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Relation of Two Different Dental Age Determination Methods to Chronological and Bone Age in a Southern Turkish Children Population

Güney Türk Çocuk Populasyonunda İki Farklı Diş Yaşı Tespit Yönteminin Kronolojik Yaş ve Kemik Yaşı ile İlişkisi

ABSTRACT

Objectives

The aim of the study is to assess the relation of Demirjian's and Nolla's dental age determination methods with chronological age and bone age in Turkish children aged between 10-15 years.

Material and Methods

In the retrospective study, 717 children were included, their chronological age and bone age in accordance with Greulich-Pyle Atlas by evaluating left hand wrist radiograms, dental age in accordance with Demirjian's and Nolla's methods by using panoramic radiograms were analyzed. Statistical analyses were performed using SPSS version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA).

Results

The bone age and the dental ages calculated according to Demirjian's and Nolla's methods was found higher than the chronological age by +0.29 year, +0.77 year and +0.23 year, respectively. The closest result to chronological age came from Nolla's method.

Conclusion

In contrast to the previous studies in the South Turkish population, Demirjian method was found to give incompatible results. In this study, it was shown that Nolla method is more reliable in determining dental age for this population.

Key Words

Chronological age, Bone age, Dental age, Demirjian's method, Nolla's method

ÖZ

Amaç

Çalışmanın amacı, 10-15 yaş aralığındaki Türk çocuklarında Demirjian ve Nolla'nın diş yaşı belirleme yöntemlerinin kronolojik yaş ve kemik yaşı ile ilişkisini değerlendirmektir.

Gereç ve Yöntemler

Retrospektif çalışmaya 717 çocuk dahil edildi, sol el bilek radyogramları değerlendirilerek Greulich-Pyle Atlas'a göre kronolojik yaşları ve kemik yaşları, panoramik radyogramlar kullanılarak Demirjian ve Nolla'nın yöntemlerine göre diş yaşları analiz edildi. İstatistiksel analizler Windows için SPSS sürüm 23.0 (SPSS Inc., Chicago, Illinois, ABD) kullanılarak yapıldı.

Bulgular

Demirjian ve Nolla'nın yöntemlerine göre hesaplanan kemik yaşı ve diş yaşları, kronolojik yaştan sırasıyla +0,29 yıl, +0,77 yıl ve +0,23 yıl yüksek bulundu. Kronolojik yaşa en yakın sonuç Nolla'nın yönteminde geldi.

Sonuç

Güney Türk popülasyonunda yapılan önceki çalışmaların aksine, Demirjian yönteminin uyumsuz sonuçlar verdiği bulundu. Bu çalışmada, Nolla yönteminin bu popülasyon için diş yaşını belirlemede daha güvenilir olduğu gösterildi.

Anahtar Sözcükler

Demirjian yöntemi, Diş yaşı, Kemik yaşı, Kronolojik yaş Nolla yöntemi

INTRODUCTION

Chronological age (CA) refers to the real, unalterable age of an individual. Age determination plays a key role in clinical dentistry. Morphological, histological and radiological age determination methods are available, but radiological methods are frequently used. Radiologically, a number of methods are used to detect bone age (BA) (1,2) and dental age (DA) (3,4). These methods combined with CA show differences in different ethnic groups because of varying genetic features, dietary habits, socioeconomic development levels of individuals and countries and climate.

BA is determined in living individuals using methods such as fusion of the diaphysis to the epiphysis of bones and fusion of the skull sutures, pubic symphysis and costal cartilage ossification and evaluation of cervical vertebrae. BA is assessed using Greulich-Pyle (1) and Tanner-Whitehouse (2) atlas in individuals younger than 22 ages. In various identification studies, teeth were often used to determine age, and several methods are available to detect DA (3-6).

In age determination, the teeth are evaluated in two major periods as primary dentition and permanent dentition. When DA is determined, the developmental stages and calcification grades of the dental tissues are considered. Assessment of dental calcification is often more useful and effective than evaluation of time of riding.

A study by Demirjian *et al.* (3) in 1973, which were updated in 1976, evaluated dental tissuesusing eight stages with a scoring system ranging from A to H for seven teeth on the left mandibular side and eight stages of development, four of which were root development stages. The Demirjian method (DM) is a common method that is easy to use, and many studies have been conducted in different countries using this method (7-11).

In 1960 Nolla's developmental tables were used to predict the CA of boys and girls based on the standarts of dental development. The development of each tooth was examined through 10 stages. In addition, maxillary and mandibular permanent teeth were evaluated using radiograms by analysing and assigning a suitable number for each tooth. Using the tables created separately for girls and boys, the age of the person was estimated by finding the age in relation to the total score of the seven teeth in the lower left half-tree (4).

The Nolla method (NM) is a commonly used method, similar to Demirjian, and it has been used in a large number of studies in different patient groups (12-16). The DM and NM have been used together in different countries to evaluate CA and DA (11,15,16).

The present study aimed to determine the age of teeth of children from a Southern Turkish population using the DM and NM, as well as evaluate their suitability by analysing their relation to CA and BA.

MATERIAL and METHODS

Subjects

This study was planned retrospectively and using panoramic radiographs from 717 south Turkish children (383 girls and 334 boys aged between 10-15 years). Panoramic images were collected from children who applied to Akdeniz University Faculty of Dentistry between 2014-2016. This study was approved by the Ethics Committee for Clinical Research at Akdeniz University Faculty of Medicine (decision no: 594, date: 16.11.2016).

Inclusion criterias of study were presence of all mandibular teeth, good radiographic quality and no previous orthodontic treatment. Exclusion criteria were hypodontia, malnutrition, supernumerary tooth, malignant disease, systemic and bone mineral disease, skeletal malocclusions, extraction, congenital anomalies and agenesis of permanent teeth from the left mandibula.

Collection of radiographs

All hand wrist and panoramic radiographs of all children were obtained by the same person as the patient's radiation dose with PLANMECA, (OY 00880 Helsinki, Finland) device. PRs were taken by giving in the patients standing with the cervical vertebrae in the vertical position as much as possible and PRs were exposed with 64-66 kVp and 8-10 mA, for 0.8-4 s depending on children size.

The radiographic views were captured with the image plate system, Fujifilm FCR. Fuji IP cassette type cc, size 15 × 30, Fuji Photofilm Co., LTD, Japan, was used for scanning. All views were evaluated using the CDR®DICOM 3.5 (Schick, USA), software, in dim light environment.

Evaluation of dental maturity and estimation of DA, BA and CA

Chronological age was determined by calculating the difference between the date of birth and the date the panoramic radiograph was taken.

BA was determined using the Greulich Pyle methods (1). The maturation stage of all the bones in the left hand-wrist region was evaluated separately. The BA of each child was determined by comparison with the sample graphs of Greulich Pyle atlas.

DA was calculated by Demirjian (3) and Nolla methods (4).

Demirjian's method

Teeth development can be categorised into eight stages: four stages involved root development and the other four stages involved calcification. In this method, seven teeth on the mandibular left side evaluated through eight stages with a scoring system from A to H. The letter corresponding to the degree of calcification in the radiogram of the person was determined and the scores corresponding to each letter in the tables were determined and added individually. Subsequently, the dental age corresponding to the scores previously found in the tables given for boys and girls was determined. The sum of all scores indicates the individual's dental formation score.

Nolla's method

The permanent maxillar and mandibular teeth, excluding the third molar teeth, were analysed by evaluating the radiographs and giving a suitable number to each tooth. Each permanent left mandibular tooth was detected and defined a number between 1 and 10 (1: No sign of calcification, 10: Apical end closed). The development process of each tooth could be divided into 10 stages, and the teeth on the radiographs are matched to the images in the development table by Nolla.

DA, BA and CA of the children were calculated by the same researcher (S.G.Y) to elimine interobserver fault. BA and DA were calculated without knowing the CA of the individual, and the findings were prevented from affecting each other.

Statistical analyses

SPSS version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA) was used for Statistical analyses. The assumption of normality was determined by the Shapiro Wilk Test. The difference of CA between different genders was tested by independent sample t-test. The data are represented as mean±standard deviation (SD). The Mann–Whitney U test was used for the evaluation of categorical variables. The relationships between continuous variables were evaluated using Spearman's rho correlation analysis. Friedman's Test / Two Way Analysis of Variance by Ranks were statistically analysedfor females and malesand the Dunn–Bonferroni posthoc adjustment for multiple comparisons. Kappa statistic was used to detect intraobserver reliability (Kappa statistics were 0.94).

RESULTS

A total of 717 panoramic and hand-wrist radiographs were examined. The distribution of the 717 children (334 boys, 383 girls) by gender and age group was shown in Table1.

Table1. The distribution of the subjects by gender and age

Group (years)	Female	Male	Total	Percent
10.0-10.9	74	54	128	17.9%
11.0-11.9	87	60	147	20.5%
12.0-12.9	88	77	165	23%
13.0-13.9	74	83	157	21.9%
14.0-14.9	60	60	120	16.7%
Total	383	334	717	100%

The differences between the mean CA, BA and calculated DA using the DM and NM for different age groups (10-15

Table 2. The differences between the mean chronologic age, bone age and estimated dental age using the Demirjian and Nolla method for different age groups for females and males (The Mann–Whitney U test)

		Female			Male			
	Age groups	**n**	**Mean±Sd**	**Median (Min-Max)**	**n**	**Mean±Sd**	**Median (Min-Max)**	***P***
CA	10-10.9	65	10.56±0.3	10.6(10-10.9)	52	10.57±0.27	10.6(10-10,9)	0.956
	11-11.9	93	11.48±0.32	11.5(11-11.9)	53	11.52±0.3	11.5(11-11,9)	0.488
	12-12.9	82	12.49±0.31	12.5(12-12.9)	81	12.55±0.3	12.6(12-12,9)	0.156
	13-13.9	76	13.42±0.32	13.3(13-13.9)	76	13.51±0.28	13.5(13-13,9)	0.044*
	14-15	67	14.42±0.33	14.3(14-15)	72	14.41±0.32	14.3(14-15)	0.709
	Total	383	12.44±1.34	12.3(10-15)	334	12.70±1.34	12.9(10-15)	0.011*
BA	10-10.9	65	10.61±0.81	11(8.9-13)	52	10.92±0.67	11(9-12.5)	0.007*
	11-11.9	93	11.78±0.9	12(10-14)	53	11.7±0.64	11.5(10-13)	0.309
	12-12.9	82	13.14±0.83	13(10-15)	81	12.48±0.72	12.5(11-14)	<0.001*
	13-13.9	76	13.71±0.67	13.8(12-15)	76	13.38±0.65	13.5(11.5-15.5)	0.001*
	14-15	67	14.66±0.66	15(12.5-16)	72	14.11±0.76	14(12.5-16)	<0.001*
	Total	383	12.76±1.57	13(8.9-16)	334	12.67±1.30	12.5(9-16)	0.386
DM	10-10.9	65	11.48±0.98	11.6(9.7-14.3)	52	11.27±0.78	11.35(9.1-13.5)	0.278
	11-11.9	93	12.53±1.18	12.4(9.9-15.6)	53	12.32±1.1	12.3(10.1-14.8)	0.277
	12-12.9	82	13.34±1.11	13.5(10.4-16)	81	12.88±1.24	12.5(10.7-15.7)	0.002*
	13-13.9	76	14.07±1.01	14.6(11.1-16)	76	14.19±1.35	14.4(11-16)	0.513
	14-15	67	14.39±1.06	14.6(11.6-16)	72	14.79±1.1	15.2(12-16)	0.065
	Total	383	13.15±1.47	13.5(9.7-16)	334	13.25±1.68	13.1(9.1-16)	0.409
NM	10-10.9	65	10.52±1.19	10(9-15)	52	10.96±1.03	11(9-14)	0.013*
	11-11.9	93	11.67±1.33	12(9-15)	53	12.08±1.25	12(10-15)	0.086
	12-12.9	82	12.55±1.45	12(9-16)	81	12.68±1.39	13(10-16)	0.547
	13-13.9	76	13.75±1.52	14(10-16)	76	13.67±1.29	14(10-16)	0.493
	14-15	67	14.01±1.53	15(10-16)	72	14.33±0.9	14(12-16)	0.596
	Total	383	12.49±1.87	12(9-16)	334	12.90±1.65	13(9-16)	0. 002*

CA=Chronological age, BA=Bone age,DM=Demirjian method, NM=Nolla method, SD:Standard deviation

years) and whole group for females and males are in Table 2. The BA and DA of both gender were higher than the CA. The mean age ± SD for CA, BA, DM and NM for the entire study group are summarised in Table 2.

In this table where the differences between the gender are shown; when only 13-13.99 age group individuals and total girls and total males were compared within the mean CA values age groups average age of males was statistically larger (p= 0.044; 0.011). The average BA values are analyzed; evcluding the total boys and girls and the age group 11-11.99, difference between the genders was statistically meaningful, (respectively=0.007, <0.001, 0.001, <0.001), in the age groups 10-10.99 (B>G), 12-12.99 (G>B), 13-13.99 (G>B)

Table 3. Friedman's Test / Two Way Analysis of Variance by Ranks for females and males

	Girls					Total Girls
Age groups	10-10.9	11-11.9	12-1.2.9	13-13.9	14-14.9	
Test; p	72.475; <0.001	68.263; <0.001	44.105; <0.001	27.481; <0.001	16.455; <0.001	157.115; <0.001
CA-BA	-0.100; 0.999	-0.618; 0.007	-0.890; <0.001	-0.605; 0.023	-0.784; 0.003	-0.615; <0.001
CA-DM	-1.515; <0.001	-1.419; <0.001	-1.037; <0.001	-1.053; <0.001	-1.149; 0.999	-1.059; <0.001
CA-NM	-0.108; 0.999	-0.242; 0.999	-0.073; 0.999	-0.737; 0.003	-0.082; 0.999	-0.217; 0.121
BA-DM	-1.415; <0.001	-0.801; <0.001	-0.146; 0.999	0.447; 0.196	-0.634; 0.027	-0.444; <0.001
BA-NM	-0.208; <0.001	-0.376; 0.281	-0.817; <0.001	-0.132; 0.999	-0.701; 0.010	0.398; <0.001
DM-NM	-1.623; <0.001	-1.177; <0.001	-0.963; 0.999	-0.316;0.790	-0.067; 0.999	0.841; <0,001
Difference	DM>BA,CA,NM	DM>BA,NM,CA BA>CA	DM>NM,CA BA>NM,CA	DM,NM,BA>CA	BA>CA,NM,DM	DM>BA, CA,NM BA>CA,NM

	Boys					Total Boys
	10-10.9	11-11.9	12-1.2.9	13-13.9	14-14.9	
Test; p	38.381;<0.001	24.287; <0.001	9.373; <0.025	27.454;<0.001	33.049; 0.001	102.943; <0.001
CA-BA	-0.808; 0.009	-0.132; 0.999	-0.241; 0.999	-0.197; 0.999	-0.583; 0.040	-0.082; 0.999
CA-DM	-1.538;<0.001	-1.085; <0.001	-0.364;0.436	-0.816; 0.001	-0.590; 0.036	-0.813; <0.001
CA-NM	-0.769; 0.014	-0.632; 0.070	-0.025; 0.999	-0.276; 0.999	-0.174; <0.001	-0.251; 0.071
BA-DM	-0.731; 0.023	-0.963; 0.001	-0.605; 0.017	-1.013; 0.999	-1.174; <0.001	-0.895; <0.001
BA-NM	-0.038; 0.999	-0.500; 0.277	-0.265; 0.999	-0.474; 0.142	-0.410; 0.341	-0.334; 0.005
DM-NM	-0.769; 0.014	-0.453; 0.425	-0.340; 0.565	-0.579; 0.060	-0.764; 0.002	-0.561;<0.001
Difference	DM>CA,BA,NM BA>CA NM>CA	DM>CA,BA	DM> CA	DM>CA,BA	DM>CA,BA,NM CA>BA	DM>CA,BA,NM NM>BA

and 14-14.99 (G>B) (respectively p=0.007, <0.001, 0.001, <0.001). When the mean values of DM are reviewed; the girls' were statistically higher than the boys' just in the group of 12-12.99 age. In the mean NM age distribution, the boys' average age was statistically higher than the girls' only in the group of 10-10.99 age and all girls-all boys (Table 2).

All age estimatation methods were checked to each other by Peer Difference Test for both gender and particularly in the all age groups including total girls and total boys and the differences and the similarities are shown in the Table 3.Considering the age groups, CA-BA and CA-NM were similar in girls in the group of 10-10.99 age, the differences between them were statistically insignificant. However, DM was statistically different from other age determination methods (DM>CA,BA,NM). In the age group 11-11.9, DM was higher than BA, CA and NM. BA was higher than CA. CA and BM was statistically similar. In the group of 12-12.99 age the findings are DM>NM, CA and BA>NM, CA while CA and NM was statistically similar. In the group of 13-13.99 age, all the age determination methods were different from, bigger than CA (DM, NM, BA > CA). In the group of 14-14.99 age, BA was at a statistically meaningful level which is higher than DM, NM and CA. CA, DM and NM was statistically indifferent.

When it was examined in girls without differentiating the age groups DM was statistically bigger than all other age determination methods (DM > BA, CA, NM and BA > CA, NM) (Table 3).

Considering the age groups, in the males in the group of 10-10.99 age the findings were as follows; NM,BA,CA<DM, and CA<BA, and CA<NM. BA and NM were statistically similar. In the group of 11-11.99 age, DM was statistically bigger than CA and BA while CA and BA were statistically similar to each other (DM>CA,BA). In the group of 12-12.99 age DM was statistically bigger than CA, and CA, BM and NM were statistically similar. In the group of 13-13.99 age DM was statistically different from CA and BA (DM>CA,BA), and CA, NM and BA were peer-like each other. In group of 14-14.99 age, statistically, DM was bigger than CA, BA, and NM. Still in this group, CA was higher than BA. NM and BA was statistically similar to each other.

Statistically, DM was observed higher than CA, BA and NM and also NM was higher

Group (All)	CA	BA	DM	NM
CA				
r	1	0.847	0.707	0.681
P		<0.001*	<0.001*	<0.001*
BA				
r	0.847	1	0.700	0.671
P	<0.001*		<0.001*	<0.001*
DM				
r	0.707	0.700	1	0.853
P	<0.001*	<0.001*		<0.001*
NM				
r	0.681	0.671	0.853	1
P	<0.001*	<0.001*	<0.001*	
Group (Female)	**CA**	**BA**	**DA**	**NA**
CA				
r	1	0.866	0.694	0.671
P		<0.001*	<0.001*	<0.001*
BA				
r	0.866	1	0.701	0.670
P	<0.001*		<0.001*	<0.001*
DM				
r	0.694	0.701	1	0.854
P	<0.001*	<0.001*		<0.001*
NM				
r	0.671	0.670	0.854	1
P	<0.001*	<0.001*	<0.001*	
Group (Male)	**CA**	**BA**	**DA**	**NA**
CA				
r	1	0.848	0.725	0.690
P		<0.001*	<0.001*	<0.001*
BA				
r	0.848	1	0.724	0.698
P	<0.001*		<0.001	<0.001*
DM				
r	0.725	0.724	1	0.874
P	<0.001*	<0.001*		<0.001*
NM				
r	0.690	0.698	0.874	1
P	<0.001*	<0.001*	<0.001*	

CA=Chronological age, BA=Bone age,DM=Demirjian method, NM=Nolla method, *:Pearson's correlation coefficients

Table 4. Results of the Pearson correlation coefficients performed for total group, total male and female samples according to the all age estimation methods

than BA in the examination among boys without any age range consideration. CA and BA were statistically similar (Table 3).

The CA, BA, Pearson coalescence (r) and p values between the dental age for DM and NM are presented in Table 4-5 for the entire study group. The differences between genders, children were assessed by the Mann–Whitney U test for each method (NM, DM, BA and CA).

In the correlation analysis without considering age groups, there was a large correlation between CA and other age determination methods and as in decreasing order: BA, DM and NM (r= 0.847; 0.707; 0.681) (Table 4).

Large correlations between CA and other age determination methods was found for all girls and boys as in decreasing order: BA, DM and NM (respectively, for girls r =0.866; 0.694; 0.671, for boys r= 0.848; 0,725; 0.690) (Table 4).

Table 5 presents the correlation analysis in the girls and boys with the consideration of age groups. According to the table; in the girls in the goup of 10-10.99 age, the highest correlations with CA were in NM, BA and DM respectively. In the girls the group of 11-11.99, the largest correlations with CA were in BA and DM respectively. In the girls the group of 12-12.99 age, the largest correlations with CA were in DM and NM respectively. In the girls the age group 13-13.99, the largest correlations with CA were in BA and DM respectively. In the girls the group of 14-14.99 age the largest correlations with CA were in BA and DM. In the boys the group of 10-10.99 age, the largest correlation with CA was in BA. In the boys the group of 11-11.99 age, the largest correlation with CA was in NM. In the boys the group of 12-12.99 age, the largest correlations with CA were in BA, NM and DM respectively. In the boys the group of 13-13.99 age, the largest correlation with CA was in BA. In the boys the group of 14-14.99 age, the largest correlations with CA were in BA and DM respectively.

DISCUSSION

Age determination is often necessary for medical, odontologic and forensic medicine aims. In this study, the relationship among the DA, BA and CA was evaluated in Turkish children. Many methods that assess skeletal and dental development have been used for age determination, but inconsistent results within the same society and in different societies were obtained (Table 6). However, in previous studies, bone age and these 2 dental age determination methods were not compared together. In most of the previous studies, it was observed that bone age folding was performed more with Demirjian method (17,18).

Age Group			Female			Male		
			BA	DM	NM	BA	DM	NM
10-10.9	CA	r	0.404**	0.337**	0.482**	0.290*	0.069	0.142
		p	0.001	0.006	<0.001	0.037	0.628	0.314
		n	65	65	65	52	52	52
	BA	r		0.268*	0.249*		0.159	0.265
		p		0.031	0.046		0.259	0.058
		n		65	65		52	52
	DM	r			0.746**			0.826**
		p			<0.001			<0.001
		n			65			52
11-11.9	CA	r	0.368**	0.231*	0.147	0.185	0.224	0.300*
		p	<0.001	0.026	0.16	0.186	0.107	0.029
		n	93	93	93	53	53	53
	BA	r		0.230*	0.18		0.187	0.121
		p		0.027	0.084		0.179	0.388
		n		93	93		53	53
	DM	r			0.826**			0.762**
		p			<0.001			<0.001
		n			93			53
12-12.9	CA	r	0.178	0.352**	0.224*	0.485**	0.271*	0.293**
		p	0.11	0.001	0.043	<0.001	0.015	0.008
		n	82	82	82	81	81	81
	BA	r		0.383**	0.341**		0.517**	0.407**
		p		<0.001	0.002		<0.001	<0.001
		n		82	82		81	81
	DM	r			,759**			,814**
		p			<0,001			<,001
		n			82			81
13-13.9	CA	r	0.326**	0.231*	0.185	0.348**	0.116	0.059
		p	0,004	0.045	0.109	0.002	0.318	0.612
		n	76	76	76	76	76	76
	BA	r		0.185	0.172		0.207	0.269*
		p		0.11	0.138		0.073	0.019
		n		76	76		76	76
	DM	r			0.747**			0.728**
		p			<0.001			<0.001
		n			76			76
14-14.9	CA	r	0.22	0.18	0.174	0.430**	0.324**	0.18
		p	0.073	0.145	0.16	<0.001	0.005	0.131
		n	67	67	67	72	72	72
	BA	r		0.271*	0.475**		0.265*	0.281*
		p		0.027	<0.001		0.025	0.017
		n		67	67		72	72
	DM	r			0.672**			0.715**
		p			<0.001			<0.001
		n			67			72

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

CA=Chronological age, BA=Bone age, DM=Demirjian method, NM=Nolla method, *:Pearson's correlation coefficients

Table 5. Results of the Pearson correlation coefficients performed according to all age estimation methods for each age groups both male and female

Panoramic and hand wrist radiographs are commonly used to determine age and BA because they are easily accessible and allow the evaluation of all teeth and wrist bones (16,19). In this study, hand wrist radiographs was used for BA.

To date, many methods have been developed to assess DA. The DM (3) and NM (4) were used for tooth assessment in this study.

The method developed by Demirjian, which is based on the evaluation of the maturation stages of the seven left mandibular teeth, is a commonly used method (3) that is easy to practice, learn and apply and it includes a scale for girls and boys.

Studies on dental determination in other countries, such as Spain and Venezuela (20), Macedonia (7), India (8), China (9), Iran (21), Saudi Arabia (22) and Turkey (10) have been conducted. The disadvantage of this method, which was originally improved for dental age determination of French Canadian children, is that it was developed and used in subsequent years in other versions (3).

In the majority of these studies, the DM was greater than the predicted CA (9,17,23-25). Similarly, we found a difference between the DM and the CA in the total population, between boys and girls; 0.77 years ($P < 0.0005$), 0.84 years ($P < 0.0005$) and 0.68 years ($P < 0.0005$), respectively. The difference between DM and CA is often linked to the fact that the DM was developed for Canadian French-born children, so it cannot be applied to other populations. Dental maturation is thought to be the reason for the difference between many factors such as ethnic, cultural and genetic differences; different socioeconomic development levels; different nutritional habits; geographical features; climatic characteristics; and when the study is done. Hormonal factors can influence the development of different teeth between genders.

The NM is a practical, easy to use and convenient method for daily clinical use. The NM (4) has been used in studies conducted in different populations in Turkey (12), Brazil (26) and India (27). In this study, the entire population between the Nolla method and CA was estimated differences in the following order 0.33, 0.18 and 0.25, for total population, girls and boys. The NM predicted the CA more effectively than the DM. In Turkey the number of studies performed using the NM is limited (12,16,25,28).

In Turkey, studies have been carried out using the DM (10,16,19,24,27) and NM (12) alone and to-

Table 6. Dental age-related studies and results according to Demirjian and Nolla method

DEMIRJIA References	Country	Patient Number	Age Group	Female Differenc	Male Difference	Applicability
10	Turkey	53	10-18	0.02-0.79	0.04-0.85	S
21	Turkey	63	7-16	0.28-0.87	0.10-0.76	N
17	Turkey	80		0.20-1.90	0.40-1.30	N
20	Turkey	90	4-12	0.50-1.44	0.36-1.43	N
8	Indian	70	9-16	-0.31	0.856	Male: S
9	China	10	11-18	0.63	0.4	N
19	Poland	99	6-16			N
22	Turkey	42	7-13	0.75	0.5	N
28	Iranian	31	9-13	0.25	0.3	S
29	Saudi	49	8.5-	0.40	0.3	N

NOLLA References	Country	Patient Numbe	Age Group	Female	Male Difference	Applicability
12	Turkey	7	6-18			Male: S
22	Turkey	4	7-13	-0.57	-	NS

gether for tooth age determination (Table 6) (16). However, only the DM was conducted in our geographical and climatic region (10). Table 6 summarises the results of studies using the DM and NM in different countries.

DA determined by the DM was found to be significantly larger than that determined according to BA and the NM ($P < 0.0005$). Although studies using both the DM and NM have been carried out in the same country and geographical region, significant differences were reported between these two methods in CA and BA in studies conducted at different age ranges and populations. The use of both methods in the same study population is an advantage of our study in terms of determining which method is more accurate.

Estimates of age were often made with different populations, age groups and varying DA determination methods (Demirjian or Nolla) in previous studies, thereby leading to confusion as to which method is correct. Özer et al. (29) compared the DM and NM with DA determination in our country and they reported that the DM determines DA closer to the CA. Meanwhile, Nur et al. (16) found that the NM is more accurate than the DM in determining the CA, similar to our study. Thomas et al. studied Spanish and Portuguese individuals, and they found that the NM is more accurate than the DM (15).

The difference between our studies and research evaluating the relationship to NM is that these two methods (DM and NM) should also be evaluated in relation to BA. Only an age difference of 0.04 was found in the entire study group between NM and BA. NM could identify BA as close to true.

CONCLUSION

The DM is unsuitable for estimating the CA of 10- to 15-year-old girls and boys in a Turkish children population. The Nolla method is superior to the Demirjian method for the chronological and dental age of Turkish children between 10 and 15 years. The BA and NM gave similar results among Turkish children aged 10–15 years.

In the light of the data obtained from this study, it was found that it is compatible with DA calculated with NM and can be used interchangeably in both girls and boys in determining the BA, which is especially important in the course of orthodontic treatments.

The presence of pubertal developmental attacks in the 10-15 age range, which is the age group of children in this study, is also important for the determination of BA by NM. In this way, both bone age and tooth age can be determined on a single radiogram, that is, panoramic images.

In the light of these, it is recommended to use NM in determining the age of teeth in Turkish population and use DA calculated with NM in BA detection.

It is suggested that this argument be evaluated in a wider age range and in more radiographs.

Abbreviations

BA: Bone age
CA: Chronological age
DA: Dental age
DM: Demirjian's method
NM: Nolla's method
PRs: Panoramic radiographs

Ethics Committe Approval

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent was obtained from all patients for being included in the study.

Author Contribution Statement

Concept – S.G.Y., A.H.; Design - S.G.Y., A.H., M.Y.P., D.E., A.T.; Supervision - S.G.Y., A.H., M.Y.P.; Resources - S.G.Y., A.H., M.Y.P., D.E., A.T.; Materials - S.G.Y., A.H., M.Y.P., D.E., A.T.; Data Collection and/or Processing - S.G.Y., A.H., M.Y.P., D.E., A.T.; Analysis and/ or Interpretation - S.G.Y., A.H., M.Y.P.; Literature Search - S.G.Y., A.H., M.Y.P.; Writing Manuscript - S.G.Y., A.H., M.Y.P.; Critical Review - S.G.Y., A.H., M.Y.P.

Conflicts of Interest

No conflict of interest was declared by the authors.

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