



ORIGINAL ARTICLE

Dental age estimation of Omani children using Demirjian's method

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Abstract Dental age plays a significant role in forensic dentistry, orthodontics and paediatric dentistry, as well as in general diagnosis and treatment planning. Different methods have been developed to determine dental age. One of the most commonly used methods is Demirjian's method, which was developed in 1973 from research on a large number of French-Canadian children. It is based on the degree of tooth mineralisation by examining the radiological appearance of the lower mandibular left quadrant. The purpose of this study was to assess the dental age of Omani children using Demirjian's method and evaluate the applicability of the method in dental age estimation for Omani children. The sample consisted of 485 digital panoramic radiographs of children (264 males, 221 females) aged between 4.6 years and 16.5 years, and obtained from the records of the Military Dental Centre in Oman. The data were analysed using SPSS. Paired *t*-tests, intraclass correlation coefficients (ICC) and difference-against-mean plots were used to compare the dental age calculated by Demirjian's method with chronological age. A single examiner scored the radiographs, and intra-observer reliability was evaluated using Cronbach's alpha on data from rescoring one out of every 20 radiographs. For boys, the mean difference between chronological age and dental age for all age groups was 0.10 (95% CI –0.03 to 0.24). For girls, the mean difference between chronological age and dental age for all age groups was 0.05 (95% CI –0.11 to 0.22). Difference-against-mean plots showed no evidence of differential bias by age. For boys, the ICC was 0.896 (95% CI 0.869–0.917); for girls, it was 0.886 (95% CI 0.854–0.911). Difference-against-mean plots for boys (Fig. 1) and girls (Fig. 2) showed some evidence of differential bias by age. In conclusion, the extent of the observed differences was sufficient for doubt to be cast upon the utility of Demirjian's method for Oman, particularly when it is considered that the method's most likely application would be in age determination for minors in the workforce.

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1. Introduction

The demand for age estimation in forensic science has increased. A plethora of disasters has resulted in an increase in the number of unidentified human remains, and that has underlined the need for accurate methods for age estimation. Moreover, the current geopolitical status of the world has resulted in a rise in the cases of children with no proof-of-identity documents such as a certificate of birth (Ritz-Timme et al., 2000). Different methods have been developed to estimate age; these include using skeletal age, morphological age, secondary sex characteristics age and dental age (Patnana et al., 2014). Of these methods, the latter is seen as the most valid method for age estimation (Bolanos et al., 2000). This is because teeth exhibit the least turnover of all body tissues, and their development is controlled by genes and is thus less susceptible to environmental influences (Panchbhai, 2011). Dental age is also used by orthodontists and paedodontists (Chen et al., 2010). It also helps to identify paediatric hormonal disturbances such as hyposecretion of growth hormones (Vallejo-Bolaños et al., 1999). Moreover, it provides orthodontists with clues to the appropriate time for initiating orthodontic treatment (Nik-Hussein et al., 2011).

One of the commonly used methods for calculation of dental age is Demirjian's method (Panchbhai, 2011), which uses the radiographic appearance of the seven mandibular teeth on the left side. Each tooth is allocated an ordinal code between A and H, according to the criteria published in Demirjian's article, and then this is converted to a score. The seven scores are summed to give a maturity score that can then be converted to an age, using sex-specific tables originally constructed using a large sample of French-Canadian children (Demirjian et al., 1973). The clinical interpretation of age assessment indicates whether the child is dentally advanced, average or delayed relative to the reference value from Demirjian's original French-Canadian sample (Liversidge, 2012). A recent systematic review (Jayaraman et al., 2013) found that using the Demirjian approach tended to over-estimate children's ages.

Dental age assessment has been undertaken for populations such as New Zealand children (TeMoananui et al., 2008), Malaysian children (Nik-Hussein et al., 2011), Chinese children (Chen et al., 2010), Indian children (Warhekar et al., 2011), Turkish children (Tunc and Koyuturk, 2008), Romanian children (Ogodescu et al., 2011), Saudi children (Al-Emran, 2008), and, Emirati children (Altalie et al., 2014). However, there are no published data from dental age assessments of Omani children. Oman has a unique population consisting mostly of Arabs, but also including Balochis, Lawatis, Swahili and Persians (Peterson, 2004). Oman, as with many other countries, has recently become more aware of the significance of age assessment practices. The legal age in Oman is considered to be eighteen and anyone younger than eighteen is considered to be a minor. The laws and penal codes in Oman that are associated with children are set at certain age thresholds. Examples of those are the Oman labour law, the child abduction penal code and the human trafficking law. The Oman labour law specifies the minimum age for employment to be fifteen years. Courts in Oman require medical practitioners to assess the age of the individual when his/her age is unknown (Smith and Brownlees, 2011). Custodial and fine

penalties are greater when the victim is a minor in cases of human trafficking and abduction (Bureau of International Labor Affairs, 2006). Accordingly, it is important to have a reference dataset specific to use for the age assessment of Omani children. Accordingly, the aim of the study was to evaluate the applicability of Demirjian's method for dental age estimation in Omani children.

2. Materials and methods

This cross-sectional study was conducted at the Military Dental Centre in Oman. Ethical approval was obtained from the Omani Ethics Committee. The data were observed from 485 panoramic radiographs of 264 males and 221 females, ranging in age from 4.6 to 16.5 years (Table 1).

The radiographs were taken directly from the Digora™ radiograph database at the Military Dental Centre and saved as JPEG images. Windows Live Photo Gallery was used to view the radiographs and adjust the size, contrast and brightness for better quality. The radiographs were excluded in cases of radiographic distortion affecting the staging of the left mandibular teeth, dental developmental abnormalities, gross pathology or significant medical history that has a direct influence on teeth development (such as a history of treatment for childhood leukaemia). A single examiner collected and assessed the radiographs. The date of birth and the date on which the radiograph was taken were used to calculate the chronological age. Age and sex were unknown to the examiner at the time of radiograph assessment using Demirjian's method.

The seven left mandibular permanent teeth were staged (A-H) using Demirjian's criteria, rated in the order of the second molar (M2), first molar (M1), second premolar (PM2), first premolar (PM1), canine (C), lateral incisor (I2) and central incisor (I1). Stages (A-H) represent the degree of mineralisation of the tooth from the beginning of calcification through to final mature form; each of these stages of mineralization is given a score which provides an estimate of dental maturity on a scale of 0–100 on percentile charts. Each stage was then converted to a score which was then summed to give a total maturity score; that was then converted directly into a dental age as per the standard tables given by Demirjian.

Table 1 Age group by sex.

Age group	Boys	Girls	Both (%)
4.6–5.5	0	2	2 (0.4)
5.6–6.5	8	2	10 (2.1)
6.6–7.5	9	5	14 (2.9)
7.6–8.5	28	32	60 (12.4)
8.6–9.5	39	32	71 (14.6)
9.6–10.5	38	27	65 (13.4)
10.6–11.5	33	24	57 (11.8)
11.6–12.5	30	25	55 (11.3)
12.6–13.5	29	15	44 (9.1)
13.6–14.5	26	18	44 (9.1)
14.6–15.5	13	22	35 (7.2)
15.6–16.5	11	17	28 (5.8)
Total	264 (54.4%)	221 (46.6%)	485 (100.0)

The Statistical Package for the Social Sciences (SPSS version 21) software was used to analyse the data. The mean differences between the chronological ages and dental ages for each sex and age group were calculated. Paired *t*-tests were used to examine the differences between the chronological age and the dental age calculated using Demirjian's method. Difference-against-mean plots (Bland and Altman, 1986) were used to determine the extent and direction of any possible bias. The latter were obtained by subtracting the actual chronological age from the Demirjian method estimate, and then plotting that value against the mean of the two. This enabled visual determination of the extent of any systematic bias between the two, with the chronological age used as the "gold standard".

Cronbach's alpha was used to evaluate intra-examiner reliability (Tavakol and Dennick, 2011). One out of every 20 radiographs (24 radiographs) was re-scored two weeks after the initial staging. For the reliability analysis, the intraclass correlation coefficient (ICC) was calculated. The Cronbach's alpha value for the two sets of measurements was 0.99 (95% CI 0.58–1.4), and the ICC was 0.98 (95% CI 0.96–0.99).

3. Results

Table 2 shows the mean chronological age, mean dental age and the mean difference between the dental age and chronological age in girls and boys. For boys, the mean difference between chronological age and dental age for all age groups was 0.10 (95% CI: -0.03 to 0.24), with the maximum mean difference of 1.00 in the age group 6.6–7.5. For girls, the mean difference between chronological age and dental age for all age

groups was 0.05 (95% CI: -0.11 to 0.22). The maximum mean difference was -1.13, seen in the age group 15.6–16.5. Overall, the mean difference between chronological age and dental age for both sexes was 0.083, with a 95% confidence interval of -0.02 to 0.19 ($P = 0.12$). Similarly, the differences between the chronological age and dental age in boys and girls were not statistically significant ($P = 0.13$ and 0.49 , respectively).

For boys, the mean difference between chronological age and dental age for all age groups was 0.10 (95% CI: -0.03 to 0.24). For girls, the mean difference between chronological age and dental age for all age groups was 0.05 (95% CI: -0.11 to 0.22). For boys, the ICC was 0.896 (95% CI: 0.869–0.917); for girls, it was 0.886 (95% CI: 0.854–0.911).

Difference-against-mean plots for boys (Fig. 1) and girls (Fig. 2) showed some evidence of differential bias by age. This was more marked for girls, for whom there was considerable divergence apparent at the youngest and oldest ends of the age range. Around the minimum employment age of 15, the difference in estimated age represented an under-estimation by some 8 months, while it was an over-estimation by 6–12 months in the five youngest age groups for girls. For boys, there was marked over-estimation in the three youngest age groups, and an 8-month under-estimation in the oldest age group.

4. Discussion

The aim of this study was to assess the dental age of Omani children using Demirjian's method and to evaluate the method's applicability for dental age estimation in that group. The findings showed a very strong correlation between the chronological age and dental age, in both sexes, but the extent

Table 2 Difference between chronological ages and dental ages calculated using Demirjian's method, by sex.

Age group	Sample size	Mean chronological age CA (SD)	Mean dental age DA (SD)	Mean difference DA-CA (SD)	95% CI
<i>Boys</i>					
4.6–5.5	0	–	–	–	–
5.6–6.5	8	6.38 (0.18)	7.14 (0.66)	0.76 (0.52)	0.43–1.11
6.6–7.5	9	7.19 (0.29)	8.19 (0.51)	1.00 (0.57)	0.68–1.34
7.6–8.5	28	8.10 (0.29)	8.68 (0.74)	0.58 (0.68)	0.36–0.83
8.6–9.5	39	9.10 (0.23)	9.13 (0.75)	0.04 (0.69)	-0.18 to 0.23
9.6–10.5	38	10.04 (0.25)	10.31 (1.10)	0.27 (1.16)	-0.06 to 0.60
10.6–11.5	33	11.10 (0.28)	10.91 (1.23)	-0.19 (1.23)	-0.62 to 0.22
11.6–12.5	30	12.01 (0.28)	12.14 (1.35)	0.13 (1.26)	-0.31 to 0.58
12.6–13.5	29	12.96 (0.26)	12.64 (1.52)	-0.32 (1.45)	-0.82 to 0.19
13.6–14.5	26	14.01 (0.31)	14.09 (1.34)	0.08 (1.29)	-0.40 to 0.60
14.6–15.5	13	15.18 (0.26)	15.29 (0.90)	0.12 (0.90)	-0.37 to 0.56
15.6–16.5	11	15.80 (0.17)	15.14 (1.14)	-0.66 (1.11)	-1.33 to -0.05
<i>Girls</i>					
4.6–5.5	2	5.30 (0.28)	6.30 (0.28)	1.00 (0.00)	- ^a
5.6–6.5	2	6.05 (0.07)	6.90 (0.71)	0.85 (0.78)	0.30–1.40
6.6–7.5	5	7.28 (0.15)	8.02 (0.24)	0.74 (0.27)	0.56–0.98
7.6–8.5	32	8.14 (0.28)	8.73 (0.98)	0.59 (0.90)	0.29–0.90
8.6–9.5	31	9.07 (0.28)	9.53 (0.98)	0.47 (0.92)	0.10–0.78
9.6–10.5	28	9.97 (0.26)	10.17 (0.91)	0.20 (0.94)	-0.15 to 0.53
10.6–11.5	24	11.07 (0.29)	11.28 (1.25)	0.20 (1.15)	-0.23 to 0.63
11.6–12.5	25	12.06 (0.31)	12.39 (1.35)	0.33 (1.38)	-0.18 to 0.86
12.6–13.5	15	13.05 (0.32)	12.72 (1.49)	-0.33 (1.48)	-1.14 to 0.33
13.6–14.5	18	14.06 (0.28)	13.64 (1.19)	-0.42 (1.19)	-0.99 to 0.08
14.6–15.5	22	14.95 (0.30)	14.25 (1.37)	-0.70 (1.36)	-1.27 to -0.17
15.6–16.5	17	15.85 (0.17)	14.72 (1.03)	-1.13 (1.05)	-1.59 to -0.67

^a Not able to be calculated.

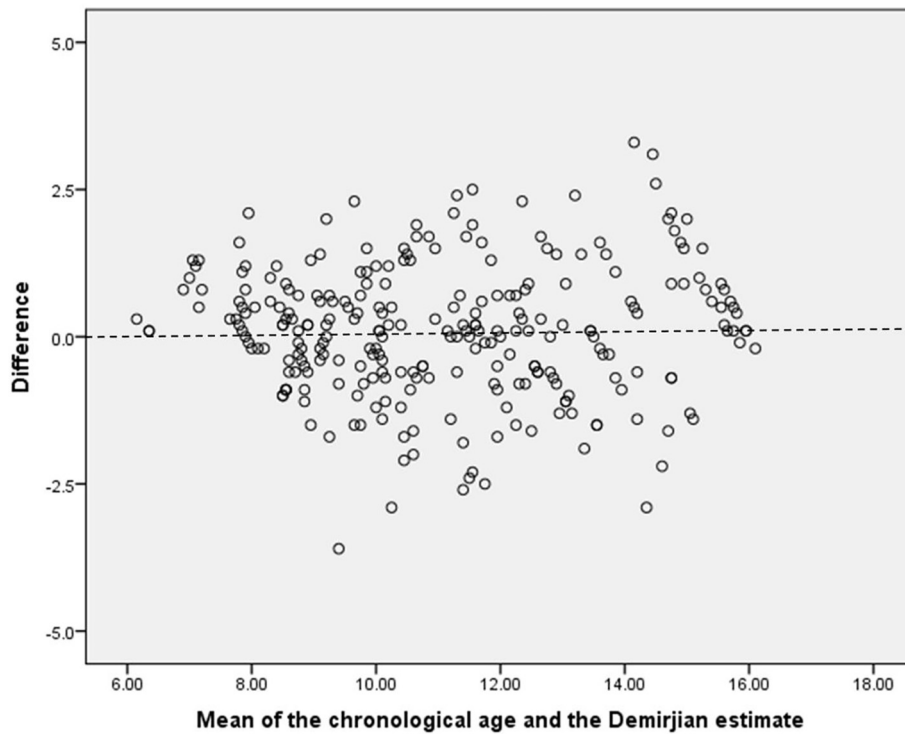


Fig. 1 Difference-against-mean plot for males (where the difference was computed by subtracting the estimated age from the actual chronological age).

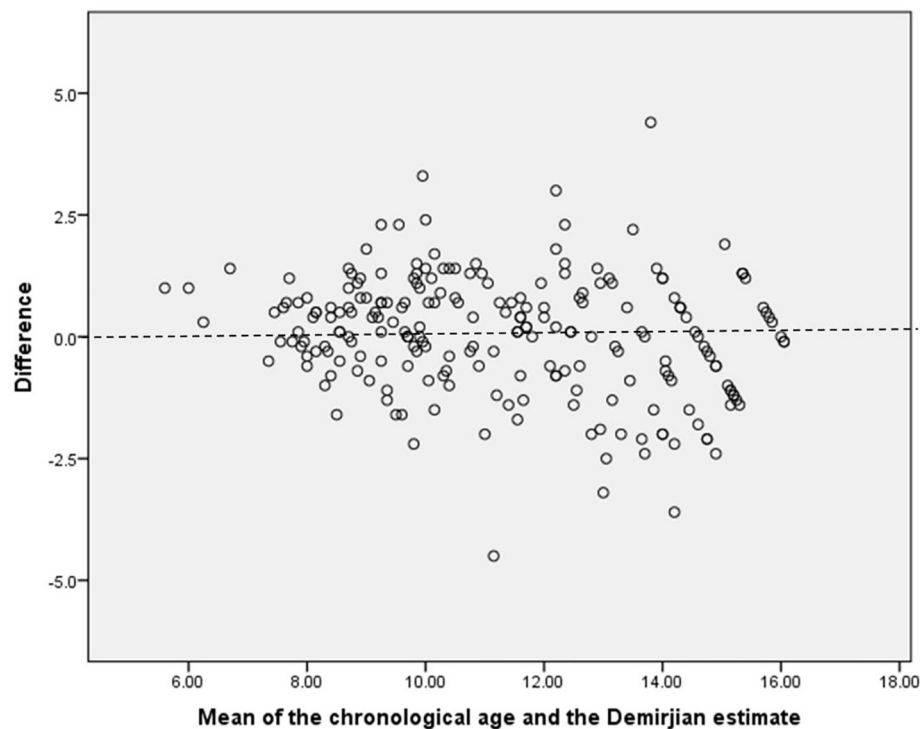


Fig. 2 Difference-against-mean plot for females (where the difference was computed by subtracting the estimated age from the actual chronological age).

of the observed differences was sufficient for doubt to be cast upon the utility of Demirjian's method for Oman, particularly

when it is considered that its most likely application would be in age determination for minors in the workforce.

There are no published data to date about dental age assessment in Omani children, so this study is the first one to do so. The sample size was relatively large and included a range of ages from both sexes. One examiner examined all radiographs, meaning that there were no issues of inter-rater reliability. The strong correlation observed between the chronological age and dental age means that Demirjian's method can indeed be used to validly estimate the dental age of Omani children. However, there needs to be more research to confirm or refute these findings.

Although this study included children aged from 4 to just over 16 years, there were far fewer in the younger age groups than in the older age groups. This might be because most OPGs are taken for orthodontic reasons after eruption of the permanent teeth, and dental practitioners tend not to take OPGs of younger children. Moreover, it can be difficult sometimes to take a clear OPG of younger children because of difficulties in keeping them still for long enough. Thus, the study findings may not hold quite as strongly for younger children, and any future studies should try to involve more younger children. It would also have been useful to extend the investigation to 19 or 20 years of age, given that age 18 is a key legal threshold age in Oman. Moreover, people in Oman originate from a number of different ethnic groups, but they were not identified here by their ethnic origin, and so the generalisability of the findings may be questionable.

Of all of the different methods of age estimation, the dental age is regarded as the best method because tooth mineralisation is much less affected by environmental factors (Bagherian and Sadeghi, 2011). Demirjian's method stages the radiographical appearance of the seven mandibular teeth on the left side, and has been used in a number of studies. The findings of those studies are notable for their heterogeneity. For example, some have found the approach to be applicable in the studied populations (Warhekar et al., 2011; Altalie et al., 2014; Bagherian and Sadeghi, 2011), whereas other have reported systematic over- or under-estimation of age (Chen et al., 2010; Nik-Hussein et al., 2011; Tunc and Koyuturk, 2008; Tavakol and Dennick, 2011). The findings of the present study do not support its utility in Oman, although further investigation is warranted, particularly in younger children and older adolescents. Further studies should use larger samples and more children in those younger age groups, and also compare different methods of dental age assessment in order to build a reference data set for future use.

The Omani laws and penal codes associated with children are set at certain age thresholds, but there are cases where the actual age is unknown and age assessment of the victim is required by the courts to make decisions. It is hoped that the findings of the current study can inform efforts at forensic age determination by the Omani Government in either employment- or marriage-related situations (Patnana et al., 2014; Panchbhai, 2011; Nik-Hussein et al., 2011; Smith and Brownlees, 2011; Karaarslana et al., 2010), or in determining the age of crime victims.

5. Conclusion

The utility of Demirjian's method for dental age assessment in Omani children remains unclear. Further investigation is

warranted, and that should focus on producing a reference set of data for age determination in the countries of the region.

Conflict of interest

The authors declare that there is no conflict of interest.

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