Dental Age Assessment for Different Climatic Regions

Kenan Cantekin, DDS, PhD, Ahmet Ercan Sekerci, DDS, PhD,† Kubra Peduk, DDS,* Ebru Delikan, DDS,* Nurcan Ozakar Ílday, DDS, PhD,‡ Sezer Demirbuga, DDS,§ and Ozkan Miloglu, DDS||*

Objective: The aim of this study was to evaluate the impact of several aspects of climate, such as temperature and altitude, on dental maturation.

Materials and Methods: The total sample consisted of 944 panoramic radiographs (473 Turkish children from Central Anatolia [228 girls and 245 boys] and 471 Turkish children from Eastern Anatolia [222 girls and 249 boys]). The children aged between 7.0 and 14.9 years. The radiographs were randomly selected from 2 cities in Turkey, Kayseri and Erzurum. Independent *t* tests and paired *t* tests were performed to compare sex, location, and age to determine the relationships between tooth developments.

Results: The Central Anatolian children were approximately 0.2 to 3.0 years more advanced in dental maturity than the Eastern Anatolian subjects.

Conclusions: The development standards proposed by Demirjian are affected by climatic factors. However, further research and detailed information to gather data are needed.

Key Words: dental age estimation, Demirjian, Turkish population, dental mineralization, pediatric dentistry, orthodontics

(*Am J Forensic Med Pathol* 2014;35: 197–200)

Age calculation is used for civil, criminal, forensic, and anthropologic purposes, as well as for both pediatric dentistry and orthodontics, to be able to determine a child's growth and developmental status. This information is especially important for diagnosis and treatment planning.[1–8] The most commonly used developmental indicators are skeletal maturity, body height and weight, sexual changes, and dental development and eruption.[9] Dental assessment based on dental maturity is one of the most reliable indicators of chronological age and the most widely used in forensic and legal dentistry.[10]

There are several ways to determine dental age based on the degree of calcification observed in radiographic examinations in permanent teeth.[11–15] The Demirjian method, a widely used one, is based on the observation of 7 left-side mandibular teeth in children of French Canadian origin. Various investigators have demonstrated differences between several ethnic groups.[3,4,16]

So far, insufficient information has been obtained about how climatic factors can influence dental mineralization. In this article, we explore the impact of several aspects of climate, such as temperature and altitude, on dental maturation.

Manuscript received April 27, 2012; accepted July 30, 2013.
From the *Pediatric dentistry; †Oral and maxillo-facial radiology, Faculty of Dentistry, Erciyes University, Kayseri; ‡Restorative dentistry, Faculty of Dentistry, Atatürk University; §Restorative dentistry, Faculty of Dentistry, Erciyes University, Kayseri; and ||Oral and maxillo-facial radiology, Faculty of Dentistry, Atatürk University, Erzurum, Turkey.
The authors report no conflicts of interest.
Reprints: Kenan Cantekin, DDS, PhD, Department of Pediatric Dentistry, Faculty of Dentistry, Erciyes University, Kayseri, Turkey. E-mail: k_cantekin@hotmail.com.

ISSN: 0195-7910/14/3503–0197
DOI: 10.1097/PAF.0000000000000096

MATERIALS AND METHODS

The data for the present cross-sectional study were collected from 2 geographic locations in Turkey—Erzurum city in Eastern Anatolia and Kayseri city in Central Anatolia. The study was performed using 944 panoramic radiographs taken from 473 healthy Turkish children (228 girls and 245 boys) from Eastern Anatolia and 471 healthy Turkish children (222 girls and 249 boys) from Central Anatolia, all of whom aged between 7 and 14.9 years. All of the x-ray technicians who performed the radiographs had had a minimum working experience of 5 years, as of 1996. The technicians used an orthopantomography device (Planmeca Proline CC 2002, 60–80 kVp, 8–10 mA, 12.8-second exposure time; Planmeca, Helsinki, Finland) with a magnification factor of 1.2. This retrospective and cross-sectional study did not require approval from the ethics committee. Children were excluded from the study based on any of the following: tooth agenesis, systemic diseases affecting the growth and development of their teeth, poor quality of the panoramic radiographs, or image deformity affecting mandibular permanent teeth.

Climatic Factors of the Locations

The mean altitude of Erzurum (Eastern Anatolia) is 1850 m, and the temperatures in the city vary between −35°C at night and −18°C in the morning. Winter is prolonged and harsh, and below-freezing temperatures are normal in this region. Indeed, Erzurum is one of the coldest and highest cities in Europe.[17] By contrast, the mean altitude of Kayseri (Central Anatolia) is 1000 m, with mean temperatures similar to European averages.

Assessment of Dental Mineralization

Chronological age was calculated by subtracting the date of the panoramic radiograph from the child's date of birth after having converted both to a decimal age. The stages of dental maturity of the 7 left-side permanent mandibular teeth for each subject were established using the 8 radiographic dental maturity stages demonstrated by Demirjian et al.[12] Potential interobserver error was eliminated by ensuring that all estimates were performed by the same observer (A.E.S.) without prior knowledge of the age or sex of the children. This ensured that the contrast enhancement of the tooth images at each stage of the 7 mandibular teeth allocated a biologically weighted score. The sum of these scores provided an estimate of the dental maturity, measured on a scale from 0 to 100. The overall maturity score was then converted to a dental age by using available tables and/or percentile curves.[12,14]

Statistical Analysis

For each age and sex group, the mean differences between the dental and chronological ages of the subjects were calculated. The Kolmogorov-Smirnov test was used to determine the normality of the distribution of the developmental stages for both mandibular third molars in each sex and age group.

TABLE 1. Age and Sex Distribution of the Subjects Examined

	Eastern Anatolian Children		Central Anatolian Children	
Age, y	Female	Male	Female	Male
7–7.9	25	24	30	28
8–8.9	25	24	20	17
9–9.9	24	28	25	24
10–10.9	20	24	41	53
11–11.9	32	43	26	24
12–12.9	40	24	40	40
13–13.9	31	29	20	20
14–14.9	25	24	26	39
Total	222	249	228	245

Independent *t* tests and paired *t* tests were performed to compare sex, location, and age to determine the relationships between tooth developments. To assess the reproducibility, 90 (almost 10% of the radiographs) randomly selected panoramic radiographs were reevaluated 1 month after the first examination by the same investigator. The percentage agreement between the 2 readings was calculated by examining these 90 radiographs of 630 teeth. Intraobserver consistency was examined through paired *t* test (0.93). Statistical analyses were performed using the SPSS 15.0 package (SPSS Inc, Chicago, Ill) for Windows.

RESULTS

Table 1 shows the distribution of the girls and boys into different age groups; 450 (47%) were girls and 504 (53%) were boys. Differences between the mean chronological ages and estimated dental ages, according to the Demirjian method, are presented in Table 2 for each group. Both sexes were advanced in dental maturity, when comparing the reference samples for the Central Anatolian population. The mean differences between the chronological and dental ages ranged from 0.2 to 1.2 years in girls and from 0.7 to 3.1 years in boys for Central Anatolian children; the mean differences between the chronological and dental ages for Eastern Anatolian children ranged from 0.03 to 0.77 years in girls and from 0.39 to 2.0 in boys (Table 3). However, Eastern Anatolian children were 0.12 to 0.93 years delayed in dental maturity in the 11- and 14-year-old groups of girls and 0.08 to 0.45 years delayed in the 12- and 13-year-old groups of boys (Table 3).

For Eastern Anatolian children, the differences between the chronological and dental ages were statistically significant in the 7- and 11-year-old groups of girls ($P = 0.00$ and $P = 0.00$, respectively) and in the 7- to 9-year-old groups and the 11-year-old groups of boys ($P = 0.00$, $P = 0.00$, $P = 0.04$, and $P = 0.00$, respectively; Table 2). However, for the Central Anatolian children, the differences between the chronological and dental ages were statistically significant in all groups, except the 9-year-old group of girls and the 9- and 11-year-old groups of boys (for girls: $P = 0.00$, $P = 0.00$, $P = 0.01$, $P = 0.03$, $P = 0.00$, $P = 0.00$, and $P = 0.00$, respectively; for boys: $P = 0.00$, $P = 0.00$, $P = 0.00$, $P = 0.00$, $P = 0.00$, and $P = 0.00$, respectively; Table 2).

Significant dental age differences between Eastern and Central Anatolian children were observed in the 12- to 14-year-old age groups of girls ($P = 0.03$, $P = 0.02$, and $P = 0.01$, respectively) and the 8- and 11-year-old age groups of boys ($P = 0.02$, $P = 0.00$, and $P = 0.00$, respectively; Table 3). The Central Anatolian subjects were approximately 0.2 to 3.0 years advanced in dental maturity than the Eastern Anatolian subjects.

Similar dental maturities were observed between Eastern and Central Anatolian children in the 7- to 11-year-old age groups for girls and in the 7-, 9-, 10-, and 14-year-old groups for boys.

DISCUSSION

Radiographs provide a permanent record, showing a moment in the progressive sequence of dental development. A

TABLE 2. Differences Between Chronological Ages and Dental Ages Determined by Demirjian Method

	Eastern Anatolian Children				Central Anatolian Children			
Age	CA	DA	SD	*P*	CA	DA	SD	*P*
Female								
7–7.9	7.42	8.19	0.3	0.000	7.48	8.35	0.672	0.000
8–8.9	8.30	8.81	1.36	0.061	8.33	9.41	0.34	0.000
9–9.9	9.30	9.48	0.66	0.246	9.23	9.48	1.74	0.462
10–10.9	10.18	10.5	0.99	0.188	10.15	11.08	2.27	0.012
11–11.9	11.23	10.29	1.49	0.001	11.19	11.95	1.8	0.038
12–12.9	12.41	12.44	1.97	0.906	12.43	13.3	1.248	0.000
13–13.9	13.51	13.39	2.45	0.775	13.49	14.77	1.38	0.000
14–14.9	14.48	14.31	2.08	0.668	14.46	15.47	1.25	0.000
Male								
7–7.9	7.47	8.2	0.42	0.000	7.36	8.22	0.67	0.000
8–8.9	8.25	8.76	0.53	0.000	8.27	9.73	1.07	0.000
9–9.9	9.48	10.14	1.54	0.047	9.6	10.31	1.9	0.078
10–10.9	10.23	10.77	1.79	0.138	10.2	11.04	0.94	0.000
11–11.9	11.25	13.25	1.57	0.000	11.19	14.35	14.24	0.29
12–12.9	12.33	12.25	1.98	0.841	12.38	14.56	1.37	0.000
13–13.9	13.27	12.81	1.73	0.141	13.37	14.98	0.91	0.000
14–14.9	14.17	14.57	1.98	0.317	14.26	15.03	0.81	0.000

CA indicates chronological age; DA, dental age.

TABLE 3. Differences Between Central Anatolian Turkish Children and Eastern Anatolian Turkish Children in Dental Maturity

	(DA–CA) Eastern Anatolian Children	SD	(DA–CA) Central Anatolian Children	SD	*P*	(DA–CA) Eastern Anatolian Children	SD	(DA–CA) Central Anatolian Children	SD	*P*
Age	**Female**					**Male**				
7–7.9	0.77	0.87	0.87	0.82	0.66	0.73	0.54	0.85	0.87	0.56
8–8.9	0.51	1.31	1.07	0.40	0.07	0.51	0.59	1.45	1.15	0.00
9–9.9	0.17	0.71	0.24	1.65	0.91	0.65	1.67	0.70	1.87	0.84
10–10.9	0.32	1.04	0.92	2.13	0.33	0.53	1.71	0.83	1.02	0.25
11–11.9	−0.93	1.73	0.75	1.76	0.60	2.00	1.54	3.15	14.27	0.00
12–12.9	0.03	1.81	0.86	1.31	0.03	−0.08	2.01	2.18	1.43	0.00
13–13.9	−0.12	2.26	1.28	1.25	0.02	−0.45	1.63	1.60	1.04	0.00
14–14.9	−0.17	1.83	1.01	1.12	0.01	0.39	1.89	0.77	0.87	0.28

CA indicates chronological age; DA, dental age.

defined scale of maturity between early development and maturity may be mathematically manipulated to relate to chronological age.[18] Several methods have been used for determining dental development.[19,20] One of the principal methods for dental age estimation is the Demirjian 8-stage method. It is among the simplest, most practical, and widely used methods.[21]

Numerous studies have been conducted for other populations, showing a great variability in the dental maturation process. Investigations of several ethnic and geographic groups using Demirjian method have shown some differences in dental formation.[3,4,9,22,23] These studies have suggested that ethnic factors, climate, nutrition, socioeconomic levels, and urbanization are the most effective markers in dental maturity. Therefore, considering the regional differences in a huge country such as Turkey and establishing specific parameters for each region would be extremely valuable. The aim of this study, then, was to assess the applicability of Demirjian method in examining Turkish children living in Eastern Anatolia and Central Anatolia to compare the dental maturity of each to that of the other and to other populations as well.

Although a common finding in reports published on different populations is that the Demirjian method for dental age estimation accurately estimates the dental age of the subjects being examined, some reports[24,25] showed an underestimation of the dental age and others[3,4] reported an overestimation. In the present study, using the Demirjian method for dental age estimation led to an overestimation of the dental development in Central Anatolian children for all age groups. Although we found an overestimation for most of the age groups, we observed underestimation in the 11-, 13-, and 14-year-old age groups of girls and the 12- and 13-year-old age groups in Eastern Anatolian subjects. As a group, Central Anatolian children were dentally advanced by 1.14 years compared with the French Canadian standards. The mean advance in girls was 0.87 years; in boys, it was 1.42 years. The Swedish sample, where the mean difference was greater, agreed with our results.[26] The Swedish boys differed by 0.4 to 1.8 years, and the girls by 0.5 to 1.8 years. However, Eastern Anatolian children were dentally advanced by only 0.29 years compared with the French Canadian standards. The mean advance in girls was 0.06 years; in boys, it was 0.53 years. The differences were statistically significant in all age groups, except in the 9-year-old group for girls and the 9- and 11-year-old groups for boys for the Western Anatolian subjects. However, the differences were statistically significant only in the 7- and 11-year-old age groups of girls and the 7- to 9-year-old age groups and 11-year-old age groups of boys for the Eastern Anatolian subjects. Also, agreeing with our results was that the mean difference for Dutch boys was 0.4 years, and for girls, it was 0.6 years.[27] In the sample of Norwegian children, the mean difference was smaller (0.2 years for boys and 0.3 years for girls).[28]

Hägg and Matsson[19] have suggested that the Demirjian method affords a high degree of reliability and precision, particularly in younger children. However, we found the largest differences between chronological age and dental age in the 7-year-old age group for both Eastern and Central Anatolian children. Similarly, Tunc and Koyuturk[16] assessed the Demirjian method on children living in Northern Turkey and have suggested that the largest discrepancy was observed in the 5- to 6-year-old age group.

The difference between chronological age and dental age in the 11-year-old age group in Eastern Anatolian children and in the 12-year-old age group for children from Western Anatolia was found to be higher than the other age groups for both sexes in the present study. These results agree with another Turkish study.[16] This greater overestimation of the dental age is probably due to the prepubertal or pubertal growth changes pertinent to this age period.[16] Similarly, Rózyło-Kalinowska et al[29] have suggested that the lowest agreement with Demirjian standard was observed in the 6-year-old age group among Polish children.

The Central Anatolian population was dentally advanced compared with the Eastern Anatolian population. The mean advancement was 0.81 years in females and 0.91 years in males. Also, the advancement for Turkish children as a whole group was 0.45 years in girls and 0.87 years in boys. Liversidge et al[24] performed a similar analysis of 2 different populations of British children to find out whether the Demirjian method was applicable to British populations. These authors have suggested that British children, as a whole group, were dentally advanced compared with the French Canadian standards. The mean advancement was 0.50 years in girls and 0.73 years in boys.

The lack of difference between ethnic groups is important. The results of our study are preliminary because of the need to evaluate how climatic factors affect dental maturation within the same ethnic population. Based on our findings, the present study suggests that regional conditions affect dental maturation. However, it is population specificity, which includes genetics, ethnicity, nutrition, disease, socioeconomic status, urbanization, and, very possibly, climate, that will affect dental maturity. Because of these limitations, it is clear that further research and

detailed information to gather data are needed. To create more valuable results, future researchers should gather data in different contexts or in other countries.

REFERENCES

1. Sahin Sağlam AM, Gazilerli U. The relationship between dental and skeletal maturity. *J Orofac Orthop*. 2002;63:454–462.
2. Willems G. A review of the most commonly used dental age estimation techniques. *J Forensic Odontostomatol*. 2001;19:9–17.
3. Koshy S, Tandon S. Dental age assessment: the applicability of Demirjian's method in south Indian children. *Forensic Sci Int*. 1998;94:73–85.
4. Maber M, Liversidge HM, Hector MP. Accuracy of age estimation of radiographic methods using developing teeth. *Forensic Sci Int*. 2006;159(Suppl 1):S68–S73.
5. Cantekin K, Celikoglu M, Miloglu O, et al. Bone age assessment: the applicability of the Greulich-Pyle method in eastern Turkish children. *J Forensic Sci*. 2012;57:679–682.
6. Cantekin K, Yilmaz Y, Demirci T, et al. Morphologic analysis of third-molar mineralization for eastern Turkish children and youth. *J Forensic Sci*. 2012;57:531–534.
7. Celikoglu M, Cantekin K, Ceylan I. Dental age assessment: the applicability of Demirjian method in eastern Turkish children. *J Forensic Sci*. 2011;56(Suppl 1):S220–S222.
8. Miloglu O, Celikoglu M, Dane A, et al. Is the assessment of dental age by the Nolla method valid for eastern Turkish children? *J Forensic Sci*. 2011;56:1025–1028.
9. Eid RM, Simi R, Friggi MN, et al. Assessment of dental maturity of Brazilian children aged 6 to 14 years using Demirjian's method. *Int J Paediatr Dent*. 2002;12:423–428.
10. Reventlid M, Mörnstad H, Teivens AA. Intra- and inter-examiner variations in four dental methods for age estimation of children. *Swed Dent J*. 1996;20:133–139.
11. Haavikko K. The formation and the alveolar and clinical eruption of the permanent teeth. An orthopantomographic study. *Suom Hammaslaak Toim*. 1970;66:103–170.
12. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. *Hum Biol*. 1973;45:211–227.
13. Gustafson G, Koch G. Age estimation up to 16 years of age based on dental development. *Odontol Revy*. 1974;25:297–306.
14. Demirjian A, Goldstein H. New systems for dental maturity based on seven and four teeth. *Ann Hum Biol*. 1976;3:411–421.
15. Nolla CM. The development of permanent teeth. *J Dent Child*. 1960;27:254–266.
16. Tunc ES, Koyuturk AE. Dental age assessment using Demirjian's method on northern Turkish children. *Forensic Sci Int*. 2008;175:23–26.
17. Emsen IM. The approach to frostbite in Turkey: a retrospective study. *Can J Plast Surg*. 2006;14:21–23.
18. Demirjian A. Dental development: index of physiologic maturation. *Med Hyg (Geneve)*. 1978;36:3154–3159.
19. Hägg U, Matsson L. Dental maturity as an indicator of chronological age: the accuracy and precision of three methods. *Eur J Orthod*. 1985;7:25–34.
20. Jaffe EC, Roberts GJ, Cahntler C, et al. Dental maturity in children with chronic renal failure assessed from dental panoramic tomographs. *J Int Assoc Dent Child*. 1990;20:54–58.
21. Garamendi PM, Landa MI, Ballesteros J, et al. 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;154:3–12.
22. Chertkow S. Tooth mineralization as an indicator of the pubertal growth spurt. *Am J Orthod*. 1980;77:79–91.
23. Davis PJ, Hägg U. The accuracy and precision of the "Demirjian system" when used for age determination in Chinese children. *Swed Dent J*. 1994;18:113–116.
24. Liversidge HM, Speechly T, Hector MP. Dental maturation in British children: are Demirjian's standards applicable? *Int J Paediatr Dent*. 1999;9:263–269.
25. Mitchell JC, Roberts GJ, Donaldson AN, et al. Dental age assessment (DAA): reference data for British Caucasians at the 16 year threshold. *Forensic Sci Int*. 2009;189:19–23.
26. Mörnstad H, Reventlid M, Teivens A. The validity of four methods for age determination by teeth in Swedish children: a multicentre study. *Swed Dent J*. 1995;19:121–130.
27. Leurs IH, Wattel E, Aartman IH, et al. Dental age in Dutch children. *Eur J Orthod*. 2005;27:309–314.
28. Nykänen R, Espeland L, Kvaal SI, et al. Validity of the Demirjian method for dental age estimation when applied to Norwegian children. *Acta Odontol Scand*. 1998;56:238–244.
29. Rózyło-Kalinowska I, Kiworkowa-Raczkowska E, Kalinowski P. Dental age in Central Poland. *Forensic Sci Int*. 2008;174:207–216.