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# Radiographic evaluation of dental age maturity in 3–17-years-old saudi children as an indicator of chronological age

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## Abstract:

**OBJECTIVE:** This study was aimed to evaluate the dental age in Saudi children from panoramic radiographs using the Demirjian method to estimate their chronological age.

**MATERIALS AND METHODS:** This retrospective cross-sectional study consisted of 1902 panoramic radiographs of 955 boys and 947 girls between the ages of 3–17 years. All children were placed in the age group closest to their chronological age. The dental age was scored on all seven left mandibular teeth by calibrated examiners. Bivariate analyses using the *t*-test and Pearson correlation were performed.

**RESULTS:** There was significant difference in both boys and girls in all the age groups between their chronological age and dental age. Even though there was a slight overestimation in boys in some age groups and slight underestimation in girls in some groups, correlation analysis showed that there was a highly significant correlation between the chronological age and dental age for both boys ( $r^2=0.96$ ,  $P < 0.001$ ) and girls ( $r^2=0.98$ ,  $P < 0.001$ ). Moreover, correlation analyses for each age group showed a significant correlation between the chronological age and the dental age, using the Demirjian method, in most age groups ( $P < 0.01$ ). When comparing the maturation score between boys and girls, the Student's *t*-test showed that there were no statistical differences between boys and girls in most age groups.

**CONCLUSION:** Saudi boys and girls living in the western region of Saudi Arabia exhibited similar pattern of dental development when compared to the Demirjian method. Hence, the Demirjian method could be used as reference in children from the western region of Saudi Arabia.

## Keywords:

Chronological age, Demirjian method, dental age, dental maturity, developmental age

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## Introduction

Age determination is an important element in the diagnosis, treatment planning, and management of dental malocclusions for both orthodontic and pediatric patients.<sup>[1-3]</sup> It is imperative for a dental practitioner treating children and preadolescents to have a proper knowledge of their dental development. To broaden the practitioners' rationale regarding the effect of growth on dental problems and improve

clinical judgment, it is necessary to study the development of teeth. The chronological age of children with unknown birth records is regularly appraised using the individuals' somatic maturity. However, because of the relatively low inconsistencies of tooth formation in relation to chronological age, the method based on tooth formation stages would be more suitable to assess the chronological age when compared to other methods that measure somatic development.<sup>[4]</sup> The calcification and

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eruption of the dental tissues has been used to determine dental age.<sup>[5]</sup> However, using tooth calcification was found to be more accurate than tooth eruption because the process of calcification is continuous and can be assessed by perpetual records such as X-ray films, whereas emergence of a tooth is a transitory event and it is rather difficult to record.<sup>[6,7]</sup>

There are several methods that use radiographs for estimating dental age in the literature. Most of them use panoramic radiographs to perform the assessment. The most widely used and well-studied method for comparing dental ages in different population is the method of Demirjian *et al.*,<sup>[6]</sup> which is based on the development of seven teeth (central incisor to second molar) on the mandibular left side of the panoramic radiograph in French–Canadian population. Each stage of tooth development is given a score according to statistical tables, and the sum of the scores provides the dental maturity score, which is converted to dental age. However, Hagg and Matsson<sup>[8]</sup> recommend the Demirjian method only in early childhood, whereas others reported that the Demirjian method could give variations when applied to different populations. Several studies conducted in several countries found that the dental age of their children were different than the French–Canadian standards reported by Demirjian.<sup>[4,9-15]</sup> In Saudi Arabia, few studies with small sample sizes tested the accuracy of the Demirjian method. However, their results were inconsistent.<sup>[9,16-18]</sup>

Therefore, the aim of this study was to test the application of the Demirjian method for assessing the dental age in a large sample of Saudi children and develop a new dental age scoring system for Saudi children using the Demirjian method.

## Material and Methods

This retrospective cross-sectional study was conducted at the Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia. The study was reviewed and approved by the Research Ethics Committee at the Faculty of Dentistry of King Abdulaziz University. The sample consisted of panoramic radiograph and clinical records of Saudi children who were seeking dental treatment at the Faculty of Dentistry and different dental clinics or dental department in government hospitals in the city of Jeddah.

All panoramic radiographs were checked for quality and the presence of all seven left mandibular teeth, and were rated by calibrated examiners. In addition, all the selected children were healthy and of Saudi origin. The age range of the boys and girls was 3 to 17 years old. Exclusion criteria were image deformity affecting lower permanent tooth visualization, systemic diseases, dental

agenesis, congenital anomalies and large caries, and any pathology in the mandible.

For each child, a panoramic radiograph view was obtained. Date of birth was recorded to establish the exact chronological age at the time of radiographic exposures. A non-investigator coded the radiographs to avoid bias during scoring the radiographs. The examiners did not know the chronological age of the children when estimating the dental age from the panoramic radiographs.

Dental age was calculated according to criteria set by Demirjian *et al.*<sup>[6]</sup> Briefly, using panoramic radiographs, the development of the seven mandibular teeth present on the left side were assessed for their respective developmental stage, which then received a score using a conversion table for girls and boys as appropriate. The scores of all seven teeth were added to give the total maturity score. After the maturity score was calculated for the children, maturity scale was converted into dental age by referring to the table given by Demirjian *et al.*<sup>[6]</sup>

**Table 1: Distribution of age and sex in the studies population**

Group	Age Distribution (Years)	Gender distribution		Total
1	3-3.4	M	22	40
		F	18	
2	3.5-4.4	M	47	92
		F	45	
3	4.5-5.4	M	52	83
		F	31	
4	5.5-6.4	M	61	111
		F	50	
5	6.5-7.4	M	62	123
		F	61	
6	7.5-8.4	M	87	184
		F	97	
7	8.5-9.4	M	88	199
		F	111	
8	9.5-10.4	M	87	189
		F	102	
9	10.5-11.4	M	61	139
		F	78	
10	11.5-12.4	M	61	123
		F	62	
11	12.5-13.4	M	66	113
		F	47	
12	13.5-14.4	M	80	148
		F	68	
13	14.5-15.4	M	80	156
		F	76	
14	15.5-16.4	M	70	140
		F	70	
15	16.5-17	M	31	62
		F	31	
	Total	M	955	1902
		F	947	

All data were collected and tabulated to compare the dental and chronological ages, and descriptive analysis of the data was performed.

The intra and inter-examiner reliability and repeatability were assessed prior to starting the study. Two calibrated examiners assessed the maturation stage of the seven left mandibular permanent teeth without knowing the actual chronological age or gender. Twenty radiographs were randomly selected and assessed by two examiners with a 2-week interval between the two scoring sessions. The Cronbach's alpha between the first rating and the second rating was 0.94, indicating a high level of reproducibility. The inter-examiner agreement assessed using the intraclass correlation (ICC) coefficient test was 0.96, demonstrating a high level of inter-examiner agreement.

### Statistical analysis

Data were tabulated and analyzed using the Statistical Package for Social Science (IBM SPSS Statistics for Mac, Version 20, Armonk, NY: IBM Corp, USA). The results were presented as mean  $\pm$  standard deviation (SD). To

test normality assumption, the Shapiro–Wilk test was used; the results showed that the data was normally distributed, and hence, the Student's *t*-test was used to compare variables. Pearson product-moment correlation coefficient was also performed. Significant level was set at  $P \leq 0.01$  to guard against Type-I error.

## Results

The sample consisted of 1902 panoramic radiograph and clinical records of Saudi children (955 boys and 947 girls). Summary of the sample distribution according to their age and sex is presented in Table 1.

The Student's paired sample *t*-tests showed that, in both boys and girls in all age groups, there were statistically significant differences between their chronological age and dental age [Table 2]. Saudi boys were slightly, on average, ahead of French–Canadian children and Saudi girls were slightly behind French–Canadian children, as described by Demirjian *et al.* When comparing the maturation score between boys and girls, the Student's

**Table 2: Bivariate comparisons between chronological age and dental age using the Demirjian method (in years) for males and females**

Age Group (Years)	Gender	<i>n</i>	Chronological Age ( $\pm$ SD)	Dental Age ( $\pm$ SD)	Difference ( $\pm$ SD)	<i>P</i>
3-3.4	M	22	3.20 (0.14)	3.14 (0.92)	0.06 (0.93)	0.75
	F	18	3.22 (0.14)	2.71 (0.67)	0.51 (0.62)	0.003*
3.5-4.4	M	47	3.94 (0.29)	4.00 (0.72)	-0.05 (0.52)	0.6
	F	45	3.90 (0.28)	3.88 (0.61)	0.02 (0.59)	0.78
4.5-5.4	M	52	4.96 (0.29)	5.46 (0.48)	-0.49 (0.42)	<0.001*
	F	31	4.95 (0.28)	5.23 (0.53)	-0.34 (0.41)	0.0008*
5.5-6.4	M	61	5.97 (0.29)	6.39 (0.29)	-0.42 (0.26)	<0.001*
	F	50	5.98 (0.28)	6.26 (0.42)	-0.29 (-0.10)	<0.001*
6.5-7.4	M	62	6.90 (0.29)	7.18 (0.43)	-0.27 (0.27)	<0.001*
	F	61	7.00 (0.29)	7.09 (0.33)	-0.10 (0.27)	0.006*
7.5-8.4	M	87	7.97 (0.27)	8.13 (0.26)	-0.15 (0.18)	0.0002*
	F	97	8.00 (0.29)	7.82 (0.21)	0.22 (0.17)	<0.001*
8.5-9.4	M	88	8.91 (0.29)	9.07 (0.63)	-0.16 (0.49)	0.03
	F	111	8.91 (0.28)	8.46 (0.4)	0.46 (0.32)	<0.001*
9.5-10.4	M	87	9.94 (0.25)	10.31 (1.16)	-0.36 (1.13)	0.004*
	F	102	9.88 (0.28)	9.43 (0.83)	0.47 (0.79)	<0.001*
10.5-11.4	M	61	10.91 (0.28)	11.33 (0.64)	-0.41 (0.64)	<0.001*
	F	78	10.91 (0.28)	10.17 (0.77)	0.80 (0.77)	<0.001*
11.5-12.4	M	61	11.97 (0.27)	12.29 (0.27)	-0.32 (0.94)	0.02
	F	62	11.95 (0.27)	11.14 (0.85)	0.84 (0.77)	<0.001*
12.5-13.4	M	66	13.02 (0.26)	16.68 (0.87)	-3.66 (0.82)	<0.001*
	F	47	12.86 (0.23)	12.33 (0.9)	0.54 (0.88)	0.0001*
13.5-14.4	M	80	13.95 (0.28)	15.01 (0.80)	-1.06 (0.71)	<0.001*
	F	68	13.96 (0.26)	13.12 (1.09)	0.84 (1.06)	<0.001*
14.5-15.4	M	80	14.95 (0.28)	15.63 (1.64)	-0.68 (1.59)	0.004*
	F	76	14.96 (0.26)	14.16 (1.07)	0.86 (1.05)	<0.001*
15.5-16.4	M	70	15.92 (0.29)	16 (0)	-0.07 (0.29)	0.03
	F	70	15.94 (0.28)	16.81 (10.83)	-0.92 (11.25)	0.5
16.5-17	M	31	16.67 (0.14)	16 (0)	0.67 (0.14)	<0.001*
	F	31	16.69 (0.14)	16 (0)	0.69 (0.14)	<0.001*

\*Significant difference at  $P \leq 0.01$

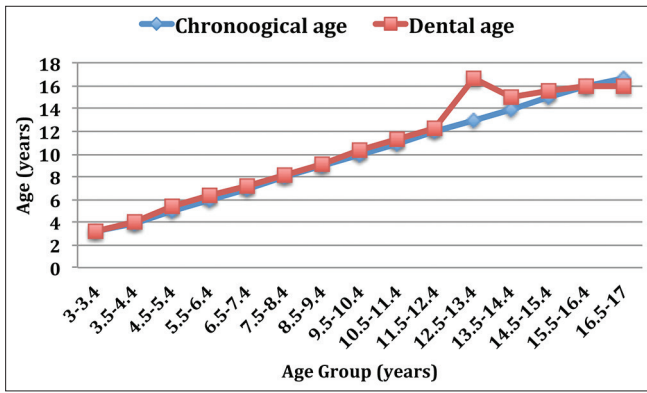


Figure 1: Linear correlation between chronological age and dental age for boys

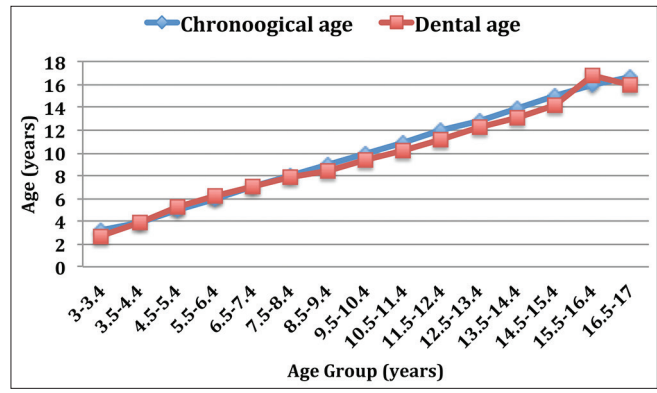


Figure 2: Linear correlation between chronological age and dental age for girls

Table 3: Bivariate comparisons for the dental age scores between males and females

Age Group (Years)	Gender	n	Mean	Standard deviation	P
3-3.4	M	22	13.06	2.13	0.19
	F	18	14	2.31	
3.5-4.4	M	47	16.61	4.46	0.26
	F	45	19.55	3.45	
4.5-5.4	M	52	29.37	4.46	0.13
	F	31	31.45	4.67	
5.5-6.4	M	61	38.73	3.84	0.0003*
	F	50	41.83	4.77	
6.5-7.4	M	62	51.77	8.51	0.04
	F	61	54.63	6.86	
7.5-8.4	M	87	73.48	4.28	0.09
	F	97	74.63	5.15	
8.5-9.4	M	88	83.31	4.50	0.6
	F	111	83.01	3.30	
9.5-10.4	M	87	90.27	2.15	0.0002*
	F	102	88.64	3.67	
10.5-11.4	M	61	92.64	1.41	0.01*
	F	78	91.79	2.53	
11.5-12.4	M	61	94.3	1.55	0.86
	F	62	94.35	1.89	
12.5-13.4	M	66	96.2	0.96	0.12
	F	47	94.71	12.27	
13.5-14.4	M	80	97.64	0.89	0.14
	F	68	97.38	1.21	
14.5-15.4	M	80	99.05	0.96	0.0001*
	F	76	98.4	1.09	
15.5-16.4	M	70	100	0	<0.001*
	F	70	99.62	0.55	
16.5-17	M	31	100	0	1.0
	F	31	100	0	

\*Significant difference at  $P \leq 0.01$

t-test showed that there was no statistical difference between boys and girls in almost all ages except for the ages 4, 8, 9, 13, and 14 [Table 3].

Even though the statistical results were significant in some age groups, the actual difference was not clinically significant [Figures 1 and 2]. Figures 1 and 2 also show

that the dental age estimation was slightly overestimating the chronological age in boys in some age groups and underestimated the age in girls in some groups, yet the relationship almost appeared linear. Pearson correlation analysis showed that there was a highly significant correlation between the chronological age and dental age for both boys ( $r^2=0.96, P < 0.001$ ) and girls ( $r^2=0.98, P < 0.001$ ). This is also demonstrated in Table 4 where the correlation analyses for each age group showed a significant correlation between the chronological age and the dental age using the Demirjian method in most age groups.

### Discussion

The importance of proper age estimation and determination of dental maturity is essential during orthodontic diagnoses and treatment planning, especially in growing children.

The method of Demirjian *et al.*<sup>[6,19,20]</sup> was chosen in the present study because of its validity, reliability, and convenience for determining the dental age.<sup>[18]</sup> This method uses the stages of tooth formation of the seven left mandibular teeth by assessing the panoramic X-rays.

Considerable differences in relation to time and sequence or eruption of permanent teeth have been reported between populations.<sup>[16,21,22]</sup> Although some of these differences may reflect inappropriate methodology or choice of sample, other studies clearly indicate differences, which could be because of systemic or local factors or both.

Assessment of age is essential for both medical and dental practices and age should be accurately estimated. This accuracy can be defined as how close to "0" is the difference between the estimated dental age and the chronological age.<sup>[22,23]</sup> Dental age estimation is commonly acknowledged as it closely correlates with chronological age.<sup>[10,16,21,22]</sup> One frequently used method, which has become the standard by which other methods

**Table 4: Correlational analysis between the chronological age and dental age scores using the Demirjian method for males and females**

Age Group	Gender	n	Chronological Age (±SD)	Dental Age (±SD)	Differences (±SD)	r	P
3-3.4	M	22	3.20 (0.14)	3.14 (0.92)	0.06 (0.93)	0.03	0.75
	F	18	3.22 (0.14)	2.71 (0.67)	0.51 (0.62)	0.40	0.003*
3.5-4.4	M	47	3.94 (0.29)	4.00 (0.72)	-0.05 (0.52)	0.78	0.6
	F	45	3.90 (0.28)	3.88 (0.61)	0.02 (0.59)	0.32	0.78
4.5-5.4	M	52	4.96 (0.29)	5.46 (0.48)	-0.49 (0.42)	0.49	<0.001*
	F	31	4.95 (0.28)	5.23 (0.53)	-0.34 (0.41)	0.70	0.0008*
5.5-6.4	M	61	5.97 (0.29)	6.39 (0.29)	-0.42 (0.26)	<0.000	<0.001*
	F	50	5.98 (0.28)	6.26 (0.42)	-0.29 (-0.10)	0.63	<0.001*
6.5-7.4	M	62	6.90 (0.29)	7.18 (0.43)	-0.27 (0.27)	0.77	<0.001*
	F	61	7.00 (0.29)	7.09 (0.33)	-0.10 (0.27)	0.67	0.006*
7.5-8.4	M	87	7.97 (0.27)	8.13 (0.26)	-0.15 (0.18)	0.76	0.0002*
	F	97	8.00 (0.29)	7.82 (0.21)	0.22 (0.17)	0.80	<0.001*
8.5-9.4	M	88	8.91 (0.29)	9.07 (0.63)	-0.16 (0.49)	0.65	0.03
	F	111	8.91 (0.28)	8.46 (0.4)	0.46 (0.32)	0.59	<0.001*
9.5-10.4	M	87	9.94 (0.25)	10.31 (1.16)	-0.36 (1.13)	0.24	0.004*
	F	102	9.88 (0.28)	9.43 (0.83)	0.47 (0.79)	0.35	<0.001*
10.5-11.4	M	61	10.91 (0.28)	11.33 (0.64)	-0.41 (0.64)	0.23	<0.001*
	F	78	10.91 (0.28)	10.17 (0.77)	0.80 (0.77)	0.17	<0.001*
11.5-12.4	M	61	11.97 (0.27)	12.29 (0.27)	-0.32 (0.94)	0.42	0.02
	F	62	11.95 (0.27)	11.14 (0.85)	0.84 (0.77)	0.42	<0.001*
12.5-13.4	M	66	13.02 (0.26)	16.68 (0.87)	-0.66 (0.82)	0.35	<0.001*
	F	47	12.86 (0.23)	12.33 (0.9)	0.54 (0.88)	0.25	0.0001*
13.5-14.4	M	80	13.95 (0.28)	15.01 (0.80)	-1.06 (0.71)	0.47	<0.001*
	F	68	13.96 (0.26)	13.12 (1.09)	0.84 (1.06)	0.24	<0.001*
14.5-15.4	M	80	14.95 (0.28)	15.63 (1.64)	-0.68 (1.59)	0.22	0.004*
	F	76	14.96 (0.26)	14.16 (1.07)	0.86 (1.05)	0.22	<0.001*
15.5-16.4	M	70	15.92 (0.29)	16 (0.8)	-0.07 (0.29)	0.02	0.03
	F	70	15.94 (0.28)	16.81 (10.83)	-0.92 (11.25)	-0.02	0.5
16.5-17	M	31	16.67 (0.21)	16 (0.21)	0.67 (0.07)	0.33	<0.001*
	F	31	16.69 (0.14)	16 (0.9)	0.69 (0.05)	0.36	<0.001*

\*Significant difference at  $P \leq 0.01$ 

are compared to for the assessment of dental age, is the method reported by Demirjian *et al.* Their suggested standard was based on a sample of 2928 (males and females) of French-Canadian origin.<sup>[6,19,24]</sup> The authors also stated that the standard obtained in their investigation may not be possibly valid.<sup>[25]</sup> In the present study, the age was found to be underestimated in children aged between 3 and 17 years old, and the range of accuracy was - 3.66 to 0.86 years. Statistical analysis showed a significant difference between chronological and dental age for several age groups for both boys and girls, as shown in Table 2.

In other populations, overestimations were found when applying the Demirjian method. For example, in a British sample overestimation was 0.73 in boys and 0.51 in girls.<sup>[26]</sup> In a Dutch population, it was 0.4 in boys and 0.6 in girls.<sup>[27]</sup> In a Turkish population, the overestimation was reported to be 0.36-1.43 in boys and 0.50-1.44 in girls.<sup>[28]</sup> These differences could be because of cultural and ethnic differences between the studied populations.<sup>[11]</sup> Additional possible reasons could include

the diversity of the socioeconomic status, dietary habits, and nutrition of the studied population.<sup>[25]</sup> Liversidge *et al.*<sup>[29]</sup> proposed that the overestimation in dental age in different populations reported in contemporary literature when the Demirjian method was used could be explained by the progressive trend in growth and development during the last 25 years. Compared to the sample of Demirjian *et al.*, nowadays, children generally exhibit earlier sexual maturation and greater height and body weight owing to the changes in the economical status and nutrition availability.<sup>[30]</sup> Another explanation could be the complexity of the Demirjian method as it involves demanding steps of adding up a score for every stage of each tooth to obtain the maturity score, followed by a conversion of the maturity score to the estimated dental age.<sup>[6,19,24,25]</sup> The comparison of mean chronic age and dental age for the current sample showed more accuracy for females than males. In addition, almost all the observed dental ages were ahead in girls compared to boys, demonstrating that males showed a later maturation in the dental development when compared to females. This finding is in agreement with previously

reported findings of other developmental parameters in females such as sexual maturation, height and skeletal development.<sup>[8,9,24]</sup> Hormonal factors may influence the sex differences in dental development.<sup>[31]</sup> Nonetheless, the definite effect of hormones on tooth development is still not fully understood.<sup>[29]</sup>

The results of this study are rather different from previously reported studies that evaluated the applicability of the Demirjian method to Saudi population.<sup>[9,16-18,32,33]</sup> This could be due to the fact that the sample size of the current study is significantly larger and the age range is broader.

One limitation of this study is that, even though the population was selected at random, it may still not represent the general Saudi population. Moreover, the ethnic background of the studied population, who are in the western region, is very diverse compared with other regions of the country and this could introduce bias in the results. Therefore, these factors should be considered in future studies in the application and adaptation of Demirjian method on Saudi children.

## Conclusions

Saudi boys and girls in the western region of Saudi Arabia exhibited similar pattern in dental development when compared to the French-Canadian population. Hence, the Demirjian method could be used as a reference in children from the western region of Saudi Arabia.

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## Conflict of interest

There are no conflicts of interest.

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