European Journal of Orthodontics 34 (2012) 77–82
doi:10.1093/ejo/cjq161
Advance Access Publication 6 December 2010

Dental age table for a sample of Pakistani children

Rashna H. Sukhia*, Mubassar Fida* and Syed Iqbal Azam**
Departments of *Surgery and **Community Health Sciences, The Aga Khan University Hospital, Karachi, Pakistan

Correspondence to: Dr Mubassar Fida, Orthodontics, Section of Dentistry, Department of Surgery, The Aga Khan University Hospital, PO Box 3500, Stadium Road, Karachi 74800, Pakistan. E-mail: mubassar.fida@aku.edu

SUMMARY The aim of this study was to evaluate the applicability of Demirjian's dental age assessment table in a sample of Southern Pakistani population and, if not applicable, to formulate a separate dental age table for Pakistani males and females. The study was conducted on the dental pantomographs of a sample size of 882 subjects (427 males and 455 females) ranging in age from 7 to 14 years. A paired *t*-test was used to assess any difference between chronological age and dental age assessed according to Demirjian's method. Logit function was used to make the relationship between dental maturity and chronological age and linear regression analysis with the equation $X = [\text{Ln}\{y/100 - y\} - a]/b$ was used to generate dental age tables for Pakistani males and females. Dental age assessed according to Demirjian's method for this male sample was over-predicted in the 7 year and 11–15 year age group ($P < 0.05$). In the female sample, there was an over-prediction in all the age groups ($P < 0.05$). Statistically significant differences were found in chronological and dental age assessed by Demirjian's method for Pakistani males and females and thus, a new table was generated to convert dental maturity calculated according to Demirjian's method into dental age for the population.

Introduction

Assessing a patient's dental age among various other maturity indicators is one of the most important aspects in orthodontic diagnosis especially for planning and initiation of fixed appliance orthodontic therapy. The importance of dental age has been emphasized in forensic dentistry. Dental age has been defined in the literature as 'subject's estimated age based on the level of tooth mineralization during the developmental process or on the eruption stage' (Gustafson and Koch, 1974). Dental age can be assessed by either the stage of tooth eruption or the stage of tooth formation (Basaran *et al.*, 2007). The moment the tooth pierces the gingiva/keratinized mucosa has been described as the time of eruption (Filipsson, 1975). This, however, is a discontinuous process and may not occur during the ages of 2.5–6, 8–0, and 13–18 years (Leurs *et al.*, 2005). Tooth formation on the other hand is proposed as a more reliable criterion for determining the dental age (Demirjian, 1978; Leurs *et al.*, 2005). The reason being that tooth eruption may be influenced by various factors, such as premature loss or prolonged retention of primary teeth, malpositioned, and ankylosed teeth (Sierra, 1987).

Other methods for dental age assessment were based on the radiographic assessment of the length of the tooth crown and root (Gleiser and Hunt, 1955). These methods were again not completely reliable as estimating that the root is half formed is difficult if the final length of the root is not correctly foreseen (Leurs *et al.*, 2005).

Tooth mineralization begins with initial cusp formation and continues till formation of the root apex. The mineralization of permanent teeth (generally assessed radiographically) has been studied by a number of researchers (Nolla, 1960; Demirjian *et al.*, 1973). As panoramic radiographs may be a part of a dental examination, information regarding radiographic assessment of mineralization of teeth may be available in clinical practice. Dental age assessment based on tooth calcification visible on a radiograph was described by Demirjian *et al.* (1973). This method was based on an objective criterion and therefore was more reliable (Leurs *et al.*, 2005). This method however was formulated on French–Canadian standards. Various researchers have tested the applicability of this method in their populations. Varying results have been reported with some showing applicability of the standards in their populations (Farah *et al.*, 1999; Hegde and Sood, 2002; Liversidge *et al.*, 2006). While others have reported significant differences among their population and the French–Canadian standards (Davis and Hagg, 1994; Leurs *et al.*, 2005; Al-Emran, 2008), thus indicating the need for formulation of separate dental age tables by 'ethnicity'.

The aim of this study was to evaluate the applicability of the dental age assessment table described by Demirjian *et al.* (1973) in a sample of the Pakistani population and, if not applicable, to formulate a separate dental age table for Pakistani boys and girls. The clinical implication of this study is that in patients with delayed dental maturity, orthodontic treatment may be started at a later stage, thus leading to shorter treatment duration and a more stable result.

Materials and methods

The present study is a cross-sectional study conducted on dental pantomographs (DPT) of 882 subjects. The sample constituted of 427 males and 455 females with a mean chronological age of 10.93 ± 2.31 years for our male sample and 11.00 ± 2.21 years for our female sample. Digital DPTs from the radiology department and the digital pre-treatment DPTs of subjects visiting the orthodontic clinic were included in the study. Pakistani subjects aged 7–14.99 years with no prior orthodontic treatment history and good quality DPTs were included. The entire sample was divided into various groups with the distribution based on their chronological age (e.g. age group 1 including subjects from 7 to 7.99 years, age group 2 including subjects from 8 to 8.99 years, and so on). Subjects with craniofacial syndromes and missing teeth other than third molars were excluded.

DPTs were assessed in a darkened room with a radiographic illuminator to ensure contrast enhancement of the bone and tooth images (Uysal *et al.*, 2004). Teeth from the central incisor to the second molar, in the mandibular left quadrant, on a DPT were analysed and assigned stages from A–H according to Demirjian's dental age assessment method (Figure 1). These individual stages were later converted into maturity scores based on separate tables for boys and girls. These maturity scores were summed to achieve a total maturity score, which is converted into dental age based on separate male and female tables (Demirjian *et al.*, 1973). In order to avoid the examiner bias at the time of collecting data, chronological age was first recorded on a data collection sheet and the dental age scores were tabulated later on a separate sheet.

The Statistical Package for Social Sciences, Windows Version 16 (SPSS Inc., Chicago, Illinois, USA) was used to analyse the data. A paired *t*-test was used to assess any significant difference between chronological age of an individual (assessed in years and months from the date of birth) and dental age (assessed from Demirjian's system). As dental maturity assessed using Demirjian's method and chronological age showed a curvilinear relation on a scatter plot (Figure 2), therefore, logit transformation $\mathrm{Ln}\{y/100 - y\}$ was performed to make the relationship linear (Figure 3), where 'y' is the dental maturity. Linear regression analysis was applied between the transformed dental maturity and chronological age separately for males and females to generate prediction tables of dental age for Pakistani population. A P value less than 0.05 was considered to be significant.

Intra-examiner reliability was assessed by the principal examiner 1 month after the initial examination for dental age using Bland–Altman Technique (Bland and Altman, 1986). A paired *t*-test was used for males and females separately in order to observe that the mean difference was significantly different from zero or not?

Results

The mean dental age assessed according to Demirjian's method for the male sample was 11.52 ± 2.87 years and for the female sample 11.86 ± 2.67 years. Figure 4 shows the chronological age distribution of males and females for the separate age groups.

Tables 1 and 2 show the results of the paired *t*-test for males and females, respectively. Dental age assessed

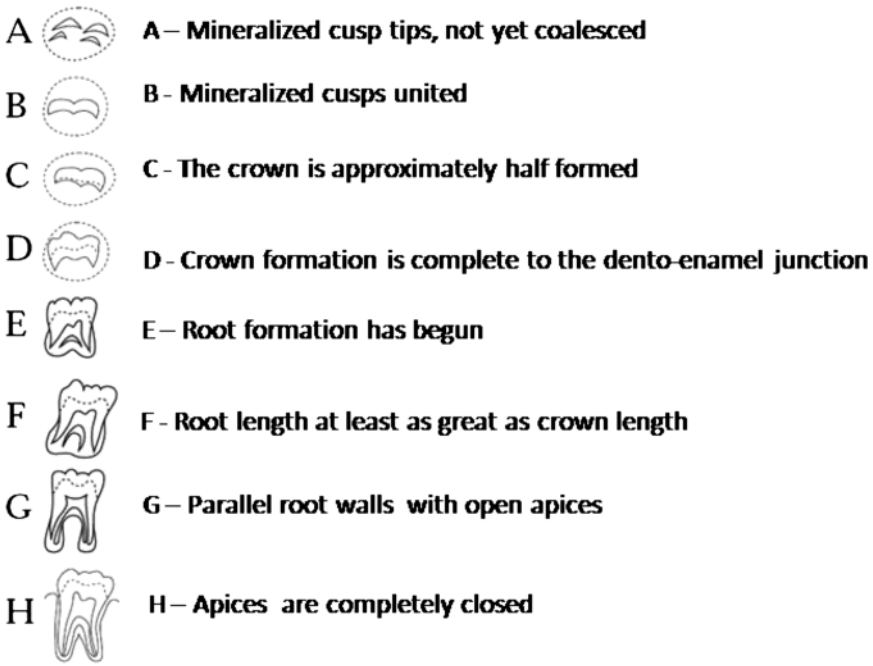

Figure 1 Dental maturity stages for dental age assessment using Demirjian's method.

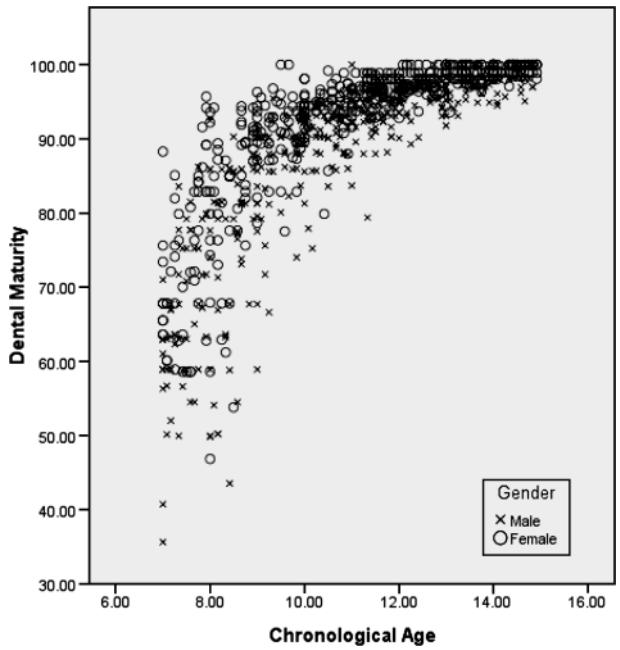

Figure 2 Scatter plot between dental maturity and chronological age.

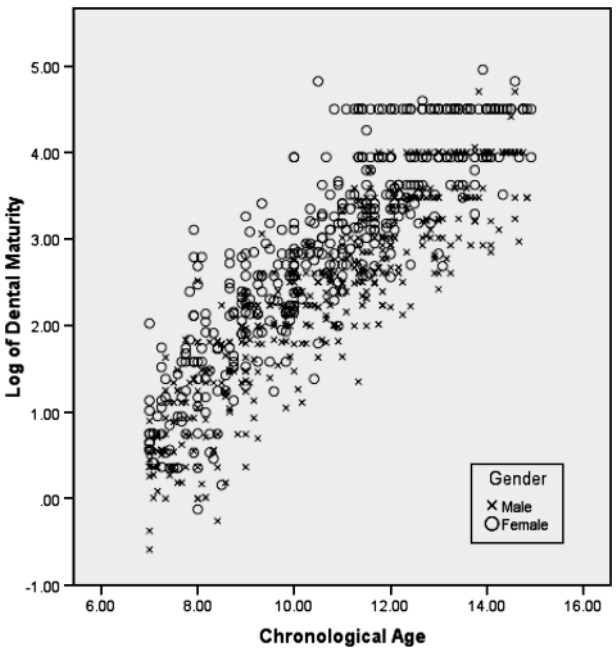

Figure 3 Scatter plot between log of dental maturity and chronological age.

according to Demirjian's method for the male sample was significantly over-predicted in the 7 year and 11–14 year age groups. For the female sample, dental age was significantly over-predicted in all age groups. The mean difference ranged from −1.17 to −0.12 for the male sample and from −1.14 to −0.02 for the female sample.

To overcome this difference in dental age assessment using Demirjian's method for the sample, a dental age table was formulated using logit function regression with the equation

$$X = [\mathrm{Ln}\{y/100 - y\} - a]/b,$$

where 'y' = dental maturity, 'X' = chronological age, 'a' = constant, and 'b' = intercept.

Linear regression was used to get the values for 'a' and 'b' for the male and female sample with logit function used as an outcome variable. Thus, the equation for the male sample was

$$X = [\mathrm{Ln}\{y/100 - y\} - (-2.591)]/0.459,$$

and for the female sample was

$$X = [\mathrm{Ln}\{y/100 - y\} - (-2.591)]/0.489.$$

Tables 3 and 4 show the dental age tables formulated for the males and females using the above equations.

Bland–Altman Technique (Bland and Altman, 1986) was used to assess the intra-examiner reliability for the dental age assessment method after 1 month of the principal examination by randomly selecting 80 cases (34 males and 46 females), and a good reliability (P = 0.368 for the male sample and P = 0.161 for the female sample) was seen among the two sets of readings for dental age. The paired t-test showed a mean difference of −0.007 years (95 per cent confidence interval for the difference of −0.024 to 0.009 years) for the male sample and a mean difference of 0.012 years (95 per cent confidence interval for the difference of −0.005 to 0.029 years) for the female sample, which again confirms good intra-examiner reliability for dental maturity assessed using Demirjian's method.

Discussion

Demirjian's method of dental age assessment has been widely used by many researchers for various fields of orthodontic research (Uysal *et al.*, 2004; Jamroz *et al.*, 2006). However, Demirjian's method was formulated using French–Canadian standards and thus may vary in different populations. Numerous studies have been conducted to determine the applicability of Demirjian's method in a particular population (Farah *et al.*, 1999; Frucht *et al.*, 2000; Eid *et al.*, 2002; Hegde and Sood, 2002) with varying results. Some show good concordance (Farah *et al.*, 1999; Hegde and Sood, 2002) for their population and some depict contrasting results with the need to formulate a separate dental age table for their population (Leurs *et al.*, 2005; Al-Emran, 2008).

For the same reason, the applicability of Demirjian's dental age assessment method was studied for the population in the present study and the results revealed a significantly advanced dental age for Pakistani males and females, thus confirming a need to generate a dental age table for Pakistani males and females.

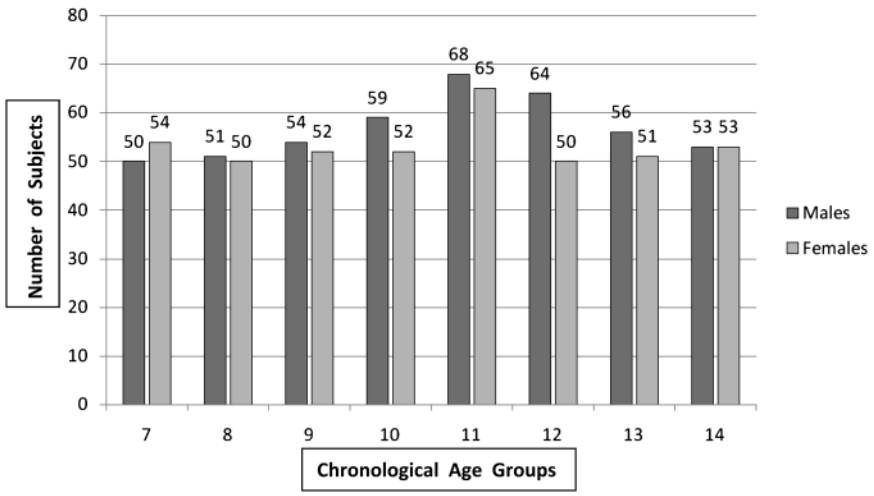

Figure 4 Distribution of subjects according to chronological age.

Table 1 Difference between chronological and dental age assessed according to Demirjian's method for boys.

Age group	Age range	Mean chronological age (SD)	Mean dental age (SD)	Mean difference	*P* value
1 (*n* = 54)	7.00–7.99	7.39 (0.30)	7.85 (0.53)	−0.46	***
2 (*n* = 50)	8.00–8.99	8.41 (0.28)	8.53 (0.87)	−0.12	0.344
3 (*n* = 52)	9.00–9.99	9.38 (0.33)	9.59 (1.01)	−0.21	0.113
4 (*n* = 52)	10.00–10.99	10.43 (0.30)	10.55 (1.03)	−0.12	0.401
5 (*n* = 65)	11.00–11.99	11.48 (0.28)	12.07 (1.55)	−0.59	**
6 (*n* = 50)	12.00–12.99	12.44 (0.33)	13.48 (1.51)	−1.04	***
7 (*n* = 51)	13.00–13.99	13.42 (0.32)	14.59 (1.46)	−1.17	***
8 (*n* = 53)	14.00–14.99	14.43 (0.29)	15.45 (0.99)	−1.02	***

N = 427 males, paired *t*-test.
**$P < 0.05$, ***$P \leq 0.001$.

Table 2 Difference between chronological and dental age assessed according to Demirjian's method for girls.

Age group	Age range	Mean chronological age (SD)	Mean dental age (SD)	Mean difference	*P* value
1 (*n* = 50)	7.00–7.99	7.45 (0.33)	8.09 (0.90)	−0.64	***
2 (*n* = 51)	8.00–8.99	8.43 (0.32)	8.75 (0.07)	−0.32	**
3 (*n* = 54)	9.00–9.99	9.45 (0.32)	10.18 (1.55)	−0.73	***
4 (*n* = 59)	10.00–10.99	10.41 (0.34)	11.22 (1.36)	−0.81	***
5 (*n* = 68)	11.00–11.99	11.42 (0.27)	12.44 (1.31)	−0.02	***
6 (*n* = 64)	12.00–12.99	12.37 (0.29)	13.48 (1.36)	−1.11	***
7 (*n* = 56)	13.00–13.99	13.36 (0.28)	14.50 (1.29)	−1.14	***
8 (*n* = 53)	14.00–14.99	14.41 (0.32)	15.14 (0.92)	−0.74	***

N = 455 females, paired *t*-test.
**$P < 0.05$, ***$P \leq 0.001$.

An overestimation of dental age assessed according to Demirjian's method has been reported by various populations (Hegde and Sood, 2002; Leurs *et al.*, 2005). Hegde and Sood (2002) in their study reported an overestimation of 0.14 years for their male sample and 0.04 years for their female sample. They however concluded that the Demirjian's system showed high accuracy when applied to Belgaum children. In the present study, the mean difference between chronological age and dental age assessed according to Demirjian's method was −0.59 years for the male sample and −0.83 years for the female sample. This difference showed a statistically significant over-prediction of dental age for the study sample and thus required the generation of a dental age table for Pakistani boys and girls.

Leurs *et al.* (2005) reported an overestimation of 0.4 and 0.6 years for Dutch boys and girls, respectively. They also reported this difference to be statistically significant and

Table 3 Dental age table for Pakistani male sample.

Dental age	Dental maturity	Dental age	Dental maturity
7	65.07	11	92.11
7.1	66.10	11.1	92.44
7.2	67.12	11.2	92.76
7.3	68.13	11.3	93.06
7.4	69.12	11.4	93.35
7.5	70.09	11.5	93.63
7.6	71.04	11.6	93.90
7.7	71.98	11.7	94.15
7.8	72.89	11.8	94.40
7.9	73.79	11.9	94.64
8	74.67	12	94.87
8.1	75.53	12.1	95.09
8.2	76.37	12.2	95.30
8.3	77.18	12.3	95.50
8.4	77.98	12.4	95.69
8.5	78.76	12.5	95.88
8.6	79.52	12.6	96.05
8.7	80.25	12.7	96.23
8.8	80.97	12.8	96.39
8.9	81.67	12.9	96.54
9	82.35	13	96.69
9.1	83.00	13.1	96.84
9.2	83.64	13.2	96.98
9.3	84.26	13.3	97.11
9.4	84.86	13.4	97.23
9.5	85.44	13.5	97.35
9.6	86.00	13.6	97.47
9.7	86.54	13.7	97.58
9.8	87.07	13.8	97.69
9.9	87.58	13.9	97.79
10	88.07	14	97.89
10.1	88.54	14.1	97.98
10.2	89.00	14.2	98.07
10.3	89.44	14.3	98.15
10.4	89.87	14.4	98.23
10.5	90.28	14.5	98.31
10.6	90.67	14.6	98.39
10.7	91.05	14.7	98.46
10.8	91.42	14.8	98.53
10.9	91.77	14.9	98.59

Table 4 Dental age table for Pakistani female sample.

Dental age	Dental maturity	Dental age	Dental maturity
7	74.84	11	95.46
7.1	75.75	11.1	95.67
7.2	76.63	11.2	95.87
7.3	77.50	11.3	96.06
7.4	78.34	11.4	96.24
7.5	79.16	11.5	96.41
7.6	79.95	11.6	96.58
7.7	80.73	11.7	96.73
7.8	81.48	11.8	96.88
7.9	82.20	11.9	97.03
8	82.91	12	97.17
8.1	83.59	12.1	97.30
8.2	84.25	12.2	97.42
8.3	84.89	12.3	97.54
8.4	85.50	12.4	97.66
8.5	86.10	12.5	97.77
8.6	86.67	12.6	97.87
8.7	87.23	12.7	97.97
8.8	87.76	12.8	98.07
8.9	88.28	12.9	98.16
9	88.78	13	98.24
9.1	89.25	13.1	98.33
9.2	89.71	13.2	98.40
9.3	90.16	13.3	98.48
9.4	90.58	13.4	98.55
9.5	90.99	13.5	98.62
9.6	91.38	13.6	98.68
9.7	91.76	13.7	98.75
9.8	92.12	13.8	98.81
9.9	92.47	13.9	98.86
10	92.80	14	98.92
10.1	93.12	14.1	98.97
10.2	93.43	14.2	99.02
10.3	93.72	14.3	99.06
10.4	94.01	14.4	99.11
10.5	94.28	14.5	99.15
10.6	94.53	14.6	99.19
10.7	94.78	14.7	99.23
10.8	95.02	14.8	99.26
10.9	95.24	14.9	99.30

hence a need for a separate dental age table for their population. In a Norwegian study by Nykanen *et al.* (1998), a difference of 0.2 years for boys and 0.3 years for girls was reported.

Girls have been reported to mature earlier than boys (Hagg and Taranger, 1980). A similar trend has also been shown for dental development (Zhao *et al.*, 1990; Al-Emran, 2008). Al-Emran (2008) in his study found girls to have an advanced dental age as compared with boys for all age groups. In this study, girls were seen to have an advanced dental age as compared with boys between 7 and 11 year age groups.

The mean difference between the chronological age and dental age ranged from 1.17 to 0.12 years for the male sample and from 1.14 to 0.02 years for the female sample. Nystrom *et al.* (1986) reported a difference of 0.45–0.7 years for Finnish boys and 0.35–0.9 years for girls. In a study by Mornstad *et al.* (1995), the mean difference ranged between 0.4 and 1.8 years for Swedish males and 0.5 and 1.8 years for their female sample.

Demirjian and Goldstein (1976) also formulated a scoring system based on four teeth to be applied to subjects with missing teeth. However, in the present study, subjects with tooth agenesis other than the third molar were excluded to have a more precise estimation of dental age. Demirjian and Goldstein's (1976) system based on four teeth can also be used to check its applicability on different populations.

As the present research was retrospective and based on data collected from the digital DPT records, data below 7 years of age could not be included as the sample was limited in this age range. This was a limitation of the study and it is recommended that the applicability of Demirjian's method should also be checked for children below 7 years of age. The validity of stage H in the Demirjian's method is

also questionable as it is not bound by an upper limit. This is a limitation of this method of dental age assessment.

Conclusions

- Statistically significant differences were found in the chronological age and dental age assessed by Demirjian's method for the Pakistani sample.
- Dental age was significantly over-predicted in the 7 year and 11–14 year age groups in males and for females in all age groups.
- A new dental age table was generated for males and females to convert dental maturity calculated according to Demirjian's method into dental age for this sample.
- Like other studies, the relationship between dental maturity and chronological age was non-linear and logit transformation of dental maturity was used to convert it into linear.

References

Al-Emran S 2008 Dental age assessment of 8.5 to 17 Year-old Saudi children using Demirjian's method. Journal of Contemporary Dental Practice 9: 64–71

Basaran G, Ozer T, Hamamci N 2007 Cervical vertebral and dental maturity in Turkish subjects. American Journal of Orthodontics and Dentofacial Orthopedics 131: 447 e413–447 e420

Bland J M, Altman D G 1986 Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1: 307–310

Davis P J, Hagg U 1994 The accuracy and precision of the "Demirjian system" when used for age determination in Chinese children. Swedish Dental Journal 18: 113–116

Demirjian A, Goldstein H, Tanner J M 1973 A new system of dental age assessment. Human Biology; An International Record of Research 45: 211–227

Demirjian A, Goldstein H 1976 New systems for dental maturity based on seven and four teeth. Annals of Human Biology 3: 411–421

Demirjian A 1978 Dentition. In: Falkner F, Tanner J M (eds). Human growth, Vol. II, postnatal growth. Plenum Press, New York, pp. 413–444

Eid R M, Simi R, Friggi M N, Fisberg M 2002 Assessment of dental maturity of Brazilian children aged 6 to 14 years using Demirjian's method. International Journal of Paediatric Dentistry 12: 423–428

Farah C S, Booth D R, Knott S C 1999 Dental maturity of children in Perth, Western Australia, and its application in forensic age estimation. Journal of Clinical Forensic Medicine 6: 14–18

Filipsson R 1975 A new method for assessment of dental maturity using the individual curve of number of erupted permanent teeth. Annals of Human Biology 2: 13–24

Frucht S, Schnegelsberg C, Schulte-Monting J, Rose E, Jonas I 2000 Dental age in southwest Germany. A radiographic study. Journal of Orofacial Orthopedics 61: 318–329

Gleiser I, Hunt E E Jr 1955 The permanent mandibular first molar: its calcification, eruption and decay. American Journal of Physical Anthropology 13: 253–283

Gustafson G, Koch G 1974 Age estimation up to 16 years of age based on dental development. Odontologisk Revy 25: 297–306

Hagg U, Taranger J 1980 Skeletal stages of the hand and wrist as indicators of the pubertal growth spurt. Acta Odontologica Scandinavica 38: 187–200

Hegde R J, Sood P B 2002 Dental maturity as an indicator of chronological age: radiographic evaluation of dental age in 6 to 13 years children of Belgaum using Demirjian methods. Journal of the Indian Society of Pedodontics and Preventive Dentistry 20: 132–138

Jamroz G M, Kuijpers-Jagtman A M, van't Hof M A, Katsaros C 2006 Dental maturation in short and long facial types. Is there a difference? Angle Orthodontist 76: 768–772

Leurs I H, Wattel E, Aartman I H, Etty E, Prahl-Andersen B 2005 Dental age in Dutch children. European Journal of Orthodontics 27: 309–314

Liversidge H M *et al.* 2006 Timing of Demirjian's tooth formation stages. Annals of Human Biology 33: 454–470

Mornstad H, Reventlid M, Teivens A 1995 The validity of four methods for age determination by teeth in Swedish children: a multicentre study. Swedish Dental Journal 19: 121–130

Nolla C M 1960 The development of the permanent teeth. Journal of Dentistry for Children 27: 254–263

Nykanen R, Espeland L, Kvaal S I, Krogstad O 1998 Validity of the Demirjian method for dental age estimation when applied to Norwegian children. Acta odontologica Scandinavica 56: 238–244

Nystrom M, Haataja J, Kataja M, Evalahti M, Peck L, Kleemola-Kujala E 1986 Dental maturity in Finnish children, estimated from the development of seven permanent mandibular teeth. Acta odontologica Scandinavica 44: 193–198

Sierra A M 1987 Assessment of dental and skeletal maturity. A new approach. Angle Orthodontist 57: 194–208

Uysal T, Sari Z, Ramoglu S I, Basciftci F A 2004 Relationships between dental and skeletal maturity in Turkish subjects. Angle Orthodontist 74: 657–664

Zhao J, Ding L, Li R 1990 [Study of dental maturity in children aged 3-16 years in Chengdu]. Hua Xi Yi Ke Da Xue Xue Bao 21: 242–246