between 6 and 18 years of age, from the archival data of Department of Oral Medicine and Radiology, Government Dental College, Kottayam and was conducted from July 2017 until December 2017. Prior to conducting the study, ethical approval was obtained from the Ethical Committee of our institution (...).

### **Inclusion criteria**

- Written record of age

- The Panoramic radiographs should be of patients aged between 6-18 years.
- The Panoramic radiographs should be free of distortion and have good contrast.
- Presence of full complement of teeth on mandibular left or right side.

#### Exclusion criteria

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

#### Sample size

The sample size was calculated as follows.

The Pearson's correlation coefficient ( $r$ ) from the study conducted by Rezwana Begum Mohammed et al was used to determine the sample size.

The formula used to calculate sample size is,

$$\text{Total sample size} = N = [(Z\alpha + Z\beta)/C] 2 + 3 = 8$$

The standard normal deviate for  $\alpha = Z\alpha = 1.960$

The standard normal deviate for  $\beta = Z\beta = 0.842$

$$C = 0.5 * \ln [(1+r)/(1-r)] = 1.267$$

A minimum of 8 subjects were required for the present study.

The study was conducted on 100 digital OPGs that comprise of 50 male and 50 female.

#### Method

Previously recorded digital panoramic radiographs in the age range of 6 to 18 years, from the archival data of Department of Oral Medicine and Radiology were analyzed. Then 100 images (50 males, 50 females) are included in the study according to fulfillment of inclusion criteria. Chronological age (CA) of each individual was calculated from the date of birth to the date when the radiograph was taken in completed years. To avoid observer bias, each digital OPG of an individual is

coded with a numerical identity number (1–100) to ensure that the examiner is blind to sex, name and age of subjects. A single-skilled examiner first analyze the soft copy of the digital panoramic radiographs that are taken using an orthopantomograph Kodak 8000C and score the eight left mandibular teeth (central incisor to third molar) depending on their stage of calcification, as per Demirjian's modified criteria which have ten tooth development stages (0-9). Gender-specific French-weighted maturity scores (Chaillet and Demirjian's modification) are entered corresponding to the grade of individual tooth. Scores are summed up to generate the total maturity score (S), which is then substitute in the regression formulas given by Chaillet and Demirjian (2004) and Acharya (2011) to estimate the dental age of each subject.

Method 1: Chaillet and Demirjian's regression formulas based on tooth development of French children (original method)

1. For males, age =  $(0.000055 \times S3) - (0.0095 \times S2) + (0.6479 \times S) - 8.4583$

2. For females, age =  $(0.0000615 \times S3) - (0.0106 \times S2) + (0.6997 \times S) - 9.3178$

Method 2: Acharya's Indian formulas for age estimation (Indian method)

1. For males, age =  $27.4351 - (0.0097 \times S2) + (0.000089 \times S3)$

2. For females, age =  $23.7288 - (0.0088 \times S2) + (0.000085 \times S3)$

These results were statistically analyzed and presented.

#### Statistical analysis

Statistical analysis were performed using SPSS (version 16) software. The differences between the estimated dental age and the chronological age were compared based on the gender with paired  $t$ -test. Significance level was set at  $P < 0.05$ . Pearson's correlation test was

performed to assess the relation between the estimated dental age according to two methods and the chronological age, and the accuracy of the two methods was obtained. Accuracy refers to how close DA is to CA, that is the mean difference between DA and known age will be zero or close to zero.

## Results

### Comparison of chronological age with the estimated dental age by Demirjian's regression formula

Table 1 shows comparison of chronological age with the estimated dental age by Demirjian's regression formula. Among the 100 samples the mean chronological age in 50 males was 12.18 years and mean chronological age in 50 females was 12.12 years. By using Demirjian's formula the mean dental age in male was 10.73 years and that in female was 10.41 years. The mean dental age by Demirjian's regression formula was compared with the corresponding chronological age. It was evaluated that the Demirjian's formula underestimated the mean dental age by 1.45 years in males and by 1.71 years in females and average 1.58 years in total. There was statistically significant difference between chronological age and dental age in Demirjian's method ( $P < 0.05$ ).

### Comparison of chronological age with the estimated dental age by Acharya's Indian formula

Table 2 shows comparison of chronological age with the estimated dental age by Acharya's Indian formula. Among the 100 samples the mean chronological age in 50 males was 12.18 years and mean chronological age in 50 females was 12.12 years. By using Indian formula, the mean dental age in male was 12.69 years and that in female was 12.88 years. The mean dental age by Acharya's Indian formula was compared with the corresponding chronological age. It was evaluated that the Acharya's method overestimated the dental age by 0.51 years in males and 0.76 years in females and average 0.63

years in total. However, there was no statistically significant difference between chronological age and dental age in Acharya's method ( $P > 0.05$ ). The mean dental age obtained using Indian formula was approximating with the chronological age in the male and female by a margin of 0.63 years.

### Correlation between the estimated dental age according to two methods and the chronological age.

Table 3 shows Karl Pearson's correlation coefficient between the estimated dental age according to two methods and the chronological age. Pearson's correlation test showed significant relation between dental age and chronological age for both Demirjian's method ( $r = 0.94$  :  $P < 0.001$ ) and Acharya's method ( $r = 0.86$  :  $P < 0.001$ ).

## Discussion

Since years Demirjian's method has been widely applied for many populations for age estimation of children and adolescents because of the simplicity of the method, as well as radiographic and schematic illustrations of tooth development with descriptions provided in all works. However, previous studies<sup>2,4,5</sup>, resulted in relatively wide variations between estimated and actual age, prompting several authors to suggest the use of population specific standards.

Previous studies<sup>4,6,7</sup> have shown overestimation of age in Indians, however all of them evaluated Demirjian's 7 teeth method and did not consider the third molar. A drawback of the Demirjian 7 teeth method was it excluded the third molar owing to its variability in regard to size, shape and likelihood of congenital absence and also because of wide variation in its development<sup>1</sup>. Nevertheless, this tooth is one of the few predictors available for the assessment of age in individuals of 16–23 years age group.

Chaillet and Demirjian method utilized third molar and developed new maturity scores for age estimation in French children and regression formulas derived in this

study were used by Acharya in Indians, as resulted in discrepancies in estimated age, led to development of India-specific regression formulas to predict age<sup>2,3</sup>. This study purposed to test the repeatability and accuracy of both the methods for South Indian children by determining mean difference for each gender and age cohort separately.

Acharya tested the Chaillet and Demirjian's formulas on 295 radiographs of individuals aged 7–16 years and compared in terms of the number of age estimates that fell outside the 95%, 97% and 99% confidence intervals<sup>3</sup>. Furthermore, developed Indian specific formulas from 355 individuals aged 7–18 years and also tested the Indian and Demirjian's cubic equations on 70 individuals of age 9 to 18 years and concluded that Indian formulas predicted age better than Demirjian' formulas.

Kumar and Gopal tested Demirjian's 8 teeth method using India-specific formulas on a sample of 121 individuals of South India and showed that in 57.9% of cases the error rate was within  $\pm 1$  year with accuracy of 1.18 years and also found that the addition of third molar increased the error rates in the older individuals<sup>8</sup>.

In the present study, for males, the mean (standard deviation [SD]) chronological age was 12.18 years (2.83 years). The mean dental age was 10.73 years (2.72 years) with a mean difference of  $-1.45$  years according to the Demirjian method and the mean dental age was 12.69 years (2.74 years) with a mean accuracy of 0.51 years according to the Indian method. For females, the mean (SD) chronological age was 12.12 years (3.28 years). The meandental age was 10.40 years (2.69 years) with a mean accuracy of  $-1.71$  years according to the Demirjian method and the meandental age was 12.88 years (2.64 years) with a mean accuracy of 0.76 years according to the Indian method [Tables 1 and 2]. In present study, there was statistically significant difference between

chronological age and dental age in Demirjian's method ( $p < 0.05$ ) and there was no statistically significant difference between chronological age and dental age in Acharya's method ( $p > 0.05$ ). similar to previous studies<sup>8-12</sup>.

The present study resulted in better age prediction in males compared to females according to Demirjian's formulas, and according to Indian formulas age was accurately predicted in males similar to previous studies<sup>3,9</sup>. However, in contrast to present study, females were accurately predicted in other study, where only Indian formuls were used<sup>8</sup>. The present study also showed that Indian formulas were more accurate (0.63 years) in predicting age compared to Demirjian (1.58 years) formulas similar to previous studies<sup>3,9</sup>. Significant correlation was found between the estimated dental age, according to Demirjian formulas ( $r = 0.9$ ) and Indian formulas ( $r = 0.88$ ), and chronological age [Table 3] in present study, similar to previous study<sup>9</sup>. Better method demonstrates the accuracy or smaller difference between dental age and the chronological age.

Acharya compared the Indian as well as Chaillet and Demirjian's cubic equations on a 9–18 years age group of 70 Indian individuals. The test of the Indian regression formulas revealed better age prediction compared to Demirjian's formulas, similar to present study. In the present study, the Indian formulas resulted in an average mean difference of 0.63 years (0.51 years in males, 0.76 years in females) and Demirjian formulas deduced an average mean difference of 1.58 years (1.45 in males and 1.71 in females).

In the present study, Demirjian's cubic equations showed an underestimation of age in agreement with the previous studies<sup>3,9</sup>. This can be attributed to the addition of the third molar, which may have resulted in an underestimation of age in all age groups. This may imply

that the third molar contributes to an overall slowing down of dental development in Indians. On the other hand, in the present study, use of Indian specific formulas tends to slightly over estimate the age. In this study, the test of the India-specific cubic functions and the original formulas revealed better ability of the former to predict age accurately in South Indians in agreement with previous studies<sup>3,9</sup>.

In contrast to previous research in Indians, the sample used in the present study is relatively smaller. This study utilized digital Panoramic radiograph for the analysis. Future studies should be directed with larger sample size to develop the maturity scores representative of the population being studied to improve the age prediction, as French weighted scores were used to perform regression analysis in Indians.

### Conclusion

Demirjian's regression equations resulted in underestimation of age and Indian specific cubic equations resulted in mild overestimation of age. However, both the methods tested using Demirjian's 8 teeth method were found to be reliable in assessing age, with Indian method as the more accurate for predicting age in Central Kerala population for children aged 6–18 years.

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Table 1. Comparison of chronological age with the estimated dental age by Demirjian's regression formula

		Mean	Standard deviation	CA-DA	t-value	P value
Male	Chronological age	12.18	2.833	1.45	9.633	0.000
	Dental age	10.725	2.722			
Female	Chronological age	12.12	3.280	1.71	10.531	0.000
	Dental age	10.408	2.698			
Both	Chronological age	12.15	3.05	1.58	10.082	0.000
	Dental age	10.566	2.71			

Table 1: Comparison of chronological age with the estimated dental age by Demirjian's regression formula

Table 2. Comparison of chronological age with the estimated dental age by Acharya's Indian formula

		Mean	Standard deviation	CA-DA	t-value	P value
Male	Chronological age	12.18	2.833	0.51	-1.569	0.123
	Dental age	12.692	2.749			
Female	Chronological age	12.12	3.280	0.76	-2.026	0.089
	Dental age	12.882	2.644			
Both	Chronological age	12.15	3.05	0.63	-1.797	0.106
	Dental age	12.787	2.696			

Table 2: Comparison of chronological age with the estimated dental age by Acharya's Indian formula

Table 3. Karl Pearson's correlation coefficient between the estimated dental age according to two methods and the chronological age.

	Correlation coefficient r-value	P value
Chronological age and Dental age by Acharya's Indian formula	0.855	0.000
Chronological age and Dental age by Demirjian's formula	0.935	0.000

Table 3: Karl Pearson's correlation between the estimated dental age according to two methods and the chronological age.