Full Length Research Paper

Age estimation and dental maturity for Sudanese children using Demirjian's system

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Abstract

The aim of this cross sectional study was to compare the accuracy of Demirjian method to estimate the age of Darforian ethnic group children in Sudan. The study included 1153 Darforian children (353 girls and 800 boys). An orthopantamogram (OPG), the date of the OPG, date of birth and sex of each studied children were recorded. In accordance with the rules of Demirjian method, the seven left mandibular teeth 1-7 was assessed. Each stage of the teeth development was given a score and dental maturity scores were calculated using the standard tables for males and females from Demirjian. Chronological age was calculated and ages were estimated on year basis. Appropriate statistical analyses were done. Demirjian System underestimated the mean age of the studied children by 0.70 years in male and 1.42 years in female. Statistically significant, the observed underestimation was manifested in the age groups of 10-11 years in male and 9-10 years in female. The study results demonstrated an underestimation of the mean age of the studied Darforian children using Demirjian method, and suggesting the need of new standards for that population. Also, factors that might affect these findings should be investigated in future studies.

Keywords: Darforian, children, Chronological age, Demirjian method, Dental age, Sudan.

INTRODUCTION

Age estimation plays a significant role in forensic medicine, pediatric endocrinology, clinical dentistry, and archaeology (Schmeling et al., 2007). Different methods are available to estimate the age of human remains in forensic science which include anthropological and dental systems (Willems, 2001). There are two main methods used in estimating chronological age of children, bone method and tooth development; in bone method skeletal maturity is used, based on radiographs of specific structure, such as epiphysis-diaphysis fusion of long bones, medial extremity of the clavicle, epiphysis head of the first rib and fusion of sphenoid bone with the basilar part of the occipital bone. However, due to variability of bone maturation, this method is inconvenient, and is liable to be influenced by environmental factors. Dental parameters, on the other hand, are more suitable for age estimation in children, because of low variability, calcification rates are more controlled by genes rather than environmental factors (Willems, 2001).

Demirjian methods, reported by Demirjian (Demirjian, 1976) are based on eight calcification stages, which is span from the first sign of tooth calcification to apex closure for the seven left permanent mandible. A score is allocated for each stage, and the some of the scores provides an estimation of subject's dental maturity. The overall score may then be converted into dental age using available tables and percentiles curves. Demirjian's data are derived from a reference sample comprising 3261 French-Canadian children. However, some studies results revealed that using Demirjian method are less accurate if another population is compared to

Demirjian standards, and recommended to create database representative for each population (Green and Koshy, 1998; Willems et al., 2000; Blenkin and Evans, 2010; Burt et al., 2011). These data base has to take into account the biological inter-ethnic differences that cause a bias in age estimation. Hence, this study aimed to compare the accuracy of Demirjian's method to estimate the age of Darforian ethnic group children in Sudan.

MATERIALS AND METHODS

Study population

This research was a cross-sectional study. Children included in this study were chosen from those attending a number of different schools dotted around the South of Khartoum. In each class or age group, healthy children of Darfur origin were selected based on their self reported ancestry and those confirmed by the teachers. Children in older groups who had no knowledge of their ancestry or date of birth were excluded. Where there was conflicting reports between official reported date of birth and that reported by the older children and/or the parent in the case of younger children the subject was excluded. The study sample included 353 girls and 800 boys due to the fact that the number of male students is much higher than females (population proportion to size). The age group in this sample was between 3-16 years. Children were given invitation letters to come to El-Razi College for free dental check up. A week later, those who agreed were come to El-Razi dental clinics and free orthopantamogram (OPG) and dental examination were provided. Furthermore, those who needed further treatment were referred to the concerned specialized dental departments.

Demirjian Methods

The sample used by Demirjian consisted of 1446 males and 1482 females of French-Canadian origin aged between 2 and 20 years. An orthopantamograms (OPGs) were taken of each case and the teeth were assessed in terms of their developmental stage and assigned a rating of "A" to "H" (with 0 indicating calcification not yet commenced). The assigned ratings (0-H) were analyzed and were used to develop the next stage of the study. This was modified based on the work of Tanner, Whitehouse, and Healy who developed an approach to age estimation based on skeletal maturity whereby each bone was given a weighted numerical score (Tanner and Whitehouse, 1962). A modification of part of this method was used to derive what Demirjian referred to as "self-weighted" numerical values for each stage of each tooth, differentiating between male and female. These figures were later reviewed and updated by Demirjian method.

More details about that method were reported in Demirjian study (Demirjian, 1976).

In accordance with the rules of Demirjian method described above, the development of the seven left mandibular teeth 1-7 was assessed. Tooth formation is divided into eight stages and criteria for the stages were given to each tooth separately. Each stage of the teeth development was given a score and the dental maturity scores were calculated using the standard tables for males and females from Demirjian. At the orthopantamogram (OPG), the date of the OPG, date of birth and sex and name of each individual was recorded. The identifications were removed during the evaluation of the dental age and a code was assigned to each radiograph. Each radiograph was scanned and loaded into a computer to enable the magnification and increase the accuracy of the evaluation of the teeth developmental stages.

All measurements were carried out by one of the authors (AR). Also, 20% of the research radiographs were randomly selected and were re-examined 2 months after the initial examination by the same author. Cohen's kappa coefficient was used to measure the intra-observer reproducibility for Demirjian's stages for each tooth. A function of Microsoft Excel was used to calculate the difference between the recorded date of birth and the date that the OPG was taken, thus giving the chronological age of the patient at the time of the radiograph. This was then recorded on the spreadsheet as "Chronological Age" under the appropriate case.

Data analysis

The Demirjian system was applied to the studied sample to predict ages in Darfur children. Predicted age (according to the Demirjian charts) was compared with true age, and deviations were calculated. The estimate of age, referred to as "Canadian Predicted Age" (CPA) was compared with the actual age for each case to measure the magnitude of the underestimates or prediction errors. The mean underestimates for each age group and overall were then calculated. A paired t test was undertaken to ascertain the significance, or otherwise, of the magnitude of the prediction error. Ethical approval for this study was obtained from El-Razi College Ethical Committee.
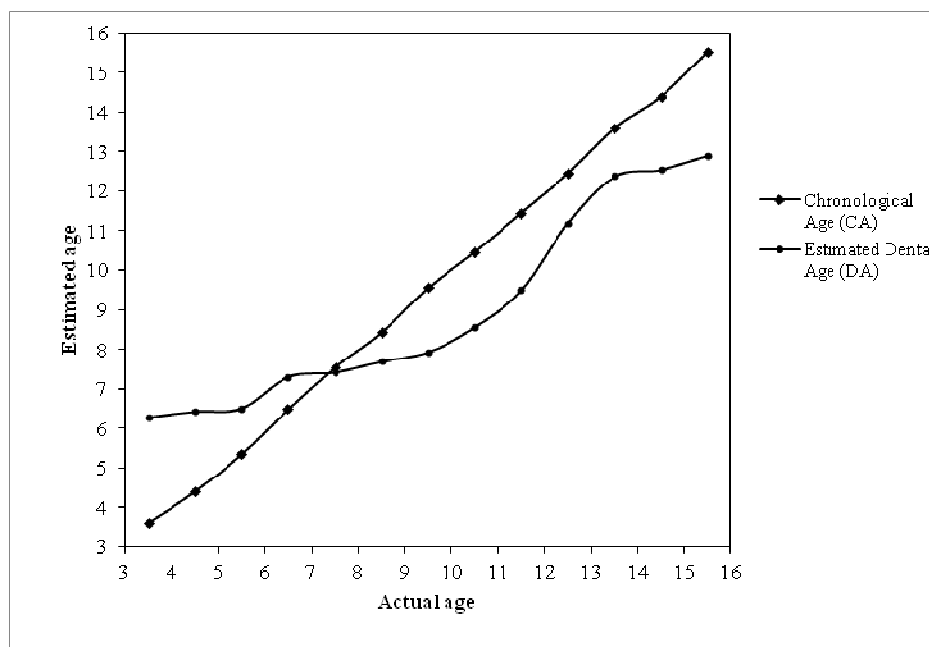
RESULTS

The age group (9-12 years) represented nearly two third of the studied female group 61% (215/351). In males the age group (11-13 years) represented approximately half of that group (49%).

According to table 1 and Figure 1, the mean difference of chronological age and dental age for

Table 1. Chronological age (CA) vs estimated dental age (DA) in the studied female children among different age groups

Age group	Number of children (%)	CA	DA	DA-CA	p-value
3.00-3.99	4 (1.0)	3.62	6.2750	2.6575	0.009
4.00-4.99	4 (1.0)	4.41	6.4250	2.0125	0.032
5.00-5.99	28 (8.0)	5.35	6.5036	1.1525	< 0.001
6.00-6.99	17 (4.8)	6.4824	7.3000	-0.8176	0.009
7.00-7.99	9 (2.6)	7.5400	7.4111	-0.1289	0.623
8.00-8.99	20 (5.7)	8.4255	7.6900	-0.7355	0.003
9.00-9.99	56 (15.95)	9.5550	7.9250	-3.2371	<0.001
10.00-10.99	49 (13.96)	10.4616	8.5571	-1.9045	<0.001
11.00-11.99	57 (16.24)	11.4526	9.4930	-1.9596	<0.001
12.00-12.99	53 (15.10)	12.4513	11.1906	-1.2608	<0.001
13.00-13.99	26 (7.41)	13.5950	12.3769	-1.0412	<0.001
14.00-14.99	13 (3.70)	14.3985	12.5538	-2.0215	0.002
15.00-15.99	15 (4.27)	15.5313	12.9133	-2.6180	<0.001

Figure 1. Female actual chronological age vs estimated dental age

females was significant (p <0.01), except at age group 7 to 8, where it was not significant (p=0.6), and the two curves cross each other approximately at age 7.7 years. The results showed that Demirjian System underestimated the Darforian female group by 1.42 years (i.e. gives readings lower than actual age by approximately 1.42 years).

According to Table 2 and Figure 2, the mean difference of chronological age and dental age for males was significant for all age group (p<0.001), although the two curves cross each other approximately at age 7.5 years. Also, Demirjian system underestimated the

Darforian male group by 0.70 year.

DISCUSSION

Age estimation plays an important role in forensic medicine, paediatric endocrinology, archaeology and clinical dentistry. Demirjian method is one of the simplest and most practical and widespread methods. Its advantage rests in the clearly defined stages and precisely defined changes occurring in the crown and the root shape, leaving the clinician not much space for

Table 2. Chronological age (CA) vs estimated dental age (DA) in the studied male children among different age groups

Age group	Number of children (%)	CA	DA	DA-CA	p-value
3.00-3.99	5 (0.62)	3.6320	6.5000	2.8680	<0.001
4.00-4.99	5 (0.62)	4.4300	6.9000	2.4700	<0.001
5.00-5.99	17 (2.13)	5.4776	7.3647	1.8871	<0.001
6.00-6.99	38 (4.75)	6.5184	7.6342	1.1158	<0.001
7.00-7.99	34 (4.25)	7.4521	7.9118	0.4597	<0.001
8.00-8.99	42 (5.25)	8.4764	8.1524	-0.3240	<0.001
9.00-9.99	79 (9.88)	9.5075	8.6190	-0.8885	<0.001
10.00-10.99	58 (7.25)	10.5871	9.1793	-1.4078	<0.001
11.00-11.99	150 (18.75)	11.5147	10.2627	-1.2520	<0.001
12.00-12.99	134 (16.75)	12.5391	11.5336	-1.0055	<0.001
13.00-13.99	109 (13.63)	13.5046	12.7844	-0.7202	<0.001
14.00-14.99	85 (10.63)	14.4813	13.5694	-0.9119	<0.001
15.00-15.99	44 (5.5)	15.4145	14.7432	-0.6714	<0.001
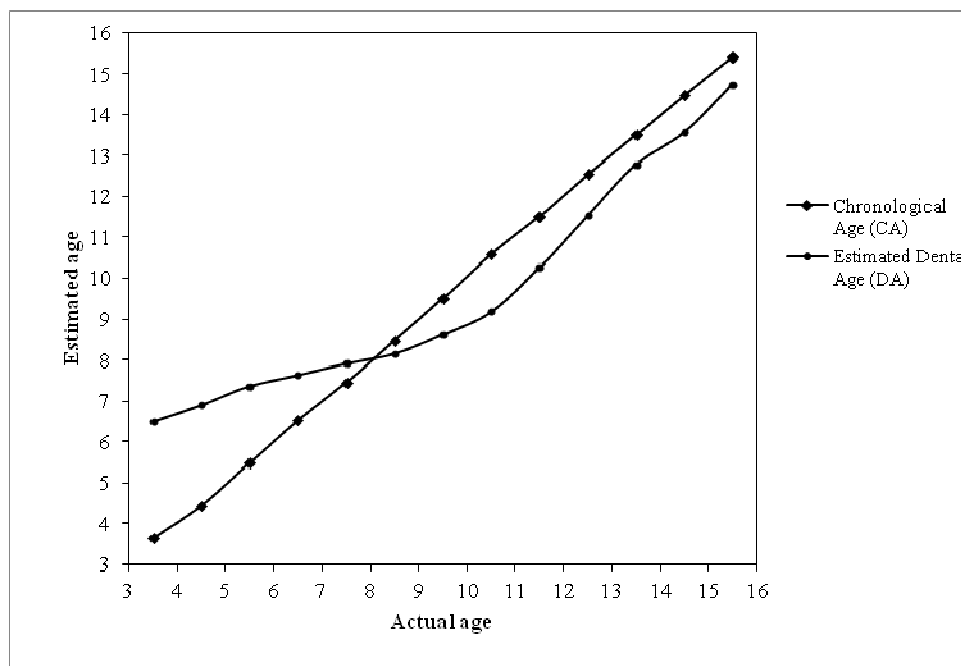
Figure 2. Male actual chronological age vs estimated dental age

guessing (Schmeling et al., 2007; Willems, 2001). The study results revealed that Demirjian system underestimates the Darfur males and females age by approximately 0.70 and 1.42 years respectively. Statistically significant, the observed underestimation was manifested in the age groups of 10-11 year in male and 9-10 years in female. Also, when scatter plots were created between dental age and chronological age, there were crossing of lines nearly at the same age in both sexes (Figure 1 and Figure 2). Unlike these results, however, Rai (2008) reported that the Demirjian method showed high accuracy when applied to Indian children aged 7.5-16 years.

In accordance with the results of the present study, other previous studies found that there are some differences between different racial groups with regards to the accuracy of the Demirjian system for estimating the chronological age of these groups. The study performed in Turkey by Tunc and Koyuturk (2008), concluded that the Northern Turkish children were more advanced in dental maturity when compared to the original Demirjian French-Canadian sample. Similarly, the study of Ivan Galic et al. (2010) on Bosnia- Herzegovina showed that children in this study are more advanced in the dental maturity scores when compared to the Demirjian sample.

Qudeimat and Behbehani (2009) tested the

applicability of the Demirjian system in Kuwait and concluded that Kuwaiti children were dentally delayed in dental maturity when compared to the French Canadian population. The same findings were concluded in the study by Cruz-Landeira and Linares-Argote (2010). In that study, the Demirjian system was tested on Spanish and Venezuelan children and there was an inaccurate estimation for the age of the studied children where the dental maturity was also delayed when compared to the French Canadian population.

The observed difference in chronological age and the obtained dental age using the Demirjian system in this and previous researches could be attributed to numerous factors, such as the accuracy of method execution, the examiners' subjectivity, sample structure (age, sex, ethnicity, nationality and social status) and the statistic approach to obtain the results (Bagic, 2008). Moreover, Demirjian method was framed almost 30 years ago and there may be a difference in the present day comparisons due to positive secular trends.

Cameriere et al. (2004) studied the effect of the nutrition and genetic factors on the dental development and concluded that the differences between the French Canadian children results and the European population is due to the fact that the strong Amerindian genetic factors influence dental maturity in case of the French Canadian children as well as the European. He also concluded that the African population has a relative acceleration of dental maturity scores when compared the original Demirjian's sample.

When linear graphs were created between dental age and chronological age, there were crossing of lines nearly at the same age in both sexes (Figure 1 and Figure 2). This implied that the younger age groups had a higher amount of overestimation compared with the older age groups showing underestimation. These findings highlighted the importance of the development of new dental maturity scores with population specific standards to increase the accuracy of the dental age estimation for different racial groups. Easily, one can notice that there are big differences in the growth and development rates among children of the same chronological age. This is why biological age demarks different stages in the child's development and maturity, whereas chronological age only roughly estimates the child's maturity (Bagic, 2008).

The reproducibility of the research results was determined using the Cohen Kappa test to measure the inter-observer reproducibility and the score was 0.86 which was almost perfect. This study used the orthopatomogram (OPG) for estimating the dental age. Assessing OPGs is a major strength of the study as it is a non-invasive approach and hence readily acceptable. Other regional studies, however, used radiographic views such as oblique jaw radiography, intra oral radiography to assess the degree of mineralisation of all permanent teeth.

The main limitation of this research is that the study selected children from only Darfur region, which is only a single phenotype of the multiracial composition of the Sudanese population so this study finding cannot be generalised for the whole nation. From this point of view, heterogeneous racial sampling reflects the nature of the Sudanese community should be included in future researches.

In summary, the study results revealed an underestimation of age by the used Demirjian system in both male and female. There was an underestimation by 0.70 years in male group and 1.42 years in female group. These findings suggest the need for new standards for this ethnic group. These differences may reflect the role of racial, genetic and environmental factors in tooth formation and development. Future researches are needed to apply more accurate and precise age prediction models, as well as to include heterogeneous racial sampling.

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