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Assessment of dental maturity of Brazilian children aged 6 to 14 years using Demirjian's method

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Summary. Dental maturity, often expressed as dental age, is an indicator of the biological maturity of growing children. A method for the assessment of dental maturity was first described by Demirjian, and is widely used and accepted, mainly because of its ability to compare different ethnic groups. This is possible, as the maturity scoring system proposed by the method is universal in application, although the conversion to dental age depends on the population considered.

Objectives. The aim of this study was to apply Demirjian's method to Brazilian children aged 6–14 years in order to obtain dental maturity curves for each sex, to compare this data with that obtained by Demirjian, and to determine whether there is a significant correlation between dental maturity and body mass index.

Methods. We retrospectively reviewed the orthopantomograms, height and weight measurements of 689 healthy children. Curves of dental maturity of males and females were constructed.

Results. When compared to the French-Canadian sample of Demirjian, Brazilian males and females were 0·681 years and 0·616 years, respectively, more advanced in dental maturity. There was no significant correlation between dental maturity and body mass index.

Introduction

The dental development determined from radiographs has been considered more definitive and useful than other maturity indicators in estimating the chronological age of children of unknown birth records [1,2] as it is less affected by variations in nutritional [3] and endocrine status [4].

Furthermore, dental maturity, often expressed as dental age, is an indicator of the biological maturity of growing children, being relevant in the study of growth disturbances and clinical orthodontics [4].

The dental age of children can be based on dental emergence or on the stages of tooth formation observed in radiographs. The second method is superior to the first, as tooth emergence is a short period determined by the time of appearance of the tooth in the mouth [5], altered by local factors such as lack of space [2] and systemic factors such as nutritional status [6,7].

Several methods for the determination of dental development from radiographs have been described [2,8,9,10–14]. The methods basically define the stages of mineralization of teeth observed in radiographs and code them according to previously determined scores. In addition to the stages observed in radiographs, Gustafson and Koch [13] considered the time of eruption in their 'tooth development diagram'. Mörnstad *et al.* [14] measured the crown height, apex width and root length of the teeth observed in radiographs. Most methods make use of panoramic radiographs for the assessment, although Moorrees *et al*. [2] made use of periapical radiographs.

One widely used method for the comparison between different populations is that first described in 1973 by Demirjian *et al*. [4,15–22].

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One of the reasons for the widespread acceptance of this method is that the maturity scoring system that it creates is universal in application, although the conversion to dental age depends on the population being considered. Furthermore, this conversion can be made with the use of relatively small local samples and can reach an equivalent dental age by comparison for different populations [1].

The method introduced by Demirjian *et al*. [8] is based on the development of the seven left permanent mandibular teeth. Tooth formation is divided into eight stages, and criteria for the stages are given for each tooth separately, in detailed written description and supplementary illustrations. Each stage of the seven teeth is given a score according to a statistical model, which has also been used for the assessment of skeletal maturity [23]. Standards are given for each sex separately, and the sum of the scores of the seven teeth is the obtained dental maturity that can be converted into dental age by use of conversion tables. The revised version of these standards was published in 1976 [9], and the data was derived from a reference sample comprising 4756 French-Canadian children aged 2–20 years.

The objective of this study was to apply Demirjian's method [8,9] to Brazilian children aged 6–14 years in order to obtain dental maturity curves for each sex, and consequently to determine the standard for this group; to compare this data with that obtained by Demirjian [9] in order to evaluate the difference in dental maturity between these populations and to determine if there is a significant correlation between dental maturity and body mass index.

In Brazil, there are studies of dental maturity which are performed based on the Brazilian population, but they are not as practical as the method developed by Demirjian et al. [8,9]. For this reason we decided to apply this method to our population in order to create our own standards. Furthermore, as this method has been applied to different populations around the world, it allows us to compare the status of the dental maturity of our population with that of other populations.

Materials and methods

We retrospectively reviewed the panoramic radiographs (orthopantomograms) of 689 healthy children [Table 1] from the files of a Radiographic Institute in São Paulo, Brazil. Each radiograph was filed in a flat case that contained the patients' data: birth date and place, height and weight measurements and a brief medical history. Height and weight measurements are routinely obtained in this institution by trained personnel. Such measurements were collected from patient's files and used in this study. As this is a retrospective study, we used data obtained from the records, giving a potential for errors that would be consistent throughout the entire population studied. We did not include radiographs from patients who were not healthy (based on medical history) and did not have all seven left mandibular teeth (incisors, canine, first and second molars). All the radiographs selected were from Brazilian children that were inhabitants of São Paulo, the biggest city in Latin America (18 million inhabitants), so the population studied was from an urban background.

Table 1. Age and sex distribution.

Chronological age	Female	Male	Total (%)
6·0–6·9	17	18	5·08
7·0–7·9	44	37	11·75
8·0–8·9	73	50	17·85
9·0–9·9	52	55	15·53
10·0–10·9	66	66	19·16
11·0–11·9	57	46	14·95
12·0–12·9	30	22	7·55
13·0–13·9	16	17	4·79
14·0–14·9	13	10	3·34
Total	368	321	100

The radiographs were rated by one examiner only, and dental maturity was obtained using Demirjian's method. Dental maturity was converted into dental age by using sex-specific tables [8,9]. The scores used in this study were the revised scores published by Demirjian & Goldstein, 1976 [9].

Statistical methods

As two of the measurements referred to age (both dental and chronological), these values were compared using the intra-class correlation coefficient and a plot as described by de Bland-Altman [24] to verify whether the difference between the two values depended on the age of the individual. This plot [24] is also used to express the analysis of repeatability (relation between the difference and the mean of compared data).

A scatter plot was drawn up (for male and female subjects) to verify how these measures were related mathematically. The plot compared the dental age

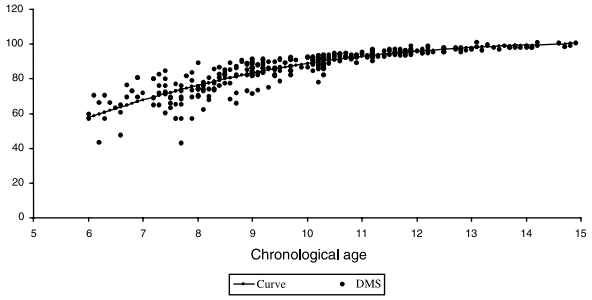

Fig. 1. Distribution of dental maturity score (DMS) obtained in relation to chronological age in males.

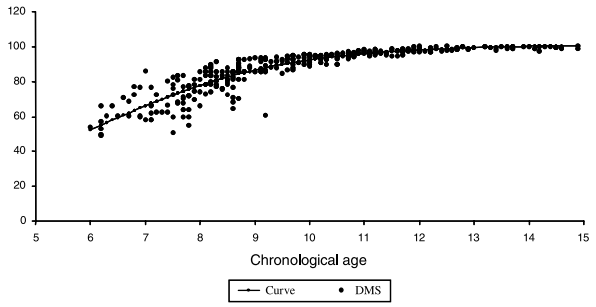

Fig. 2. Distribution of dental maturity score (DMS) obtained in relation to chronological age in females.

(dependent variable) and the chronological age (independent variable). A regression curve was estimated with the equation:

$$y = \frac{a}{1 + e^{b+cx}}$$

This showed that there was a strong relationship between the measurements. As the relation was not linear, it could not be expressed by a Pearson linear correlation coefficient. The equation may be used to present expected values for dental age from chronological age; as Y = dental maturity score obtained and X = chronological age of the subjects of the sample.

The body mass indices (wt/ht^2) of the subjects were obtained and compared to percentiles curves [25]. The subjects were divided into five categories according to the percentiles reached: category 1 (below the 5th percentile or malnutrition), category 2 (between the 5th and the 15th percentiles), category 3 (between the 15th and the 85th percentiles), category 4 (between the 85th and the 95th percentiles) and category 5 (above the 95th percentile or obesity). In order to verify whether the difference between dental and chronological age was the same for different categories of body mass index (BMI), an analysis of variance (ANOVA) was carried out on the data.

Results

The dental maturity curves for Brazilian males and females are presented in Figs 1 and 2. The logistic model representing these curves was:

$$y = \frac{a}{1 + e^{b+cx}}$$

Table 2. Intraclass correlation coefficient between the dental age estimated by Demirjian's method and chronological age.

	Intraclass correlation coefficient
Males	0·8743
Females	0·8823

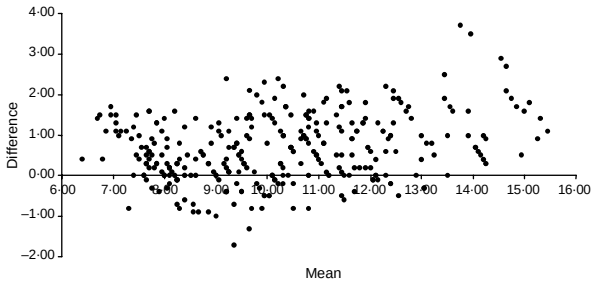

Fig. 3. Repeatability analysis relating difference and mean between dental and chronological age in males.

As Y = dental maturity, X = chronological age, the curve parameters a, b and c for the curve were estimated to be: a = 102·70, b = 2·15, c = –0·40 and a = 101·17, b = 3·38 and c = –0·57 for males and females, respectively.

The intra-class correlation coefficient [Table 2], used to compare the dental age estimated by Demirjian's method to the chronological age of the subjects from the sample, was 87% for males and 88% for females, showing a high rate of consonance between the measures [26]. The Bland & Altman plot [Figs 3 and 4] showed that the differences were more or less constant for all ages, although the positive differences tended were more frequent than the negative ones. It can be seen that there was an overestimation of age for the method in all ages analysed in our sample. The mean difference between the dental age determined from the French-Canadian

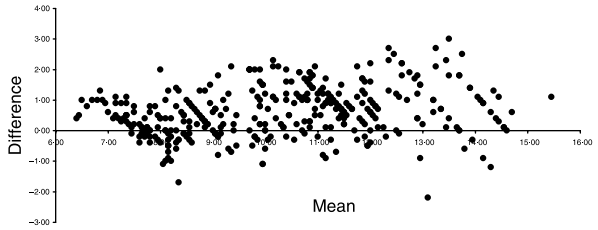

Fig. 4. Repeatability analysis relating difference and mean between dental and chronological age in females.

Table 3. Comparison between dental and chronological age for males.

	Mean	SD	SE
Dental age	10·61	2·21	0·12
Chronological age	9·93	1·98	0·11
Difference	0·68	0·23	0·01

$P < 0·001$.

Table 4. Comparison between dental and chronological age for females.

	Mean	SD	SE
Dental age	10·57	2·18	0·11
Chronological age	9·96	1·98	0·10
Difference	0·62	0·20	0·01

$P < 0·001$.

Table 5. Difference between dental and chronological age for each category of body mass index (BMI) for males.

Category of BMI	*n*	Mean	SD	SE
1	11	0·65	0·76	0·23
2	18	0·64	0·79	0·19
3	189	0·59	0·87	0·09
4	60	0·71	0·73	0·09
5	43	0·95	0·77	0·12
Total	321	0·68	0·82	0·05

standards and chronological age was 0·681 years for males and 0·616 years for females [Tables 3 and 4]. The difference was significant ($P < 0·001$). This result means that Brazilian males and females are 0·681 years and 0·616 years, respectively, more advanced in dental age than chronological age.

The mean differences between dental age estimated by the method and chronological age for each category of body mass index are presented in Tables 5 and 6. When applying analysis of variance to these data, we found that there was no significant association between body mass index and the medium values of the differences (dental age – chronological age).

Table 6. Difference between dental and chronological age for each category of body mass index (BMI) for females.

Category of BMI	*n*	Mean	SD	SE
1	20	0·45	0·78	0·17
2	13	0·26	0·57	0·16
3	214	0·57	0·81	0·08
4	86	0·74	0·80	0·09
5	35	0·61	0·84	0·14
Total	368	0·62	0·81	0·04

Discussion

As our study was retrospective, there were limitations in the scope of the background information we could obtain from the subjects in the sample. Our sample comprised Brazilian children of unknown ancestry. The Brazilian population is a very heterogeneous group encompassing people of ethnic groups.

It can be seen [Figs 1 and 2] that there is large variation in the magnitude of dental maturity of children aged 6–10 years. After 10 years of age, the dental maturity scores are close to 100, which concurs with the biological process.

The intra-class correlation coefficient obtained from the dental age estimated by Demirjian's method and the chronological age of the subjects was high [Table 2] for both sexes, showing the validity of the method. When we analysed the plots made using the method of Bland & Altman [Figs 3 and 4], there was an overestimation of the dental age compared to chronological age in all the ages studied, which did not vary significantly with age, although there was a slight tendency towards greater overestimation in older children.

The results showed that, on average, Brazilian children were 0·681–0·616 years more advanced in their dental maturity than indicated by their chronological age, difference that was significant ($P < 0·001$).

Demirjian's method has been tested in different populations [4,15,16,18,20–22]. In all populations authors have obtained an overestimation of dental age with Demirjian's method, ranging from 0·02 to 3·04 years. Koshy and Tandon [21] recorded a greater overestimation than was seen here (2·82 years for females and 3·04 for males) when studying the Indian population. The difference was also more pronounced in older children. Liversidge

et al. [22] tested Demirjian's method in British children, but divided them into two groups: one of Bangladeshi origin and one of Caucasian origin. The authors compared the two groups with Demirjian's French-Canadian sample. Results showed that the British groups did not differ in dental maturity amongst themselves but were more advanced in dental maturity (0·73 years for males and 0·51 years for females) when compared to the French-Canadian sample. Liversidge *et al*. [22] believe that the overestimation in dental age in recent findings using Demirjian's method in different populations may be partly explained by a positive secular trend in growth and development during the last 25 years.

The BMI was chosen as this index is adopted by WHO as the most specific method for evaluating nutritional status of populations as it allows determination of malnutrition, excess weight and risk of obesity (excess of fat mass) in children aged 2–20 years in relation to sex. BMI can also be applied in adult populations. The greatest advantage is that it permits comparison between different populations as an indirect measure of body mass. The evaluation of weight as an isolated measure is not adequate when applied to adolescents and low height can be influenced by many factors other than nutritional status.

In adults, BMI can be used to determine the nutritional status when compared to an established cut-off point. In children and adolescents, BMI must be compared to specific curves with distribution for sex and age, and cut-off points are determined according to the percentiles.

The lack of significant association between category of body mass index and variation in dental age (difference between dental age estimated by Demirjian's method and chronological age) is in agreement with findings in the literature [3,27], which indicates that nutritional status has minor influence on dental maturity when compared to other maturity indicators.

In conclusion, Brazilian children are significantly more advanced in dental maturity compared to Demirjian's French-Canadian sample, supporting the need for population-specific standards.

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Resumé. *Objectif.* L'objectif de cette étude a été d'appliquer la méthode de Demirjian (1,2) à des enfants brésiliens âgés de 6 à 14 ans afin d'obtenir les courbes de maturité dentaire pour chaque sexe, de comparer ces données à celles obtenues par Demirjian (2) et de déterminer s'il existe une corrélation significative entre la maturité dentaire et l'indice de masse corporelle.
Méthodes. Les orthopantomogrammes, les mesures de poids et de taille de 689 enfants ont été examinés rétrospectivement. Des courbes de maturité dentaire des garçons et filles ont été construites.
Résultats. Par rapport à l'échantillon de Canadiens francophones de Demirjian (2), les garçons et filles brésiliens présentaient une maturité dentaire plus avancée de respectivement 0,681 et 0,616 ans. Il n'y avait pas de corrélation entre la maturité dentaire et l'indice de masse corporelle.

Zusammenfassung. *Ziel.* Das Ziel dieser Studie war es, die Zahnentwicklung bei brasilianischen Kindern von 6 bis 14 Jahren mit der Demirjian-Methode zu ermitteln, um getrennte Entwicklungskurven für jedes Geschlecht zu erhalten, diese sollten mit den Originaldaten von Demirjian verglichen sowie auf eine Korrelation mit dem body-mass-Index untersucht werden.
Methoden. Retrospektiv wurden Orthopantomographien sowie Daten zu Körperlänge und Körpermasse von 689 gesunden Kindern ausgewertet. Für Jungen und Mädchen wurden getrennte Zahnentwicklungskurven erstellt.
Ergebnisse. Im Vergleich zu der franko-kanadischen Stichprobe von Demirjian waren die brasilianischen Jungen 0.681 Jahre und die Mädchen 0.616 Jahre früher in der Zahnentwicklung. Eine signifikante Korrelation zum body-mass-Index bestand nicht.

Resumen. El objetivo de este estudio fue aplicar el método de Dermijian (1,2) a niños brasileños entre 6 y 14 años para obtener las curvas de madurez dental para cada sexo, para comparar estos datos con los obtenidos por Dermijian (2) y determinar si hay una correlación significativa entre la madurez dental y el índice de masa del cuerpo.
Métodos. Revisamos retrospectivamente las ortopantomografías, mediciones de altura y peso de 689 niños sanos. Se construyeron las curvas de madurez dental de niños y niñas.
Resultados. Cuando se comparó a la muestra franco-canadiense de Dermijian (2), los niños y niñas

brasileños estaban 0,681 y 0,616 años respectivamente más avanzados en madurez dental. No hay una correlación significativa entre la madurez dental y el índice de masa del cuerpo.

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