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ORIGINAL ARTICLE

# Dental Age Estimation using Demirjian's Methods: A Comparative study

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## ABSTRACT

### Introduction

**Context:** There are various methods have been developed for dental age estimation, of these; Demirjian's seven teeth method is most tested and accepted method worldwide. It is based on the tooth development rather than tooth eruption, because developmental process is strictly controlled by genes and less influenced by dietary insufficiency, endocrinal disturbances and environmental insults.

**Aims:** The purpose of this study is to evaluate the applicability of two Demirjian's methods in a sample of the Varanasi region.

**Setting and Design:** This is a cross sectional prospective study.

**Material and Methods:** The evaluation of digital panoramic images of total 432 children and adolescents (237 boys and 195 girls) of age rang 3-16 years from population of the Varanasi region. Seven left mandibular teeth excluding third molar were rated and scored to obtain dental age using Dem73 and Dem76 methods.

**Statistical Analysis:** Paired t-test was applied to determine the significant difference between estimated dental age and chronological age and correlation was established using Pearson's correlation coefficient.

**Results:** The Dem73 method overestimated the dental age in boys by 0.23 (±0.80) years and by 0.12 (±0.85) years in the total sample. In the girls' sample, there was no discernible difference in mean age. In boys, girls, and the total sample, Dem76 method overestimated dental ages by 0.85 (±1.14), 0.45 (±1.00), and 0.67 (±1.10) years, respectively. Pearson's correlation revealed high coefficient value between dental and chronological ages.

**Conclusions:** Dem73 method is more applicable than Dem76 method for age estimation among children and adolescents in the Varanasi region.

keywords |Age estimation; Dental age; chronological age; Tooth Development; Demirji an's method

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**Key Massages:** Tooth development is the most reliable indicator of a person's actual age than bone age and secondary sexual characters. Demirjian's development method is the most tested and acceptable method for dental age estimation worldwide. Dem73 method was found more applicable for dental age estimation than the Dem76 method in Varanasi region population.

## INTRODUCTION

A domain of the forensic sciences i.e., estimation of age is medico legally significant in forensic casework. Assessing chronological age is fundamental for distinguishing proof of criminal cases, survivors of mass catastrophes, and examinations of human remaining parts in archaeological investigations. It is critical to choose whether blamed individual or casualty is beneath or over the age threshold for the criminal law, therefore age assurance for living people is needed to evaluate criminal obligations.[1] Numerous medical and paramedical areas such as diagnosis and treatment planning in orthodontics and pediatric dentistry, pediatric medicine and endocrinology are also concerned with the significance of age determination.[2]

For juveniles and adolescents, age is estimated utilizing formative markers, for example, skeletal development, body weight, and height, sexual turn of events, dental eruption, and maturity. Dental development is the most precise, dependable, and quick indicator of age and is determined by assessing dental advancement stages utilizing radiographs.[3] In humans, dental development starts in the intrauterine period and endures until adulthood. When contrasted with the advancement of different organs, the development of teeth shows the most elevated relationship with the chronological age of juvenescent.[4]

Dental maturation may be evaluated either by the phase of dental eruption or by the calcification and mineralization phase of teeth. The timing and sequence of dental eruption may be influenced by confined conditions such as ankylosis, crowding, extractions, retention of primary teeth, malpositioning, cysts, and dental trauma. Various conditions, both systemic and hereditary, are related to the configuration of postponed tooth eruption. Moreover, it is not feasible to evaluate the specific time of eruption of each tooth for a similar person.[5] The level of calcification is related to various mineralization morphological stages that can be ascertained radio-graphically. The patch of mineralization is substantially more uniform, ongoing, sequenced, and persistent than the tooth eruption, and is less influenced by endocrine illness, dietary insufficiency, and changes in environmental conditions.[6]

The Demirjian's method of dental age estimation is very simple, non-invasive, and does not require highly skilled people to perform, but it is applicable only to the 3–16 year age range, so cases below 3 years and above 16 years cannot be precisely calculated by this method. OPG radiographs of younger children are quite difficult to obtain because they become very nervous and violently shaking their heads could cause injury to them or diminish the quality of the radiographs, making this method more difficult. The Demirjian technique is a broadly applied strategy because of its veracity and feasibility.[7] The utilization of Demirjian's development scale in various populations around the globe has uncovered that a few populations share the comparable pattern of dental maturity achievement as the French-Canadians, while different populations contrast altogether. This pattern was seen in ethnically divergent populations and populations inside an equivalent topographical territory. This features the restricted applicability of such reference information.[8]

The purpose of this study was to evaluate the accuracy and comparison of the Demirjian's seven-teeth method[9] (Dem73) and Demirjian's revised seven-teeth method[10] (Dem76) for assessing age in the Varanasi region population and to examine the practicability of Demirjian's procedure in various age bunches for both sexes.

## MATERIALS AND METHODS

In this cross-sectional study, a total of 432 digital panoramic radiographs of children

and adolescents, including 237 boys and 195 girls, from the age range of 3-16 years from the population of Varanasi region, Uttar Pradesh, India were evaluated to calculate dental age (Table 1). The samples, which belong to the inclusion criteria of the study, were collected from the patients who visited the Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, for regular dental checkups and treatments. None of the cases have been taken for study purposes only.

**Table 1:** Age group and sex distribution of studied sample

| Age group | Chronological age | Gender | | Total (%) |
|---|---|---|---|---|
| | | Male (%) | Female (%) | |
| 3 | 3.00 - 3.99 | 7 (1.62) | 4 (0.93) | 11 (2.55) |
| 4 | 4.00 – 4.99 | 10 (2.31) | 2 (0.46) | 12 (2.78) |
| 5 | 5.00 – 5.99 | 14 (3.24) | 9 (2.08) | 23 (5.32) |
| 6 | 6.00 – 6.99 | 20 (4.63) | 7 (1.62) | 27 (6.25) |
| 7 | 7.00 – 7.99 | 13 (3.01) | 9 (2.08) | 22 (5.09) |
| 8 | 8.00 – 8.99 | 19 (4.40) | 14 (3.24) | 33 (7.64) |
| 9 | 9.00 – 9.99 | 25 (5.79) | 15 (3.47) | 40 (9.26) |
| 10 | 10.00 – 10.99 | 28 (6.48) | 21 (4.86) | 49 (11.34) |
| 11 | 11.00 – 11.99 | 22 (5.09) | 19 (4.40) | 41 (9.49) |
| 12 | 12.00 – 12.99 | 22 (5.09) | 24 (5.56) | 46 (10.65) |
| 13 | 13.00 -13.99 | 28 (6.48) | 26 (6.02) | 54 (12.50) |
| 14 | 14.00 – 14.99 | 11 (2.55) | 22 (5.09) | 33 (7.64) |
| 15 | 15.00 – 15.99 | 18 (4.17) | 23 (5.32) | 41 (9.49) |
| | Total | 237 (54.86) | 195 (45.14) | 432 (100) |

A subject aged 3 to 16 years old of Indian origin, having radiographs with clearly visible teeth with an exact known date of birth and date of radiograph were included in the study. Radiographs that were unclear or had impacted teeth or had any dental anomalies were excluded from the study.

Dental age estimation was done using Dem73 and Dem76 methods. In the Dem73 method, the development of seven left mandibular teeth, from the second molar to the central incisor, were evaluated using digitized panoramic radiographs with the help of DIACOM software. Each tooth was rated individually on an eight-stage scale from A-H and maturity scores were allocated to designated stages for each tooth from the self -weighted score table designed separately for boys and girls. The sum of the scores for each subject was converted into dental age using a standardized age conversion table available in this method for boys and girls separately. In the Dem76 method, the same seven teeth were used, but scores were allocated from the revised self-weighed score table separately for boys and girls based on the calcification stages, and dental age was calculated using the conversion table given in the previous method. Chronological age was calculated in decimals by subtracting the date of birth from the date of a radiograph of each subject.

## STATISTICAL ANALYSIS

The degree of inter and intra observer agreement was assessed using Cohen's Kappa statistics before the data was analyzed. For the proposed study, the data was statistically analyzed using IBM SPSS version 24 software. The significant difference between estimated dental age and chronological age for individual

age groups and the combined sample was determined using a paired t-test. Each age category comprises a range of 12 months. For example, age group 3 includes ages from 3.00 to 3.99 years, and so on, and analysis was performed according to the age category and gender wise. Statistical significance was set at $p<0.05$. The correlation between estimated dental age and chronological age for boys, girls, and the total sample was confirmed separately for both the methods using Pearson's correlation (r-value). In this test, the r value close to 1 was considered to represent the strong positive relationship between the compared data.

## RESULTS

Among the boys, girls, and the total sample, the mean chronological ages evaluated in the study were 10.16 (±3.28), 11.37 (±3.11), and 10.71 (±3.26) years, respectively. For boys, girls, and the total sample, the mean estimated dental ages using the Dem73 method were 10.39 (±3.42), 11.37 (±3.04), and 10.83 (±3.29) years, respectively. The differences between mean estimated dental ages and mean chronological ages were 0.23 (±0.80), 0.00 (±0.89), and 0.12 (±0.85) years, for boys, girls, and the total sample, respectively. Statistically significant differences were observed in boys (p = 0.000)

**Table 2:** Paired t-test showing the mean difference between estimated dental age according to Demirjian's seven teeth method and chronological age for boys sample, girls and total sample

| Gender | Age group | Mean ± SD | | | 95 % CI | p value |
|---|---|---|---|---|---|---|
| | | CA ± SD | EDA ± SD | (EDA – CA) ± SD | | |
| **BOYS** | 3 | 3.64 ± 0.25 | 3.43 ± 0.21 | -0.21 ± 0.24 | -0.44, 0.01 | 0.057 |
| | 4 | 4.57 ± 0.29 | 4.46 ± 0.64 | -0.11 ± 0.68 | -0.59, 0.38 | 0.631 |
| | 5 | 5.52 ± 0.28 | 6.03 ± 0.96 | 0.51 ± 0.88 | 0.01, 1.02 | 0.048* |
| | 6 | 6.38 ± 0.28 | 7.00 ± 0.35 | 0.62 ± 0.27 | 0.49, 0.74 | 0.000* |
| | 7 | 7.54 ± 0.32 | 7.69 ± 0.36 | 0.15 ± 0.39 | -0.09, 0.39 | 0.196 |
| | 8 | 8.48 ± 0.27 | 8.34 ± 0.57 | -0.14 ± 0.52 | -0.39, 0.11 | 0.259 |
| | 9 | 9.51 ± 0.23 | 9.43 ± 0.75 | -0.08 ± 0.73 | -0.39, 0.22 | 0.570 |
| | 10 | 10.50 ± 0.34 | 10.59 ± 0.93 | 0.10 ± 0.94 | -0.27, 0.46 | 0.593 |
| | 11 | 11.53 ± 0.30 | 11.96 ± 1.15 | 0.43 ± 0.98 | 0.00, 0.87 | 0.051 |
| | 12 | 12.45 ± 0.24 | 13.01 ± 0.74 | 0.56 ± 0.75 | 0.23, 0.89 | 0.002* |
| | 13 | 13.43 ± 0.29 | 13.52 ± 1.12 | 0.09 ± 1.07 | -0.33, 0.50 | 0.675 |
| | 14 | 14.43 ± 0.24 | 15.17 ± 0.61 | 0.74 ± 0.61 | 0.33, 1.15 | 0.002* |
| | 15 | 15.48 ± 0.33 | 15.56 ± 0.67 | 0.07 ± 0.73 | -0.29, 0.43 | 0.671 |
| | **Total Boys** | 10.16 ± 3.28 | 10.39 ± 3.42 | 0.23 ± 0.80 | 0.13, 0.33 | **0.000*** |
| **GIRLS** | 3 | 3.50 ± 0.30 | 3.36 ± 0.28 | -0.14 ± 0.30 | -0.62, 0.34 | 0.420 |
| | 4 | 4.53 ± 0.13 | 5.75 ± 1.70 | 1.22 ± 1.82 | -15.17, 17.61 | 0.518 |
| | 5 | 5.53 ± 0.23 | 5.77 ± 0.76 | 0.24 ± 0.67 | -0.27, 0.75 | 0.312 |
| | 6 | 6.54 ± 0.32 | 6.87 ± 0.78 | 0.33 ± 0.86 | -0.46, 1.12 | 0.349 |
| | 7 | 7.56 ± 0.31 | 7.76 ± 0.33 | 0.20 ± 0.41 | -0.12, 0.51 | 0.188 |
| | 8 | 8.50 ± 0.32 | 8.19 ± 0.47 | -0.32 ± 0.46 | -0.58, -0.05 | 0.023* |
| | 9 | 9.51 ± 0.32 | 9.41 ± 0.58 | -0.10 ± 0.56 | -0.41, 0.21 | 0.506 |
| | 10 | 10.65 ± 0.25 | 10.92 ± 1.04 | 0.26 ± 1.02 | -0.20, 0.73 | 0.251 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | 11.48 ± 0.28 | 12.18 ± 0.74 | 0.70 ± 0.74 | 0.34, 1.05 | 0.001* |
| 12 | 12.55 ± 0.35 | 12.71 ± 1.23 | 0.16 ± 1.15 | -0.33, 0.65 | 0.509 |
| 13 | 13.56 ± 0.29 | 13.28 ± 0.81 | -0.29 ± 0.86 | -0.64, 0.06 | 0.101 |
| 14 | 14.46 ± 0.34 | 14.43 ± 0.80 | -0.04 ± 0.75 | -0.37, 0.30 | 0.828 |
| 15 | 15.41 ± 0.25 | 14.67 ± 0.64 | -0.74 ± 0.67 | -1.03, -0.45 | 0.000* |
| **Total Girls** | 11.37 ± 3.11 | 11.37 ± 3.04 | 0.00 ± 0.89 | -0.13, 0.12 | **0.964** |
| **Total Sample** | 10.71 ± 3.26 | 10.83 ± 3.29 | 0.12 ± 0.85 | 0.04, 0.20 | 0.003* |

Age group 3 means: 3.00 – 3.99 years and so on

CA = chronological age; EDA = estimated dental age; SD = standard deviation; EDA – CA = mean age difference; CI = confidence interval

p* = statistically significant difference ($p < 0.05$)

and the total sample ($p = 0.003$) only. When considering individual age groups, boys of age groups 5, 6, 12, and 14 exhibited significant differences, while girls of age groups 8, 11, and 15 showed significant differences. (Table 2)

In the Dem76 method, boys, girls, and total samples had mean estimated dental ages of 11.01 (±3.8), 11.82 (±3.36), and 11.37 (±3.63) years, respectively. For boys, girls, and the total sample, the difference between mean estimated dental ages and mean chronological ages was 0.85 (±1.14), 0.45 (±1.00), and 0.67 (±1.10) years, respectively. All three groups, boys, girls, and the entire sample, had statistically significant differences ($p<0.05$). Statistically significant differences were found in all individual age groups (except 4, 7, 9 & 10) in boys, while in girls, all individual age groups (except 3, 4, 6, 7, 10 & 15) (Table 3). The Pearson's correlation coefficient revealed a strong positive relationship between estimated dental age and chronological age for boys ($r = 0.972$, $p = 0.000$), girls ($r = 0.958$, $p = 0.000$), girls and the total sample ($r = 0.966$, $p = 0.000$), in the Dem73 method; and for boys ($r = 0.958$, $p = 0.000$), girls and the total sample ($r = 0.955$, $p = 0.000$), in the Dem76 method. The correlation was found to be statistically significant ($p<0.05$) for all the sets of data (Table 4).

**Table 3:** Paired t-test showing the mean difference between estimated dental age according to revised Demirjian's seven teeth method and chronological age for boys, girls and total sample

| Gender | Age group | Mean ± SD | | | 95 % CI | p value |
|---|---|---|---|---|---|---|
| | | CA ± SD | EDA ± SD | (EDA – CA) ± SD | | |
| **BOYS** | 3 | 3.64 ± 0.25 | 4.19 ± 0.14 | 0.54 ± 0.26 | 0.30, 0.79 | 0.002* |
| | 4 | 4.57 ± 0.29 | 5.00 ± 0.62 | 0.43 ± 0.67 | -0.05, 0.91 | 0.073 |
| | 5 | 5.52 ± 0.28 | 6.33 ± 0.63 | 0.81 ± 0.51 | 0.52, 1.11 | 0.000* |
| | 6 | 6.38 ± 0.28 | 7.19 ± 0.27 | 0.81 ± 0.23 | 0.70, 0.92 | 0.000* |
| | 7 | 7.54 ± 0.32 | 7.70 ± 0.27 | 0.17 ± 0.36 | -0.05, 0.38 | 0.121 |
| | 8 | 8.48 ± 0.27 | 8.19 ± 0.59 | -0.29 ± 0.56 | -0.56, -0.02 | 0.038* |
| | 9 | 9.51 ± 0.23 | 9.41 ± 0.98 | -0.10 ± 0.97 | -0.50, 0.30 | 0.595 |
| | 10 | 10.50 ± 0.34 | 10.88 ± 1.34 | 0.39 ± 1.31 | -0.12, 0.90 | 0.127 |
| | 11 | 11.53 ± 0.30 | 13.07 ± 1.72 | 1.54 ± 1.53 | 0.86, 2.22 | 0.000* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 12.45 ± 0.24 | 14.67 ± 0.73 | 2.22 ± 0.72 | 1.90, 2.54 | 0.000* |
| | 13 | 13.43 ± 0.29 | 15.09 ± 0.90 | 1.66 ± 0.88 | 1.32, 2.00 | 0.000* |
| | 14 | 14.43 ± 0.24 | 16.00 ± 0.00 | 1.57 ± 0.24 | 1.41, 1.73 | 0.000* |
| | 15 | 15.48 ± 0.33 | 15.97 ± 0.14 | 0.49 ± 0.33 | 0.32, 0.65 | 0.000* |
| | **Total Boys** | 10.16 ± 3.28 | 11.01 ± 3.80 | 0.85 ± 1.14 | 0.70, 0.99 | **0.000*** |
| **GIRLS** | 3 | 3.50 ± 0.30 | 3.91 ± 0.36 | 0.41 ± 0.30 | -0.07, 0.89 | 0.073 |
| | 4 | 4.53 ± 0.13 | 6.00 ± 1.49 | 1.47 ± 1.61 | -13.01, 15.96 | 0.420 |
| | 5 | 5.53 ± 0.23 | 5.98 ± 0.65 | 0.45 ± 0.54 | 0.03, 0.87 | 0.038* |
| | 6 | 6.54 ± 0.32 | 6.91 ± 0.62 | 0.36 ± 0.72 | -0.30, 1.03 | 0.226 |
| | 7 | 7.56 ± 0.31 | 7.73 ± 0.26 | 0.17 ± 0.39 | -0.13, 0.47 | 0.226 |
| | 8 | 8.50 ± 0.32 | 7.98 ± 0.38 | -0.53 ± 0.42 | -0.77, -0.29 | 0.000* |
| | 9 | 9.51 ± 0.32 | 9.08 ± 0.65 | -0.43 ± 0.63 | -0.78, -0.08 | 0.020* |
| | 10 | 10.65 ± 0.25 | 10.92 ± 1.35 | 0.27 ± 1.31 | -0.33, 0.86 | 0.361 |
| | 11 | 11.48 ± 0.28 | 13.04 ± 0.96 | 1.55 ± 0.91 | 1.11, 1.99 | 0.000* |
| | 12 | 12.55 ± 0.35 | 13.49 ± 1.33 | 0.94 ± 1.27 | 0.40, 1.47 | 0.001* |
| | 13 | 13.56 ± 0.29 | 14.16 ± 0.71 | 0.60 ± 0.78 | 0.28, 0.91 | 0.001* |
| | 14 | 14.46 ± 0.34 | 15.19 ± 0.61 | 0.72 ± 0.57 | 0.47, 0.98 | 0.000* |
| | 15 | 15.41 ± 0.25 | 15.39 ± 0.40 | -0.03 ± 0.43 | -0.21, 0.16 | 0.766 |
| | **Total Girls** | 11.37 ± 3.11 | 11.82 ± 3.36 | 0.45 ± 1.00 | 0.31, 0.59 | **0.000*** |
| **Total Sample** | | 10.71 ± 3.26 | 11.37 ± 3.63 | 0.67 ± 1.10 | 0.56, 0.77 | **0.000*** |

Age group 3 means: 3.00 – 3.99 years and so on

CA = chronological age; EDA = estimated dental age; SD = standard deviation; EDA – CA = mean age difference; CI = confidence interval

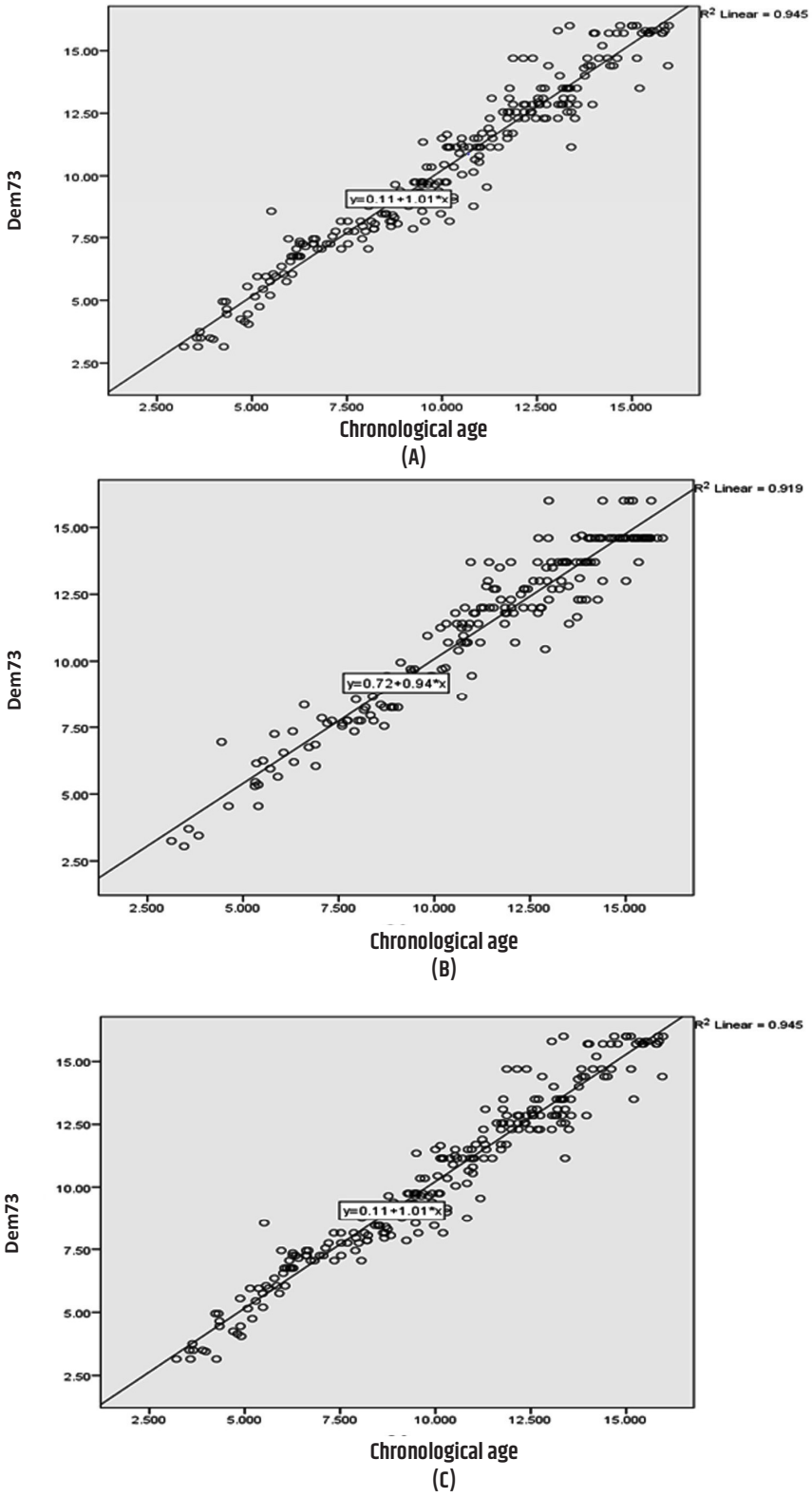
p* = statistically significant difference ($p < 0.05$)

**Table 4:** Showing the Pearson`s correlation coefficient between estimated dental age and chronological age for the samples.

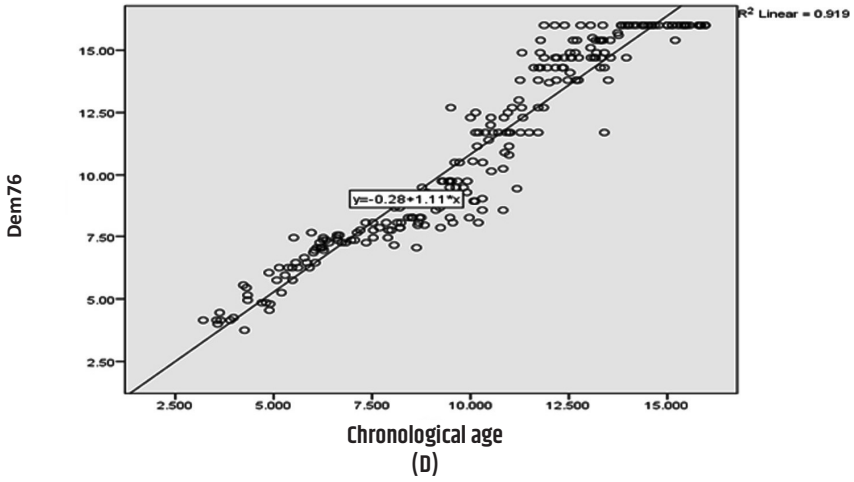
| Sample size | Dem73 | | Dem76 | |
|---|---|---|---|---|
| | Correlation (r) | Significance | Correlation (r) | Significance |
| Boys (N = 237) | 0.972 | 0.000 | 0.958 | 0.000 |
| Girls (N = 195) | 0.958 | 0.000 | 0.955 | 0.000 |
| Total (N = 432) | 0.966 | 0.000 | 0.955 | 0.000 |

Significant difference $p<0.05$

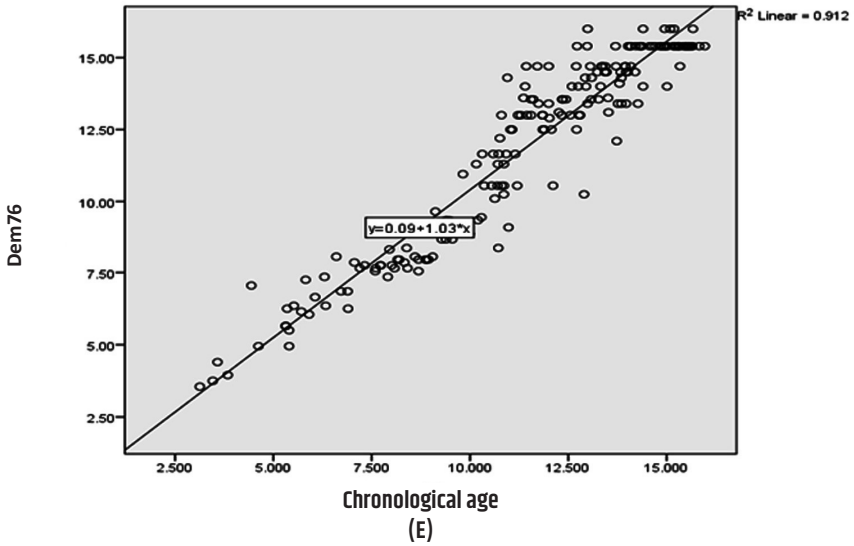
**Graph 1:** Scatter plots showing Pearson's linear correlation between estimated dental ages using Dem73 method and chronological ages for boys (a), girls (b) and total sample (c)



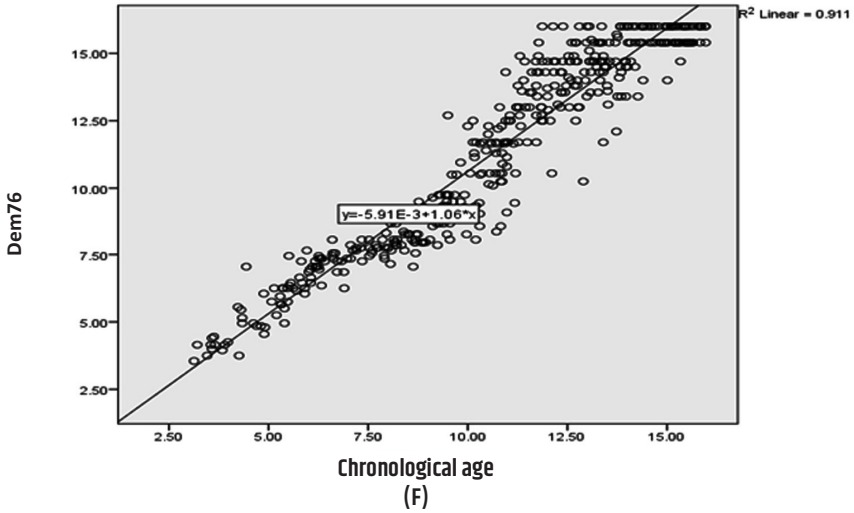
**Graph 2:** Scatter plots showing Pearson's linear correlation between estimated dental ages using Dem76 method and chronological ages for boys (d), girls (e) and total sample (f)




(D)




(E)




(F)

## DISCUSSION

There are various population specific methods of dental age estimation that have been envisaged in different parts of the world, but due to varying differences in different ethnic groups, no universal system of dental age estimation has been developed. That's why each existing method needs to be tested in different ethnic groups.[2] Dental age can be estimated by tooth eruption through tooth count and by the development process through the level of mineralization and calcification. Dental development is a more reliable indicator of age estimation because it is strictly controlled by genes, but tooth eruption and gingival emergence are mostly influenced by space available in the dental arch, extraction of deciduous predecessors, teeth tipping, or teeth impaction. The timing of dental eruption and gingival vary in different ethnic groups and the same ethnic group, making it an unreliable indicator. One more problem associated with dental eruption is that it can only be observed as a single event in time for each tooth. Bone age and secondary sexual characteristics are more influenced by environmental factors as well as dietary habits and diseased conditions.[7]

We examined the dental age estimates obtained using the Dem73 and Dem76 methodologies on the Varanasi region population for boys and girls separately and in a combined sample. While utilizing the Dem73 approach, early dental development was identified in boys, but no difference was found in girls, and when using the Dem76 method, early dental development was detected in both boys and girls when compared to French Canadian children. Individual age groups 5-7 and 10-15 for boys showed early tooth development and the remaining age groups were delayed in tooth development, while individual age groups 4-7 and 10-12 for girls showed early tooth development, and the remaining age groups were delayed in tooth development when compared to the French Canadian population using the Dem73 method. In comparison to the French Canadian population, all individual age groups except 8 and 9 in boys and all individual age groups except 8, 9, and 12 in girls reported early tooth development when using the Dem76 approach.

Only a few studies from various populations have been reported to compare these two age estimating methods simultaneously; of these, only one study was reported from India i.e. Hegde S et al.[11] which agreed with our study, except for the girls' population in the Dem73 approach. They reported higher overestimation in the Dem73 method by 0.75 (SD = ±1.50), 0.64 (SD = ±1.44), and 0.69 (SD = ±1.46) years respectively, for boys, girls, and the total sample, and slightly less overestimation for the Dem76 method by 0.11 (SD = ±0.81), 0.24 (SD = ±0.80) and 0.19 (SD = ±0.80) years respectively, for boys, girls and the total sample as compared to our study. Flood et al.[12] in the South Australian population found that the Dem73 method overestimated ages in boys and girls by 0.61 (SD = ±0.06) and 0.75 (SD = ±0.07) years, respectively, while the Dem76 method overestimated ages by 0.49 (SD = ±0.06) and 0.47 (SD = ±0.06) years in boys and girls, respectively. Another study was conducted on the Western Australian population by Flood et al.[13] also reported over estimation by 0.51 (SD = ±0.12) and 0.63 (SD = ±0.15) years for boys and girls, respectively, using the Dem73 method, and 0.19 (SD = ±0.13) and 0.41 (SD = ±0.14) years for boys and girls, respectively, using the Dem76 method. These two studies are also in agreement with our study, except for the girls' population using the Dem73 approach.

When the Dem73 method, was considered alone, it was found that studies have reported overestimation, underestimation, or high degree of accuracy for dental age as compared to chronological age. Studies conducted on the Indian population are; Koshi and Tondon[14] on 184 south Indian children have reported overestimation by 3.04 years and 2.82 years in boys and girls, respectively. Another study conducted by Prabhakar et al.[15] in the Devangere population of South Indian reported overestimation by 1.20 (SD = ±1.02) years in males and 0.90 (SD = ±0.87) years in females, respectively. Hegde and Sood[16] conducted a study in the Belgaum population of South India on 197 children in age groups 6-13, showed an overestimation by 0.15 years in males and 0.04

years in females, respectively. Studies reported from the rest of the world are; Liversidge et al.[17] reported overestimation by 0.73 (SD = ±0.73) years in males and 0.51 (SD = ±0.79) years in females, respectively. Mani et al.[18] on Malay children reported overestimation by 0.75 years in males and 0.61 years in females, respectively. Studies conducted in the Middle East region by, Al Emran[19] on Saudi Arabian children reported overestimation by 0.3 years in males and 0.4 years in females, Qudeimat et al.[20] on Kuwaitian children reported overestimation by 0.71(SD = ±1.18) in boys and 0.67 (SD = ±1.30) years in girls, Baghdadi Z D[21] on Saudi children reported overestimation by 0.77 (SD = ±0.85) years in males and 0.85 (SD = ±0.79) years in females, Alshiri AM et al.[6] on Western Saudi children reported overestimation by 0.66 (SD = ±1.14) years in males and 0.059 (SD = ±1.26) years in females, Alassiry A et al.[7] on Saudi children reported overestimation by 0.57 (SD = ±1.48) years in males and 0.44 (SD = ±1.66) years in females. The studies were conducted in other parts of the world by, Willems G et al.[22] Tunk ES and Koyuturk AE,[23] Nystrom M et al.[24], Cen J W et al.[25], Leurs IH et al.[26], Bagic I C et al.[27], and Martínez GVM and Ortega-Pertuz AI[28], also reported overestimation of estimated dental age in males and females. All these studies supported our study for the male population only. Hagg and Matson[29], Nykanen et al.[30], Farah C S et al.[31] and Hegde RJ et al.[32] reported a high degree of accuracy and precision for the Dem73 method. Zhai Yui et al.[33], on Northern Chinese population and Hegde RJ et al.[34], on Indian population reported underestimation of dental age in boys and girls, contradicted our study.

The results of our study confirm the necessity of developing population specific scores because differences exist in different population standards within the country and other study groups around the world. Hence, it is imperative to use population specific scores for age estimation in civil and criminal cases for the population being considered.[6] A slight variation was observed when applying the Dem73 method to a Varanasi region in the boys' population, but no variation was observed in the girls' population. Although a mean age difference of 0.5 years is regarded as more correct in forensic studies,[13,35] a difference of one year is also acceptable,[36] and our study utilizing the Dem73 method satisfied both the criteria, while the Dem76 method is within the acceptable range of one year being less accurate than the Dem73 method. These differences may be explained by different factors, such as biological variation in individual children, sampling methods, ethnicity, geographical location, environmental factors, nutrition, socioeconomic status, and the time difference between the two studies.[7]

## CONCLUSION

It was concluded that the Dem73 method is more applicable than Demirjian's Dem76 method for age estimation in children and adolescents of Varanasi region.

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