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Original Article

Investigating the Age of the Formation of Permanent Teeth in the Mandible in 5- to 16-Year-Old Children; A Study in Mashhad, Iran

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Abstract

Background: The study of tooth mineralization is one of the most reliable approaches to determining the age of individuals. Given the presence of various ethnicities in Iran, this study aimed to determine the exact age at different stages of the development of permanent mandibular teeth in children aged 5-16 years in Mashhad, Iran.

Methods: In this cross-sectional study, 235 digital panoramic radiographs of children aged 5-16 years were assessed. Maturation of the permanent teeth was evaluated according to Demirjian's classification system. Data was analyzed using SPSS 16.0. T-test was performed to compare the homologous teeth of the same arch as well as boys and girls in different stages of tooth calcification.

Results: The mean age of participants was 9.78 ± 2.53 years. Homologous teeth were not significantly different in terms of maturation time in all cases. In some stages, certain teeth developed more quickly in girls while some others developed faster in boys. These differences were statistically significant only in certain stages and for certain teeth.

Conclusions: As far as developmental stages were concerned, girls were at a significantly lower age. The dental charts presented in this article includes information that could be beneficial for dental clinicians in making appropriate diagnosis and planning for orthodontic and surgical procedures. These charts also provide datasets for estimation of dental age for a sample of Iranian children.

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Background

Since there is a definite relationship between physical maturity and age, the estimation of chronological age can be accomplished by examining physical manifestations of puberty, such as skeletal age, menstruation, size, stature, and dental calcification.

Due to the minimal effects of environmental and hormonal factors on tooth eruption, the estimation of dental age can be used to calculate the chronological age and serve as a useful guide in studies of the relevant development process (1).

The study of dental evolution and development can also be helpful in other domains, such as archeology and forensics, where there is a need to identify dead and living individuals (2).

Since the majority of methods used for assessing dental development are non-invasive, the process is believed to be suitable for determining the age of humans (3,4). However, the extent of tooth eruption used for determining the dental age has its own limitations, including insufficient space available in the dental arch, premature extraction of deciduous teeth, tooth tipping, and tooth impaction. Thus, the application of novel methods seems essential to estimate dental age (5,6).

Estimation of dental age has been made possible by means of radiographs long before and after tooth eruption (7). This non-invasive method is considered as a part of routine dental examination and its implementation is also simple (8).

The method proposed by Willems et al (9) has been reported as a useful technique for determining the

Highlights

- The dental development age was significantly lower in girls than in boys.
- The maturation time of homologous teeth were not significantly different.
- The dental charts presented in this study provides datasets for estimation of dental age for a sample of Iranian children.

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chronological age of children. According to Demirjian et al (7), the estimation of dental age should be based on the dental developmental stages rather than the eruption process. This method can be useful in estimating the age of children with unknown birth date, and is also useful in cases of adopted children or juvenile delinquents. In addition, the age of unidentified skeletons belonging to children can be estimated using this method (10).

So far, many studies have been performed in various countries, involving different methods to evaluate tooth mineralization stages (11).

Given the presence of various ethnicities in Iran, provision of a separate and up-to-date dental chart for each population seems very important. The present study aimed to determine the exact age at different stages of dental development in children aged 5-16 years in Mashhad, Iran in 2015-2016.

Materials and Methods

In this cross-sectional study, 235 normal children aged 5-16 years who were referred to a private radiology center in one of the central districts of Mashhad in 2015 were enrolled. All the panoramic radiographs that met our inclusion criteria where selected. Children with systemic diseases affecting dental calcification, such as hypophosphatemia, amelogenesis imperfecta, hypophosphatasia, Ehlers-Danlos syndrome, and endocrine disorders, as well as those suffering from evolutionary developmental defects, congenital anomalies, and defective dentin formation were excluded.

First, a questionnaire, including demographic characteristics and clinical data, was completed for all children. The exact age of the children was drawn from their identification card and then recorded in a separate form. Next, digital panoramic radiographs (Planmeca ProMax® panoramic system; Computed Radiography, Finland) were obtained from all children by a trained technician. Panoramic radiography was performed using a single device whose contrast, magnification, brightness, and resolution levels were carefully set. The radiation rate was adjusted based on the child's age and size.

Dental age was estimated according to a revised version of Demirjian's method. The developmental stages of all mandibular permanent teeth (from the central incisor to the mandibular third molar) are shown in Figure 1.

This method involves a system of rating based on an 8-stage scale from A to H: (A) bone crypt is visible without any dental germ inside it; (B) complete mineralization of the cusp and crowns are clear; (C) half of the tooth crown has developed, the pulp chamber is growing, and an ivory deposition has emerged; (D) crown formation is complete down to the cementoenamel junction and the pulp chamber has a trapezoid form; (E) the walls of the pulp chamber now form straight lines, the formation of the furca area in multi-rooted teeth initiates, and the root grows to a length which is less than the height of the crown

Figure 1. A Sample of Panoramic Radiographs.

in single-rooted teeth; (F) the apex ends in a funnel shape and the root length is equal to or greater than the crown's height; (G) the walls of the root canal are now parallel and apex is still partially open; and (H) the apical end of the root canal is completely closed, with the periodontal membrane having a uniform width around the root and the apex (Figure 2).

Accordingly, the dental age was determined separately by 2 trained examiners (a last-semester student of dentistry and an oral-maxillofacial radiologist). The graphs were evaluated using a computer under the same conditions. Observers were blinded to the chronological age and gender of the children. In case of discrepancy, a second maxillofacial radiologist was consulted to estimate the dental age.

After registration of the children's characteristics, their dental age was recorded in homologous charts.

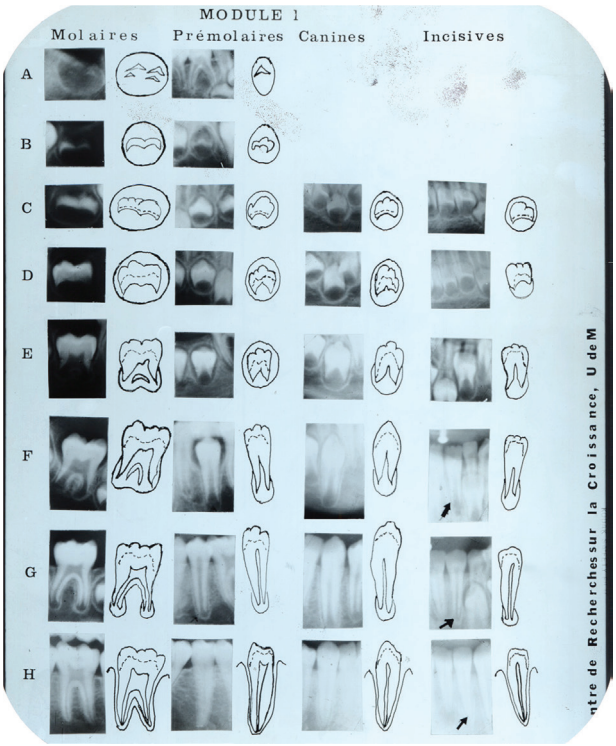

Figure 2. Demirjian's Classification System.

The chronological age of the children was calculated by subtracting their birthdates from the date on which the radiograph was taken. The developmental stage of all 16 mandibular permanent teeth was determined Demirjian's method (8). In the present study the FDI tooth numbering system was used. The data was analyzed using *t* test or its nonparametric equivalent in SPSS version 16. *P* value less than 0.05 was considered significance level.

Results

Overall, 56.2% of the children were girls and 43.8% of them were boys. The mean age of the children was 9.78 ± 2.53 (range: 5-16) years. The chronological age and gender distributions are presented in Table 1. Based on the results, the most absent teeth were the left third molar followed by the right third molar. The distribution of teeth representing the 2 mandibular quadrants is shown in Table 2.

It was observed that dental development occurred faster in girls than in boys in certain developmental stages, while in some other developmental stages, dental development occurred faster in boys than in girls. The mean values of dental development, based on age and gender in different dental stages, are presented in Table 3.

There was no significant difference in mean dental age between the 2 genders in the stages H and G. However, the mean age of the girls was less than that of the boys in the stages A, B, C, and E, whereas the mean age of the boys was less than that of the girls in the stages F and D.

Regarding mandibular second molars in the developmental stages C and E, a significant difference in the age of children was observed on both sides between the 2 genders, so that it was significantly higher in girls than in boys in the stage C ($P=0.002$) but was significantly higher in boys than in girls in the stage E ($P=0.023$).

As far as the stages A, B, C, and D were concerned, no significant difference was observed in the age-related development of the mandibular first molars on both sides between boys and girls ($P>0.05$). This value was found to be higher in girls than in boys in the stages E, F, G, and H, but the difference was not statistically significant.

Regarding the stages A and B, there was no significant difference in the dental age of the mandibular second premolars on both sides between the 2 genders. Nevertheless, the dental age of the right second premolars in the developmental stages F ($P=0.017$) and G ($P=0.045$) revealed significant differences between the 2 genders. Additionally, dental age of the left second premolars in the stage F was significantly different between boys and girls ($P=0.004$).

The stage F also showed a significant difference in the age of the right ($P=0.027$) and the left ($P=0.043$) mandibular first premolars between the 2 genders. Further, a significant difference was seen in the age of the right canine in the stages F ($P=0.044$) and G ($P=0.006$) between the 2 genders. Similarly, the assessment of the left canine showed a significant difference between the 2 genders in the stages F ($P=0.013$) and G ($P=0.026$). The gender-based assessment of the mandibular central and lateral incisors indicated no significant differences between the 2 genders in none of the stages of dental growth.

The gender-related mean dental age in different dental stages are shown in Table 4.

In general, our findings showed that the central and lateral incisors, canines, and first premolars had fully developed at earlier ages in girls compared with boys, whereas the second premolars, first molars, and second molars had completely developed at earlier ages in boys compared with girls.

The mean age at the onset of the calcification of the mandibular third molars was 9.21±1.34 years in girls and 9.35±1.41 years in boys. The mean age at the complete development of crown of the mandibular third molars was 12.47±1.4 years in girls and 12.24±2.14 years in boys. The mean age at complete development of permanent mandibular teeth, except for the third molars, was 14.27±0.5 years in girls and 14.12±1.36 years in boys.

Table 1. Age and Gender Distributions of the Participants

		Girls, No. (%)	Boys, No. (%)	Total, No. (%)
5-5.99	No.	2 (22.2)	7 (77.8)	9 (100.0)
6-6.99	No.	11 (61.1)	7 (38.9)	18 (100.0)
7-7.99	No.	14 (45.2)	17 (54.8)	31 (100.0)
8-8.99	No.	22 (55.0)	18 (45.0)	40 (100.0)
9-9.99	No.	24 (66.7)	12 (33.3)	36 (100.0)
10-10.99	No.	19 (55.9)	15 (44.1)	34 (100.0)
11-10.99	No.	10 (66.7)	5 (33.3)	15 (100.0)
12-10.99	No.	9 (47.4)	10 (52.6)	19 (100.0)
13-10.99	No.	5 (71.4)	2 (28.6)	7 (100.0)
14-10.99	No.	15 (68.2)	7 (31.8)	22 (100.0)
15-10.99	No.	1 (25.0)	3 (75.0)	4 (100.0)
Total	No.	132 (56.2)	103 (43.8)	235 (100.0)

Table 2. The Distribution of Teeth Based on the Respective Mandibular Quadrant

Absent	Present	Tooth	Absent	Present	Tooth
107	128	38	105	130	48
1	234	37	0	235	47
0	235	36	2	233	46
7	228	35	5	230	45
0	235	34	0	235	44
0	235	33	0	235	43
3	232	32	4	231	42
0	235	31	0	235	41

Discussion

In the present study, 235 digital panoramic radiographs of children aged 5-16 years were assessed, and the stages

Table 3. The Mean Age at Dental Development According to Age and Gender in Different Dental Development Stages

No.	Gender	A	B	C	D	E	F	G	H
48	Boy	9.17±1.2	9.87±1.45	10.39±1.24	12.42±1.39	14.05±0.58	14.58±0		
	Girl	9.23±1.44	10.06±1.28	11.39±1.18	12.24±2.14	14.57±0.72	13.00±2.12		
	P value	0.899	0.728	0.087	0.795	0.166	0.652		
47	Boy			7.17±0	7.66±1.16	9.03±0.82	10.37±0.93	12.01±1.29	14.37±0.36
	Girl			5.07±0.09	7.46±0.99	9.84±1.63	10.81±1.21	12.85±1.84	14.13±1.43
	P value			0.002	0.426	0.023	0.200	0.128	0.531
46	Boy					5.54±0.00	6.40±0.86	8.20±1.08	11.55±1.99
	Girl					5.21±0.32	6.09±0.96	7.93±0.95	11.43±1.90
	P value					0.467	0.541	0.221	0.727
45	Boy			6.41±0	7.29±1.23	8.72±0.98	9.89±0.99	11.41±1.40	13.58±1.36
	Girl			5.26±0.28	6.94±0.94	8.59±1.23	10.80±1.53	12.62±1.26	13.53±2.08
	P value			0.072	0.312	0.641	0.017	0.045	0.931
44	Boy			5.54±0	6.51±0.69	8.30±1.02	9.35±0.93	10.87±1.15	13.27±1.47
	Girl			5.00±0	6.33±1.11	8.01±0.98	9.98±1.1	11.51±1.50	13.50±1.84
	P value				0.648	0.240	0.027	0.139	0.663
43	Boy				5.54±0	6.89±0.85	8.85±1.06	10.70±1.06	12.99±1.56
	Girl				5.29±0.41	7.15±1.12	9.31±1.07	11.85±1.24	13.56±1.91
	P value				0.706	0.413	0.044	0.006	0.288
42	Boy					5.91±0.55	7.24±0.77	8.33±1.01	11.03±2.12
	Girl					5.83±0.91	7.31±0.83	8.17±1.08	11.50±1.97
	P value					0.866	0.790	0.606	0.196
41	Boy					5.54±0	6.34±0.70	7.69±1.01	10.78±2.16
	Girl					5.49±0.69	6.72±0.98	7.41±0.81	10.95±2.09
	P value					0.951	0.387	0.315	0.618
38	Boy	9.25±1.48	9.98±1.42	10.69±1.44	12.53±1.40	14.06±0.62	14.58±0.00		
	Girl	9.47±1.39	10.54±2.02	11.39±1.18	12.24±2.14	14.67±0.79	13.39±1.65		
	P value	0.679	0.376	0.278	0.678	0.170	0.595		
37	Boy		5.54±0.00	7.17±0.00	7.66±1.16	9.03±0.82	10.31±0.89	12.04±1.28	14.19±0.59
	Girl		5.00±0.00	5.82±1.50	7.49±0.97	9.38±1.41	10.85±1.22	12.89±2.05	14.13±1.43
	P value		-	0.478	0.511	0.268	0.115	0.132	0.888
36	Boy					5.54±0.00	6.92±1.57	8.16±1.06	11.55±1.99
	Girl					5.02±0.03	6.09±0.96	7.93±0.95	11.48±1.97
	P value					0.042	0.234	0.287	0.825
35	Boy			6.41±0.00	7.29±1.23	8.70±0.97	9.85±0.95	11.56±1.17	13.76±1.13
	Girl			5.26±0.28	6.94±0.94	8.48±1.14	10.92±1.49	12.49±1.33	13.65±2.06
	P value			0.072	0.312	0.387	0.004	0.111	0.845
34	Boy			5.54±0.00	6.51±0.69	8.32±1.00	9.36±0.85	11.30±0.90	13.07±1.66
	Girl			5.00±0.00	6.33±1.11	8.00±0.97	9.93±1.18	11.43±1.52	13.60±1.88
	P value			-	0.648	0.184	0.043	0.759	0.355
33	Boy				5.54±0.00	6.89±0.85	8.80±1.01	10.87±0.94	12.88±1.68
	Girl				5.29±0.41	7.18±1.13	9.39±1.18	11.74±1.26	13.56±1.91
	P-value				0.706	0.347	0.013	0.026	0.229
32	Boy					5.91±0.55	7.24±0.77	8.35±0.99	11.06±2.12
	Girl					5.83±0.91	7.31±0.83	8.06±1.02	11.41±1.96
	P value					0.690	0.866	0.790	0.343
31	Boy					5.54±0.00	6.34±0.66	7.74±0.97	10.78±2.16
	Girl					5.49±0.69	6.72±0.98	7.34±0.80	10.87±2.11
	P value					0.951	0.356	0.146	0.799

Table 4. The Mean Age According to Mandibular Quadrants and Gender in Different Dental Stages

	No.	A	B	C	D	E	F	G	H
Girls	48	9.17±1.20	9.87±1.45	10.39±1.24	12.42±1.39	14.05±0.58	14.58±0.00		
	38	9.25±1.48	9.98±1.42	10.69±1.44	12.53±1.40	14.06±0.62	14.58±0.00		
	47			7.17±0.00	7.66±1.16	9.03±0.82	10.37±0.93	12.01±1.29	14.37±0.36
	37		5.54±0.00	7.17±0.00	7.66±1.16	9.03±0.82	10.31±0.89	12.04±1.28	14.19±0.59
	46					5.54±0.00	6.40±0.86	8.20±1.08	11.55±1.99
	36					5.54±0.00	6.92±1.57	8.16±1.06	11.55±1.99
	45			6.41±0.00	7.29±1.23	8.72±0.98	9.89±0.99	11.41±1.40	13.58±1.36
	35			6.41±0.00	7.29±1.23	8.70±0.97	9.85±0.95	11.56±1.17	13.76±1.13
	44			5.54±0.00	6.51±0.69	8.30±1.02	9.35±0.93	10.87±1.15	13.27±1.47
	34			5.54±0.00	6.51±0.69	8.32±1.00	9.36±0.85	11.30±0.90	13.07±1.66
	34			10.39±1.24	5.54±0.00	6.89±0.85	8.85±1.06	10.70±1.06	12.99±1.56
	33				5.54±0.00	6.89±0.85	8.80±1.01	10.87±0.94	12.88±1.68
	42					5.91±0.55	7.24±0.77	8.33±1.01	11.03±2.12
	32					5.91±0.55	7.24±0.77	8.35±0.99	11.06±2.12
	41					5.54±0.00	6.34±0.70	7.69±1.01	10.78±2.16
	31					5.54±0.00	6.34±0.66	7.74±0.97	10.78±2.16
Boys	48	9.23±1.44	10.06±1.28	11.39±1.18	12.24±2.14	14.57±0.72	13.00±2.12		
	38	9.47±1.39	10.54±2.02	11.39±1.18	12.24±2.14	14.67±0.79	13.39±1.65		
	47			5.07±0.09	7.46±0.99	9.84±1.63	10.81±1.21	12.85±1.84	14.13±1.43
	37		5.00±0.00	5.82±1.50	7.49±0.97	9.38±1.41	10.85±1.22	12.89±2.05	14.13±1.43
	46					5.21±0.32	6.09±0.96	7.93±0.95	11.43±1.90
	36					5.02±0.03	6.09±0.96	7.93±0.95	11.48±1.97
	45			5.26±0.28	6.94±0.94	8.59±1.23	10.80±1.53	12.62±1.26	13.53±2.08
	35			5.26±0.28	6.94±0.94	8.48±1.14	10.92±1.49	12.49±1.33	13.65±2.06
	44			5.00±0.00	6.33±1.11	8.01±0.98	9.98±1.10	11.51±1.50	13.50±1.84
	34			5.00±0.00	6.33±1.11	8.00±0.97	9.93±1.18	11.43±1.52	13.60±1.88
	34				5.29±0.41	7.15±1.12	9.31±1.07	11.85±1.24	13.56±1.91
	33				5.29±0.41	7.18±1.13	9.39±1.18	11.74±1.26	13.56±1.91
	42					5.83±0.91	7.31±0.83	8.17±1.08	11.50±1.97
	32					5.83±0.91	7.31±0.83	8.06±1.02	11.41±1.96
	41					5.49±0.69	6.72±0.98	7.41±0.81	10.95±2.09
	31					5.49±0.69	6.72±0.98	7.34±0.80	10.87±2.11

of dental development in all permanent mandibular teeth (central incisors to third molars) were examined. Dental development was recorded according to the stages of dental development presented by Demirjian et al (7). Using this method, the authors completed a chart including the exact age at different stages of the development of permanent mandibular teeth (A to H).

Several studies (5,12-17) have suggested that the development of permanent teeth is faster in girls than in boys, which is in agreement with the findings of the current study.

Based on the results of the present study, this difference was significant only in certain stages of dental development; that is, the stages E and C for the second molars, the stages F and G for the right second premolars, the stage F for the left second premolars as well as the left and right first premolars, and the stages F and G for the canine teeth on both sides.

Consistent with the current study, Lee et al proposed that the gender-related differences in dental development were more significant in the stages E, F, and G in comparison with the other stages (16). According to the study of Feijóo et al, this difference was more pronounced in the stage G compared with the other stages. They reported a significant difference in the development of permanent teeth between boys and girls, so that in the stage G the mandibular left first molars, the maxillary left lateral incisors, and the mandibular lateral incisors were significantly different; in stage E both the mandibular and maxillary first premolars were significantly different; and in the stages E and G the maxillary lateral incisors were significantly different (13).

The study of Tunc and Koyuturk showed a significant difference between the 2 genders in terms of the development of the canines in the stages C, F, G, and H; the first premolars in the stage F; and the second premolars and the second molars in the stage B (5).

The greatest difference between the 2 genders in relation to the age of dental development is observed in the mandibular canines during the stage when the closure of the apex occurs (stage H), which was confirmed by the present study and other studies (13,17-19). Based on our results, as far as the central and lateral incisors are concerned, the completion of the root development process and the closure of the apex occur at a later point of time in boys as compared to girls. Moreover, this stage occurs earlier in boys than in girls concerning the second premolars, which can be explained given different developmental mutations in boys and girls.

The evaluation of the development of the third molars revealed that the calcification of the buds of the mandibular third molars started at the age of nine in both genders. In addition, the crown of these teeth completed at the age of 12 in both genders. According to the study of Karadayi et al, the calcification of the mandibular third molars seems to begin at the age of eight in both genders, and their crown appears to complete between the ages of 13 and 14 (12).

In the present study, the full development of the permanent mandibular teeth, except for the third molars, occurred at the age of 14 in both genders, which is inconsistent with the estimation of Karadayi et al (at the age of 15) (12). A different observation was also reported by AlQahtani et al (15), suggesting the age of 16.5 in both genders.

The full growth of the mandibular permanent teeth occurred at a comparatively older age in the Iranian population, which is inconsistent with findings in the Korean, Finnish, and Canadian populations, in whom this process occurred at a lower age. The same comparative difference applies to the Northern Turkey, French-Canadian, and Danish populations. However, the findings concerning the mandibular permanent teeth are comparably similar in the Iranian and Spanish populations.

As it can be noted, there is contradictory evidence regarding difference in dental development between the 2 genders. Dentition can be adversely affected by the early loss or prolonged retention of deciduous teeth, positional deviation, and ankylosis. Other factors may also exert a adverse effect on the dental development, including gender, climatic conditions, and ethnicity.

The rate of dental mineralization is varied in children from different geographical areas. As such, there is no definitive criterion to estimate the dental age, and therefore several factors should be cautiously taken into account (11).

The validity of the techniques to identify the individual biological variations has been assessed with regard to dental maturity in many studies. In many of these studies, Demirjian's method was used to evaluate the dental age of children at different ages (9).

Similar to other studies (8,12,17,22,23), the Demirjian's approach to assessing the dental development was used in the present study.

In the present study, a dental age chart was designed for each tooth and different age groups in a sample of Iranian children of both genders. This information can assist dentists in making a correct diagnosis and in opting for the appropriate orthodontic surgical interventions.

One of the main limitations of the current study was the small number of the panoramic radiographs of comparably younger (less than 7-year) children, which could have confounded the precise estimation of age in the early stages of dental development. This drawback was also observed in other similar studies (16,23,24,25). Therefore, the authors suggest further studies involving the assessment of digital panoramic radiographs of younger children. Another limitation of the present study was the inadequate resolution of the panoramic radiographs of the maxillary permanent teeth, especially those of the premolars and molars, which could have interfered with the accurate examination of the maxillary permanent teeth. It is also advisable to conduct additional studies on the potential effects of other factors, such as nutrition, birth weight, systemic diseases, and developmental disorders, on the development of permanent teeth in Iranian populations as well as in other countries.

Conclusions

The dental development age was significantly lower in girls than in boys. The dental charts include information that could be beneficial for dental clinicians to make appropriate diagnosis and opt for the optimal orthodontic and surgical procedures.

Authors' Contribution

All authors have contributed to the conception and design of the study. SHZ and NA contributed to the data collection. The statistical analyses and interpretation of data were carried out by RD.SM and RS and SA drafted the manuscript. All the authors have read and approved the final manuscript.

Ethical Statement

The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences.

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

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References

1. Hegde RJ, Sood PB. Dental maturity as an indicator of

chronological age: radiographic evaluation of dental age in 6 to 13 years children of Belgaum using Demirjian methods. J Indian Soc Pedod Prev Dent. 2002;20(4):132-8.
2. Maber M, Liversidge HM, Hector MP. Accuracy of age estimation of radiographic methods using developing teeth. Forensic Sci Int. 2006;159 Suppl 1:S68-73. doi: 10.1016/j.forsciint.2006.02.019.
3. Bagherpour A, Imanimoghaddam M, Bagherpour MR, Einolghozati M. Dental age assessment among Iranian children aged 6-13 years using the Demirjian method. Forensic Sci Int. 2010;197(1-3):121.e1-4. doi: 10.1016/j.forsciint.2009.12.051.
4. Başaran G, Ozer T, Hamamci N. Cervical vertebral and dental maturity in Turkish subjects. Am J Orthod Dentofacial Orthop. 2007;131(4):447.e13-20. doi: 10.1016/j.ajodo.2006.08.016.
5. Tunc ES, Koyuturk AE. Dental age assessment using Demirjian's method on northern Turkish children. Forensic Sci Int. 2008;175(1):23-6. doi: 10.1016/j.forsciint.2007.04.228.
6. Kırzıoğlu Z, Ceyhan D. Accuracy of different dental age estimation methods on Turkish children. Forensic Sci Int. 2012;216(1-3):61-7. doi: 10.1016/j.forsciint.2011.08.018.
7. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45(2):211-27.
8. Sukhia RH, Fida M, Azam SI. Dental age table for a sample of Pakistani children. Eur J Orthod. 2012;34(1):77-82. doi: 10.1093/ejo/cjq161.
9. Willems G, Van Olmen A, Spiessens B, Carels C. Dental age estimation in Belgian children: Demirjian's technique revisited. J Forensic Sci. 2001;46(4):893-5.
10. Bagherian A, Sadeghi M. Assessment of dental maturity of children aged 3.5 to 13.5 years using the Demirjian method in an Iranian population. J Oral Sci. 2011;53(1):37-42.
11. Leurs IH, Wattel E, Aartman IH, Etty E, Prahl-Andersen B. Dental age in Dutch children. Eur J Orthod. 2005;27(3):309-14. doi: 10.1093/ejo/cji010.
12. Karadayi B, Afşin H, Ozaslan A, Karadayi S. Development of dental charts according to tooth development and eruption for Turkish children and young adults. Imaging Sci Dent. 2014;44(2):103-13. doi: 10.5624/isd.2014.44.2.103.
13. Feijóo G, Barbería E, De Nova J, Prieto JL. Permanent teeth development in a Spanish sample. Application to dental age estimation. Forensic Sci Int. 2012;214(1-3):213.e1-6. doi: 10.1016/j.forsciint.2011.08.024.
14. Ogodescu AE, Bratu E, Tudor A, Ogodescu A. Estimation of child's biological age based on tooth developmen. Rom J Leg Med. 2011;19(2):115-24.
15. AlQahtani SJ, Hector MP, Liversidge HM. Brief communication: The London atlas of human tooth development and eruption. Am J Phys Anthropol. 2010;142(3):481-90. doi: 10.1002/ajpa.21258.
16. Lee SE, Lee SH, Lee JY, Park HK, Kim YK. Age estimation of Korean children based on dental maturity. Forensic Sci Int. 2008;178(2-3):125-31. doi: 10.1016/j.forsciint.2007.12.010.
17. Nyström ME, Ranta HM, Peltola JS, Kataja JM. Timing of developmental stages in permanent mandibular teeth of Finns from birth to age 25. Acta Odontol Scand. 2007;65(1):36-43. doi: 10.1080/00016350600965900.
18. Martin-de las Heras S, García-Fortea P, Ortega A, Zodocovich S, Valenzuela A. Third molar development according to chronological age in populations from Spanish and Magrebian origin. Forensic Sci Int. 2008;174(1):47-53. doi: 10.1016/j.forsciint.2007.03.009.
19. Sahlstrand P, Lith A, Hakeberg M, Norén JG. Timing of mineralization of homologues permanent teeth--an evaluation of the dental maturation in panoramic radiographs. Swed Dent J. 2013;37(3):111-9.
20. Olze A, Reisinger W, Geserick G, Schmeling A. Age estimation of unaccompanied minors. Part II. Dental aspects. Forensic Sci Int. 2006;159 Suppl 1:S65-7. doi: 10.1016/j.forsciint.2006.02.018.
21. Garamendi PM, Landa MI, Ballesteros J, Solano MA. Reliability of the methods applied to assess age minority in living subjects around 18 years old. A survey on a Moroccan origin population. Forensic Sci Int. 2005;154(1):3-12. doi: 10.1016/j.forsciint.2004.08.018.
22. Abesi F, Haghanifar S, Sajadi P, Valizadeh A, Khafri S. Assessment of dental maturity of children aged 7-15 years using demirjian method in a selected Iranian population. J Dent (Shiraz). 2013;14(4):165-9.
23. Liversidge HM. Interpreting group differences using Demirjian's dental maturity method. Forensic Sci Int. 2010;201(1-3):95-101. doi: 10.1016/j.forsciint.2010.02.032.
24. Nykänen R, Espeland L, Kvaal SI, Krogstad O. Validity of the Demirjian method for dental age estimation when applied to Norwegian children. Acta Odontol Scand. 1998;56(4):238-44.
25. McKenna CJ, James H, Taylor JA, Townsend GC. Tooth development standards for South Australia. Aust Dent J. 2002;47(3):223-7.