

## Age estimation in children using Demirjian's technique: A retrospective study

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### Abstract

Age estimation is a sub discipline of forensic odontology which plays an important part in every identification process, especially when information related to the deceased is unavailable. The aim of this study was to evaluate the accuracy of Demirjian's Dental Age Estimation technique, with the help of Ortho-Pantomographs (OPG) in 50 children.

50 OPGs of children in the age group of 6-16 years were randomly selected and a cross-sectional retrospective study was conducted. Age estimation was done by the method given by Demirjian and two tailed test of the data was carried out.

A significantly high difference was observed in the estimated and chronologic ages in the age group of 13-16 years than in 6-12 years.

Demirjian's original method, using seven mandibular teeth is an accurate method of age estimation in children especially of the younger age group (6-12 years of age).

**Key words:** age estimation, younger age group, Demirjian's technique.

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### Introduction

Age estimation in children is an important part of forensic science for situations such as criminal responsibility, rape, paternity in question, alleged date of conception, kidnapping, and punishments for juveniles, for children of unknown birth data such as adopted children or unidentified skeletons of children, and child employment.

Teeth are one of the key systems in the body, and their degree of development is used as one of the indices of biological age. Development of human dentition follows a reliable and predictable developmental sequence up to the second decade of life (1). Variations in tooth development are very small and thus dental estimation of chronological age is an important method of age determination especially for children. Compared to

bone mineralization, tooth mineralization is much less affected by variation in endocrine and nutritional status, and tooth development thus provides a better estimation of chronologic age, although the above factors cannot be completely ignored (2). This article highlights the technique per se and the advantages and disadvantages of this technique in forensic odontology.

### Aims and Objectives

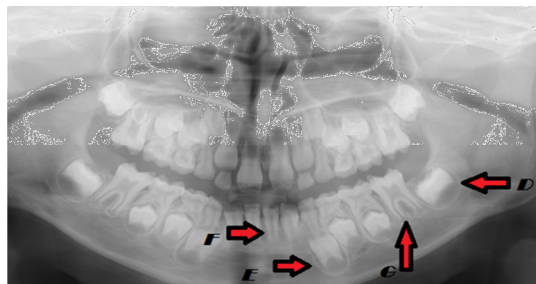
Demirjian's method is a very popular and time-tested method for age estimation, especially in children, hence a study was conducted: (1) to study the accuracy of Demirjian's method of age estimation in children who reported to Government Dental College & Hospital, Mumbai, (2) to study the variation in accuracy of the

method in males and females, and (3) to study the applicability criterion for applying Demirjian's method in forensic science.

### Materials & Methods

A cross-sectional retrospective study was conducted on 50 OPGs, randomly selected from the archives of the Department of Oral Medicine and Radiology, Government Dental College & Hospital, Mumbai.

The inclusion criteria was: age group between 3-16 years, healthy children; who were free from any disorder affecting growth; good radiographic quality; the presence of all seven left or right mandibular permanent teeth (erupted or un erupted). The exclusion criteria was age of patient >16 years of age, developmental deformities causing defects in the area of interest, unclear OPGs, bilaterally missing corresponding mandibular teeth (except third molars).



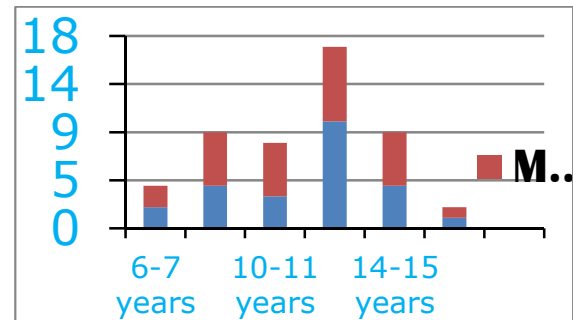
**Fig. 1:** Arrows showing tooth development stage

Dental age estimation was performed according to Demirjian's method as described in literature (3). The observer was blinded as regards the chronological age of the sample units. Stages of tooth development were compared on the OPG (Fig. 1) to the diagrams given by Demirjian (Fig. 2). Maturity scores were given according to developmental stages (A-H) of each of the seven left permanent teeth of the mandible (different for males and females) and were tabulated (Figs. 3 and 4). These scores were then summed up to obtain an overall maturity score. This total score was then converted into dental age using published conversion tables (Figs. 5 and 6)(2).

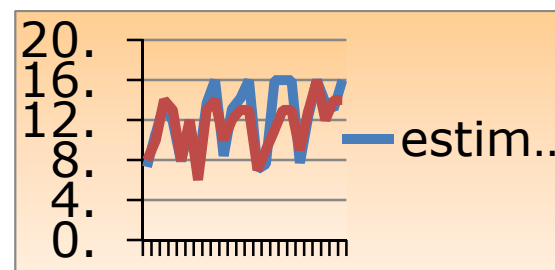
### Results

Age-wise distribution of the sample is depicted in Graph 1. Comparative analysis of males and females, revealed similar correlation coefficients (females-0.873111 and males-0.890906). No

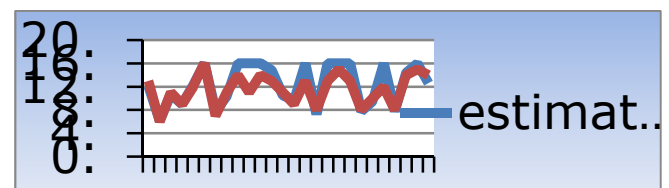
significant difference was found in the accuracy of the method for boys and girls (Graphs 2 and 3). The correlation of the estimated age and chronologic age is depicted in Graph 4. The overall correlation coefficient is high ( $=0.882368$ ). A significantly high difference is observed in the accuracy of the method when all the teeth have reached the H stage, regardless of the age and sex (Table 1).



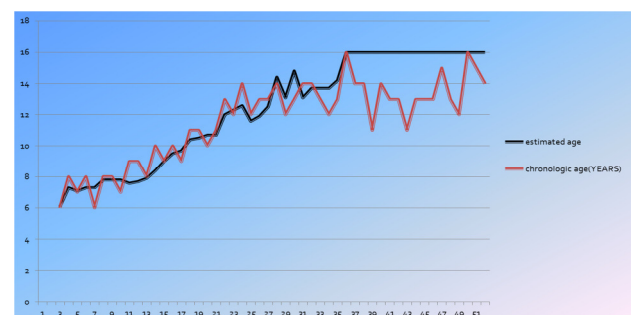
**Graph 1:** Age wise distribution of the sample



**Graph 2:** Correlation coefficient for males



**Graph 3:** Correlation coefficient for males



**Graph 4:** Correlation of estimated age and chronological age of entire sample

**Table 1:** A significantly high difference is observed in the accuracy of the method when all the teeth have reached the H stage, regardless of the age &sex

| Sample                         | Correlation Coefficient | Bias    | Inaccuracy | Standard deviation | Standard Error of Means<br>(SEM) |
|--------------------------------|-------------------------|---------|------------|--------------------|----------------------------------|
| Entire Sample                  | 0.882368                | -0.014  | 0.014      | 1.223893           |                                  |
| At least one tooth in <H stage | 0.939332                | -0.0061 | 0.0061     | 0.484358           | 0.08425                          |
| All 7 teeth in H stage         | 0.087594                |         |            | 1.462773           | 0.35459                          |

(The two-tailed P value is less than 0.0001).

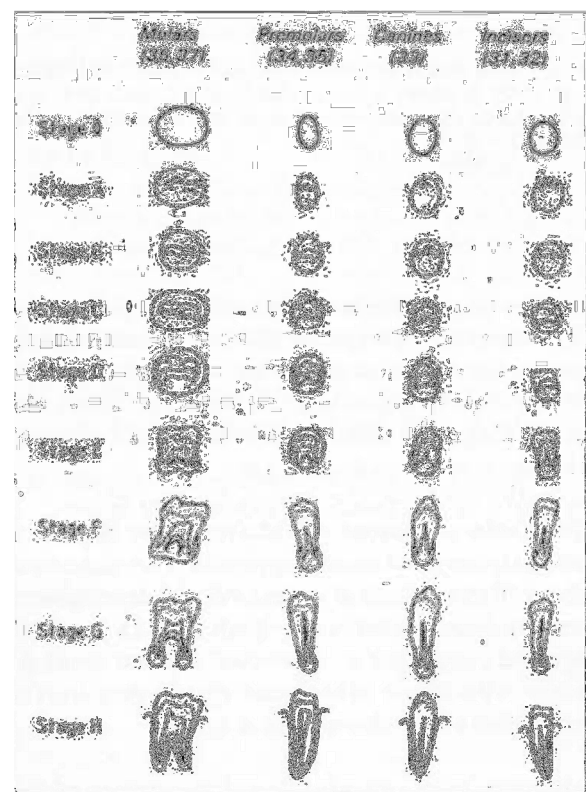
## Discussion

Forensic age diagnosis should comprise of the following: a physical examination, signs of sexual maturation, potentially age-relevant developmental disorders, examination of the left hand wrist radiograph, examination of the medial clavicular epiphyseal cartilage and a dental examination with an OPG. Dental methods of age estimation in adults are i) Morphological - Gustaafson (4), ii) Radiological: size of pulp chamber (5), iii) Kvaal and Solheim combined morphological and radiological measurements (6).

Dental maturity helps in estimating the chronological age because of low variability of dental indicators. There are different techniques used to estimate the age in forensic science. Among various dental age estimation techniques for children and young adults are those using the Atlas approach such as Schour and Massler (7), Moorrees et al (8) and Anderson (9). The alternative approach is by using the scoring systems; such as given by Demirjian et al (3) and Willems et al (10). Out of these approaches, the Demirjian's method is very popular and thus was selected for the purpose of this study. This system of age estimation is based on the degree of development of the whole tooth, and not upon clinical emergence, and is thus considered more reliable in determining dental age.

Overestimation of chronological age when using the method reported by Demirjian was consistently found by various authors

(10),(11),(12),(13). Demirjian et al had given their standards on children of French-Canadian origin.



**Fig. 2:** Graphical presentations of stages of tooth development, as given by Demirjian (2).

The reported overestimation in the literature has been attributed to the fact that the scores were not population-specific and hence the difference in age estimation. Likewise, the standards of dental age described by Demirjian et al. in 1973 and 1976

were not suitable for northern Turkish children (14). Each population of children may need their own specific standard for an accurate estimation of chronological age

|    | A   | B   | C   | D    | E    | F    | G    | H    |
|----|-----|-----|-----|------|------|------|------|------|
| 31 |     |     |     | 0    | 1.9  | 4.1  | 8.2  | 11.8 |
| 32 |     |     | 0   | 3.2  | 5.2  | 7.8  | 11.7 | 13.7 |
| 33 |     |     | 0   | 3.5  | 7.9  | 10   | 11   | 11.9 |
| 34 |     | 0   | 3.9 | 7    | 11   | 13.2 | 15.2 | 17.2 |
| 35 | 1.7 | 3.1 | 5.2 | 7.7  | 12   | 15.2 | 17.2 | 19.2 |
| 36 |     |     | 0   | 5    | 10.6 | 13.7 | 17   | 19.3 |
| 37 | 2.1 | 3.5 | 5.9 | 10.5 | 13.5 | 16.5 | 19.5 | 21.5 |

**Fig. 3:** Individual maturity scores as given by Demirjian for Males (2).

|    | A   | B   | C   | D    | E    | F    | G    | H    |
|----|-----|-----|-----|------|------|------|------|------|
| 31 |     |     |     | 0    | 2.4  | 5.1  | 9.3  | 12.9 |
| 32 |     |     | 0   | 3.2  | 5.6  | 8.0  | 12.2 | 14.2 |
| 33 |     |     | 0   | 3.8  | 7.3  | 10.3 | 11.6 | 12.4 |
| 34 |     | 0   | 3.2 | 11.3 | 13.1 | 15.1 | 17.1 | 19.1 |
| 35 | 1.7 | 3.1 | 5.2 | 7.7  | 12   | 15.2 | 17.2 | 19.2 |
| 36 |     |     | 0   | 4.2  | 10.2 | 13.2 | 16.2 | 19.2 |
| 37 | 2.1 | 3.5 | 5.9 | 10.5 | 13.5 | 16.5 | 19.5 | 21.5 |

**Fig. 4:** Individual maturity scores as given by Demirjian for Females (2)

New population-specific scores have been developed by various authors for their respective populations. Angelines Cruz-Landeira et al showed Demirjian's scores were inadequate after the age of 12 while Chaillet's scores offered useful information until 14 years of age (15). M Maber et al discovered that Haavikko's method for individual teeth using first premolar and second molar were most accurate; and more accurate than the mean value of all developing teeth. The most accurate method was by Willems than Demirjians (16). Cameriere et al showed that Willems method was better than that of Demirjian but was significantly less accurate than that of Cameriere (17). Few studies report accuracy with Age estimation using Demirjian's method (18).

A statistical analysis of this study revealed that the overestimation was more in the age group of 13-16years. The average difference was 2.04 years, which is significantly higher than the average difference of the younger age group of 6-12 years. The two tailed P value is less than 0.0001, which is statistically significant.

The advantages of this method include: (1) easy applicability, since no metric measurements were used, rather the stage of development was used as a marker, (2) better accuracy, since it was based on developmental stages and not on clinical

emergence, which is more affected by environmental and nutritional influences, (3) consideration of sufficient number of stages (A-H), thus decreasing the inter-observer disagreement, (4) sexual dimorphism is taken into consideration as the scores are different for boys and girls (5) uses OPGs which are extra oral radiographs and thus the problems caused by rigor mortis for intraoral radiography or clinical methods of age estimation are overcome.

| Age | score | Age | score | Age  | score | Age  | score | Age  | score |
|-----|-------|-----|-------|------|-------|------|-------|------|-------|
| 3   | 12.4  | 5.6 | 30.3  | 8.2  | 75.1  | 10.8 | 91.6  | 13.4 | 96    |
| 3.1 | 12.9  | 5.7 | 31.1  | 8.3  | 76.4  | 10.9 | 91.8  | 13.5 | 96.1  |
| 3.2 | 13.5  | 5.8 | 31.8  | 8.4  | 77.7  | 11   | 92    | 13.6 | 96.2  |
| 3.3 | 14    | 5.9 | 32.6  | 8.5  | 79    | 11.1 | 92.2  | 13.7 | 96.3  |
| 3.4 | 14.5  | 6   | 33.6  | 8.6  | 80.2  | 11.2 | 92.5  | 13.8 | 96.4  |
| 3.5 | 15    | 6.1 | 34.7  | 8.7  | 81.2  | 11.3 | 92.7  | 13.9 | 96.5  |
| 3.6 | 15.6  | 6.2 | 35.8  | 8.8  | 82    | 11.4 | 92.9  | 14   | 96.6  |
| 3.7 | 16.2  | 6.3 | 36.9  | 8.9  | 82.8  | 11.5 | 93.1  | 14.1 | 96.7  |
| 3.8 | 17    | 6.4 | 39    | 9    | 83.6  | 11.6 | 93.3  | 14.2 | 96.8  |
| 3.9 | 17.6  | 6.5 | 39.2  | 9.1  | 84.3  | 11.7 | 93.5  | 14.3 | 96.9  |
| 4   | 18.2  | 6.6 | 40.6  | 9.2  | 85    | 11.8 | 93.7  | 14.4 | 97    |
| 4.1 | 18.9  | 6.7 | 42    | 9.3  | 85.6  | 11.9 | 93.9  | 14.5 | 97.1  |
| 4.2 | 19.7  | 6.8 | 43.6  | 9.4  | 86.2  | 12   | 94    | 14.6 | 97.2  |
| 4.3 | 20.4  | 6.9 | 45    | 9.5  | 86.7  | 12.1 | 94.2  | 14.7 | 97.3  |
| 4.4 | 21    | 7   | 46    | 9.6  | 87.2  | 12.2 | 94.4  | 14.8 | 97.4  |
| 4.5 | 21.7  | 7.1 | 48.3  | 9.7  | 87.7  | 12.3 | 94.5  | 14.9 | 97.5  |
| 4.6 | 22.4  | 7.2 | 50    | 9.8  | 88.2  | 12.4 | 94.6  | 15   | 97.6  |
| 4.7 | 23.1  | 7.3 | 52    | 9.9  | 88.6  | 12.5 | 94.8  | 15.1 | 97.7  |
| 4.8 | 23.8  | 7.4 | 53.8  | 10   | 89    | 12.6 | 95    | 15.2 | 97.8  |
| 4.9 | 24.6  | 7.5 | 55.8  | 10.1 | 89.8  | 12.7 | 95.1  | 15.3 | 97.9  |
| 5   | 25.4  | 7.6 | 57.8  | 10.2 | 90.2  | 12.8 | 95.3  | 15.4 | 98    |
| 5.1 | 26.2  | 7.7 | 59.8  | 10.3 | 90.6  | 12.9 | 95.5  | 15.5 | 98.1  |
| 5.2 | 27    | 7.8 | 61.8  | 10.4 | 91    | 13   | 95.7  | 15.6 | 98.2  |
| 5.3 | 27.8  | 7.9 | 63.8  | 10.5 | 91.4  | 13.1 | 95.9  | 15.7 | 98.3  |
| 5.4 | 28.6  | 8   | 65.8  | 10.6 | 91.8  | 13.2 | 96.1  | 15.8 | 98.4  |
| 5.5 | 29.4  | 8.1 | 67.8  | 10.7 | 92.2  | 13.3 | 96.3  | 15.9 | 98.5  |
| 5.6 | 30.2  | 8.2 | 69.8  | 10.8 | 92.6  | 13.4 | 96.5  | 16   | 98.6  |

**Fig. 5:** Overall maturity scores as given by Demirjian for Males (2)

| Age | score | Age | score | Age  | score | Age  | score | Age  | score |
|-----|-------|-----|-------|------|-------|------|-------|------|-------|
| 3   | 12.4  | 5.6 | 30.3  | 8.2  | 75.1  | 10.8 | 91.6  | 13.4 | 96    |
| 3.1 | 12.9  | 5.7 | 31.1  | 8.3  | 76.4  | 10.9 | 91.8  | 13.5 | 96.1  |
| 3.2 | 13.5  | 5.8 | 31.8  | 8.4  | 77.7  | 11   | 92    | 13.6 | 96.2  |
| 3.3 | 14    | 5.9 | 32.6  | 8.5  | 79    | 11.1 | 92.2  | 13.7 | 96.3  |
| 3.4 | 14.5  | 6   | 33.6  | 8.6  | 80.2  | 11.2 | 92.5  | 13.8 | 96.4  |
| 3.5 | 15    | 6.1 | 34.7  | 8.7  | 81.2  | 11.3 | 92.7  | 13.9 | 96.5  |
| 3.6 | 15.6  | 6.2 | 35.8  | 8.8  | 82    | 11.4 | 92.9  | 14   | 96.6  |
| 3.7 | 16.2  | 6.3 | 36.9  | 8.9  | 82.8  | 11.5 | 93.1  | 14.1 | 96.7  |
| 3.8 | 17    | 6.4 | 39    | 9    | 83.6  | 11.6 | 93.3  | 14.2 | 96.8  |
| 3.9 | 17.6  | 6.5 | 39.2  | 9.1  | 84.3  | 11.7 | 93.5  | 14.3 | 96.9  |
| 4   | 18.2  | 6.6 | 40.6  | 9.2  | 85    | 11.8 | 93.7  | 14.4 | 97    |
| 4.1 | 18.9  | 6.7 | 42    | 9.3  | 85.6  | 11.9 | 93.9  | 14.5 | 97.1  |
| 4.2 | 19.7  | 6.8 | 43.6  | 9.4  | 86.2  | 12   | 94    | 14.6 | 97.2  |
| 4.3 | 20.4  | 6.9 | 45    | 9.5  | 86.7  | 12.1 | 94.2  | 14.7 | 97.3  |
| 4.4 | 21    | 7   | 46    | 9.6  | 87.2  | 12.2 | 94.4  | 14.8 | 97.4  |
| 4.5 | 21.7  | 7.1 | 48.3  | 9.7  | 87.7  | 12.3 | 94.5  | 14.9 | 97.5  |
| 4.6 | 22.4  | 7.2 | 50    | 9.8  | 88.2  | 12.4 | 94.6  | 15   | 97.6  |
| 4.7 | 23.1  | 7.3 | 52    | 9.9  | 88.6  | 12.5 | 94.8  | 15.1 | 97.7  |
| 4.8 | 23.8  | 7.4 | 53.8  | 10   | 89    | 12.6 | 95    | 15.2 | 97.8  |
| 4.9 | 24.6  | 7.5 | 55.8  | 10.1 | 89.8  | 12.7 | 95.1  | 15.3 | 97.9  |
| 5   | 25.4  | 7.6 | 57.8  | 10.2 | 90.2  | 12.8 | 95.3  | 15.4 | 98    |
| 5.1 | 26.2  | 7.7 | 59.8  | 10.3 | 90.6  | 12.9 | 95.5  | 15.5 | 98.1  |
| 5.2 | 27    | 7.8 | 61.8  | 10.4 | 91    | 13   | 95.7  | 15.6 | 98.2  |
| 5.3 | 27.8  | 7.9 | 63.8  | 10.5 | 91.4  | 13.1 | 95.9  | 15.7 | 98.3  |
| 5.4 | 28.6  | 8   | 65.8  | 10.6 | 91.8  | 13.2 | 96.1  | 15.8 | 98.4  |
| 5.5 | 29.4  | 8.1 | 67.8  | 10.7 | 92.2  | 13.3 | 96.3  | 15.9 | 98.5  |
| 5.6 | 30.2  | 8.2 | 69.8  | 10.8 | 92.6  | 13.4 | 96.5  | 16   | 98.6  |

**Fig. 6:** Overall maturity scores as given by Demirjian for Females (2).

The disadvantages of this method include: (1) consistent overestimation has been reported in literature, (2) it does not include third molars, (3) it cannot be used for children over 16 years of age, (4) it requires the use of mandibular teeth, in cases where the mandible has been crushed, dislocated and lost it cannot be used and (5) intra-observer and inter-observer error has been reported as the main cause for inaccuracy.

### Conclusion

Demirjian's original method, using seven mandibular teeth, is an accurate method of age estimation in children, especially, of the younger age group (6-12 years). However, it should not be considered as a reliable method when dealing with individuals who have completed root development in all of the seven teeth. The third molar should be included in the score for such cases or an alternative method should be used. This study did not use population specific scores; original scores given by Demirjian were used in spite of high accuracy. Larger sample size and further studies are required. The consistent overestimation reported in literature is specific to the older age group of around 12-16 years. The method is highly accurate in children <12 years of age.

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### Conflict of interest

None Declared

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