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Assessment of Dental Maturity with Three Methods of Dental Age Estimation in the Children of Mosul City

Ruba J Mohammad*

Department of Peadodontics, Orthodontics and Preventive Dentistry, College of Dentistry, University of Mosul, Mosul, Iraq

ABSTRACT

Background and Aim: Various methods available to estimate the dental maturation. The aim of this study is to evaluate the applicability of three "Demirjian, Häävikko, and Nolla" methods of dental age (DA) estimation in the Mosul population.

Materials and Methods: The samples contain 252 digital dental panoramic radiographs (DPR) for 130 girls and 122 boys with age range 6–15 years old of Mosul city population. Chronological age (CA) of each child was obtained by subtracting the date of birth from the date at which the radiograph was taken. Dental age (DA) was estimated according to the Demirjian, Häävikko, and Nolla methods of analysis. Descriptive statistics were calculated for mean and standard deviation. A paired t-test was done to compare means between chronological (CA), and dental age (DA) for different estimation methods and for both genders.

Results: A significant difference was seen in the comparison between the CA and DA by Demirjian and Häävikko methods in girls and in boys ($p<0.05$). There is no significant underestimation of the DA in girls and boys ($p = 0.117, 0.396$) when it is estimated with Nolla`s method.

Conclusion: The present study concluded that the Demirjian's method and Häävikko`s method are not suitable for DA estimation in Mosul city children aged 6-15 years old. Whereas no significant underestimation of DA with Nolla`s method makes it a more accurate and precise method than the others.

Key words: Demirjian, Häävikko, Nolla, Dental age, Chronological age

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Corresponding author: Ruba J Mohammad

e-mail✉: rubajassim@uomosul.edu.iq

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INTRODUCTION

Tooth formation is usually used to assess maturity and age estimation. In dentistry, this information aids in diagnosis and treatment planning [1]. Dental development plays a role in the development of surrounding tissues of the face. During the process of eruption and the development of teeth, important changes in the growth patterns may occur in the surrounding hard and soft tissues [2].

Physiological age refers to the estimation of the maturation of one or more tissue systems. Developmental marks include bone development, secondary sex characteristics, body weight, and dental development. Dental age (DA) can be determined by the stages of tooth eruption or by the stages of tooth formation [3]. Dental development shows less variability in relation to chronological age (CA) for determining dental maturation. The simplicity to recognize the dental development stages, together with the availability of dental radiographs in most dental clinics are advantages in attempting to assess physiological maturity [4,5].

Several techniques are widely used for dental age estimation assessment by Demirjian et al. [6], Häävikko et al. [7], and Nolla et al. [8] methods

using dental panoramic radiographs (DPR). These methods are based on the calcification of the permanent teeth either erupted or not. The calcification of a tooth is divided into stages, and each stage has given a numerical score according to gender. These numerical scores are considered to estimate the individual's dental age [9,10]. Dental radiography plays an important role in human age determination as a simple, valuable, and available diagnostic tool [11,12].

There is no previous study in the literature regarding the estimation of dental age in Mosul Population. Therefore this study aimed to determine the validity of three "Demirjian, Häävikko, and Nolla" methods of dental age (DA) estimation using developing teeth from dental panoramic radiographs in Mosul population in comparison with their chronological age (CA).

MATERIALS AND METHODS

The samples contain 252 digital dental panoramic radiographs (DPR) for 130 girls and 122 boys with age range 6 – 15 years old. The DPRs were collected from data archives of Al-Rasheed Radiologic Center, in Mosul city/Iraq. The collected data about each sample included the name, gender, and date of birth. The selected radiographs should compensate for the inclusion criteria and exclusion criteria. The application of inclusion criteria checked by an oral radiologist with an expert about 30 years of specialty.

Exclusion criteria

A DPR showing obvious artifacts, obvious dental pathology, presence of impacted teeth, severe crowding, teeth with endodontic treatment, and congenital anomalies.

Inclusion criteria

Age groups range between 6-15 years, the entire samples are Mosul city population, good quality DPRs, complete mandibular permanent dentition (erupt or not), and no signs of syndromes.

Radiographic examination

A digital panoramic machine type Carestream, digital panoramic and cephalometric machine with CS imaging software version 7.0.1. from Carestream Dental (New York–USA). The machine operated at 64 kVp, 10 mA and exposure time 13.1 sec. The included radiographs divided into 9 groups, each group with one year of the time interval. Thus, age group 1 involved a child aged 6.0 to 6.9 years and so on. To escape bias, each radiograph is given a numerical code to ensure that the examiner is sightless to sex, name, and age of subjects.

Chronological age (CA) of each child was obtained by subtracting the date of birth from the date at which the radiograph was taken and converted into years with two decimals to simplifying the statistical analysis. Dental age (DA) estimation depended on the development of seven left permanent mandibular teeth according to the Demirjian, Häävikko, and Nolla methods of analysis. All DPRs were examined by the same examiner. The examiner was blinded with concerns to the chronologic age of the patient.

Demirjian method

According to the Demirjian method [6], tooth development divided into eight stages (from A to H) in the seven left permanent mandibular teeth (from the central incisor to the 2nd molar). Each tooth was given a stage that converted to a numerical score from a specific table, the summation of scores of the seven teeth is converted to the DA using a gender-specific table for translating the results of dental maturity.

Häävikko method

Seven mandibular teeth of the left side were estimated by Häävikko [7] dental maturation method. When the stage of tooth development was identified, the corresponding code was given to that tooth. These codes were converted to the gender-specific numerical scores from the median age of Häävikko method. The individual scores were summed and divided by the number of teeth assessed to directly obtain the dental age in years.

Nolla method

The Nolla`s method [8] divided the tooth formation into ten stages (0=No crypt, 9=Complete root formation). Each stage was given a numerical score from a specific table and the summation of the scores for all examined teeth to provide the subject's total score which converted to dental age using the available gender-specific tables. The Nolla method requires very constant discernment by the observer in assessing dental maturity through radiography.

Statistical analysis

Data entry and analysis was done using Statistical Package for Software Science (IBM SPSS Version 26.0). Descriptive statistics were calculated for mean and standard deviation. A paired t-test was done to compare means between chronological (CA), and dental age (DA) for different estimation methods and both genders.

RESULTS

The total number of samples is 252, includes 122 girls and 130 boys. The samples divided into nine age groups from 6 to 15 years, with one year of the time interval. The number and percent of each group of girls and boys are presented in Table 1. Table 2 shows an overestimation of the DA in all age groups of girls and boys as it is assessed by the Demirjian method in comparison with CA. While, there is an underestimation of DA is recognized in all age groups of both genders as they assessed by Häävikko and Nolla methods, except the age group of 6 years shows an overestimation of DA for girls (-0.1, -0.01) respectively.

A significant difference is seen in the comparison between the CA and DA by Demirjian and Häävikko methods in girls (0.000, 0.000) respectively, and in boys (0.000, 0.000) respectively. While this comparison is not significant with Nolla`s method (Table 3 and Figure 1). Although there is an underestimation of the total mean of DA in girls and boys when estimated by Nolla`s method. it is very small and not significant (p-value = 0.117, 0.396) respectively as that difference detected by the Häävikko method.

Table 1: Age and gender distribution of the examined samples.

Age group	Girls		Boys		Total	
	No.	%	No.	%	No.	%
6–6.9	8	6.56	9	6.92	17	6.75
7–7.9	20	16.39	21	16.15	41	16.27
8–8.9	18	14.75	18	13.85	36	14.29
9–9.9	17	13.93	18	13.85	35	13.89
10 –10.9	13	10.65	18	13.85	31	12.3
11–11.9	12	9.84	12	9.23	24	9.52
12–12.9	11	9.02	12	9.23	23	9.13
13–13.9	12	9.84	12	9.23	24	9.52
14–15	11	9.02	10	7.69	21	8.33
Sum	122	100	130	100	252	100

Table 2: Shows the mean differences between chronological ages and dental ages determined by Demirjian, Häävikko, and Nolla methods.

Age group	CA	Demirjian		Häävikko		Nolla	
		DA	Mean difference (CA-DA)	DA	Mean difference (CA-DA)	DA	Mean difference (CA-DA)
				Girls			
6–6.9	6.64	7.66	- 1.02*	6.74	- 0.1*	6.65	-0.01*
7–7.9	7.35	8.41	- 1.06*	7.34	0.01	7.21	0.14
8–8.9	8.47	9	- 0.53*	8.2	0.27	8.43	0.04
9–9.9	9.55	10.02	- 0.47*	8.82	0.73	9.41	0.14
10–10.9	10.61	10.66	- 0.05*	9.85	0.76	10.43	0.18
11–11.9	11.43	11.72	- 0.29*	10.11	1.32	10.87	0.56
12–12.9	12.24	12.43	- 0.19*	10.9	1.34	12.09	0.15
13–13.9	13.23	13.73	- 0.50*	10.6	2.63	13.04	0.19
14–14.9	14.65	14.83	- 0.18*	13.17	1.48	14.55	0.1
				Boys			
6–6.9	6.43	6.63	- 0.20*	6	0.43	6.33	0.1
7–7.9	7.27	8.03	- 0.76*	6.83	0.44	7.22	0.05
8–8.9	8.47	9.23	- 0.76*	7.37	1.1	8.36	0.11
9–9.9	9.47	10.37	- 0.90*	9.38	0.09	9.23	0.24
10–10.9	10.47	10.65	- 0.18*	8.98	1.49	9.55	0.92
11–11.9	11.5	11.98	- 0.48*	10.55	0.95	11.42	0.08
12–12.9	12.2	12.95	- 0.75*	11.1	1.1	12.15	0.05
13–13.9	13.48	14.55	- 1.07*	11.55	1.93	13.45	0.03
14–14.9	14.25	16	- 1.75*	12.97	1.28	14.23	0.02

CA: Chronological age, DA: Dental age, (*); Overestimation

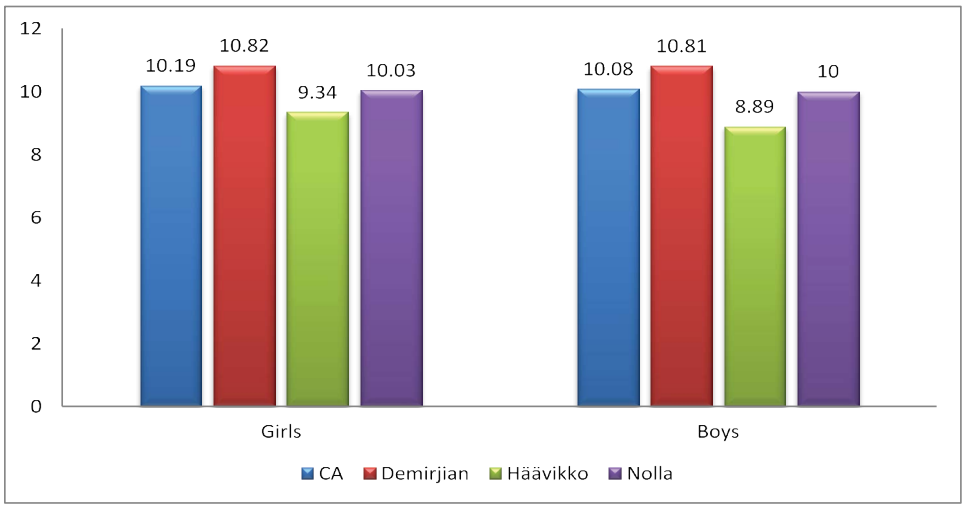

Figure 1: Shows the total mean of the Chronological age (CA), and the dental age (DA), estimated by Demirjian, Häävikko, and Nolla methods in both gender.

Table 3: Shows the comparison between chronological ages and dental ages determined by Demirjian, Häävikko, and Nolla methods.

Gender	Pairs	No.	Mean	Mean difference (CA-DA)	SD	t - value	p -value
Girls	CA	122	10.19	-0.63	1.321	-5.2	0
	Demirjian	122	10.82				
	CA	122	10.19	0.89	1.226	7.739	0
	Häävikko	122	9.34				
	CA	122	10.19	0.17	1.181	1.579	0.117
	Nolla	122	10.03				
Boys	CA	130	10.08	-0.73	1.164	-7.238	0
	Demirjian	130	10.81				
	CA	130	10.08	1.18	1.19	11.319	0
	Häävikko	130	8.89				
	CA	130	10.08	0.07	1	0.851	0.396
	Nolla	130	10				

CA; chronological age, DA; dental age, SD; standard deviation, not significant; $p \geq 0.05$.

DISCUSSION

The evaluation of dental age in children and adolescents is a particularly important aspect for planning and timing of dental treatment during the optimal growth stage (pubertal growth spurt) [13], the establishment of individual and chronological age correlations [14,15]. Dental development is a useful measure of maturity as it represents a series of noticeable changes that occur in the same categorization from an initial episode of tooth formation to the complete root apex formation [16]. The radiological method of age estimation is one of the most reliable, available, fast, and simple methods used to investigate individual maturation [17,18]. In the literature, there is no previous study conducted to evaluate dental maturation in the Mosul city/Iraqi population. Therefore, this study is performed to evaluate the validity of Demirjian, Häävikko, and Nolla`s methods in this population. For accuracy and reliability, all measurements were recorded by a single examiner and were reviewed twice with an interval of one month between each measurement.

The results of the present study show a significant overestimation in the mean of DA by Demirjian method in comparison with chronological age (CA) for girls (+0.63) and boys (+0.73) ($p<0.05$). These findings are confirmed by other studies that demonstrated that the Demirjian method overestimated the dental age between 0.04 years (12) to 3.04 years [16,19].

The inapplicable overestimated dental age by Demirjian`s method generally noticed in different Middle East Arab populations; the Kuwaiti populations [20] show the mean of overestimation in girls is 0.67 years and in boys, it is 0.71 years (age ranged from 3 to 8 years). Also in the Egyptian population [21,22], the overestimation of DA is noticed in both genders. In

the Tunisian population [23], the overestimation in DA as determined by Demirjian`s method ranged from 0.26 to 1.37 years for young girls and from 0.3 to 1.32 years for young boys (age ranged from 3 to 8 years). The Saudi Arabian population [13,24], the range of overestimation is (0.059–0.44) years in girls and (0.57–0.66) years in boys in the 4–16 years age group. Except two studies conducted by Al-Dharrab et al. [25] and Souror et al. [26] concluded that the Demirjian`s method could be applicable in the western region of Saudi Arabia with minor underestimation in the DA. Concerning that the population was selected randomly not represent the general Saudi population, in addition to great diversity in the ethnic background of the studied population in the western region in comparison to the other regions of the country. These findings make the Demirjian`s method for DA estimation is inconvenient for the Middle East Arab population, where the Mosul population considered as a part of them. Because the DA is more advanced in French-Canadian white population which considered in Demirjian's method when compared to the Middle East Arab population. Thus a new table of scoring is necessary to evaluate this population. Although, the Demirjian method is simple and easy to apply [18,27], it cannot be applied to all ethnic populations [28].

On contrary, several studies confirm the clinical applicability of Demirjian's method with minor overestimation or underestimation observed among boys and girls in the DA on other populations, for example; in the Iranian population [19,29], overestimated dental age up to 0.77 in both genders. For Indian children, illustrate an underestimated DA by 1.55 years for girls and 1.66 years for boys in South Indians [30]. While other studies [16,18,31] conducted in the south of India suggesting a minor overestimation in the DA in both females and males. Malaysian population [32] exhibits an overestimation of mean DA of about 0.3 in comparison with the mean of CA. In the Nepalese population [14], Demirjian's method is considered more applicable to assess the dental age with minor and not significant underestimation. Also, Demirjian's method is indicative of children in Venezuelan [33] and Romanian children [15].

The Häävikko`s method is applied in the present study considering seven left mandibular teeth which is more accurate than four teeth method [34]. Although, there is a significant underestimation that can be noticed in the DA of girls and boys in all age groups of Mosul population when it is assessed by Häävikko method ($p<0.05$). These findings come in agreement with studies conducted by; Butti et al. [35] and Pizzo et al. [36] they found that Häävikko's standards tended to underestimate DA and cannot be applied in the Italian sample. Indian population [34] shows an underestimation of DA in comparison with CA in 5-13 years of age children. The same finding is noticed in the population of Bangladeshi and British Caucasian ethnic origin children [37]. While, in the Turkish population [38], the Häävikko's method considered as an applicable method for DA with minor underestimation in girls (−0.56 ± 0.81), boys (−0.60 ± 0.80).

Nolla`s method is one of the most commonly used techniques in teaching and clinical practice. According to the literature, its application is accurate in over 90% [12], but it is not tested to estimate the DA in the Mosul and Middle East Arabic populations. For these reasons this method, is considered in this study. The results of the present study illustrate a not significant minor underestimation of DA mean by Nolla`s method in comparison with CA mean in all age groups of girls and boys, except the age of 6 years old girls show minor overestimation (Table 2). These findings supported by several studies; in western and northern Turkish children [12,39], Indian population [16,40,41] and Portuguese and Spanish sample [42] they found that the Nolla`s method showed greater predictive capacities than the Demirjian one, where the Demirjian`s method tends to overestimate DA and the Nolla method tended to underestimate it. On contrary, other studies suggested that Nolla`s method is found to be inapplicable of DA estimation as compared to the Demirjian's method in Venezuelan [10], Malaysian [32] and Indian population [14,43].

The accuracy of Nolla`s method in the evaluation of DA, may be related to the presence of additional stages of teeth development in this method, allowing greater inter-stage and sub-divisions in the differentiation of dental maturity. This makes it be more accurate and reliable than Demirjian's method and it is widely used around the world [43,44]. While other authors concluded that the Demirjian's

method is the commonly used method because of lesser complex and least exhaustive staging of development in comparison with Nolla's method [29,45]. As mentioned previously there is a great controversy to determine the most suitable and accurate method of DA estimation, because the DA estimation affected greatly by, ethnicity, environmental, nutritional, genetic, socioeconomic and geographic factors and according to the type and size of sample selection. Where the selection of population differs from area to area even in the same Nation [28,34].

The overestimation of DA with Demirjian is less in girls than that in boys and it is underestimation with Häävikko and Nolla methods in the girls are higher when compared with boys. These findings may be related to that the female`s growth rate is faster in girls than boys especially in 11-15 years of age (Tables 2 and 3). However, the dental development of girls was more advanced than boys. This finding can be explained by earlier prepubertal and pubertal growth changes that occur in that age period in girls [16,19]. The overestimation in DA by Häävikko and Nolla methods in the six years age group (Table 2) may be related small sample size which may affect the statistical results. Chronological age of both genders shows a significant difference in comparison with dental age, where it is evaluated by Demirjian and Häävikko methods in girls and boys ($p<0.05$), while not significant as the Nolla`s method is applied for both genders ($p>0.05$) (Table 3). These findings make the Nolla`s method is more accurate and applicable to estimate the DA in Mosul city population aged 6–15 years old, rather than Demirjian and Häävikko methods. A special standard table of scoring is essentially developed to estimate the dental age for this population.

CONCLUSIONS

The results of the present study concluded that the Demirjian and Häävikko methods are not suitable for DA estimation in Mosul city children aged 6-15 years old, and a new table of standardized scoring is necessary for evaluating this population. A not significant minor underestimation of DA by Nolla`s method makes it a more accurate and precise method than the others.

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