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Original communication

Dental age assessment in a northern Chinese population

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ABSTRACT

Introduction: Age estimation is imperative in the fields of paediatric dentistry, orthodontics and forensic science. Studies have shown that dental age estimation by the radiological method is reliable and non-destructive. Although Demirjian's method was the most widely used estimation method, in recent studies, the Willems' method has been found to be more accurate. The aim of this study was to compare the accuracy of dental age estimation methods and to modify the Demirjian method to make it more applicable for a northern Chinese population.

Materials and methods: An assessment was made of 1004 digital orthopantomographs of a northern Chinese population (392 boys and 612 girls) ranging in age from 11 to 18 years old. Dental ages were calculated using both the Demirjian method and the Willems method. Discrepancies between chronological ages and dental ages were statistically analysed by the paired t-test and the Wilcoxon signed rank test. A nonlinear fitting method was applied to construct a mathematical model to modify the Demirjian method.

Results: The Demirjian method underestimated age by 0.47 y in boys and 0.63 y in girls, while the Willems method underestimated age by 0.54 y and 1.01 y in boys and girls, respectively. The mean absolute error was 1.08 y for the Demirjian method and 1.22 y for the Willems method.

Conclusion: The Demirjian method was more accurate for estimating dental age compared with the Willems method. However, the Demirjian method may not be suitable for the northern Chinese population; therefore, it should be modified so that it can be used for this population.

1. Introduction

Age estimation is frequently applied in the fields of paediatric dentistry,[1] orthodontics and forensic science.[2,3] For a living person whose birth certificate is not available, age estimation is used to determine certain social responsibilities, such as employment and marriage.[4] Most importantly, age estimation is used in criminal law cases to determine whether a suspect that does not have valid identification documents has reached the age of criminal responsibility and whether adult criminal law should be applied.[5] Age estimation is also used to identify corpses.[4]

Compared with age estimation using skeletal indicators, such as cervical vertebrae and hand wrist bones, dental age estimation (DAE) is more reliable and genetically controlled.[6] Among all of the methods used to estimate dental age (DA), such as anatomy, histology and radiology,[7–9] the radiological method is less variable and less non-destructive.

Currently, the Demirjian method is the most frequently applied radiological method. The Demirjian classification system is based on a definitive anatomical shape and shows very good agreement for both intra- and inter-examiners. These clearly defined stages, and a few intermediate stages, also allow for better reproducibility.[10,11] However, as the Demirjian method was developed through the study of French-Canadian children, inaccuracies have been observed when applying the Demirjian method to different regions of the world and different ethnic groups. The Demirjian method tends to overestimate age.[12]

In response to this inaccuracy, Willems[13] modified the Demirjian's scoring system in 2001 by creating new tables in which the

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maturity score could be directly converted into an age. This modification has been tested among various populations and has been reported to be more accurate compared with the original Demirjian method.[14–16] However, the majority of DAE studies in the northern Chinese population focus on the Demirjian method alone, and there are a limited number of studies that simultaneously compare the accuracy of the Demirjian method and the Willems method in this population.[17] This study aims to:

1 Evaluate the applicability of the Demirjian method and the Willems method for assessing the DA of 11 to18-year-olds in a northern Chinese population;
2 Modify the Demirjian method to make it more accurate with regard to DAE for 11 to 16-year-olds in a northern Chinese population.

2. Materials and methods

2.1. Subjects

At the Affiliated Hospital of Qingdao University, 1004 digital orthopantomograms of Northern Chinese individuals were randomly selected from patients who received treatment from January 2010 to May 2014. The selection consisted of 392 boys and 612 girls between 11 and 18 years old (Table 1).

The exclusion criteria included: missing teeth in the left mandible (except the third molar); serious jaw deformities; severe malocclusions; or images in which the mandibular teeth were not clearly visible.

The research was approved by the independent ethics committee of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiao Tong University, School of Medicine (2014133).

2.2. Methods

2.2.1. Dental age estimation

Chronological age (CA) was calculated by subtracting the birth date from the date of the radiograph and was expressed to two decimal places. In each digital orthopantomogram of the 1004 subjects, all seven teeth on the left mandible were rated on a scale of 'A' to 'H' according to the criteria of Demirjian et al.[18] Using the Demirjian method, each rating was converted into a score. The total maturity score was derived from adding the scores of all seven teeth. Then, the maturity score was transformed to DA as described by Demirjian et al. Using the Willems method,[13] each rating was converted into a score, and the DA was obtained by adding the scores of the seven teeth. The digital orthopantomograms were scored separately by three examiners who were skilled in both the Demirjian method and in the Willems method. For each orthopantomogram, when all three examiners reached the same conclusion, the result was chosen as the final DA; if their results were inconsistent, then they discussed the cases to reach conclusion. We supposed that, in this the case, it was unnecessary to test the inter- and the intra-rater reliability and that the reliability of data was guaranteed.[19] To avoid observer bias, the examiners were not given the sex, name or age of subjects.

Table 1
The age and sexual distribution of 1004 Northern Chinese subjects.

Age (years)	Boy	Girl	Total
11.0–11.9	59	72	131
12.0–12.9	59	80	139
13.0–13.9	76	81	157
14.0–14.9	49	73	122
15.0–15.9	58	71	129
16.0–16.9	35	73	108
17.0–17.9	38	74	112
18.0–18.9	18	88	106
Total	392	612	1004

2.2.2. Statistical method

The relation between the CA and the DA was analysed using each method for gender, age group and the total population. The statistics were analysed by SPSS 16.0 (SPSS Inc., Chicago, IL). P values less than 0.05 were considered statistically significant.

1 Discrepancies between CA and DA were statistically analysed based on age and gender using the paired t-test and the Wilcoxon signed rank test (the Kolmogorov–Smirnov test was used to test whether the data distribution of CA-DA differed from the normal distribution. If the test did not obey the assumed normal distribution, Wilcoxon signed rank tests were used; otherwise, paired t-tests were applied). The mean absolute error (MAE) was used to quantify the accuracy of the two methods.
2 The nonlinear fitting method was applied to the estimated Demirjian DA and CA to construct the mathematical model used to modify the Demirjian method.

3. Results

The analysed CA ranged from 11.0 to 18.9 years, and the mean CA of all of the subjects was 14.66 ± 2.21 years (boys, 14.27 ± 2.03 years and girls, 14.90 ± 2.28 years) (Table 6).

3.1. Demirjian method

Tables 2 and 3 compare the Demirjian DAs and CAs of boys and girls, respectively. The mean age difference (CA-DA) was 0.47 years (SD 1.21) for boys ($P < 0.05$) and 0.63 years (SD 1.27) for girls ($P < 0.05$).

After applying the Kolmogorov–Smirnov test, the result showed a normal distribution of data (CA-DA) in subjects of all ages, except for 13.0- to 13.9-year-old boys, 13.0- to13.9-year-old girls and 17.0- to 18.9-year-old girls, and the total sample of girls.

For boys, statistically significant differences were observed in all age groups, except for 13.0- to13.9-years-olds, and the mean DA was underestimated in all age groups, except for 11.0–12.9 year olds. However, an underestimation of 0.47 y was noted in DA the entire sample compared to CA.

For girls, the mean DA was 14.27 ± 1.60 y. All of the age groups, except 14.0–14.9 year olds, showed statistically significant differences, and DA was underestimated in all age groups, except for 11.0–12.9 y olds. The DA was underestimated by 0.63 y in the entire sample compared to CA.

3.2. Willems method

Tables 4 and 5 compare the Willems DA and CA of boys and girls, respectively. The mean difference (CA-DA) was 0.54 years (SD 1.37) for boys ($P < 0.05$) and 1.01 years (SD 1.19) for girls ($P < 0.05$).

After applying the Kolmogorov–Smirnov test, the result showed a normal distribution of data (CA-DA) in subjects of all ages, except for 15.0- to18.9-year-old girls.

For boys, all age groups, except 13.0–13.9 y olds, showed statistically significant differences, and the mean DA was underestimated in all age groups, except for 11.0–12.9 y olds. However, an underestimation of 0.54 y was noted in the entire sample compared to CA.