

Evaluation of dental maturation in children according to sagittal jaw relationship

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ABSTRACT

Objective: The aims of this retrospective study were to determine compliance with dental and chronological ages and to analyze the relationships between dental age and orthodontic sagittal anomalies. **Materials and Methods:** A total of 221 subjects between the ages of 7 and 15.9 years (165 girls and 156 boys) were included in the study. The dental age of seven left mandibular teeth was assessed according to the Demirjian method. The maxillary protrusion, mandibular protrusion, maxillo-mandibular and vertical plane angles were measured from cephalometric films. **Results:** The mean difference between the chronological age and dental age in female patients was 0.94 years and 0.33 years in male patients ($P < 0.01$). No differences between the sagittal classification groups were found. There was no relationship between dental age and the SNA° or the $GoGn-SN^\circ$. A statistically significant negative relationship was found between dental age and the SNB° and there was a significant linear relationship between dental age and the ANB° . **Conclusion:** Dental age in girls and boys has been estimated to be more advanced than chronological age in all classes and dental maturation advanced in cases with a tendency to develop Class II malocclusions.

Key words: Chronological age, Demirjian method, dental age, orthodontic anomaly

INTRODUCTION

Developmental age is an indicator of the stage of development of a child as a proportion of chronological age. Various biological ages, such as skeletal age and morphological age, secondary sexual characteristics, as well as dental age have been proposed for determining developmental age.^[1] These criteria can be applied separately or collectively in order to assess the degree of physiological maturity of a growing child. Of all methods, dental age is least affected by variations in nutritional and endocrine systems.^[2]

Thus far, several methods like radiographic or gingival emergence methods have been used to determine dental age. Gingival emergence represents only one stage in the continuous process of dental development or migration to reach the occlusal level. Emergence may be influenced by local factors: ankylosis, early or

delayed extraction of the deciduous tooth, impaction and crowding of the permanent teeth.^[3,4] In contrast, the formation rate of the permanent teeth is not affected by premature loss of the deciduous teeth.^[4,5] Furthermore, clinical emergence of teeth can be used during some intervals because of the completion of deciduous dentition. Previous studies investigating the relationship between gingival emergence and tooth formation concluded that tooth formation is a more reliable indicator of dental maturity than gingival eruption.^[6,7]

Most methods make use of panoramic radiographs obtained by full mouth periapical radiography because of the more radiation. Among radiological methods for dental age estimation in children, the Demirjian method is widely used and accepted, mainly because it allows comparison of different ethnic groups.^[2] This was based on the ratings

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of radiographs of the seven left-side teeth of the mandible. In this method, each tooth is given a mark indicating a developmental stage. There are eight stages; A to H and each stage is assigned a given numeric value from tables prepared separately for boys and girls. The value obtained on the summation of the obtained values indicates the dental age of the patient, which is derived from standard tables or centile charts.^[8,9] Another dental age estimation method based on 4 teeth for patients with missing teeth in the mandible was developed.^[9]

Dental age is of particular interest to orthodontists in planning the treatment of different types of malocclusion in relation to maxillofacial growth.^[8] It can also be of help in determining the age of cadavers or skeletal material where other parts of the body are missing. The difference between dental age and known chronological age is of interest, indicating an advancement or delay compared with the standard.^[10]

Although comparative studies of chronological age and dental age have been conducted, no direct association between different malocclusions obtained using the Demirjian method was found in the literature. Therefore, the purpose of this study was to investigate the relationship between chronological age and dental age in cases of different malocclusions by using the Demirjian method.

MATERIALS AND METHODS

Panoramic and lateral cephalometric radiographs of 321 children (165 girls and 156 boys) referred to the Department of Orthodontics between 2007 and 2010 were obtained. The age range was 7-15.9 years. Standard lateral cephalograms and panoramic films were taken at the same magnification (magnification error, <1.1) with the same equipment by using a cephalostat incorporated into a conventional X-ray device (Proline 2002, Planmeca OY, Finland). Subjects with no orthodontic treatment history were included in the study. No patient had a systemic disease. Patients with any syndromes, missing teeth or cleft lip and palate were excluded from the study.

The chronological ages of the patients were calculated on the basis of the time from the child's birth to the day the panoramic radiograph was obtained. The entire sample was divided into subgroups with the distribution based on the chronological age. These chronological ages were translated to decimal ages.

Dental age assessment

Dental maturation on the mandibular left-side was evaluated according to the method described by Demirjian *et al.*^[8,9] The range of the stages ascribed to the state of development of the teeth in the present study was between C and H. If the development of a tooth was found to be between two stages, a half-value was assigned. The development of the seven left permanent mandibular teeth was then assessed using panoramic radiographs by means of the eight-grade scale according to the Demirjian system. The total dental maturity score can be converted into dental age by using a table of standards for boys and girls. The evaluation of the dental ages from 30 panoramic films was completed twice by the same author for intra-observer variability, evaluated by the pediatrician again for inter-observer variability, then calculated using Dahlberg's formula. The intra-observer variability in dental age assessment was $r = 0.93$ and inter-observer variability was $r = 0.81$. Disagreement between examiners never occurred at more than one stage.

Cephalometric parameters

In cephalometric radiographs, SNA°, SNB°, ANB° and GoGnSN° angles were measured. All patients were divided into three subgroups according to the ANB° angle: Class I, Class II and Class III groups.

Statistical analysis

Data were analyzed using the SPSS statistical program (version 15.5, SPSS Inc., Chicago, Illinois, USA). Descriptive statistics were calculated for each parameter. Whether the distributions of continuous variables were normal was determined by performing the Shapiro-Wilk test. Chronological and dental ages showed normal distribution while SNA°, SNB°, ANB° and GoGn-SN° did not show normal distribution. Therefore, inter-group comparisons regarding normally distributed data were analyzed by unpaired *t*-test, whereas Mann-Whitney U-test was used for abnormally distributed data. The comparison of dental age and chronological age according to gender was evaluated by the Student's *t*-test. Predicted age was compared with actual age and the mean differences were calculated for each gender-specific age group. The differences were calculated by means of the *t*-test. The comparisons between the dental and chronological age in each sagittal classification were assessed by paired sample *t*-test. The relationships between dental age and SNA°, SNB°, ANB° and GoGnSN° parameters were evaluated using the Spearman's rank correlation coefficient. *P* values of less than 0.05 were regarded as significant.

RESULTS

This study was conducted in 321 patients (156 men and 165 women). Distribution of the patients according to gender and sagittal classifications are shown in Table 1.

Chronologic age and dental age according to gender

The chronological age range of the male patients was between 7.0 and 15.7 and the mean age was 11.84 ± 1.57 years. Their dental ages ranged from 7.8 to 15.1 and the mean was 12.12 ± 1.56 years. In male patients, the difference between chronological age and dental age was 0.33 years and this difference was statistically significant ($t = 5.000$, $P < 0.001$). Dental age was therefore greater than chronological age. There was also a strong linear relationship between dental age and chronological age ($P < 0.001$).

The chronological ages of the female patients ranged from 7.0 to 15.9 years and the mean age was 11.38 ± 1.70 years. Their dental ages ranged from 7.8 to 15.8 years and the mean age was 12.23 ± 1.87 years. The dental age of female patients was therefore greater than that of the male patients by 0.94 years. This difference was also statistically significant ($t = 11.948$, $P < 0.001$). A stronger linear relationship between dental age and chronological age ($P < 0.001$) was found

in girls. The difference between chronological age and dental age seen in the female patients was greater than the difference seen in the male patients.

Chronological age and dental age according to the sagittal classification

The mean chronological ages of patients with Class I, Class II and Class III malocclusions were 11.71 ± 1.65 years, 12.29 ± 1.41 years and 10.98 ± 1.44 years, respectively. The corresponding mean dental ages were 12.05 ± 1.71 , 12.49 ± 1.31 and 11.35 ± 1.60 years. Chronological age and dental age were compared in each group and were significantly different [Table 2]. Dental age was greater than chronological age in all classes. This was statistically significant for girls in all grades and male patients with Class I and Class II malocclusions ($P < 0.01$) while the statistical significance for male patients with Class III malocclusions was $P < 0.05$.

Chronological ages by gender within each class were evaluated and the chronological ages of boys and girls with Class I and Class III malocclusions were similar. The mean chronological age of the boys with Class II malocclusions, however, was significantly higher than that of the girls with Class II malocclusions ($P < 0.01$). In terms of dental age, similar values were observed in boys and girls in each class.

Dental age and chronological age differences between the groups were evaluated and the difference was found to be much greater in female patients than in male patients in both Class I ($P = 0.029$) and Class II ($P < 0.001$) groups, but not in the Class III group, in spite of the greater difference in female patients ($P = 0.128$). The difference was found

Table 1: Gender distribution according to classes

Sagittal classification	Male		Female	
	n	Percentage	n	Percentage
Class I (n=107)	49	45.8	58	54.2
Class II (n=152)	75	49.3	77	50.7
Class III (n=62)	32	51.6	30	48.4
Total (n=321)	156	48.6	165	51.4

Table 2: Differences in chronological age and dental age according to gender and classes

Class	Age	Male	Female	Male versus female	
		Mean±SD	Mean±SD	t	P
I	Chronologic	11.71±1.65	11.57±1.85	0.386	0.700
	Dental	12.05±1.71	12.18±1.94	0.365	0.716
	Difference (D-C)	0.34±0.75	0.61±1.28	1.262	0.210
	C versus D t (P)*	3.239 (0.002)	3.640 (0.001)	-	-
II	Chronologic	12.29±1.41	11.61±1.42	2.990	0.003
	Dental	12.49±1.31	12.66±1.65	0.703	0.483
	Difference (D-C)	0.20±0.79	1.05±0.85	6.449	<0.001
	C versus D t (P)*	2.160 (0.034)	10.942 (<0.001)	-	-
III	Chronologic	10.98±1.44	10.44±1.81	1.300	0.199
	Dental	11.35±1.60	11.24±1.91	0.247	0.806
	Difference (D-C)	0.37±1.00	0.80±1.03	1.666	0.101
	C versus D t (P)*	2.094 (0.045)	4.253 (<0.001)	-	-
Class difference	F=0.339; P=0.713	F=1.753; P=0.177	-	-	-

*Paired sample t test. C versus D: Chronological age versus dental age, SD: Standard deviation

to be similar between the classes in both females and males.

Differences between dental and chronologic ages according to sub-age groups are shown in Table 3. There were statistically significant differences between the dental and chronological ages in all age groups ranging from 7 to 13.9 years in female patients, while there was no difference in 14-15.9 years age groups. In male patients, there were significant differences only in the age groups 10-10.9 and 11-11.9 years and the differences were not statistically significant in the other age groups.

Correlations

The distribution of classes in SNA°, SNB°, ANB° and GoGnSN° measurements are shown in Table 4. The relationships between the dental age and these parameters were first evaluated in general and then evaluated separately for each class. Dental age did not show any significant correlation with the SNA° or GoGnSN° angle, while a weak, statistically significant negative relationship was observed between dental age and the SNB° angle ($\rho=0.205$, $P < 0.001$). There was a weak, linear and statistically significant correlation between dental age and the ANB° angle ($\rho =0.313$, $P < 0.001$).

When the dental age was evaluated according to gender and classes, only in boys did the ANB° angle shows a statistically significant correlation with dental age, although a weak linear correlation was found ($\rho =0.346$, $P < 0.05$).

DISCUSSION

Despite the development of dental maturation, prediction methods in the 1970's, studies conducted in many countries over the recent years show that there is still much to be investigated about this issue. The Demirjian method is the most widely used method for determining dental maturation. The main reason this method is used is that the scoring is performed according to the shape of the tooth instead of the length of the tooth. Thus, the magnification between 3% and 10% in the panoramic film is eliminated as a possible source of error. In addition, depending on the length of the root, it may be difficult to provide an assessment of standardization. The reason for preferring the Demirjian method is its high reproducibility. As with the many studies previously reported here, intra- and inter-observer variability assessment of dental maturation is lower.^[11]

In this study, the upper age limit of the selected patients was 15.9 years, at which there is closure of the latest erupted permanent teeth apices (except the third molar), as in previous studies.^[12,13] The lower limit was determined to be 7 years, because only a very limited number of patients admitted to the orthodontics clinic were under 7 years of age. This age group is also the most common age group of patients in the practice of orthodontics. Clinical orthodontists are more likely to encounter patients with malocclusion or jaw malposition in this age group than in the normal population. Therefore, the relationship between malocclusion and dental age, as well as the relationship

Table 3: Differences between dental and chronologic ages in sex and age groups

Age groups	Male				Female			
	n	Mean±SD median (IQR)	Test statistics	P	n	Mean±SD median (IQR)	Test statistics	P
7.0-8.9	8	0.60±1.20	Z=1.689	0.091	13	0.60±1.10	Z=2.512	0.012
9.0-9.9	7	0.20±1.00	Z=0.000	1.000	14	0.45±0.98	Z=2.139	0.032
10.0-10.9	27	0.67±0.93	t=3.727	0.001	30	0.30±0.86	t=3.684	0.001
11.0-11.9	31	0.48±0.68	t=3.942	<0.001	44	1.07±1.03	t=6.899	<0.001
12.0-12.9	46	0.20±0.92	t=1.455	0.153	41	1.11±0.81	t=8.765	<0.001
13.0-13.9	23	0.05±0.55	t=0.418	0.680	13	0.90±0.45	Z=2.661	0.008
14.0-15.9	14	0.20±1.10	Z=0.756	0.450	10	0.75±2.18	Z=1.633	0.102

Z: Wilcoxon test statistics, t: Paired sample t test statistics, SD: Standard deviation, IQR: Interquarter range

Table 4: Median values of SNA°, SNB°, ANB° and GoGnSN° parameters

Class	SNA°		SNB°		ANB°		GoGnSN	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
I	79.00	4.50	78.50	6.00	1.00	3.00	34.00	5.50
II	80.00	5.50	75.00	5.00	5.25	3.00	34.00	8.00
III	79.25	5.13	81.25	4.13	-2.00	2.00	33.00	7.00

IQR: Interquarter Range, SNA°: Maxillary protrusion angle, SNB°: Mandibular protrusion angle, ANB°: Maxilla-mandibular angle, GoGnSN°: Vertical plane angle

between chronological age and dental age needs to be investigated because dental age is one of the most important issues in orthodontic treatment planning. In cases with delayed maturation, orthodontic treatment may begin at a later stage and more stable results can be obtained.^[11] In this study, in girls, the dental age was greater than the chronological age by 0.94 years, the corresponding value in boys was 0.33 years. These values are also statistically significant. This difference can be considered clinically insignificant in males, but it can be considered as clinically important in girls. Jamroz *et al.*^[14] reaffirm that a difference of more than 6 months between chronological age and dental age is clinically important. This difference in girls may be attributed to the fact that girls attain puberty earlier than boys and the difference may be related to a significant development in facial structure.^[15] Similarly, in many previous studies, dental age was found to be more than chronological age in both girls and boys.^[10-12,16-18] However, compared with the dental maturation in French-Canadian children, dental maturation of children in Kuwait was found to be delayed by approximately 0.7 years.^[19] In addition, dental age in the Demirjian method is exactly as predicted in certain populations.^[20] The age of the sample group, the statistical method, method reliability and each child's individual genetic and geographic variation can influence the differences reported in the results.^[15,21] Genetic research conducted on monozygotic and dizygotic twins showed that the effect of environmental factors is not as high as that of genetic factors, which influence more than 50% of dental maturation.^[22]

Dental maturation and chronological age may not show a linear relationship. This is important in orthodontic treatment planning. In other words, the relationship between dental maturation and chronological age may remain stable during some age, after which it may accelerate. Krarup *et al.*^[23] reported that the position of tooth buds remained relatively stable inside the jaw until root formation started. Therefore, eruption is accelerated with the beginning of root formation. In a study of dental development related to the dental and skeletal maturation in children, Uysal *et al.*^[24] found that skeletal maturation was closely related to dental development. Liversidge *et al.*^[25] contrasted this situation in their study of delayed dental maturation between the ages of 4 and 9 years. In another similar study conducted in the Turkish population, a significant development in dental maturation could be seen between the ages of 7 and 11 years.^[10]

Previous studies have investigated the relationship between skeletal maturation and dental maturation; however, the relationship between dental maturation and malocclusion had not been investigated. This study shows that Class I, Class II and Class III malocclusion groups have different chronological and dental ages [Table 2]. Dental ages were found to be greater than chronological ages in all malocclusion groups. However, dental and chronological age differences were not found to be significantly different between classes. In the present study, SNA°, SNB° and ANB° angles, which are the most common parameters used for classifying anomalies in the sagittal aspect, were used. The results of correlation studies indicate there is no relationship between dental age and the SNA° angle. However, there is a negative and weak statistically significant correlation between dental age and SNB° angle. A positive and weak correlation between ANB° angle and dental age is noteworthy. In other words, as a case presented a tendency to Class II, dental maturation increases. This finding suggests that dental age is more closely related to mandibular age. However, since the values indicate a weak correlation, the results should be interpreted carefully.

Growth of teeth and dental age play quite an important role in orthodontics. Furthermore, teeth eruption and mastication play an important role in alveolar development. During normal growth and development of the maxillofacial area, there is a consistency between the vertical growth of the nasomaxillary complex, maxillary and mandibular vertical alveolar bone growth and the vertical growth of the mandibular condyle. Janson *et al.*^[26] conducted the first study to investigate the influence of facial type on dental development in subjects of the same chronological age. They reported that compared to subjects with small faces, subjects with long faces showed a tendency to have an advanced dental maturation. In another study in dental maturation in subjects with small and long faces were evaluated, no clinically significant difference was found in terms of dental maturation.^[22] In our study, the mandibular plane angle (GoGnSN°) showed no correlation with dental maturation. These findings suggest that dental maturation and the mandibular vertical growth pattern are probably controlled by different genes. Studies need to be conducted in bigger malocclusion groups as well as groupings that compare the vertical aspects of the jaws and face.

CONCLUSION

Evaluation with the Demirjian method revealed statistically significant differences in the chronological

and dental ages for children in all classes. Dental age was significantly greater than chronological age in the 10-10.9 year and 11-11.9 year age groups in male patients and in all age groups between 7 and 14 years in female patients. Female patients were found to have significantly more advanced dental maturation than male patients.

In individuals evaluated in terms of sagittal jaw relationship, dental maturation showed a weak and negative correlation with the SNB° angle and a weak linear correlation with the ANB° angle. In individuals evaluated according to the vertical plane, dental maturation did not reveal any relationship with the GoGnSN° angle.

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