



Evaluation of the Modified Demirjian Chart (DAEcc) for Dental Age Estimation by Dental Interns

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Abstract

Aim: The original Demirjian method for dental age estimation is very lengthy, because it involves a number of charts to estimate the dental age. So, a simplified comprehensive chart (DAEcc) was developed to facilitate dental age estimation by the Demirjian method. The aim of the study was to check the applicability and reproducibility of the simplified comprehensive DAEcc chart for dental age estimation by a group of dental interns.

Methods: Twenty-eight interns were trained to identify the correct stage of calcification on dental radiographs by tracing seven mandibular permanent teeth (lower central and lateral incisors, canine, first and second premolars, first and second molars in the fourth quadrant) on orthopantomographs of the left side. After assigning the corresponding scores, all the scores were summed up and ease of applicability of the simplified method was assessed for dental age estimation.

Results: The correlation coefficient between chronological age and dental age as estimated by the interns was 0.995, which showed an excellent correlation; and the average time taken by the interns for the interpretation was 1-2 minutes, which is much less compared to the original method. The excellent correlation and the little time taken by the interns, demonstrate the ease of applicability of this modified chart.

Conclusion: Dental age was correctly estimated by dental interns by applying this simplified chart in a significantly shorter time period.

Keywords: Age estimation, Age groups, Dental students, Dentistry, Minors.

1. Background

Age estimation is preliminary step in identification of an individual by forensic experts. It plays a significant role in the identification of unknown bodies in mass disasters or criminal investigations. It is also useful in medico-legal or civil cases of child marriages, rape, child labor, immigration, retirement benefits, and etc.

Currently, in developing countries like India, increasing cases of age forgery in juvenile crimes or in sports as well as the lack of birth registrations in rural areas have made age estimation a vital part of the medical curriculum.

Various methods for age estimation are used

such as chronological age, dental age, skeletal age, and sexual age. Amongst these, dental age estimation is the most important component as teeth are the last to be destroyed in any crime scene and dental records can be traced in any mass disaster. Dental age estimation involves both the physical examination of the teeth and radiographs, i.e. intra oral periapical radiographs (IOPA) or panorex (OPG).

Dental age is estimated based on calcification of the crown/root, and clinical emergence as well as root formation. Of these, the Demirjian (3,4) and Nolla (5) methods are used widely in different ethnic populations. The Demirjian original method is based on separate scoring of calcification stages

of the left mandibular seven teeth (central and lateral incisors, canine, first and second premolars, first and second molars) in boys and girls to calculate the estimated age. However, this method, though accurate, is time consuming, lengthy, and uses multiple charts.

In order to make this method more user-friendly and less time-consuming, Jain et al. (6) introduced a comprehensive dental age estimation chart (DAEcc) that provides pictorial illustrations of various calcification stages, and they comprehensively made one chart to combine scoring for both boys and girls. The DAEcc chart outlines tooth number using the FDI notation and the eight developmental stages of each tooth, which are individually shown in the original tables by Demirjian (3). The DAEcc chart also comprises scanned copies of images of the developmental stages of all four different types of teeth (i.e., incisors, canines, premolars and molars). The DAEcc also consists of a scoring system for each developmental stage for males and females, and at the end of the table this sum is added to determine the final score. The final score is then used to calculate the dental age in reference to the original tables by Demirjian for both sexes. A general depiction of all the stages, considering the amount of calcified crown and root, formation of root apices, and closure of root apices is included in Appendix 1.

The ease of the operator was previously checked on 50 second-year BDS students (6), where a single instructor demonstrated the tracing of the seven mandibular teeth on the OPG as given in the original Demirjian method, subsequent to matching the tracing to the image of the teeth in the DAEcc and assigning the corresponding score to the tracing. All individual scores were tallied for locating the analogous dental age in the original tables using the Demirjian method, individually for both sexes. It took approximately 15 minutes for the students to accomplish; then they were assigned a practice trace.

The validity of this simplified chart has been tested in the north Indian population (7), however, ease of applicability has not been tested in dentistry.

Hence, the current study aimed to test the ease, time taken, and accuracy of age estimation performed by undergraduate BDS interns using the DAEcc chart. The hypotheses states that interns, being the most experienced amongst all dental levels will be able to accurately and easily apply this chart for dental age estimation.

2. Methods

This retrospective and observational study was conducted on the population of Ludhiana (Punjab, India). Eighty-eight OPGs of the patients (45 males and 43 females) with the age range of 7-15 years old, who were already undergoing orthodontic treatment in a private practice were assessed by dental interns. The exact chronological age of all patients was recorded.

Patients whose exact chronological age was unknown were not included. Also patients with developmental abnormalities, syndromes, or missing teeth on the left side of the mandible, and poor quality radiographs were excluded from the study.

Informed consent form was signed by the patients' guardians or parents and the data was anonymized to ensure privacy.

Sample size calculation

The number of interns was calculated to be $n=28$ by using the formula: $n = Z^2 \alpha/2^2 * P(1-P) / d^2$, where $Z \alpha/2$ is the critical value of the normal distribution at $\alpha/2$ (for our study the confidence level of 95%, α was 0.05 and the critical value was 1.96), $p=93\%$ is the proportion and $d=10\%$ is margin of error.

An experienced faculty member demonstrated tracing of calcification stages of the left mandibular seven teeth as depicted in the original Demirjian technique (3) and filling out the DAEcc chart to 28 interns. After the demonstration, each intern performed the following steps, as given in the DAEcc chart (3):

- Tracings of the left mandibular seven teeth in OPGs were done by all the interns.
- These tracings were matched with the pictorial illustrations of the teeth in the DAEcc chart and corresponding scores to each tooth were assigned.
- All the values of these scores were summed up to get a total final score.
- The final scores were matched with the age in original Demirjian tables, separately for boys and girls (6).

The same steps were repeated for all the OPGs assessed by the interns.

One observer recorded the time taken by each intern to perform the age assessment following all the above mentioned steps. Statistical analysis was performed to test the accuracy of the estimated age for each of the radiographs and for calculation of time taken by the interns in the process for the assessment.

Statistics

All the tracings were evaluated and the results were tabulated. Categorical variables were indicated in count (percentage) and continuous variables were indicated in mean +/- SD or median (QR). Pearson Coefficient was used to find the correlation between the estimated and actual age. The p value < 0.05 was determined to be significant. Bland Altman analysis was done to check the agreement between these two measurements (estimated and chronological age). All the analyses were done using the SPSS software version 26.0.

3. Results

The average estimated age by all the interns showed that they correctly estimated the age of 28.4% of the patients. The criteria for correct age estimation was how efficiently the estimated dental age was correlating with the chronological age of the patient. Out of 28 interns, 23 interns correctly estimated the age for 25 out of 88 patients (Table 1).

Results showed that all the interns underestimated the age of 40.9% (36 patients) of the patients by 2-3 months with a median of 2 months, and overestimated the age of 30.7% (27 patients) by 1-3 months with a median of 2 (Table 1).

Corrected estimate	25	28.4	0	0
Under estimate	36	40.9	-0.16	0.14
Over estimate	27	30.7	0.24	0.17
Total	88	100.0		

The correlation coefficient between chronological age and dental age as estimated by interns was 0.995, which shows an excellent correlation (Fig. 1). This correlation coefficient (0.995) comprises all the patients including underestimated and overestimated patients, demonstrating the strength and degree. The difference for overestimation and underestimation was low, which is the cause of very high correlation between chronological age and estimated age.

The time taken by the interns for the interpretation was much less as compared to the original method. The average time taken by four students was 60 seconds, 12 students took 90 seconds to complete the task, while another 12 students took 90-120 seconds to assess their radiographs (Table 2).

Bland Altman analysis shows the level of agreement for measurement of one parameter (age of the patient) by two different methods considering the chronological age as the reference method. The presented Bland Altman plots have limit of agreement (LoA), which indicates the level

Table 1. Estimation of age by interns

Frequency	Percent	Mean difference	Standard deviation
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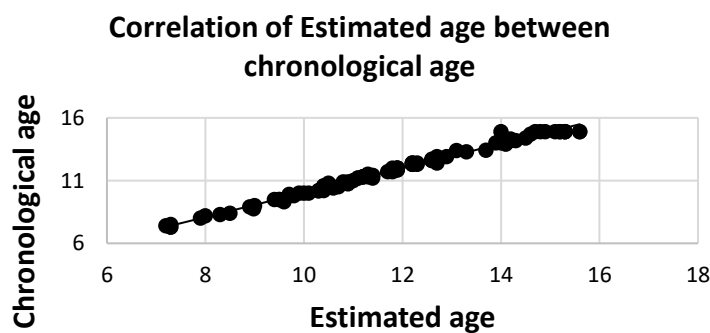


Figure 1. Correlation coefficient of estimated age

Table 2. Time taken by interns

	Frequency	Valid Percent
Time taken ≤ 60 seconds	4	14.3
Time taken 61-90 seconds	12	42.9
Time taken > 90 seconds	12	42.9
Total	28	100.0

of mean difference between chronological age and median estimated age by the interns. The upper and lower LoA are placed at ±2 standard deviation of mean difference. The data points closer to the middle line indicates closest agreement between

the two methods, and as the data points go further, the LoA decreases. Generally data points beyond the upper and lower LoA are interpreted as no LoA.

As we can see (Fig. 2), for the whole study sample, most of the data points are within the

upper and lower limit of agreement (LoA) (83 out of 88, 94.32%); only five points (5.68%) were beyond the LoA, where the level of agreement was beyond two standard deviations of mean difference.

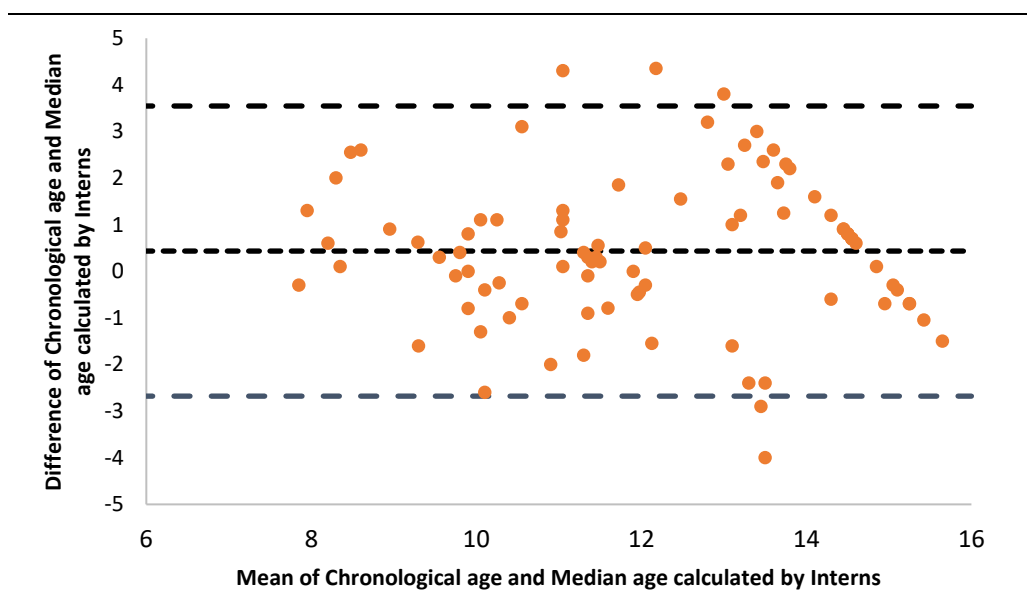


Figure 2. Bland Altman Plot for all the study samples.

4. Discussion

Age estimation has always been a matter of concern for the forensic experts particularly in the Indian scenario, where there are a lot of hurdles in routine investigations. Considering the importance of time, the modified DAEcc was developed (6) and its ease of applicability was tested on a group of dental interns for the estimation of age as this group of dental undergraduates is considered to be the most experienced amongst all the undergraduates. The applicability of this comprehensive chart has already been tested on second year dental students (6), where, 42 students out of 50 were able to do the correct tracing, and 39 students completed the correct scoring. The time taken by 10 students was less than 10 minutes, 23 students took 10-12 minutes and more than 12 minutes were taken by six students. The current study demonstrates that the interns correctly estimated 28.4% of the patients' age and 23 interns correctly estimated the age for 25 patients. There was an excellent correlation between chronological age and estimated dental age. The average time taken by all 28 interns ranged between 60 seconds to 120 seconds. A Bland-Altman plot/analysis is used to quantify agreement between two quantitative measurements by constructing limits of agreement. In the present study, the Bland

Altman analysis showed closest agreement between the two methods as most of the data points are within the upper and lower limit of agreement (LoA) (83 out of 88, 94.32%) (Fig. 2). The age estimated through the simplified chart was found to be in agreement by around 95% with the chronological age of the patients.

This can be attributed to the fact that dental interns have the highest level of experience and knowledge compared to lower level dental students, which is why they were able to apply this simplified chart easily and more accurately within a shorter duration of time as compared to the second year BDS students (6).

This study found that the age identified through Demirjian method falls very close to the chronological age of the patients. Closely 95% of the age identified by the interns belonged within ± 2 standard deviation of the mean difference between the two methods. Individuals of the same chronological age could have a different level of calcification, which could be influenced by an individual's nutritional status, genetics or other physiological conditions. The small differences that occurred could be due to these differences.

Age estimation in crime scenes requires precision as well as timely evaluation. Hence, the current study attempted to assess the DAEcc chart for both characteristics, on dental undergraduates

who are not trained for forensics on-field expertise.

Many studies have been done previously on Indian population (8-17) and worldwide (18-22) to estimate dental age using different methods presently available. Koshy et al. (8) and Prabhakar et al. (9) checked the practicality of the Demirjian method in the south Indian population and the Davengere population, and both determined that the accuracy of age estimation based on the Demirjian method was not useful for these children. However, Hegde et al. (10) and Malik et al. (11) showed contrasting results, wherein the Demirjian method showed high accuracy for the populations under investigation.

Sinha et al. (12) compared two methods of age estimation and concluded that the Demirjian method is applicable for every age group and for both sexes with better accuracy than the Nolla method, which had a limited utility in the younger age group. Hegde et al. (17) compared four methods and the results considered the Willem method to be the most accurate.

Gungor et al. (18) checked the validity of the Demirjian method on the Turkish population and found this method to be suitable, while Nur et al. (22) checked the validity of two methods on the Turkish population and found the Nolla method to be more accurate for dental age estimation.

Alshihri et al. (19) demonstrated that Demirjian's standards digress somewhat when applied on western Saudi Arabian children. Chen et al. (20) assessed the dental maturity for western Chinese children with results showing the standards of dental age assessment based on Demirjian may be not practical for Chinese children. Hussein et al. (21) checked the validity of the two methods of dental age estimation and found the Willems method to be better applicable for Malaysian children.

Thus far, it is clear that the Demirjian method is not applicable universally because of ethnic variations. Moreover, different studies have compared different methods for dental age estimation worldwide; however, none of them have checked the reproducibility of this chart up to now.

The original method employed by Demirjian is incredibly complicated, involving a number of charts and tables and is laborious and requires patience. Thus, simplicity of use and time requirements, hastened the creation of this in-depth chart. However, the study has a few limitations as it was done within the academic institute only and not on field as for the forensic purposes. Furthermore, the study was tested on interns only and not at the other higher levels of

experience like the faculty level.

Conclusion

Interns were able to apply the modified DAecc very effectively and accurately for dental age estimation using the Demirjian method. Considering this, the reliability of this chart is very high for age estimation by interns.





























Conflict of interest

The authors have no conflict of interest to declare.

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Patient ID: _____		OPD number: _____						
Gender: _____		Nationality: _____						
Date of data collection: _____		Place of origin: _____						
Deviation present: _____								
Determination of score based on developmental stages of the tooth#								
Tooth number	Developmental stages of the tooth							
	A	B	C	D	E	F	G	H
31				0.0/0.0	1.9/2.4	4.1/5.1	8.2/9.3	11.8/12.9
CS: 3y/Gr								
32			0.0/0.1	3.2/3.2	5.2/5.6	7.1/8.0	11.7/12.2	13.7/14.2
CS: 3y/Gr								
33			0.0/0.1	3.5/3.8	7.9/7.3	10.0/10.3	11.0/11.6	11.9/12.4
CS: 3y/Gr								
34		0.0/0.0	2.4/3.7	3.0/7.5	11.0/11.8	12.3/13.1	12.7/13.4	13.5/14.1
CS: 3y/Gr								
35	1.7/.8	3.1/3.4	5.4/6.5	9.7/10.1	12.0/12.7	12.1/13.5	13.2/13.8	14.4/14.6
CS: 3y/Gr								
36			0.0/0.1	8.0/4.5	9.6/6.2	12.3/9.0	17.0/14.0	19.3/16.2
CS: 3y/Gr								
37	2.1/2.7	3.5/3.9	5.9/6.1	10.1/11.1	12.5/13.5	13.2/14.2	13.6/14.5	15.4/15.6
CS: 3y/Gr								
Total score								

Appendix1. Comprehensive chart for dental age estimation (6)