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| ORIGINAL

Dental age estimation of Jordanian children: applicability of Demirjian method

Estimativa de idade dentária em crianças jordanas: aplicabilidade do método Demirjian

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ABSTRACT

Objectives: To evaluate the accuracy of Demirjian method in estimating the chronological age of male and female Jordanian children and to establish a new dental age curve if the Demirjian method was not found to be accurate. **Methods**: Orthopantomograms (OPTs) of 1374 Caucasian Jordanian children (684 females and 690 males) aged 4 to16 years were selected and the dental age was determined by Demirjian method. The chronological ages of the children were obtained by subtracting their birthdates from the date of taking the radiograph. The OPTs were obtained from Archives of Dental Teaching Clinics /XXX and other private orthodontic practices in Irbid and Amman. **Results**: Demirjian method overestimated chronological age in female and male subjects aged 4 to 8 years. Afterwards, the method underestimated chronological age in females aged 9-11 years and 14-16 years. In male subjects, chronological age was underestimated in subjects aged 9-12 years and 15-16 years. New the dental age curves for Jordanian females and males were constructed. The constants for the quadratic model for the new curves were (b0=-25.341, b1=17.557, b2=-0.623) for females and (b0=-29.809, b1=17.396, b2=-0.595) for males. **Conclusion**: Demirjian method overestimated the chronological age of Jordanians below the age of 8 years and underestimated the age of Jordanians above 8 years. A new DA standard for Jordanian children was developed and tested for accuracy.

Indexing terms: Applicability. Chronological. Demerjian. Dental. Jordanians.

RESUMO

***Objetivo**: Avaliar a precisão do método Demirjian na estimativa da idade cronológica de crianças jordanianas do sexo masculino e feminino e estabelecer uma nova curva de idade dentária, se o método Demirjian não for acurado. **Métodos**: Foram selecionados radiografias panorâmicas (OPTs) de 1374 crianças jordanianas caucasianas (684 do sexo feminino e 690 do sexo masculino) com idades entre 4 e 16 anos, e a idade dentária foi determinada pelo método de Demirjian. As idades cronológicas das crianças foram obtidas subtraindo as datas de nascimento a partir da data da realização da radiografia. Os OPTs foram obtidos em Archives of Dental*

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Teaching Clinics / XXX e outras clínicas ortodônticas particulares em Irbid e Amã. ***Resultados****: O método Demirjian superestimou a idade cronológica em indivíduos do sexo feminino e masculino com idades entre 4 e 8 anos. Posteriormente, o método subestimou a idade cronológica em mulheres de 9 a 11 anos e 14 a 16 anos. Nos homens, a idade cronológica foi subestimada nos indivíduos de 9 a 12 anos e 15 a 16 anos. Novas curvas de idade dentária para mulheres e homens jordanianos foram construídas. As constantes para o modelo quadrático para as novas curvas foram (b0 = -25.341, b1 = 17.557, b2 = -0.623) para mulheres e (b0 = -29.809, b1 = 17.396, b2 = -0.595) para homens.* ***Conclusão****: O método Demirjian superestimou a idade cronológica dos jordanianos abaixo de 8 anos e subestimou a idade dos jordanianos acima de 8 anos. Um novo padrão DA para crianças jordanianas foi desenvolvido e testado quanto à precisão.*

Termos de indexação: *Applicability. Chronological. Demerjian. Dental. Jordanians.*

INTRODUCTION

In many cases, chronological age (CA) and biological age may not be the same, due to developmental variations. Hence, different parameters such as dental and skeletal ages are considered as indicators for biological age and body development [1].

Dental age (DA) can be determined by either the stage of emergence or the stage of tooth formation [2]. Tooth formation (calcification) is a more reliable indicator of dental maturity than eruption (gingival emergence) because it is not affected by local factors such as loss of primary teeth, lack of space, malnutrition, dental decays, ankylosis, or orthodontic anomalies and is instead much more genetically determined [3,4]. It has many advantages over emergence when used to evaluate maturity and estimate a patient's age. These include the ability to study the majority of teeth in one radiographic examination, whereas tooth emergence is only a short phase of the process of tooth eruption, which limits the number of teeth available to study. Based on these facts, using the formation and calcification of teeth to determine dental age is a much more accurate, precise, and reliable indicator of dental maturity than tooth emergence [5].

Dental maturity, expressed as dental age has an important role in forensic medicine, pediatric dentistry and orthodontic treatment planning [6]. A child's growth and development status are especially important in diagnosis and treatment planning. Orthodontists use such knowledge to predict the timing of particular treatments.

Many methods have been introduced to determine dental age using dental calcification stages of permanent teeth including Demirjian [3] and Nolla [7]. The most commonly used method of assessing dental maturity is that of Demirjian [3]. However, there are concerns with this method, as the reference group was French Canadian, and the possible effect of ethnicity was not considered [8]. Thus, French-Canadian dental developmental standards and data might not be applicable for the Jordanians.

Although, Demerjian method was used to assess DA in Jordanians [9], to our knowledge, there is no published studies regarding the applicability of Demerjian method in Jordanians. For this reason, the objectives of this study were to evaluate the accuracy of Demirjian method in estimating the CA of Jordanian male and female children between 4 and 16 years of age, and to establish a new DA standard for the Jordanian population if the Demirjian method was not accurate.

METHODS

The sample size for this study was calculated using the confidence interval formula n = (Z^*s/D)2 where 'n' is sample size in each group. 'Z' is the two-sided Z value required for the 95% confidence interval (CI) which is equal to 1.96. S is the standard deviation (SD) from source population which was estimated from sample of previous study [8], S = 0.78 years. D assigned as 0.3. Therefore, the sample size for each age group calculated using the formula is 25 subjects and the total sample size of 14 age groups (from 4 to 16 years of age) and for both genders is 728. With the consideration of 5% nonresponse (e.g. radiographic distortion, under- or over-exposure), the final sample size required is (728 + 37) = 765 subjects.

In this retrospective study, orthopantomograms (OPTs) of 1374 healthy (no history of chronic disease, illness or syndrome known to significantly affect dental development), Caucasian Jordanian children of known CA and gender were selected; 684 were females and 690 were males and their ages ranged from 4 to 16 years. The OPTs were obtained from Archives of Dental Teaching Clinics /XXX and other private orthodontic practices in Irbid and Amman. Only good quality radiographs, with the presence of all permanent teeth from the lower left and

right quadrant teeth (except the 3rd molar) were selected. Radiographs with distortion (overlapping images of the teeth or lacking clarity) or incomplete information such as date of birth, or date of exposure of radiograph were excluded.

DA was assessed using the method of Demirjian et al. [3]. With this method, the 7 left mandibular teeth (excluding the third molars) were assessed in each OPT. When a tooth was missing on the left side, the corresponding tooth on the right side was used for the assessment. Each tooth was given a stage from A to H by following the criteria described in writing and by comparing the tooth to the diagrams in the original article [3]. Stages assigned for each of the 7 left mandibular teeth were converted into maturity scores with the conversion table. The scores were then added together, and the total score for each subject was converted into dental age by using the two tables of standards for boys and girls constructed by Demirjian et al [3].

All OPTs were examined by one examiner. The examiner was blinded with regards to the CA and other details such as the name and gender of the subject when evaluating the radiograph. The process was repeated for each tooth from the lower left quadrant except the third molar.

CA was obtained by subtraction of the date of the radiograph from the date of birth and the resultant age was converted into decimal.

An external sample of 78 Jordanian children (39 boys and 38 girls) aged between 4 and 16 years was randomly selected in order to test the accuracy of the new DA standard on Jordanian population. These external samples were patients in Jordan university of Science and Technology Dental Teaching Clinics who came for routine dental check-up and had their OPT taken and they are not involved in the making of the Jordanian standard curve.

Statistical analyses

The DAs from all samples were analyzed using the Statistical Package for Social Science (SPSS) version 22 for Windows. Paired sample t- test was used to compare the 'chronological age' and the 'dental age' and to examine the accuracy of Demirjian method in estimating the CA of male and female Jordanian children between 4 and 16 years of age. In order to establish a new DA standard for the Jordanian population, CA was regressed against maturity scores using nonlinear regression analysis (Quadratic model).

Method error

Intra-examiner reproducibility for 'maturity scores' and 'DA" have been assessed. A total of 50 OPTs have been assessed twice with one-week interval between the first and the second assessments. The Cohen's kappa value and the intraclass correlation (ICC) have been calculated.

The results for the reproducibility in assessment of the maturity scores and DA showed that the intra examiner correlation was high (0.96) and the reproducibility in assigning the stages showed that the overall values for intra-examiner was 0.88. The examiner had undergone training period by an experienced orthodontist (E. AA) and checked the inter-examiner variability (the inter-examiner correlation was 0.94) prior the conduct of the study.

RESULTS

The means and standard deviations (SD) of CA and DA and the difference between them (years) for females, males and total groups are shown in tables 1-2. Demirjian method underestimated CA in females which did not reach any significant level (P=0.371) and overestimated the CA in males (P=0.040). Demirjian method overestimated male's CA by an average of 0.12 years (44 days).

Demerjian method overestimated CA in female and male subjects aged 4 to 8 years (P<0.001). However, after 9 years of age, the method underestimated CA in females aged 9-11 years (P<0.001, P<0.05) and 14-16 years (P<0.01 and P<0.001). In male subjects, CA was underestimated in subjects aged 9-12 (P<0.01 and P<0.05) years and 15-16 years (P<0.05).

The maturity score curves of Jordanians and French-Canadians were superimposed upon each other and were compared (figure 1). The comparison between DA of Demerjian method for Jordanians with French Canadians showed an advanced maturation of Jordanian children up to 8-9 years. The results showed that DA for older age group (11-14 years in females and 12-15 years in males) is comparable to the French Canadian children. However, after 14 years in females and 15 years in males the difference became statistically different.

Table 1. Differences between CA and DA (years) for females in the different age groups.

Age (years)	CA Mean (SD)	DA Mean (SD)	Mean of age difference (95% CI)	t-value	P value
4-4.9	4.14 (0.22)	5.28 (1.65)	-1.14 (-1.76 , -0.52)	-3.74	0.001***
5-5.9	5.10 (0.30)	6.31 (0.92)	-1.22 (-1.46 , -0.97)	-9.78	0.000***
6-6.9	6.12 (0.25)	7.20 (0.64)	-1.08 (-1.29 , -0.87)	-10.56	0.000***
7-7.9	7.21 (0.29)	7.84 (1.02)	-0.63 (-0.88 , -0.38)	-4.95	0.000***
8-8.9	8.16 (0.25)	8.17 (0.64)	-0.01 (-0.17 , 0.16)	-0.05	0.961
9-9.9	9.20 (0.27)	8.63 (0.89)	0.57 (0.34 , 0.80)	4.95	0.000***
10-10.9	10.28 (0.29)	9.87 (1.52)	0.41 (0.01 , 0.80)	2.05	0.044*
11-11.9	11.34 (0.29)	11.06 (1.66)	0.28 (-0.25 , 0.81)	1.07	0.292
12-12.9	12.30 (0.32)	11.92 (1.66)	0.38 (-0.06 , 0.82)	1.74	0.087
13-13.9	13.37 (0.34)	12.93 (1.84)	0.44 (-0.14 , 1.02)	1.54	0.132
14-14.9	14.23 (0.23)	13.63 (1.43)	0.60 (0.18 , 1.03)	2.87	0.006**
15-16.0	15.66 (0.43)	14.13 (2.07)	1.52 (1.06 , 1.98)	6.62	0.000***
Total	9.76 (3.39)	9.70 (3.02)	0.06 (-0.06 , 0.17)	0.90	0.371

Table 2. Differences between CA and DA (years) for males in the different age groups.

Age (years)	CA Mean (SD)	DA Mean (SD)	Mean of age difference (95% CI)	t-value	P value
4-4.9	4.15 (0.25)	5.80 (1.33)	-1.65 (- 2.16 , -1.15)	-6.71	0.000***
5-5.9	5.11 (0.22)	6.43 (0.76)	-1.32 (- 1.51 , -1.11)	-13.05	0.000***
6-6.9	6.13 (0.24)	6.96 (0.72)	-0.83 (- 1.03 , -0.63)	-8.18	0.000***
7-7.9	7.16 (0.24)	7.95 (0.71)	0.79 (- 0.97 , -0.61)	-8.76	0.000***
8-8.9	8.17 (0.27)	8.24 (0.58)	-0.63 (- 0.21 , 0.09)	-0.83	0.407
9-9.9	9.18 (0.25)	8.87 (0.89)	0.31 (0.08 , 0.54)	2.65	0.010**
10-10.9	10.18 (0.26)	9.82 (1.44)	0.36 (0.03 , 0.70)	2.16	0.034*
11-11.9	11.27 (0.29)	10.76 (1.39)	0.51 (0.07 , 0.94)	2.35	0.024*
12-12.9	12.21 (0.28)	11.88 (1.63)	0.33 (-0.10 , 0.75)	1.55	0.127
13-13.9	13.28 (0.31)	13.09 (1.82)	0.19 (-0.26 , 0.64)	0.86	0.395
14-14.9	14.24 (0.25)	13.88 (1.53)	0.36 (- 0.20 , 0.92)	1.31	0.201
15-16.0	15.48 (0.42)	14.48 (2.35)	1.00 (0.36 , 1.65)	3.12	0.003**
Total	9.57 (3.27)	9.68 (2.94)	-0.12 (-0.23 , -0.01)	-2.05	0.040*

New DA curves for Jordanian females and males were constructed using non-linear regression model (figure 2). The results showed that constants for the quadratic model (Y= b0+b1x+b2x2) for the new curves were (b0=-25.341, b1=17.557, b2=-0.623) for females and (b0=-29.809, b1=17.396, b2=-0.595) for males. The accuracy of the new curves for estimating CA was assessed using external sample. The mean difference between CA and DA was 0.06 years for females and 0.05 years for males (table 3).

Table 3. Difference between chronological age and dental age (years) for females, males for the test group.

	CA Mean (SD)	DA Mean (SD)	Mean of age difference (95% CI)	t-value	P value
Females	8.73 (1.50)	8.79 (1.17)	0.06 (-0.09 - 0.21)	1.29	0.205
Males	9.49 (3.27)	9.44 (1.99)	-0.05 (-0.26 - 0.16)	-0.50	0.623

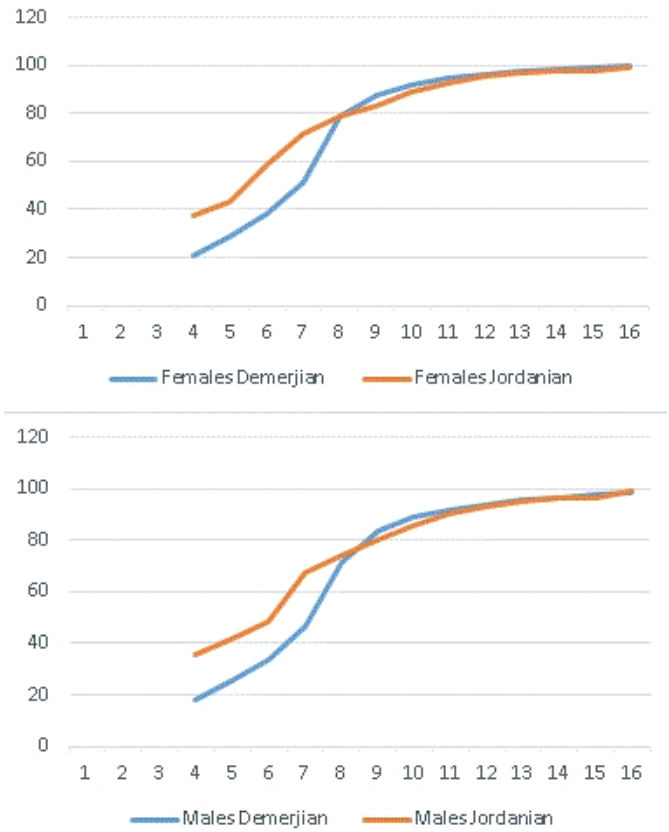

Figure 1. The maturity score curves of Female and Male-Jordanians and French-Canadians superimposed upon each other.

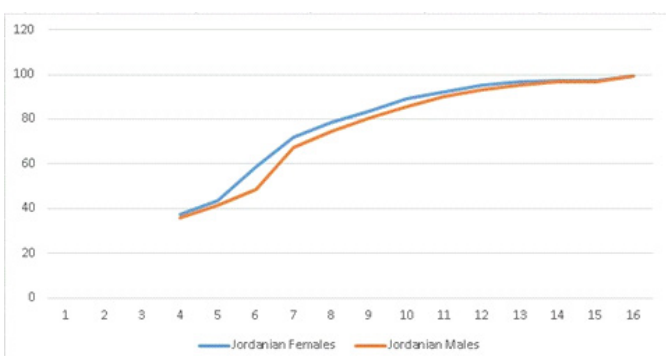

Figure 2. New DA curves for female and male. Jordanians.

DISCUSSION

Many methods are available for determining dental age. However, no universal system currently exists, as methods vary in accuracy when applied to different ethnic populations [8].

Although, the accuracy of Demirjian's method has generally been considered by many investigators as high for European populations [10], recent investigations using this method suggested ethnic differences [6,8,11-14]. These reports demonstrate the necessity of establishing reference data representative to each population.

A common finding in research conducted in different countries is that Demirjian's French–Canadian standards do not accurately estimate the dental age of studied subjects. While some studies reported an underestimation of the predicted CA [15-26], others reported an overestimation of CA [27-32] (table 4)

Gender difference in dental age assessment is said to exist due to maturational differences [33]. In the present study, Demirjian's method underestimated CA of Jordanian females (0.06 year) and overestimated CA of males (0.12 year). On comparison between the mean values of differences between estimated dental ages and chronological ages in both sexes, boys were more delayed before the age of 8 years, which may indicate that boys were delayed in overall body growth than girls in this period; however, thereafter, the boys caught up with the girls and their dental development was more advanced than the girls. The finding of this study does not support the expected significant sex differences based on that girls mature faster than boys.

Researchers reported that significant variability in individual dental age increased with age [17]. This was in disagreement with the current work where statistically significant differences were observed in both younger and older age groups with no tendency towards such variability.

In the present study, younger age groups had advanced dental maturity, while in older age groups, dental maturation was delayed compared to the French Canadians. The mean differences between the chronological and dental ages varied from -1.22 to 1.52 years in females and from -1.65 to 1 year in males. This was in agreement with Bagherian and Sadeghi [30] who found that overestimation was more common in younger age groups and in contradiction with Koshy and Tandon [6] who discovered a greater overestimation in older age groups. These differences can be explained by difference in sample size, method of age calculation, age range, grouping and statistical analysis used.

Demirjian method overestimated the CA in Jordanians below the age of 8 years and underestimated the CA in older Jordanians (>8 years) which indicates that

Table 4. Applicability of Demerjian method on the different populations.

Study	Year	Population	Sample number	Age range	Gender	CA-DA Diff	Description
Nykänen et al.[17]	1998	Norwegian	261	5.5-6.5 yr 8.5-9.5 yr 11.5-12.5 yr	Females Males	0- 7.5 months 1.5- 4.0 months	Advanced dental maturity
Liversidge et al.[15]	1999	British	521	4-9 yr	Females Males	0.51 (0.79)yr 0.73 (0.73)	Advanced dental maturity
EID et al. [16]	2002	Brazilian	689	6–14 yr	Females Males	0·62 yr 0·68 yr	Advanced dental maturity
Leurs et al.[18]	2005	Dutch	451	3- 17 yr	Females Males	0.6 yr (0.06-1.23) 0.4 yr (-0.68-1.28)	Advanced dental maturity
Ngom et al.[27]	2007	Senegalese	200	6- 14 yr	Females Males	-0.89 yr - 0.48 yr	Delayed dental maturity
Mani et al.[29]	2008	Malaysian	428		Females Males	-0.75- 0.61 yr	Delayed dental maturity
Qudeimat and Behbehani[28]	2009	Kuwaiti	509	3-14 yr	Females Males	-0.67 yr -0.71yr	Delayed dental maturity
Chen et al.[19]	2010	Western Chinese	445	8-16 yr	Females Males	0.01- 1.25yr -1.0- 1.30 yr	Advanced dental maturity
Galić et al.[20]	2010	Bosnia-Herzegovina	1106	5-14 yr	Females Males	1.27 yr 1.46 yr	Advanced dental maturity
Weddell and Hartsfield [21]	2010	Indianapoiis	257	5- 17.5 yr	Females Males	0.57±1.03 yr 0.61±0.91 yr	Advanced dental maturity
Bagherian and Sadeghi [30]	2011	Iranian	519	3.5-13.5 yr	Females Males	-0.21 yr -0.15 yr	Delayed dental maturity
Al-Tuwirqi et al.[22]	2011	Australian and Saudi Arabian	842 Aus 456 SA	5-14 yr	Females Males	0.33-1.10 yr	Advanced dental maturity
Abu Asab et al. [23]	2011	Kelantanese Malay	905	6-16yr	Females Males	0.011 yr 0.17 yr	Advanced dental maturity
Celikoglu et al.[24]	2011	Eastern Turkish	807		Females Males	0.2-1.9 yr 0.4-1.3 yr	Advanced dental maturity
Santoro et al.[31]	2012	Italian	535	7-15 yr	Females Males		Delayed dental maturity
Pinchi et al.[32]	2012	Italian	501	11-16 yr	Females		Delayed dental maturity
Celik et al.[26]	2014	Southern Turkish	932	4-18 yr	Females Males	-1.20-1.36 yr -1.02-1.69 yr	Dental maturity is advanced in some groups and delayed in others
Altunsoy et al.[25]	2015	Western Turkish	635	7-16 yr	Females Males	0.28-0.87 yr 0.10-0.76 yr	Advanced dental maturity
This study	2017	Jordanians	1374	4-16 yr	Females Males	-1.22 to 1.52 yr -1.65 to 1.00 yr	Dental maturity is advanced in young age groups and delayed in older ones

Note: -/ Delayed dental maturity. +/Advanced dental maturity.

the method is less accurate when applied on Jordanian children. In this study, the modified DA curve for Jordanian children based on the Demirjian method has been produced and tested over external samples. It was shown to be more accurate and can be used as a baseline to determine DA in Jordanians.

CONCLUSIONS

Demirjian method is not accurate to estimate the CA in Jordanian children. Demirjian method overestimated the CA in Jordanians below the age of 8 years and underestimated the CA in older Jordanians above 8 years. A new DA standard was developed for Jordanian children.

Collaborators

E ABU ALHAIJA, study design, data analysis and writing up of the manuscript. A OWAIS, study design, collection of data and helping in the writing up of the manuscript. G ALJAMAL, help with study design, training Yousef on the use of Demirjian method, reading the radiographs and help in writing the manuscript. Y NASRAWI, measurement of the radiographs and calculation of the dental age.

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