Accuracy of Demirjian's Method to Estimate Chronological Age in 5–17-Year-Old Iranian Population

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Authors' contributions

*This work was carried out in collaboration among all authors. All authors read and approved the final
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ABSTRACT

Introduction: To detect physiological maturity of a child, use of dental and skeletal development can be helpful. The Demirjian's Method is one of the commonly used methods to estimate dental age. The aim of the present study was to evaluate the validity of Demirjian method in Iranian population with different races.
Materials and Methods: The present cross-sectional study was performed on a randomly selected sample of panoramic radiographs of 3073 patients aged 5–17 years. The chronological age (CA) was calculated by subtracting the date of birth from the date on which the radiographs were taken. Estimated age (EA) was performed by Demirjian method using seven left mandibular teeth. Paired t-test was used to compare differences between chronological and estimated age.
Results: The mean of CA was 11.14±2.61 years whereas the mean EA was 11.35±2.62;

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therefore, EA was calculated 2.5 months more than CA. According to paired t-test the difference between CA & EA was significant (P≤ 0.001). Pearson's correlation coefficient showed a strong linear correlation between CA and EA in total (r=0.891, P≤0.001), in girls (r=0.895, P≤ 0.001) and in boys (r=0.876, P≤ 0.001). The new regression line equation based on Iranian standards would be CA=1.08±0.89EA in total, CA=1.09±0.89EA in girls and CA=1.12+0.88EA in boys.

Conclusion: Using Demirjian's Method overestimated dental age in the Iranian population. A new regression line equation based on Iranian standards was obtained according to the results of the present study.

1. INTRODUCTION

Several forms of biological age, such as skeletal, morphological, and dental, assess the physiological maturity of a child [1]. Dental age as a means for determining chronological age is valuable in cases of adopted children, children who have committed legal offences, or in forensic cases. A scoring system, such as the Demirjian's method, scores the different stages of tooth development resulting in a dental maturity score [2].

The estimate of dental development is one of the most trusted indicators of chorological age, and it is most widely used in forensic and legal dentistry, since teeth are less affected than other body tissues by endocrine diseases and environmental damage [2].

Dental age and developing teeth of children can be measured in two ways: dental eruption and calcification as observed on radiographs. The second method is considered better than the first because tooth eruption occurs over a shorter period. It is a discontinuous and variable measurement affected by local factors such as lack of space and systemic factors such as malnutrition, causing premature loss of primary teeth, crowding and dental decay. On the other hand, dental calcification is believed to be a better measurement because it has a low coefficient of variation and environmental resistance factors [2].

Several methods of determining the dental age based on the degree of calcification of the permanent teeth as seen on radiographs have been described. Currently, one of the most well-known and widely used methods for estimating dental age is the Demirjian's method, first described in 1973 and based on a large sample of French-Canadian children [2].

This method is based upon morphological stages that can be identified during the continuous process of tooth formation. The advantage of using this method is that it is based on relative values of objective criteria (such as shape criteria and the proportion of root length to relative crown height) rather than on the absolute lengths of developing teeth. This means that foreshortened or elongated projections of the developing teeth will not affect the validity of the assessment [3].

A study [4] that compared dental age to chronological age in Somalian children to that of matched white Caucasian children in England showed Somalian children appear to be significantly more dentally mature than their Caucasian peers. Similarly, another study [5,6] tested the accuracy of the dental age estimation methods of Moorrees et al and Demirjian on children of different ethnic groups in South Africa. Since the study found that the Moorrees et al method consistently underestimated age and the Demirjian's method overestimated age, dental age tables were developed specifically for these ethnic groups. When tested, these tables were found to be more accurate than both the Moorrees et al and the Demirjian's methods [7]. According to some studies [4–6] findings suggest a need for population-specific dental development standards based on ethnicity to improve the accuracy of dental age assessment.

The validity of Demirjian's method has been different in various studies [1,7–12]. As Bagherpoor et al study, which was the only research on an Iranian population, did not include the different races who live in Iran, the present study was undertaken to evaluate the sufficiency of Demerjin's method in Iran [13].

The aim of the present study was to evaluate the validity of Demirjian's method in Iranian population with different races.

2. MATERIALS AND METHODS

The present cross-sectional study was performed on a randomly selected sample of panoramic radiographs of 3073 patients (including 2055 girls and 1018 boys) aged 5–17 years. A convenience sampling method was used. The panoramic radiographs were taken as part of their routine treatment. They were referred to dental faculties and clinics of ten big cities of Iran, consisting of Isfahan, Mashhad, Ahwaz, Kerman, Tabriz, Khoram Abad, Babol, Rasht, Ardabil and Oromye.

Inclusion criteria consisted of healthy cases, without any nutritional and hormonal disorders or no congenital or acquired systemic diseases, absence of any local factors influencing calcification, e.g. trauma or history of local inflammation, and suitable quality of radiographs for interpretation.

Exclusion criteria consisted of the absence of teeth on both sides of the mandible.

The chronological age (CA) was calculated by subtracting the date of birth from the date on which the radiographs were taken. Decimal ages were recorded to facilitate statistical calculation, and ages were estimated on a yearly basis (e.g., 8 years 6 months was recorded as 8.5 years). Estimated age (EA) was performed by Demirjian's method [9,10]: the seven left mandibular teeth were evaluated.

According to the stage of calcification of each tooth, eight stages (A to H) were assigned. Each stage had its own score. Total maturity score (TMS) had ranges between 0 and 100 and was transformed to a dental age by using a pilot or table of Demirjian.

The radiographs were analyzed by two radiologists. Each examiner evaluated 30 radiographs twice (intra-class correlation coefficient) and 30 radiographs of the other examiner (inter-class correlation coefficient) to identify reliability.

2.1 Statistical Analysis

To evaluate the intra- and inter-examiner correlation the ICC test was used. Paired t-test was used to compare differences between chronological and estimated ages. Pearson's coefficient test was applied to evaluate the correlation between chronological and estimated ages. These calculations were performed for each gender separately and for all the cases.

3. RESULTS

Pearson's test revealed 85% inter- and 76% intra-examiner reliability of TMS (Table 1).

The whole data of the present study are arranged in Tables 2–9, in terms of cities.

In all the cases the overall results showed that estimated dental age using Demirjian's method overestimated the chronological age. The mean of CA was 11.14±2.61 years old whereas the mean EA was 11.35±2.62; therefore, EA was calculated 2.5 months more than CA. The mean of CA and EA are shown in Table 10 in terms of sex.

According to paired t-test the difference between CA and EA was significant (P≤0.001).

Table 1. Person correlation based on sex

Person correlation	EA-Self	EA-Other
Total	0.85	0.76
Girl	0.87	0.78
Boy	0.84	0.77

Table 2. Chronologic age and estimated age of Azarbayejan city

	Total	Boy	Girl
	404	**157**	**274**
Mean of CA	9.82	9.82	9.82
Mean of EA	9.89	9.98	9.84
r	0.82	0.78	0.84
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=2.67+0.72X	Y=2.96+0.69X	Y=2.55+0.74X

Table 3. Chronologic age and estimated age of Lorestan city

	Total	Boy	Girl
	281	**74**	**234**
Mean of CA	13.25	13.42	13.20
Mean of EA	13.26	13.50	13.18
r	0.704	0.661	0.712
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=2.73+0.72X	Y=2.49+0.69X	Y=2.77+0.74X

Table 4. Chronologic age and estimated age of Isfahan city

	Total	Boy	Girl
	750	**292**	**458**
Mean of CA	10.69	10.68	10.70
Mean of EA	11.38	11.27	11.44
r	0.88	0.903	0.87
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=1.14+0.84X	Y=0.65+0.89X	Y=1.39+0.81X

Table 5. Chronologic age and estimated age of Mazandaran city

	Total	Boy	Girl
	301	**118**	**183**
Mean of CA	9.48	10.01	9.14
Mean of EA	9.52	10.03	9.18
r	0.968	0.954	0.971
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=0.05+0.99X	Y=-0.1+1.01X	Y=0.1+0.985X

Table 6. Chronologic age and estimated age of Khozestan city

	Total	Boy	Girl
	168	**41**	**127**
Mean of CA	12.84	11.99	13.11
Mean of EA	12.91	11.74	13.29
r	0.905	0.943	0.893
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=0.05+0.99X	Y=-0.1+0.1.01X	Y=0.1+0.985X

Table 7. Chronologic age and estimated age of Kerman city

	Total	Boy	Girl
	350	**126**	**224**
Mean of CA	10.93	10.34	11.27
Mean of EA	11.06	10.60	11.32
r	0.932	0.878	0.951
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=1.15+0.88X	Y=1.88+0.80X	Y=1.00+0.91X

Pearson's correlation coefficient showed a strong linear correlation between CA and EA in total (r=0.891, P≤0.001), in girls (r=0.895, P≤ 0.001) and in boys (r=0.876, P≤ 0.001).

As a result, the new regression line equation based on Iranian standards would be CA=1.08±0.89EA in total, CA=1.09±0.89EA in girls and CA=1.12+0.88EA in boys.

Table 8. Chronologic age and estimated age of Khorasan city

	Total	Boy	Girl
	338	124	217
Mean of CA	10.89	10.38	11.18
Mean of EA	11.05	10.61	11.31
r	0.894	0.893	0.892
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=1.36+0.86X	Y=1.68+0.82X	Y=1.31+0.87X

Table 9. Chronologic age and estimated age of Gilan city

	Total	Boy	Girl
	314	102	212
Mean of CA	12.31	12.25	12.34
Mean of EA	12.34	12.53	12.24
r	0.730	0.684	0.754
P value	≤0.001	≤0.001	≤0.001
Regression line	Y=3.62+0.71X	Y=4.01+0.66X	Y=3.38+0.73X

Table 10. The mean of CA and EA based on sex

Sex	Number	CA	EA
Girl	2055	11.32±2.7	11.52±2.7
Boy	1018	10.77±2.36	11.01±2.36

CA: Chronologic Age
EA: Estimated Age

4. DISCUSSION

To estimate physiological age which is used to estimate the chronological age of skeletal remains in forensic or archeological contexts, dental and skeletal developments can be helpful [14]. Dental age is estimated in two ways: eruption patterns and stage of calcification (tooth development) [15]. Eruption refers to emergence of the tooth, which can be influenced by some elements such as infection, obstruction and crowding of adjacent teeth [14,15]. To avoid these problems, use of the state of calcification of teeth on radiographs can be valuable [1].

The Demirjian eight-stage method is one of the principal methods used to quantify the degree of maturity from 3 to 17 years of age [16].

Based on the results of the present study, Iranian children showed the dental age range of 2.5 months, compared with French-Canadian children, consistent with the results of other studies in different countries [11,12,17–21]. Due to the complete discrepancy with Demerjian's findings in Leus et al., Sen et al. and Kalnowska et al. studies [19,20], it was reported it was not a very valid method; on the other hand, other studies considered Demerjian's method valid as

overestimation was negligible in their countries [22,23].

It is important to remember that the difference in chronological age and dental age may be attributed to different factors, including the accuracy of the method, examiner's training and experience, sample size and distribution, and statistical approach to the results achieved [24]. However, it is equally important to realize that no age estimation will accurately determine the exact age for every individual as development naturally varies between individuals. Forensic science uses age ranges when estimating age for just this reason [15]. Differences between real age and estimated age up to 12 months were considered to be within normal standards by some authors [25].

According to Kalinoscous et al the difference between CA and EA is variable in different age groups (0.4 month for girls and 0.2 month for boys in the 15-year age group, whereas this is 1.1–1.5 years in 11–12-year-old girls and 1.5 years in 13-year-old boys) [25].

Bagherpoor et al. demonstrated that Demirjian's method can estimate dental age in 9–13-year-old people of Iran. Their study suggested the need

5

for more comprehensive studies with larger sample sizes [13].

According to the present study, Demirjian's method is generally applicable for age estimation in Iran. Although EA was estimated only 2.5 months more than CA, the significant difference between them was due to the large sample size; in this context, Nakanen et al. declared the larger the sample size, the greater the similarity of results to Demirjian's estimated dental age [21].

Moavie et al. reported that CA in boys and girls was respectively 0.67 and 0.71 year lower than EA [26]. Chen et al estimated a difference of 0.007-1.25 years for boys and -1.00- 1.20 years for girls between CA and EA [27], in contrast with the results of the present study.

Maber et al. [28] (England, 2008) in their study on the accuracy of current methods in dental age estimation demonstrated that Demirjian's method was the second method in accuracy but the first in simplicity and ease. In our study the discrepancy between CA and EA was 0.24 year, with 2.9 months in boys and 0.2 year (2.4 months) in girls, indicating that Demirjian's method was more accurate in girls than boys.

5. CONCLUSION

Demirjian's method overestimated dental age in the Iranian population. A new regression line equation based on Iranian standards was obtained according to the results of the present study.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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