

DENTAL AGE ASSESSMENT: ARE DEMIRJIAN'S STANDARDS APPROPRIATE FOR SOUTHERN CHINESE CHILDREN?

J. Jayaraman,^a N. M. King,^a G. J. Roberts,^b H. M. Wong.^a

^a Faculty of Dentistry, The University of Hong Kong, Pokfulam, Hong Kong

^b Honorary Professor, Department of Paediatric Dentistry, King's College London Dental Institute, Bessemer Road, London SE5 9RS, United Kingdom

ABSTRACT

Estimation of age is an important requisite in forensic, judicial and criminal proceedings. Dental age can be estimated from a dataset that has been prepared from a similar or a different population group. Demirjian and his co-workers proposed dental maturity scores from a French-Canadian population and this has served as a reference dataset for evaluation of age for various population groups. Considering the high number of illegal immigrants who have entered Hong Kong from neighboring countries, age estimation studies on southern Chinese is warranted. This study aimed to validate the applicability of Demirjian's dataset on a southern Chinese population. A total of 182 dental panoramic tomographs comprising an equal number of boys and girls with an age range from 3 to 16 years were scored. Dental maturity scores were obtained from the Demirjian's dataset and dental age was calculated. The difference in chronological and estimated dental ages was calculated using the paired t-test. There was a mean overestimation of dental age of 0.62 years for boys ($p < 0.01$) and 0.36 years for girls ($p < 0.01$). Demirjian's dataset is not suitable for estimating the age of 3-16 years old southern Chinese children.

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INTRODUCTION

Age estimation is an important requisite in some judicial proceedings. Circumstances where age assessment is required are; asylum seekers of unknown age, young people accused of criminal activities, and convicted criminals whose age is claimed to be less than 18 years prior to sentencing.¹ Universal law enforces that any asylum seeker under the age of 18 years should be considered as a child and has the right of abode in the country where asylum is claimed. Age assessment is, on occasions, required to assist in the identification process, especially of subjects from mass disasters.²

Age of an unknown person can be assessed by correlating the physical, skeletal and dental maturity of an individual. Many radiological

methods involving dental maturity as an indicator have been widely studied.^{3,4} This includes age estimations based on measurement of open apices of teeth, pulp-tooth ratio and the staging of tooth development.⁵⁻⁷ The Tooth Development Stages (TDS) described by Demirjian and his co-workers is considered the most simple and reliable method as it has the highest values for both intra- and inter- observer agreement.⁸

The development of clinically useful radiographic images, especially the Dental Panoramic Tomograph (DPT), which shows the whole of the dentition on a single image, has provided clinical investigators with a uniquely effective way of assessing dental maturation.⁹ Dental maturity scores based on the development of teeth from a French-Canadian population have been widely used as a standard reference.⁸ Many investigators have evaluated its applicability for other populations. The results showed wide variations from the known chronological age of the subjects in the study.¹⁰⁻¹²

The number of illegal immigrants intercepted in Hong Kong from mainland China has increased from 1890 in the year 2009 to 2340 in 2010 representing a total increase of 23.8%. Considering this high increase, age estimation studies in southern Chinese are warranted.¹³ The only study which utilized the Demirjian dataset for age assessment on southern Chinese was reported by Davis and Hagg who confined it to 5 and 7 year old children.¹⁴ Consequently, there is a necessity to test the applicability of the Demirjian's dataset on a wide age group of southern Chinese population. Hence, the aim of this study was to evaluate the applicability of the Demirjian dataset on 3 to 16 years old southern Chinese children.

MATERIALS AND METHODS

Sample distribution

The study sample comprised 182 dental panoramic tomographs (DPT) obtained from the archives of Prince Philip Dental Hospital, Hong Kong. All of these films had been taken previously for routine diagnostic purpose so they were being reused. The sample numbers were divided into 13 groups with ages ranging from 3 to 16 years. Following this, 14 DPTs (7 for boys and 7 for girls) were randomly selected to represent each age group.

Inclusion and exclusion criteria

Good quality dental panoramic tomographs (DPTs) belonging to subjects who were of southern Chinese ethnicity were included. Subjects with one or more bilaterally missing mandibular teeth and with a medical history of developmental anomalies of the dentition were also excluded from the study.

Demirjian staging of tooth developmental stages (TDS)

Demirjian's classification of tooth development stages (TDS) was adopted in our study.⁷ The staging system recognizes eight stages starting from initial calcification (Stage A) to root completion (Stage H).

Scoring method

The DPTs were scanned (Canon, Canon Inc, Japan) and transferred to a desktop computer (HP Pro 2000, HP Inc, US), so they could be viewed on a monitor under a magnification of 160 % for better visualization. A single calibrated examiner, who was well trained and experienced in assessing tooth development from radiographs analyzed all of the DPTs and scored the corresponding TDS for seven mandibular teeth on the left side. When a tooth was missing, the corresponding tooth on the right side was scored.

Intra-examiner reliability

Fifteen DPTs were scored for a second time after a period of 2 weeks to assess intra-examiner reproducibility. Cohen's kappa calculations were performed by comparing the TDS scores between the original and re-assessed DPTs.¹⁵ The calculated Cohen kappa value (0.88) showed that the intra-examiner agreement was "almost perfect".

Calculation of chronological age (CA) and dental age (DA)

Chronological age (CA) was the age of the patient obtained by subtracting the date of birth (DOB) from the date at which the radiograph was taken (DOR) and the resultant

values were expressed in decimal years. The Dental maturity score (DMS) for each TDS was obtained from the Demirjian dataset and the scores of all the teeth were added to provide an overall maturity score for each subject. This process was performed independently for boys and girls. The overall DMS was then converted to an approximate dental age using the comparison chart. The differences between the estimated dental age (DA) and the chronological age (CA) were calculated (DA-CA) separately for boys and girls and the overall differences were expressed in years.

Statistical tests

Data were analyzed using the statistical analysis computer software (SPSS 15.0.1 for Windows[®], SPSS Inc. Chicago, US). As the normality (Kolmogorov-Smirnov test) assumption of the data appeared to be valid, paired t-test was used to analyze the differences between the estimated DA and CA. Statistical significance was set at $p < 0.01$ to make the test more stringent and thereby to avoid the possibility of a difference in age estimation from occurring by chance. Pearson correlation analysis was also performed in order to derive the scatter plots of the mean difference in the dental age among various age groups.

RESULTS

The overall mean difference between the estimated dental age and chronological age for boys was 0.62 (± 1.09) years ($p < 0.01$) while for girls, it was 0.36 (± 0.95) years ($p < 0.01$). Among the various age groups, the least difference in dental age was observed at approximately 7 years for boys and 9 years for girls (Table 1). Pearson correlation analysis further demonstrates variation between the estimated DA and CA among the boys and the girls ($p > 0.01$). Minimal difference was observed in the younger children than the older ones (Figs. 1 and 2). The difference in the estimated dental age varied between +4.12 and -2.62 years for boys and +3.39 and -1.95 years for girls respectively.

DISCUSSION

Demirjian and his co-workers derived the initial dataset in 1973 and later updated the dataset with additional samples, both belonging to French-Canadian populations.^{7,16} Our study evaluated the applicability of the original dataset by Demirjian et al (1973) on southern

Chinese children. This study has demonstrated the inapplicability of the Demirjian dataset in estimating the age of southern Chinese and the overall mean difference was 0.62 years for boys ($p < 0.01$) and 0.36 years for girls ($p < 0.01$). Genetic influences, socio-economic status, nutritional conditions and dietary habits have been reported as possible reasons for variations in skeletal and dental maturity among different populations and ethnic groups.^{10,17}

In the current study, a total of 182 radiographs were chosen to estimate the applicability of the Demirjian dataset. A small number of radiographs (17 out of 182) were scored but the corresponding maturity scores were unavailable from the Demirjian's dataset, particularly at the upper and the lower extreme age groups. This could be attributed to variations in the dental maturity between the French-Canadian and the Chinese ethnicities. However, no effort was made to compensate for the missing numbers with additional radiographs in order to be consistent with the randomization procedure. Most studies that aimed to test the applicability of a dataset had variable numbers of subjects in each age group which, as a consequence, might affect the overall outcome of the study.¹⁰⁻¹² Hence, an effort was made in this study to standardize the procedure with an equal numbers of DPTs in each age group so that appropriate overall differences between the chronological age (CA) and the dental age (DA) could be determined.

Overestimation of age has been a consistent observation when the Demirjian dataset was applied for other populations and this has ranged from 0.20 years to 3.04 years in boys and from 0.23 years to 2.82 years in girls.^{10,18,19} In contrast, underestimation of age was reported only in a Venezuelan population.²⁰ The finding that overestimation was more pronounced in the older children was also made by Nykanen and co-workers.¹¹ They indicated that the self-weighted scores of the Demirjian dataset were based on the midpoint between two successive stages and the appropriate score was assigned to that of the higher developmental stage. In addition, the time period between each individual stage increases with the age of the subject and so this phenomenon would result in an overestimation of the age expected for the older children. Furthermore, abnormal Gaussian distribution of dental age after a certain chronological age in the older

individuals has also been suggested as a possibility for the overestimation of age.²¹

The number of stages included for calculation of the dental age determines the accuracy of age estimation. Hagg and Matsson compared the number of teeth and the various stages of development involved in dental age estimation between younger and older children.²¹ They found that the stages occurring in younger age were of shorter duration and thus the higher degree of accuracy which occurred in young children may be attributable to the large number of stages with shorter duration. In our study, the estimated difference in dental age declined towards negative in older children and consistent underestimation of age was observed after 13 years in both the boys and girls. This was consistent with the studies conducted in Malaysian, western Chinese and Iranian populations which also demonstrated underestimation of age for older children.²²⁻²⁴ In contrast, overestimation of age of older children was observed in northeastern Brazilian and south Indian populations.^{10,25}

The Demirjian method of staging was utilized in our study because it has been claimed to be the simple and reliable method.⁹ The DPT's were digitized so that the images could be magnified to make analysis much easier. However, difficulty was encountered when staging the teeth which were approaching root completion. The duration of time required for attaining the next consecutive stage is longer for stages F and G and this may have resulted in poor accuracy and reliability.¹¹ Moreover, certain stages of dental development were found to be easier to score and therefore more reliable. This was supported by Dhanjal and co-workers who reported that Stage E was the most reliable stage among Demirjian's classification of tooth developmental stages.²⁶ Considering the complexity of scoring and for better accuracy of the results, it has also been suggested that it would be beneficial to further split the stages proposed by Demirjian and his co-workers, especially, stages F and G.¹⁷ The stages were split into F1 and G1 and the resulting ten stage method has been successfully used.²⁷ However, this method of splitting the stages was refuted by De Salvia and co-workers who reported inaccuracy in the scores and poor inter-rater correlation.²⁸

It has been postulated that Demirjian's dataset is only applicable for individuals aged from 3 years to 16 years. Our findings supported the notion that the Demirjian dataset was applicable for southern Chinese with

chronological ages starting from 3.26 years for boys and 3.05 years for girls. When Demirjian's dataset was used to estimate the age, inaccurate results have been observed between different populations and also different groups of the same population.^{19,25,29} This observation was found to be true when comparing the estimation results derived for western Chinese subjects, for whom the difference in dental age observed was -0.08 years for boys and 0.15 years for girls while for southern Chinese subjects, it was 0.62 years for boys and 0.36 years for girls.²³

Davis and Hagg evaluated the applicability of Demirjian's dataset on southern Chinese children aged 5 to 7 years and found the dataset overestimated the age of boys by 10.8 months and girls by 7.2 months.¹⁴ A similar age group (5 to 7 years) in our study was evaluated and the outcome was consistent with the previous study as the dataset overestimated the age of boys by 15 months (1.25 years) and girls by 6 months. Different statistical methodologies have been employed to adapt the existing data with Demirjian's dental maturity scores. The adapted scores represent statistical adjustments of the data and are not truly representative of the population. Furthermore, this statistical transfer of the data would not be able to take into account age estimations beyond 16 years of age.

CONCLUSION

Statistically significant difference and no correlation between the estimated dental age and the chronological age clearly indicates the inapplicability of the Demirjian's dataset to precisely estimate the age of southern Chinese children aged 3 to 16 years. Thus, it can be concluded that the Demirjian's dataset is inappropriate for estimating the age of southern Chinese children.

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Address of corresponding author:

Professor Nigel M. King
Paediatric Dentistry & Orthodontics,
Prince Philip Dental Hospital,
34, Hospital Road,
Hong Kong
e-mail: profnigelking@mac.com

Address of the primary author:

Dr Jayakumar Jayaraman
Paediatric Dentistry & Orthodontics,
Prince Philip Dental Hospital,
34, Hospital Road,
Hong Kong
e-mail: jayakumar83@hotmail.com

Table 1. Difference between the estimated dental age (DA) and chronological age (CA) among various age groups.

Age group	Mean CA	Mean DA	(DA-CA)	P-value
<u>Female</u>				
3-3.9	3.68	3.55	-0.13	0.459
4-4.9	4.60	4.96	0.36	0.346
5-5.9	5.56	5.70	0.14	0.575
6-6.9	6.66	7.24	0.58	0.008*
7-7.9	7.52	7.69	0.16	0.297
8-8.9	8.30	9.09	0.79	0.068
9-9.9	9.54	10.00	0.46	0.307
10-10.9	10.63	11.66	1.03	0.075
11-11.9	11.33	11.65	0.32	0.565
12-12.9	12.57	13.36	0.79	0.098
13-13.9	13.48	13.92	0.43	0.244
14-14.9	14.89	14.15	-0.74	0.392
15-15.9	15.51	14.10	-1.41	0.036
Average	8.92	9.28	0.36	0.001*
<u>Male</u>				
3-3.9	3.57	4.36	0.79	0.001*
4-4.9	4.45	4.47	0.02	0.949
5-5.9	5.61	6.90	1.29	0.000*
6-6.9	6.41	7.49	1.07	0.006*
7-7.9	7.23	7.74	0.51	0.002*
8-8.9	8.50	9.00	0.50	0.160
9-9.9	9.58	9.30	-0.28	0.405
10-10.9	10.80	11.54	0.74	0.123
11-11.9	11.51	12.43	0.92	0.307
12-12.9	12.60	13.45	0.85	0.008*
13-13.9	13.40	14.92	1.52	0.013
14-14.9	14.54	14.50	-0.04	0.227
15-15.9	15.30	13.65	-1.65	0.340
Average	8.93	9.55	0.62	0.000*

* P value < 0.01

CA, chronological age; DA, dental age

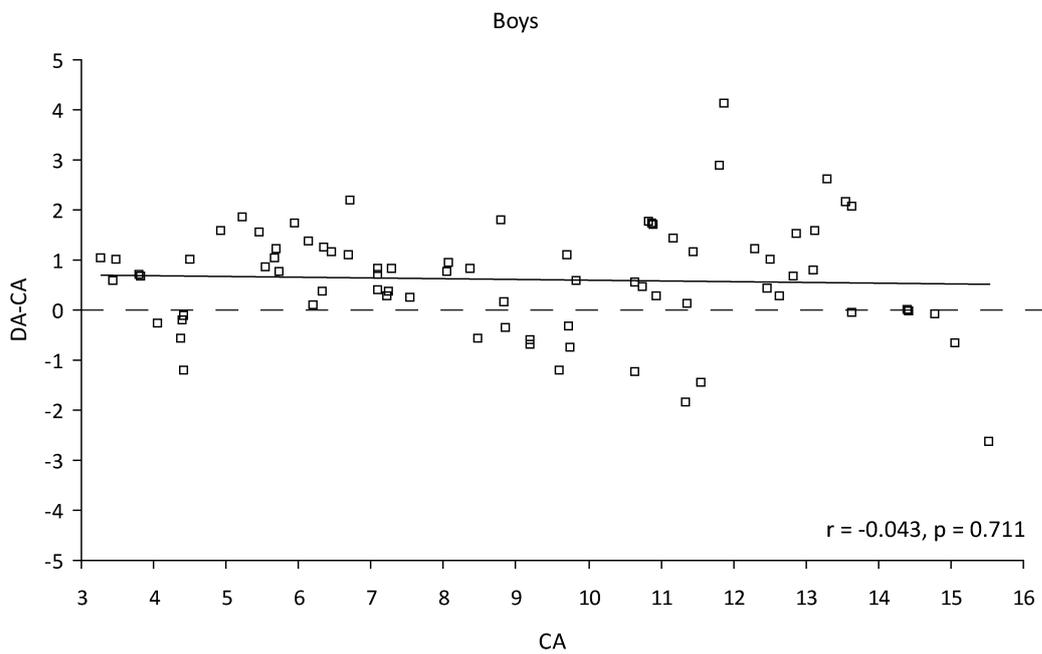


Fig. 1. Regression line and Scatter plot showing differences in dental age and chronological age among southern Chinese boys.

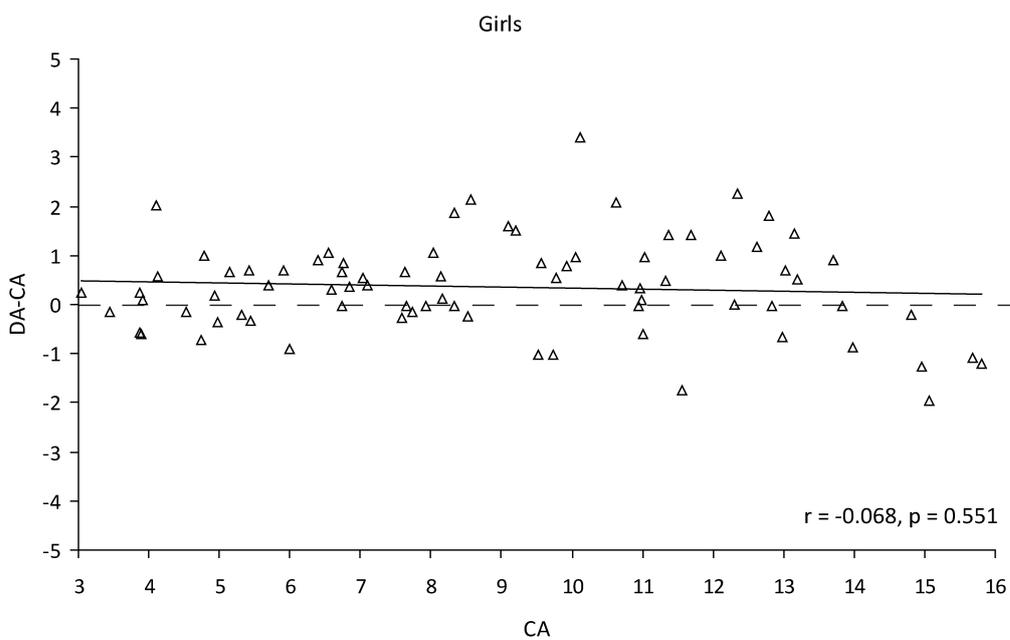


Fig. 2. Regression line and Scatter plot showing differences in dental age and chronological age among southern Chinese girls.