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Forensic Anthropology Population Data

Validity of Demirjian and Willems methods for dental age estimation for Malaysian children aged 5–15 years old

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ABSTRACT

Background: One of the most commonly used method for dental age assessment is the method reported by Demirjian and coworkers in 1973. It was later modified by Willems and coworkers whereby they “performed a weighted ANOVA” in order to adapt the scoring system.
Aim: To evaluate the applicability of Demirjian and Willems methods for dental age estimation for Malaysian children and to correlate the accuracy of the findings with the chronology of tooth development of premolars and second molars.
Materials and methods: A total of 991 dental panoramic radiographs of 5–15-year-old Malaysian children were included in the study. The mean Demirjian and Willems estimated ages were compared to the mean chronological age.
Results: The mean chronological age of the sample was 10.1 ± 2.8 and 9.9 ± 3.0 years for males and females respectively. Using the Demirjian method, the mean estimated dental age was 10.8 ± 2.9 years for males and 10.5 ± 2.9 years for females. For Willems method, the mean estimated age was 10.3 ± 2.8 years males and 10.0 ± 3.0 years respectively.
Conclusions: Willems method was more applicable for estimating dental age for Malaysian children. Overestimation in Demirjian method could be due to advanced development of second bicuspids and molars.

1. Introduction

Chronological age (CA) is defined as the length of time that one has existed; that is the duration of one's life after birth. CA is important in most societies for school attendance, employment, social benefits and marriage [1]. Age determination is also useful in forensic odontology and medicolegal purposes as this can aid the identification of age at death of a deceased person. Age estimation is also beneficial in archaeology as it can provide important information with regard to past populations [2].

However, there are many instances where CA is not known due to undocumented or missing birth data. One of the most accurate, reliable and fast method of age determination especially in the growing children is by using the dental method of age estimation.

Dental age is estimated by comparing the dental development status of a person of unknown age with published dental developmental surveys. Most of the methods employed for dental age determination were based on comparison of radiographic development of teeth with standard proposed based on studies of a large number of persons (3). The aim of an ideal age estimation method is to arrive at an age as close to the CA as possible.

Dental age is of particular interest to the paedodontists and orthodontists in the management of developing occlusions in relation to maxillo-facial growth [3]. Dental age may be assessed either by tooth eruption dates or by the progress of tooth calcification. Tooth calcification is superior to tooth emergence because emergence of a tooth is a fleeting event and its precise time is very difficult to determine whereas calcification is a continuous process that can be assessed by permanent records such as X-ray films [4]. Besides that, tooth emergence is a short period, which is determined by the time of appearance of the tooth in the mouth [5] and can be altered by local factors, such as a lack of space [6] and systemic factors, such as nutritional status [7]. Tooth eruption dates cannot be applied between the ages of 3 and 6 years, or past the age of 13 [8]. This is because the accuracy decreases simultaneously with the completion of a person's dental development [9].

In comparison, the teeth progressively calcify in several easily definable stages so that age can be reliably defined by the stage of calcification. The stage of calcification is the least susceptible to change over the centuries to environmental influences [10,11] and is independent of somatic growth [12] so it is the most accurate way of estimating dental age [13].

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There are a number of forensic advantages to using tooth calcification to determine age. Calcified teeth are extremely durable, often surviving conditions which consume all other human tissues and may be used to age cadavers [8]. This has similar application in archaeology where the degree of age related change in a tooth may be used to estimate the age of human remains. Tooth calcification may also be used to rapidly and accurately determine an individual's age for legal purposes [8].

Although different types of radiography have been proposed panoramic radiographs (PRs) have been adopted by most authors due to their accessibility and the possibility to visualize all teeth.

One of the most commonly used methods of dental age estimation is the method reported by Demirjian et al. [9]. Comparisons have been made between the French-Canadian standards reported by Demirjian et al. [9] (subsequently referred as Demirjian method) and numerous other racial and ethnic groups [3–5,10–15]. The main advantages of Demirjian method include the objective criteria describing stages of tooth development, which have been illustrated with line diagrams and radiographic images in a clear cut manner [12]. However almost all of the studies reported overestimation of dental ages [3–5,11–15], although Liversidge et al. [10] refuted that the Demirjian standards vary between populations, as they found that in their study, both the Caucasians and Bangladeshi children had similar standards of tooth development.

Since Demirjian et al. [9] published their reports of dental age estimation, other methods have been proposed by Haavikko [16], Nolla [17], Willems et al. [18] and Cameriere et al. [19]. The method proposed by Willems et al. (subsequently referred as Willems method) is based on the Demirjian method whereby the authors creating new tables for the scores that could be directly expressed in years. The cumbersome step of conversion of maturity score to dental age was omitted, thus making it simpler, yet retaining the advantages of the Demirjian method. Maber et al. [20] compared the Nolla, Haavikko, Demirjian and Willems methods on a sample of children of Bangladeshi and British Caucasian ethnic origins. They found that Willems method was the most accurate, followed by Demirjian method, hence these two methods were the obvious methods for this study.

Recently, several authors indicated that discrepancy between CA and DEA could be due to an overall positive secular trend in growth and development [10,21] and this could have also contributed to advanced dental development. This could indeed be so as Willems et al. [18] undertook the study and published their adjusted maturity scores almost 20 years later than Demirjian et al. original study that was reported in 1973 [9]. Thus, the time frame Willems et al. maturity score was closer to the present.

The aims of this study are to evaluate the applicability of Demirjian and Willems methods for Malaysian population and subsequently to reanalyze the data based on variability of development of posterior teeth.

2. Materials and methods

The design of this study was a retrospective cross-sectional study of digital PRs that are were taken using the Sirona Orthophos XG 5 OPGs that were taken at the Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia.

After obtaining the approval from the Ethics Committee of Faculty of Dentistry, University Malaya and following a period of training and calibration, the radiographs were read by two of the authors (GP and KKM). The developmental stages of the seven permanent teeth in the left mandible were assessed according to method proposed by Demirjian et al. [9]. The teeth were read and rated in the following order: second molar, first molar, second bicuspid, second bicuspid, canine, lateral incisor and central incisor (subsequently known as M2, M1, PM2, PM1, C, I2 and I1 respectively). The rating was assigned by following carefully the written criteria for each dental development stage, and by comparing the tooth with the diagrams and radiograph images and descriptions for each stage as given by Demirjian et al. [9]. In cases of doubt, they were discussed by both examiners and the earlier stage was assigned to the tooth.

All PRs of children aged 4–16 years old that were taken in the course of diagnosis and treatment from 2004 to July 2009 and stored as JPEG image with dimension of 2440 × 1280 pixels in the department were then examined. The selection of images was done based on the following inclusion criteria: Malaysian patients aged between 4 and 16 years old and availability of treatment records and PRs of good quality. Images that were deformed that affecting the mandibular permanent tooth visualization, presence of hypodontia, gross pathology and previous or undergoing orthodontic treatment were excluded. Subsequently, a total of 991 subjects from 610 Malays, 254 Chinese and 127 Indian aged 5–15 years old were included in the study.

The date of birth of each subject was not known to the investigator to avoid bias when analyzing the dental stages of the teeth. Upon completion, the dates of birth of these patients were then obtained from the entry in the Radiology Workbook.

The CA for each subject was calculated by subtracting the date of birth from the date that the PR was taken. The age was then converted to year to one decimal age.

The results were then entered into a computer using the Statistical Package for the Social Sciences version 12.0. Separate files for females and males were created.

The developmental stage of each or the seven teeth were then converted to a maturity score according to tables provided by Demirjian et al. [9] for males and females. This score represented the maturity score for the subject. The maturity score was then converted to dental age by using Conversion Tables as provided by Demirjian et al. [9]. This estimated age will subsequently be known as DEA.

The developmental stage of each of the seven teeth was also converted to age score expressed directly in years using tables provided by Willems et al. [18]. The scores for all seven teeth were added together to give the dental age. This estimated age will subsequently be known as WEA.

2.1. Data processing and analysis

All data were processed by SPSS software (12.0, SPSS Inc., Chicago IL, USA). A Kolmogorov Smirnov Test for both male and results indicated that the distribution was normal. Thus, for comparing means of variables, a paired *t*-test was used to test for statistical significance. A *p*-value less than 0.05 was considered as statistically significant.

3. Results

A total of 1020 PRs (the PRs would subsequently be referred as subjects) were examined. However, after stratification into different age groups, gender and ethnicity, it was noted that the number of subjects in some groups were either very small or none. In a similar study, Mani et al. [12] reported that in order to make a meaningful statistical inference, the minimum number of subjects in each group should be 19. Thus, the results would be analyzed according to age groups and gender but not according to the main ethnic groups in the country. Similarly, data from the 4- and 16-year-old age groups were excluded as there were only one subject in the 4-year-old age group and 12 males and 16 females in the16-year-old age group. Subsequently, a total of 991 subjects from 610 Malays, 254 Chinese and 127 Indian aged 5–15 years old were included in the study.

Almost all the studies that were published in the literature on this subject reported the estimated age according to two decimal places. However, the original publication by Demirjian et al. [9] and Willems et al. [18] reported the tabulation of data of age groups based on one decimal place only. Thus, the results in this study would be reported according to one decimal place only.

The mean CA and estimated dental age using the Demirjian method and the Willems method for the different age groups and total sample for males and females are shown in Tables 1 and 2 respectively. The mean CA for males was 10.1 ± 2.8 years as compared to mean DEA of 10.8 ± 2.9 years and mean WEA of 10.3 ± 2.8 years. For the females, the mean CA was 9.9 ± 3.0 and mean DEA and WEA were 10.5 ± 2.9 and 10.0 ± 3.0 years respectively. Except for the 15-year-old age group for females that underestimated the age by 0.2 years as indicated by the −ve sign, the DEA overestimated age for all the other age groups in the range of in the range of 0.2–1.7 years and the largest overestimation was noted in the 5- and 6-year age groups which overestimated age in the range of 1.0–1.7 years. WEA underestimated age for some of the age groups in both males and females and the range of accuracy ranged from −0.7 to 0.6 year.