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Dental Age Estimation in A Sample of Kurdish Subjects (Aged 9-15 Years Old) in Erbil City Adopting Demirjian Method

A Radiographic Study

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Background and objectives: Dental maturation is widely used to assess maturity and to predict age. Age estimation plays a great role in clinical dentistry, especially in orthodontics, pedodontics and forensic dentistry and aid in diagnosis and treatment planning. Demirjian method is one of a commonly used methods. The aim of this study was to find out the applicability of Demirjian's method for dental age estimation for Kurdish subjects in Erbil City.

Methods: The study was conducted on orthopantomograms of 125 Kurdish subjects (65 males, 60 females) in Erbil City, their ages ranged between 9 to 15 years old. Demirjian method was used to assess dental age based on the degree of mineralization of the seven left mandibular teeth, and t-tests were used to assess the difference between dental age and chronological age.

Results: A strong linear correlation between dental and chronological ages for both males and females were observed (r = 0.845, 0.893). The mean difference between the chronological and dental ages showed an overestimation of 0.18 and 0.56 years for males and females respectively.

Conclusion: Demirjian's method of dental age estimation showed accuracy in most age groups (except in 9 and 12 age groups in females) in Kurdish subjects in Erbil City.

Keywords: Dental age, Chronological age, Demirjian's method, Radiographic assessment, Children.

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Introduction

Correct age estimation based on dental records is crucial and useful in a broad range of different fields, including pediatric dentistry, orthodontics, forensic medicine, pediatric endocrinology, orthopedics, and anthropological studies.[1-3] Chronological age (CA) represents the measure of time elapsed since birth. However, the relationship between real growth and chronological age is not linear. Hence, to ascertain this correlation, many authors have proposed various methods for age estimation based on skeletal and dental development.[4] Dental age (DA) is an important factor to consider when treating malocclusion or unfortunate facial growth.[5-7]

Dental age may be assessed either by tooth eruption time or by the progress of tooth calcification. Dental eruption is influenced by various factors such as crowding, extractions, ankylosis, ectopic positions, and persistence of primary teeth.[8] Also, tooth eruption time cannot be realistic between the ages of 3 and 6, or after the age of 13. Therefore, tooth calcification is thought to be a more

reliable criterion for determining DA.[9] Several authors have shown that dental parameters are more suitable for age estimation in children because the variability is lower since calcification rates of teeth are controlled more by genes than by environmental factors.[5]

It should be realized that orthodontic diagnosis and treatment planning are based largely on the evaluation of the patient's dental age, and any deviation of this measure of maturity from the chronological age will affect the dental treatment decision both in timing and modality.[10] The development of clinically useful radiographic images, especially the orthopantomogram (OPG), which shows the whole of the dentition on a single image, has provided clinical investigators with a uniquely effective way of assessing dental maturation.[11]

Demirjian method which is based on the development of teeth from a French-Canadian population has been widely used as a standard reference.[12] No previous attempts have been done to investigate the association between dental maturity and chronological ages in Kurdish population.

It is important to mention that this is the first study that tried to estimate dental age and assess the relationship between chronological and dental ages of Kurdish subjects, therefore, the main objective of this study was to compare the chronological age and the dental age as assessed from X-rays using the Demirjian method, in children aged between9 to 15 years. Our study also aimed to test the applicability of Demirjian's method on Kurdish subjects, to compare results with other countries and to determine differences between males and females regarding dental development.

Methods

A cross-sectional study was carried out on a sample of 125 orthopantomograms taken from 65 males and 60 females aged from 9 to 15 years. All of them attended the clinics of Orthodontics, Pedodontics and Preventive Dentistry (P.O.P.) and Oral Diagnosis Departments, College of Dentistry / Hawler Medical University from October 2014 to January 2015. A convenience sampling method was used. The study protocol was approved by the ethics committee of the College of Dentistry / Hawler Medical University. The sample had been divided into seven age groups (one year apart: 9, 10, 11, 12, 13, 14 and 15) for each gender. But for the correlation purposes, the study sample was subdivided into two age groups, 9 to 11 and 12 to 15 years old due to small sample size.

Criteria for sample selection. All the subjects were Iraqi Kurdish ethnic residents in Erbil City.

1. None of them was under or had previously received any orthodontic or orthopedic treatment in the lower dental arch.
2. Individual with no history of trauma to facial skeleton.
3. Within each orthopantomogram, the seven left mandibular permanent teeth must be present. If only a single tooth were not present, its correspondent on the right side of the mandible must be present for substitution.
4. No proved serious illness and systemic diseases (developmental, hereditary, nutritional and endocrine disorders).[5]

The subject with deviation from any of the above-mentioned criteria has not been included in this study.

All x-rays were rated by one examiner with no knowledge of the patients' age. To test the study feasibility and practicality, a pilot study was carried out on 14 randomly selected orthopantomograms. Inter and intra examiner calibrations were carried out after one month to evaluate the error in determining the dental maturation stages.

Dental age was judged based on the degree of maturation of the seven left mandibular teeth, excluding the third molar. Eight stages of development, from calcification of the tip of the cusp to the closure of the apex, are designed by letters A to H, corresponding to the eight stages

as shown in Figure 1. If a single tooth was missing or could not be rated for any reason, the corresponding tooth from the right side of the mandible must be available for substitution. If there was no sign of calcification, the rating 0 is given. The crypt formation was not taken into consideration. Each stage was given a numerical score (Table 1 and Table 2), the sum of which provides an estimate of an individual's dental maturity on a scale from 0 to 100.

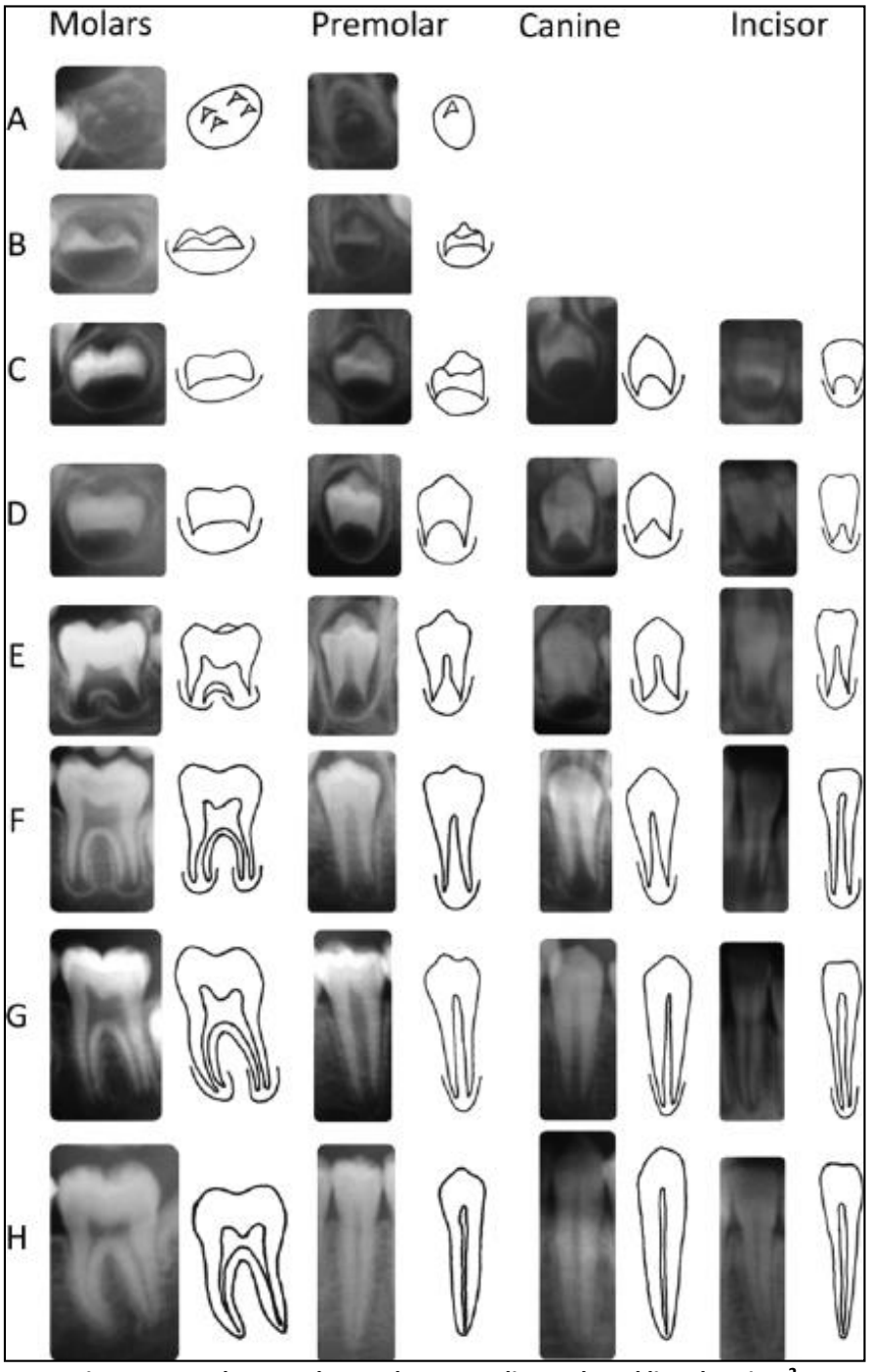

Figure 1: Tooth stages by tooth type, radiograph and line drawing.[2]

The scores are calculated separately for males and females. The assigned ratings (0-H) were analyzed, and for each case analyzed, Demirjian converted the attributed stage for each tooth to a self-weighted numerical score based on Table 1 and Table 2. This conversion gives a set of tooth scores for each case, the sum of which results in total 'Maturity Score" for that case, which was converted into a dental age based on separate male and female tables. To avoid the examiner bias at the time of collecting data, chronological age was first recorded on a data collection sheet, and the dental age scores were tabulated later on a separate sheet.

This method would be used to estimate the age of a case by taking the following steps:

1. Assign each tooth left mandibular 2nd molar, 1st molar, 2nd premolar, 1st premolar, canine, lateral incisor and central incisor using the above descriptions.
2. Convert this rating to a Demirjian maturity score using conversion table of self-weighted scores.
3. Estimate the age of the individual using the conversion table.

It is important to mention that the tooth staging procedure in this study adopted a type of blind technique in which the radiographs were coded by their serial numbers on the case sheets from the beginning. Later, each radiograph was staged blindly without knowing neither the chronological age nor the gender of each patient. This procedure was utilized to ensure valid staging and scoring values.

Table 1: Conversion table self-weighted scores for dental stages, female.[5]

Tooth	Stage 0	A	B	C	D	E	F	G	H
M_2	0.0	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6
M_1				0.0	4.5	6.2	9.0	14.0	16.2
PM_2	0.0	1.8	3.4	6.5	10.6	12.7	13.5	13.8	14.6
PM_1			0.0	3.7	7.5	11.8	13.1	13.4	14.1
C				0.0	3.8	7.3	10.3	11.6	12.4
I_2				0.0	3.2	5.6	8.0	12.2	14.2
I_1					0.0	2.4	5.1	9.3	12.9

Table 2.: Conversion table self-weighted scores for Dental Stages, male.[5]

Tooth	Stage 0	A	B	C	D	E	F	G	H
M_2	0.0	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4
M_1				0.0	8.0	9.6	12.3	17.0	19.3
PM_2	0.0	1.7	3.1	5.4	9.7	12.0	12.8	13.2	14.4
PM_1			0.0	3.4	7.0	11.0	12.3	12.7	13.5
C				0.0	3.5	7.9	10.0	11.0	11.9
I_2				0.0	3.2	5.2	7.8	11.7	13.7
I_1					0.0	1.9	4.1	8.2	11.8

Stage 0 is no calcification **M_2:** Second Molar **PM_2:** Second Premolar **I_2:** Lateral Incisor
C: Canine **M_1:** First Molar **PM_1:** First Premolar **I_1:** Central Incisor

Chronological age determination. The chronologic age was obtained by a simple mathematical calculation using the Microsoft Excel sheet. The date of birth of the patient subtracted from the date of taking the radiograph and then divided by 365 to express the chronological age in decimal years. This provided the chronological age of the patient on the date at which the radiograph was captured. As the original publication by Demirjian *et al*[5] reported the tabulation of data of age groups based on one decimal place only. Thus, the results of the present study were reported according to one decimal place only.

Statistical analysis. All data of the sample were subjected to computerized statistical analyses using SPSS (Statistical Package for Social Sciences) computer program version 22 for data entry and analysis. Paired t-test was used to analyze the differences between the estimated DA and the CA. Relationships between chronologic age and dental age were examined using Pearson's correlation coefficient. A *P*-value of less than 0.05 was considered as statistically significant.

Results

The total sample size comprised of 125 subjects, 65 males (52%) and 60 females (48%), their ages ranged from 9 to 15 years old, and the participant had been divided into seven age groups according to chronological ages of separate males and females, considering an age interval of one year. Results showed a strong linear correlation between dental and chronologic ages for the total male sample (r = 0.845) and female sample (r = 0.893). It was found that females have higher correlation than males (Table 3). For males and females, the maximum correlation was found in age group (12-15), while minimum correlation was found in age group (9-11) (Table 4).

Table 3: Correlation of total sample of males and females.

Females		
	R	r^2
Simple linear correlation	0.893	0.798
P value	<0.001	
Males		
	R	r^2
Simple linear correlation	0.845	0.714
P value	<0.001	

Table 4: Correlation between CA and DA for males and females.

	Age Group	**N**	**Correlation (r)**	***P* value**
Males	9-11	35	0.622	<0.001
	12-15	30	0.749	<0.001
Females	9-11	28	0.541	<0.001
	12-15	32	0.718	<0.001

The mean of CA of the total sample (combined males and females) was 12.12 (±1.91) years and mean of DA was 12.48 (±2.18) years and mean differences were 0.36 year, this indicates there is an overestimation of dental age. There were statistically significant differences between total CA and DA in the total sample (*P*-value < 0.001). The

mean difference between the CA and DA in total age groups ranged from 0.13 to 0.73 years. Overestimations of dental age were seen in all total age groups, the lowest value of mean difference was observed in the age group 14, while the highest value of mean difference was observed in the age group 13 (a negative value indicates underestimation, a positive sign indicates an overestimation of age). There were no statistically significant differences between dental and chronological ages in all age groups except in 12 and 13 age groups, their *P*-values were 0.038 and 0.043 respectively, as shown in Table 5.

Table 5: Comparison between CA and DA in years using Demirjian Method (Total sample).

Age Group (years)	Mean ± Standard deviation		Difference between means	*P* value
	CA	DA		
9	9.562 ± 0.294	9.771 ± 1.195	0.209	0.460
10	10.495 ± 0.275	10.790 ± 1.255	0.295	0.290
11	11.448 ± 0.279	11.948 ± 1.307	0.500	0.094
12	12.453 ± 0.315	12.984 ± 1.024	0.532	0.038
13	13.364 ± 0.290	14.100 ± 1.144	0.736	0.043
14	14.321 ± 0.269	14.457 ± 0.573	0.136	0.403
15	15.313 ± 0.250	15.460 ± 0.746	0.147	0.362
Total	**12.124 ± 1.918**	**12.488 ± 2.184**	**0.364**	**<0.001***

* Highly significant

Total mean of CA for males 12.05 (± 1.75) years, total mean of DA was 12.23 (± 2.20) year, DA was overestimated by 0.18 years, there were statistically non-significant differences between the total DA and CA in males (*P*-value = 0.212). The mean difference between the CA and DA in age groups ranged from −0.42 to 0.61 years in males. In all age groups no statistically significant differences were observed, however, overestimations were observed in most age groups except in 9 and 12 years age groups, in which there was underestimation by 0.42 and 0.01 years respectively, as shown in Table 6. For females, the total mean of CA was 12.20 (± 2.09) years, while the total mean of DA was 12.76 (± 2.15) years. DA was overestimated by 0.56 years in total sample in females compared with CA; there were statistically high significant differences between total CA and DA in females (*P*-value < 0.001). The mean difference between the CA and DA of age groups of females ranged from 0.04 to 1.13 years in females. Overestimations were observed in all age groups, that means dental age preceded chronological age, for all age groups, in females. In all age groups, there were no statistically significant differences observed, except in age group 9 and 12, *P*-values were <0.03 and <0.001 respectively, as shown in Table 7.

Comparison of mean dental age between males and females showed a more advanced mean dental age for the females for all the age groups except for age group 10 and 15, in which dental age of males are more advanced than females in these two groups (Table 6, Table 7). On average males reached dental maturation 0.38 years ahead of females when mean dental ages are compared.

Table 6: Comparison between CA and DA in years using the Demirjian Method (males)

Age Group (years)	Mean ± Standard deviation		Difference between means	*t* value	*P* value
	CA	DA			
9	9.720 ± 0.161	9.300 ± 1.223	-0.420	-1.047	0.323
10	10.567 ± 0.274	10.933 ± 1.348	0.366	0.978	0.349
11	11.515 ± 0.294	11.892 ± 1.475	0.376	0.941	0.365
12	12.560 ± 0.279	12.550 ± 1.131	-0.010	-0.029	0.977
13	13.243 ± 0.229	13.857 ± 1.195	0.614	1.252	0.257
14	14.314 ± 0.254	14.443 ± 0.772	0.128	0.447	0.671
15	15.200 ± 0.154	15.500 ± 0.540	0.300	1.627	0.165
Total	12.052 ± 1.750	12.236 ± 2.201	0.184	1.259	0.212

Table 7: Comparison between CA and DA in years using the Demirjian Method (Females).

Age Group (years)	Mean ± Standard deviation		Difference between Means	t value	*P* value
	CA	DA			
9	9.418 ± 0.318	10.200 ± 1.040	0.781	2.536	0.030
10	10.400 ± 0.259	10.600 ± 1.169	0.200	0.484	0.641
11	11.338 ± 0.226	12.038 ± 1.064	0.700	1.795	0.116
12	12.333 ± 0.324	13.467 ± 0.650	1.133	5.941	<0.001*
13	13.486 ± 0.307	14.343 ± 1.125	0.857	1.828	0.117
14	14.329 ± 0.303	14.471 ± 0.340	0.142	0.918	0.394
15	15.389 ± 0.280	15.433 ± 0.888	0.044	0.193	0.852
Total	12.201 ± 2.098	12.761 ± 2.150	0.560	4.412	<0.001*

*Highly significant

Discussion

Dental growth and development can be studied in parallel with other physiological maturity indicators such as skeletal age, menarche, and height.[7] For the clinical orthodontist, the dental development and maturation are of prime importance for diagnosis, treatment planning and medical evaluation of the patient.

In the present study, the dental age was assessed using Demirjian method,[5] which is widely accepted and has been studied extensively on various populations by many authors.

The correlation between dental age and chronological age in the present study was very strong and statistically significant (r=0.845, *P*-value < 0.0001 for males and r=0.893, *P*-value < 0.0001 for females). The result of the present study is in agreement with other populations, as in Finnish,[1], Brazilian,[14] South Australian,[15] South Indian,[7] Indian Davangere,[16] North Turkish[17] and Central Indian.[18]

The findings in the present study revealed that the dental ages were advanced to chronological ages, for all age groups, in females. The differences were non-significant in most age groups except in 9 and 12 age groups. In males, the dental ages were advanced in 10, 11, 13, 14 and 15 years and the differences were non-significant, while the dental ages were delayed to chronological ages in age groups 9 and 12, the differences between dental and chronological ages were statistically non-significant.

Demirjian *et al*.[19] stated that most maturation parameters, such as height, sexual maturation,

and skeletal development occur earlier in females. The findings of the present study do not support these parameters, as on average, males reached dental maturity earlier than females, although in some age groups females reached dental maturity earlier than their counterpart as in age groups 10 and 15. This might be due to ethnic background, methodology, sample size or dental development in males is ahead of females in Kurdish ethnicity. However, a large size study sample needed to confirm this advanced dental maturation in males compared to females.

The higher overestimation of the dental age observed in the age group 13 years for males and age group 12 years for females could probably be due to the pre-pubertal or pubertal growth changes during this period. Some researchers found more dental advancement around the pubertal growth spurts.[20-22]

Comparison of results between Kurdish children and the French–Canadian reference sample in the present study showed that Kurdish children were advanced in dental maturity. The present study revealed advanced dental ages for both males and females, 0.18 and 0.56 years respectively, compared to French-Canadian children. This was in agreement with other studies carried out by other authors in different populations, such as; Finnish,[23] South Indians,[21] British,[24] Caucasians,[25] Indian, Belgaum,[7] Iraqi Arabic,[26] Dutch,[27] Poland,[28] Saudi Arabia,[29] North Turkish,[17] Korean,[30] Pakistani[31] and Southern Turkish.[32]

The variations in the results seen in the present study could be attributed to the fact that the original Demirjian study, which was carried out on the French-Canadian population, which may explain the difference in the race and ethnicity. The normal distribution of the differences between chronologic age and dental age in this study could be caused by biologic variation. Other probable causes of differences are environmental factors such as socio-economic status, malnutrition, and dietary habits that may vary in different populations.[33]

Conclusions

The results of the present study showed that the Demirjian data set when used to estimate the dental age of 9 to 15 years old of Kurdish subjects resulted in an overestimation of the age. The total mean difference between dental and chronological age was 0.18 years in males and 0.56 years in females.

In females, dental maturation was ahead of chronological age for all age groups, whereas in males the dental age is ahead of chronological maturation in most age groups, except for 9 and 12 years age groups.

Dental maturation of males was more advanced than females (males 0.38 years ahead of females).

It was found that in males, the chronological age can be assessed more appropriately using Demirjian method, and this means that Demirjian method is more suitable for males.

There was moderate to a strong significant correlation between the dental age and the chronological age.

Conflicts of interest

The authors reported no conflicts of interest.

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