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Accuracy of Dental and Chronological Age Estimation in A Sample Turkish Caucasion Children: Comparison of Demirjian's and Willems Methods

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ABSTRACT

Objective: The purpose of this study is to apply Demirjian's and Willems' methodologies and to define whether there are any discrepancies in predicting dental age versus chronological age in a sample Turkish Caucasian children.

Methods: A total of 150 Turkish Caucasian children with known chronological age and gender were chosen. The chronological age was determined by subtracting the date of birth from the date of the radiograph, and it was expressed as a number with two decimal places. Each age group was determined to have a minimum sample size of 12 and a maximum sample size of 27. All panoramic radiographs were scored according to the criteria of Demirjian's and Willems methodologies with Onyx Ceph 3.1.54 software.

Results: The dental ages of the cases ranged from 4.82 to 15.66 years calculated by the Demirjian's method, with an average of 9.47±2.27 years, while the Willems method of the cases ranged from 4.13 to 14.34 years calculated by the Demirjian's method, with an average of 8.87±2.24 years. According to Demirjian's method, in the developmental evaluation of dental age, 45.3% of boys were found to have a statistically higher chronological age than girls ($p<.05$), while no statistically significant difference was found between dental age and chronological age in developmental evaluation according to Willems method ($p>.05$).

Conclusion: The Willems method was shown to be more accurate in determining dental age in Turkish children. Further studies on large population groups and diverse ethnicities are required to increase the reliability and repeatability of the results.

Keywords: Dental age, chronological age, Demirjian's method, Willems method

1.INTRODUCTION

Estimating chronological age is critical in many domains, including forensic medicine, pediatric endocrinology, archaeology, and clinical dentistry. The chronological age is determined by the phases of maturity of various tissues (1). Skeletal age, morphological or somatic age, secondary sex character age, and dental age are some of them (1,2). Somatic maturity refers to yearly increases in height or weight (3). Secondary sexual traits such as voice changes in boys and menarche in girls show sexual maturity (3). These maturity indicators have limited value because they can be applied only after serial recordings of height or the inception of puberty (2). Skeletal maturation is an complementary part of individual patterns of growth and development (4). Skeletal maturity evaluation approaches include visual observation of the growing bones' form and size changes (2). The foot, the ankle, the hip, the elbow, the hand, and the wrist, as well as the cervical vertebrae, have been used to calculate skeletal age using a variety of approaches (2). On the basis of hand wrist radiography procedures, these approaches were used to determine skeletal age (4). The basic premise is that osseous abnormalities in the hand and wrist are markers of broader skeletal changes (5). In orthodontics, radiographs of the cervical vertebrae, as well as hand and wrist radiographs, are routinely used to determine skeletal maturation stage (6).

Dental maturity is the last physiologic measure. Estimation of dental age comprises two principles that have been used to determine tooth eruption and mineralization stage of dental tissues (7). The stage of tooth production has been presented as a more valid criterion for determining dental maturity than the stage of tooth eruption, and it is commonly used to assess and forecast age. This information is helpful for diagnosis and treatment management in clinical dentistry (8). Because intraoral or panoramic radiographs may be used to identify dental developmental phases, physiologic maturity can be easily assessed in most orthodontic or pediatric dentistry clinics without the need of hand wrist radiography (2). Dental age is of great importance to the orthodontist when planning therapy for various forms of malocclusions in maxillofacial development. In archaeology and forensic odontology, age estimations can assist in the identification process, particularly when there is no information on the deceased, as well as provide skeletal and dental information about historical populations (9). Also in pediatric endocrinopathies,

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recognising of dental age may help practitioner to diagnose and evaluate the development of child (1).

Methods for estimating the age of children based on their dental development, such as the atlas method and scoring systems. In addition, radiological and morphological approaches are employed on adults (10). Among several methods of age assessment, the Demirjian's method which was described in 1973 and 2928 French-Canadian parentage of panoramic radiographs is commonly used (1,11).

A meta-analysis of the results from several research on different populations using Demirjian's method revealed that the Demirjian data set overstated the age of men and females by 6 months on average (12). Willems used Demirjian's approach in a Belgian research with the intention of minimizing the error rates of the method (13). Although just a few studies evaluating it have been published, this approach was more accurate than the Demirjian's method for determining dental age (14-18).

Demirjian's approach in Turkish parentage has been published in a number of studies (19–26), however few studies have compared Demirjian's and Willems methods (27,28). Applying Demirjian's and Willems' methods to a sample of Turkish Caucasian children will enable this study to determine whether there are any differences between dental age and chronological age estimates.

2.METHODS

2.1. Subjects

A total of 150 Turkish Caucasian children of known chronological age and gender were chosen. There were 75 boys and 75 girls, ranging in age from 4 to 14 years. Panoramic radiographs were selected from the patient record database of Marmara University's Faculty of Dentistry's Oral Diagnosis and Radiology Department between 2013 and 2015. The panoramic radiographs were obtained using Planmeca Promax (Planmeca Oy, Helsinki, Finland). The inclusion criteria for the sample were the availability of a high-quality orthopantomogram in their clinical records and the absence of a medical or surgical history that might impact the existence and development of permanent teeth. This research eliminated children with congenital or systemic illnesses, unclear panoramic radiographs, and aplasia of permanent mandibular teeth. The study protocol numbered as 09.2015.171 was approved by Clinical Research Ethics Committee, Marmara University Faculty of Medicine on 03.07.2015. Prior to analysis, all patient data and information were rendered anonymous and de-identified.

The chronological age was calculated by subtracting the date of birth from the date of the radiograph and was represented with two decimal places. According to chronological age, the sample was separated into nine groups of one year each. For each age group, a minimum sample size of 12 and a maximum sample size of 27 were determined for finite population.

2.2. Dental age estimation method

Demirjian et al. (1) and Willems et al. (13) scoring standards were used to all panoramic radiographs. For the digital technique, direct digital panoramic radiographs were recorded in the Joint Photographic Experts Group format and transferred to the OnyxCeph3™ 3.1.54 (Image Instruments, Chemnitz, Germany) dental analysis software for analysis. Digital measurements were evaluated using a 23-inch Acer 1920×1080-pixel HP Reconstruction PC monitor. The seven mandibular teeth on the left were scored. First, the calcification stage of each tooth was used to categorize its stage from 'A' to 'H'. Stage 0 indicated the absence of the case, but Stage 1 indicated the radiolucent bud prior to calcification (Fig. 1). Using the Willems technique, the dental maturity of the left mandibular seven permanent teeth was scaled similarly to the Demirjian method, but the maturity score for each tooth was determined using the Willems method's tables. As mentioned by Demirjian et al. (1) and Willems et al., each score was transformed into a dental age by gender (13).

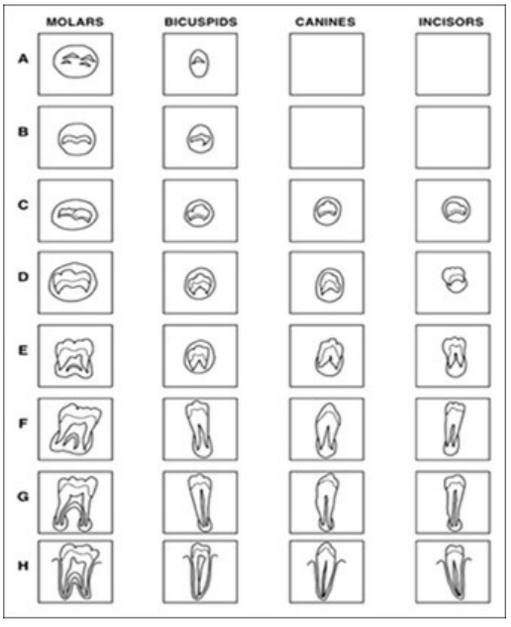

Figure 1. *Schematic drawing of the developmental stages of teeth.*

All panoramic radiographs was examined by a single oral and maxillofacial radiologist (EI). To measure dependability, all photos were reexamined by the same examiner three months later. Cohen's kappa coefficient was used to determine the reproducibility of the statistics.

2.3. Statistical Analysis

The data were analysed with the IBM SPSS (Statistical Package for Social Sciences) Statistics 22 (IBM SPSS, Turkey) was used for Windows 15.0 software. Descriptive statistical methods (mean, standart deviation) were used for the evaluation of the data. For the comparison of quantitative data paired sample t test was used and also comparison of

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qualitative data Chi-square test was used. P values < .05 were considered statistically significant.

3.RESULTS

The patients ranged in age chronologically from 4.45 to 13.47, with an average age of 9.07 ±2.12 years. Demirjian's dental age estimation technique revealed that the patients' dental ages ranged from 4.82 to 15.66 years, with an average of 9.47±2.27 years. With an average age of 8.87 ± 2.24 years, the method-determined Willems dental ages ranged from 4.13 to 14.34 years. Girls' chronological ages ranged from 5.22 to 13.47 years, with an average of 9.05± 2.2 years, while boys' chronological ages ranged from 4.45 to 12.79 years, with an average of 9.09±2.06 years. According to Demirjian's dental age estimation method, girls' dental ages ranged from 4.82 to 15.66 years, with an average of 9.64 ± 2.29 years. With an average age of 9.29 ± 2.26 years, boys with dental issues ranged in age from 4.82 to 14.58 years. Girls' dental ages, as determined by Willems method, ranged from 4.18 to 13.84 years, while boys' dental ages ranged from 4.13 to 14.34 years.

In the developmental evaluation of dental age conducted using Demirjian's method, it was discovered that 45.3% of boys had a statistically higher chronological age than girls (p= .043), whereas in the developmental evaluation conducted using Willems method, there was no statistically significant difference between dental age and chronological age (p>.05) (Table 1).

Table 1. *Developmental evaluation of gender, chronological age, dental age with Demirjian's and Willems methods*

	Gender		p
	Girls	Boys	
	n (%)	n (%)	
Demirjian's method dental age			
Higher than chronological age	22 (29.3%)	34 (45.3%)	**.043***
Lower than chronological age	53 (70.7%)	41 (54.7%)	
Willems method dental age			
Higher than chronological age	49 (65.3%)	46 (61.3%)	**.611**
Lower than chronological age	26 (34.7%)	29 (38.7%)	

*Chi-square test; * p< .05*

Demirjian's method revealed that for girls, the average dental development age was substantially higher than chronological age (p= .001). Additionally, chronological age was statistically considerably higher than usual for years of dental development age (p= .006) when calculated using Willems method. There is no statistically significant difference between the two methods for boys' average age of dental development (p> .05) (Table 2).

According to Demirjian's method for dental development, the average dental age of the patients was statistically substantially higher than the average chronological age for the age ranges of 5.00–5.99 and 6.00–6.99 years (p= .001). Demirjian's method for dental development also revealed that the average dental age of the patients for the age range of 7.00–7.99 years was statistically substantially higher than the average chronological age (p= .011). There was no statistically significant difference between the Demirjian's method-calculated dental development ages and the patients' chronological ages for the age ranges of 8.00–8.99, 9.00–9.99, 10.00–10.99, 11.00–11.99, and 12.00 –12.99 years (p> .05) (Table 3) (Fig 2).

The average chronological age of the patients was statistically substantially higher than the average dental age determined using the Willems method for the age ranges of 5.00–5.99 and 12.00–12.99 years (p< .05). There was no statistically significant difference between the chronological ages of the patients and the dental development ages calculated using the Willems method for the age ranges of 6.00–6.99, 7.00-7.99, 8.00 –8.99, 9.00 –9.99, 10.00 –10.99 and 11.00 –11.99 years (p> .05) (Table 4) (Fig. 2).

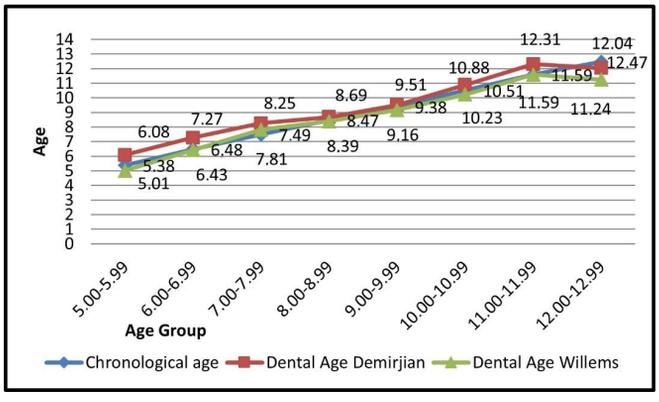

Figure 2. *Age groups according to chronological age, dental age calculated by the methods of Demirjian's and Willems*

For patients adopting the Demirjian's method for dental development, the average dental age was statistically significantly higher than the average chronological age for girls between the ages of 5.00-5.99, 6.00-6.99, 7.00-7.99 and 8.00-8.99 (p< .05). The average dental age of the patients using the Demirjian's method for dental development was statistically substantially higher than the average chronological age for boys aged 5.00–5.99 and 6.00–6.99 (p< .05) (Table 5).

According to the Willems method for dental development, the average chronological age of girls between the ages of 12.00 – 12.99 was statistically substantially higher than the average dental age of the patients (p< .05). No statistically significant differences were observed in the age ranges of 5.00–5.99, 6.00–6.99, 7.00–7.99, 8.00–8.99, 9.00–9.99, 10.00-10.99, and 11.00–11.99 years between the patients' chronological ages and the dental development ages determined using the Willems method (p> .05) (Table 6) (Fig 3).

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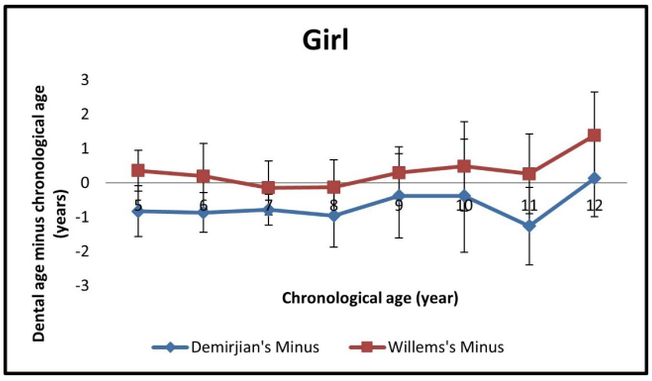

Figure 3. *Dental age minus chronological age for girls*

According to the Willems method for dental development, the average chronological age of boys aged 8.00–8.99 was statistically substantially higher than the average dental age of the patients (p= .044). There were no statistically significant variations between the patients' chronological ages and the dental development ages determined using the Willems method for the age ranges of 5.00–5.99, 6.00–6.99, 7.00–7.99, 9.00–9.99, 10.00–10.99, 11.00–11.99, and 12.00–12.99 years (p> .05) (Table 6) (Fig 4).

The intra-observer reproducibility tests resulted in almost perfect agreement according to Landis and Koch guidelines (29) K = 0.839 for intra-observer agreement.

Table 2. *The amount of deviation from the chronological evaluation of dental development years regarding gender and age by Demirjian's and Willems methods*

Gender	Chronological Age	Demirjian's method dental age	Age Difference	p	Chronological Age	Willems method dental age	Age Difference	p
	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
Girls	9.05±2.2	9.64±2.29	-0.59±1.14	.001*	9.05±2.2	8.71±2.17	0.34±1.04	.006*
Boys	9.09±2.06	9.29±2.26	-0.2±1.28	.174	9.09±2.06	9.02±2.31	0.07±1.14	.621

*SD: Standart Deviation, Paired sample t testtest; * p< .05*

Table 3. *Evaluation of the deviation amount of dental age and chronological age calculations according to age groups with Demirjian's method*

Age range	Number of Child	Chronological Age	Demirjian's method dental age	Age difference	p
	n	Mean±SD	Mean±SD	Mean±SD	
5.00-5.99	15	5.38±0.38	6.08±0.82	-0.69±0.64	**.001****
6.00-6.99	12	6.48±0.32	7.27±0.58	-0.79±0.49	**.001****
7.00-7.99	21	7.49±0.3	8.25±1.17	-0.76±1.25	**.011***
8.00-8.99	20	8.47±0.29	8.69±0.81	-0.22±0.82	**.241**
9.00-9.99	26	9.38±0.27	9.51±1.29	-0.13±1.19	**.589**
10.00-10.99	27	10.51±0.26	10.88±1.53	-0.37±1.52	**.216**
11.00-11.99	16	11.59±0.39	12.31±1.84	-0.72±1.57	**.087**
12.00-12.99	13	12.47±0.42	12.04±1.33	0.43±1.23	**.233**

*Paired sample t test, * p< .05, **p< .01*

Table 4. *Age groups according to chronological age, dental age calculated by the method of Willems*

Age range	Number of Child	Chronological Age	Willems method dental age	Age Difference	p
	n	Mean±SD	Mean±SD	Mean±SD	
5.00-5.99	15	5.38±0.38	5.01±0.66	0.37±0.52	**.014***
6.00-6.99	12	6.48±0.32	6.43±0.93	0.06±0.86	**.818**
7.00-7.99	21	7.49±0.3	7.81±1.21	-0.33±1.24	**.242**
8.00-8.99	20	8.47±0.29	8.39±0.51	0.08±0.54	**.495**
9.00-9.99	26	9.38±0.27	9.16±0.9	0.22±0.79	**.166**
10.00-10.99	27	10.51±0.26	10.23±1.29	0.28±1.28	**.267**
11.00-11.99	16	11.59±0.39	11.59±1.66	0.01±1.47	**.996**
12.00-12.99	13	12.47±0.42	11.24±1.38	1.23±1.28	**.005****

*Paired sample t test ; *p< .05, **p< .01*

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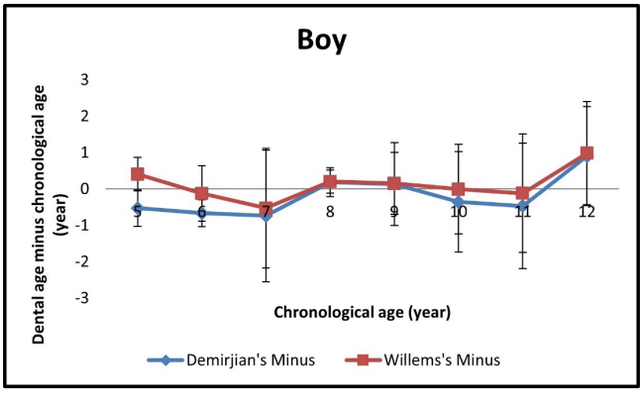

Figure 4. *Dental age minus chronological age for boys*

Table 5. *The amount of deviation of boys and girls between the chronological age and developmental dental age by Demirjian's method*

	Age Range	Number of Child	Chronological Age	Demirjian's method dental age	Age Difference	p
		n	Mean±SD	Mean±SD	Mean±SD	
Girls	**5.00-5.99**	8	5.5±0.29	6.34±0.91	-0.83±0.74	**.015***
	6.00-6.99	7	6.52±0.29	7.39±0.48	-0.87±0.58	**.007****
	7.00-7.99	11	7.36±0.29	8.14±0.4	-0.79±0.45	**.001****
	8.00-8.99	7	8.39±0.34	9.35±0.94	-0.96±0.92	**.032***
	9.00-9.99	13	9.39±0.23	9.78±1.36	-0.38±1.23	**.282**
	10.00-10.99	16	10.51±0.27	10.89±1.73	-0.38±1.65	**.375**
	11.00-11.99	5	11.88±0.09	13.14±1.04	-1.26±1.13	**.067**
	12.00-12.99	8	12.49±0.5	12.36±1.17	0.13±1.12	**.748**
Boys	**5.00-5.99**	7	5.24±0.44	5.78±0.65	-0.53±0.5	**.031***
	6.00-6.99	5	6.44±0.38	7.11±0.71	-0.67±0.37	**.015***
	7.00-7.99	10	7.63±0.26	8.36±1.69	-0.74±1.81	**.230**
	8.00-8.99	13	8.51±0.27	8.34±0.43	0.18±0.4	**.138**
	9.00-9.99	13	9.37±0.33	9.24±1.21	0.13±1.14	**.693**
	10.00-10.99	11	10.52±0.27	10.88±1.27	-0.36±1.38	**.408**
	11.00-11.99	11	11.45±0.39	11.93±2.04	-0.47±1.73	**.385**
	12.00-12.99	5	12.44±0.31	11.54±1.54	0.9±1.36	**.214**

Paired sample t test ; p< .05, **p< .01*

Tablo 6. *The amount of deviation of boys and girls between the chronological age and developmental dental age by Willems method*

	Age Range	Number of child	Chronological age	Willems method dental age	Age Difference	p
		n	Mean±SD	Mean±SD	Mean±SD	
Girls	**5.00-5.99**	8	5.5±0.29	5.15±0.71	0.35±059	**.138**
	6.00-6.99	7	6.52±0.29	6.33±0.85	0.19±0.96	**.618**
	7.00-7.99	11	7.36±0.29	7.51±0.74	-0.15±0.78	**.547**
	8.00-8.99	7	8.39±0.34	8.52±0.77	-0.13±0.8	**.678**
	9.00-9.99	13	9.39±0.23	9.1±0.88	0.29±0.76	**.196**
	10.00-10.99	16	10.51±0.27	10.03±1.38	0.48±1.3	**.164**
	11.00-11.99	5	11.88±0.09	11.62±1.07	0.26±1.16	**.638**
	12.00-12.99	8	12.49±0.5	11.11±1.31	1.38±1.27	**.018***
Boys	**5.00-5.99**	7	5.24±0.44	4.85±0.6	0.4±0.46	**.062**
	6.00-6.99	5	6.44±0.38	6.57±1.12	-0.13±0.76	**.730**
	7.00-7.99	10	7.63±0.26	8.15±1.55	-0.53±1.64	**.336**
	8.00-8.99	13	8.51±0.27	8.31±0.31	0.2±0.32	**.044***
	9.00-9.99	13	9.37±0.33	9.22±0.95	0.15±0.85	**.523**
	10.00-10.99	11	10.52±0.27	10.53±1.14	-0.01±1.23	**.975**
	11.00-11.99	11	11.45±0.39	11.58±1.92	-0.12±1.63	**.808**
	12.00-12.99	5	12.44±0.31	11.46±1.6	0.98±1.42	**.198**

Paired sample t test ; p< .05*

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4. DISCUSSION

Tooth development is commonly used to determine dental maturity and age. This information aids in diagnostic and treatment planning in clinical dentistry. In archaeology and forensic odontology, age estimate techniques can help in determining the age of death of a deceased child and provide vital information about former populations. Age estimation is also important in immigration administration when birth documents are lacking or contested in order to determine physiological age (8,14).

Panoramic radiographs were employed to evaluate dental maturity because they are widely available in dental clinics, the mandibular region is clearly visible, and intraoral radiography without image distortion is difficult to create (2,16-19).

There are many standard scales available for rating the tooth calcification stage. In the present study, the approach provided by Demirjian et al was chosen because its criteria are focused on form and proportion of root length, utilizing the perceived importance to crown height rather than absolute length. In radiography, shortened or lengthened projections of growing teeth have no effect on the validity of evaluation (2,7,11).

Willem's dental age estimate method, a variant of Demirjian's method, was also adopted in the current investigation since it gave more accurate age estimation than Demirjian's methods (11, 27,28). This is supported by our findings.

Enlarging the sample size might ensure more appropriate information about distrubution of the dental developmental stages (2). The present study consisted of 150 subjects; 75 males and 75 females with similar sample size of many studies (7, 11, 16). Some studies provide us with a total of tooth scores for each year of age, and we utilized this to predict age in 1-year intervals (8).

It is suggested that tooth mineralization relative to stages of skeletal maturation be considered individually for genders (2). The tooth development rate was higher in females than in males and have shown differences by gender for 10 years of age and above because of hormonal factors and puberty (8, 14, 15). This is in agreement with our findings where girls were dentally more advanced than boys for the dental maturation (1, 7, 15, 18, 21). Similarly, the chronological age of the patients between 12 and 13 years is statistically significantly higher than the average of the dental development age assessed by the Willems method in this study.

In this study the average age of dental development is statistically significantly higher than the chronological age average calculated by Demirjian's and Willems method for cases up to 6 years. The Demirjian's method revealed the smallest differences between chronological and estimated dental ages in boys aged 8 to 9 years and females aged 9 to 11 years. Willems method revealed the smallest differences between chronological and estimated dental ages in boys aged 10 to 11 years and girls aged 8 to 9 years. The current study contradicted a prior result that age may be predicted more correctly in younger children than in older children (8).

The most differences between the chronological and estimated dental ages were observed in the 12 to 13 year age groups in boys and 11 to 12 year age groups in girls in Demirjian's method and 12 to 13 year age groups in boys and 12 to 13 year age groups in girls in Willems method. This higher overestimation of the dental age observed in the older children in this study was probably due to the pubertal growth changes related during this age period (19).

No universal consensus has been adopted to classify the identifiable human groups based on ethnicity. A country which is defined by a geographical boundary could contain different ethnic groups of varying genetic predispositions. Individual evaluations of these ethnic groups need to be performed to obtain a detailed understanding of dental growth among these groups (13, 15, 17). In Maber et al.'s (8) study there were no significant differences across ethnic groups for any technique for either gender, and data from both ethnic groups were merged. While many ethnicities are prevalent in the Turkish population, we did not take this into account in our study.

5. CONCLUSION

The current study's findings confirm prior research that indicate the dependability of the Demirjian's method as it may be used to determine tooth production phases in the Turkish population. The Willems method, on the other hand, found to be more accurate in assessing dental age in Turkish children. Further research is needed on large population groups and different ethnicity in order to improve the reliability and reproducibility of the results.

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Design of the study: FNP, EI
Acquisition of data for the study: EI
Analysis of data for the study: FNP
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Drafting the manuscript: E I, FNP
Revising it critically for important intellectual content: EI, FNP
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