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Original article

Estimation of children's age based on dentition via panoramic radiography in Surabaya, Indonesia

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ABSTRACT

Background: *Age may be estimated using tooth eruption sequence and/or calcification stage. Because many factors may affect the time of eruption, the tooth calcification stage shows higher accuracy than the time of tooth eruption. Demirjian's and Willems' methods have been most commonly used for dental age estimation. Both Willems and Demirjian use the calcification stage as an indicator. Studies comparing these methods have shown varied results, as they have been performed on different populations.* **Purpose:** *This paper aims to analyse the estimation of children's age based on dentition via panoramic radiography in Surabaya, Indonesia.* **Methods:** *This is a cross-sectional study using a purposive sampling method. One hundred digital panoramic radiographs of children between 6 and 15 years that match the inclusion criteria from the Airlangga University dental hospital in Surabaya, Indonesia were evaluated. One researcher analysed estimated dental age (EDA) three times in a one-week time-lapse using Demirjian's and Willems' methods. Statistical analysis was carried out using a Paired t-test and Wilcoxon signed-rank test. EDA was calculated using both Demirjian's and Willems' methods.* **Results:** *The mean chronological age (CA) was 10.57 ± 2.70 for males and 10.73 ± 2.84 for females. The mean difference between CA and EDA using the Demirjian and Willems methods was -0.57 ± 1.17 and 0.10 ± 0.96 for males and 0.58 ± 1.40 and 0.44 ± 0.94 for females.* **Conclusion:** *The results suggest that Willems' method is more precise than Demirjian's method in males and females and more suitable for children in Surabaya, Indonesia.*

Keywords: *Demirjian; dental age estimation; dentistry; forensic odontology; Willems*

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INTRODUCTION

Forensic odontology is a branch of forensic science that plays a role in identifying victims of natural and non-natural disasters.[1,2] The scope of forensic odontology includes identification using dental records, bitemark analysis, and age estimation.[3] Age estimation has various advantages, including identifying unknown victims, determining age at death, and determining the chronological age (CA) of children with unknown birth documents.[4]

In general, the objects used in age estimation are teeth and bones. Teeth have the advantage of making it possible to estimate an individual's age from prenatal to adult age, whereas bones can only be used in a certain age range.

In addition, teeth are the strongest parts of the body, so they can be used for identification even if the body has been burned, mutilated, or decomposed.[5]

There are several methods of estimating dental age, including radiographic, morphological, and biochemical methods. The selection of a method must consider the individual's status (alive or dead), age range, dental condition, and also the availability of facilities.[5] Radiography is one of the most common methods for age estimation. It also provides nearly exact estimations for both living and deceased victims.[1,5] In this study, Willems' and Demirjian's radiographic methods were used because they are considered simple and non-invasive. These methods were also chosen because they use the stage of

tooth calcification as an indicator of their assessment and are, therefore, more precise than the tooth eruption sequence.[4]

In research on age estimation, some researchers compare the Demirjian's and Willems' methods to analyse which method is more precise in determining dental age. In the research of Yang et al.,[6] the Demirjian method was shown to be more precise than Willems' in the South China population, where the estimated dental age (EDA) of the Demirjian method was underestimated by -0.03 ± 1.20 years for males and overestimated by 0.03 ± 1.05 years in females. The Willems method, meanwhile, overestimated by 0.44 ± 1.15 years for males and 0.54 ± 1.08 years for females. Contrarily, in Ozveren et al.'s research on the Turkish population, Willems' method was shown to be more precise than Demirjian's method, with the EDA of the Demirjian method being an underestimation of -1.04 ± 0.95 years for males and an underestimation of -0.87 ± 0.92 years for females.[7] The Willems method underestimated by -0.40 ± 0.85 years for males and -0.17 ± 1.02 years for females. According to research conducted by Esan et al.[8] regarding the differences in the results of the Demirjian's and Willems' methods, different results were achieved because they were conducted on different populations. This study aims to analyse the estimation of children's age based on dentition via panoramic radiography in Surabaya, Indonesia.

MATERIALS AND METHODS

This study's sample was 100 digital panoramic radiographs from 50 males and 50 females aged 6 to 15 years who matched the inclusion criteria. The inclusion criteria were clear panoramic radiographs, seven permanent mandibular left teeth shown on the panoramic radiographs, and confirmation of both birth date and panoramic radiograph date. The exclusion criteria were: panoramic radiographs showing any pathological condition and/or tooth extraction, systemic diseases or genetic disorders that could impair skeletal and dental development, orthodontic appliances, and congenital or developmental anomalies.

Demirjian's and Willems' methods were used to score all digital panoramic radiographs. The seven left mandibular teeth were evaluated based on the stage of tooth calcification. Each tooth score was turned into a gender-specific chronological table. Radiographic pictures were used to categorise tooth development into eight stages ranked on a scale of 'A' to 'H,' and schematic diagrams were used to explain the specific parameters required for each step in both uniradicular and multiradicular teeth.[9]

CA is determined based on the date, month and year of birth. It is calculated from the date the panoramic radiograph was taken minus the date of birth. EDA is the age obtained through calculations using the Demirjian's and Willems' methods from panoramic radiographs. Each method was calculated separately.[9]

Data calculations were carried out three times with an interval of one week with one observer to eliminate bias in the results. The sample was analysed by statistical tests using IBM® SPSS® Statistics version 26.0 (IBM, Armonk, NY, USA). A Cronbach's alpha test was used to determine the level of reliability of the variables. The Demirjian method variables were 0.96 and the Willems method was 0.98, which means that both methods are feasible to use. Shapiro Wilk and Levene's tests were used to perform normality and homogeneity tests. Variables that have a p-value > 0.05 were elaborated using the paired t-test, while variables that have a p-value < 0.05 were elaborated using the Wilcoxon signed-rank test.

RESULTS

A Cronbach's alpha test was conducted to examine the inter-examiner agreement of tooth development stage scoring, with a coefficient of 0.6. The Kolmogorov-Smirnov test result indicated that the data were normally distributed and suitable for further statistical analysis, with a p-value > 0.05. To determine the significance of differences between CA and EDA, a paired t-test was used.

Table 1 compares CA and EDA based on the Demirjian method for males and females. In both sexes, the overall mean difference between CA and EDA was -0.57 ± 1.17 and 0.58 ± 1.40, respectively. The age categories were classified for further analysis. In ages 6 to 10, the mean difference between CA and EDA was -0.14 ± 0.80 and 0.22 ± 0.94 for males and females, respectively. In the age group of 10 to 15, the mean difference between CA and EDA was -1.07 ± 1.34 and 0.95 ± 1.68 for males and females, respectively.

Table 1. Comparison of chronological age (CA) and estimated dental age (EDA) based on Demirjian's method

Gender	Age group	CA $X \pm SD$	EDA $X \pm SD$	Age Difference $X \pm SD$	p-value	Remarks
Male	6–10	8.42 ± 1.40	8.57 ± 1.35	-0.14 ± 0.80	0.35	Underestimate
	11–15	13.10 ± 1.27'	14.17 ± 1.63	-1.07 ± 1.34	0.00*	Underestimate
	Total	10.57 ± 2.70'	11.15 ± 3.18'	-0.57 ± 1.17	0.00*	Underestimate
Female	6–10	8.27 ± 1.43	8.05 ± 1.04'	0.22 ± 0.94	0.07	Overestimate
	11–15	13.18 ± 1.37	12.23 ± 1.95	0.95 ± 1.68	0.00*	Overestimate
	Total	10.73 ± 2.84'	10.14 ± 2.61'	0.58 ± 1.40	0.00*	Overestimate

Paired T-test, Wilcoxon Signed-rank test (*p < 0.05)

Table 2. Comparison of chronological age (CA) and estimated dental age (EDA) based on Willems' method

Gender	Age group	CA $X \pm$ SD	EDA $X \pm$ SD	Age Difference $X \pm$ SD	p-value	Remarks
Male	6–10	8.42 ± 1.40	8.39 ± 1.71	0.02 ± 0.93	0.87	Overestimate
	11–15	13.10 ± 1.27	12.91 ± 1.40	0.18 ± 1.02	0.39	Overestimate
	Total	10.57 ± 2.70'	10.47 ± 2.75	0.10 ± 0.96	0.27	Overestimate
Female	6–10	8.27 ± 1.43	7.90 ± 1.77	0.27 ± 0.68	0.01*	Overestimate
	11–15	13.18 ± 1.37	12.66 ± 1.76	0.52 ± 1.16	0.03*	Overestimate
	Total	10.73 ± 2.84'	10.28 ± 2.97	0.44 ± 0.94	0.00*	Overestimate

Paired T-test, Wilcoxon Signed-rank test (*$p < 0.05$)

Table 2 compares CA and EDA based on Willems' method for males and females. In both sexes, the overall mean difference between CA and EDA was 0.10 ± 0.96 and 0.44 ± 0.94, respectively. The age categories were classified for further analysis. In the 6 to 10 years old group, the mean difference between CA and EDA was 0.02 ± 0.93 and 0.27 ± 0.68 for males and females, respectively. In the age group of 10 to 15, the mean difference between CA and EDA was 0.18 ± 1.02 and 0.52 ± 1.16 for males and females, respectively.

DISCUSSION

A person's age can be established by a number of factors, including bones and teeth. Teeth reflect a wide range of ages, from intrauterine to adult. Dental age estimation methods such as Demirjian's and Willems' methods are used for children. Demirjian (1973) introduced a new system of calculating dental age based on seven teeth on the left side of the mandible (central incisor to second molar teeth) to calculate dental maturity scores. In 2001, Willems improved Demirjian's dental age estimation approach. Willems' method showed increased accuracy in determining CA.[10]

Demirjian's and Willems' techniques estimate children's CA using teeth calcification sequence as an indicator. Researchers continue to discuss the Demirjian and Willems dental age estimation methods for various populations, as different results are achieved for each researcher with different populations.[8]

Based on the findings of the current study, it can be stated that the Willems method shows more precise results than the Demirjian method. These findings are consistent with several similar studies, namely Nik-Hussein et al.[11], Grover et al.[12], Ye et al.[13], and Kumaresan et al.[14], who also concluded that the Willems method was more precise than the Demirjian.

Nik-Hussein et al.'s study[11] was carried out on the Malaysian population. The Demirjian method in the male and female groups overestimated the ages by 0.7 ± 1.3 and 0.5 ± 1.2 years, respectively. Meanwhile, the Willems method overestimated the ages by 0.3 ± 1.3 years for the male group and 0.05 ± 1.1 years for the female group.[11]

Grover et al.[12], who conducted their study on the population of South India, showed that the Demirjian method in the male and female groups underestimated the ages by -0.66 ± 0.38 and -0.56 ± 0.36 years, respectively. The Willems method overestimated by 0.36 ± 0.41 years in the male group and 0.23 ± 0.43 in the female group.[12]

In a study by Ye et al.[13] on the Chinese population, the Demirjian method in the male and female groups overestimated the ages by 1.68 ± 1.29 and 1.28 ± 1.17 years, respectively. The Willems method overestimated the ages by 0.36 ± 1.19 years in the male group and underestimated by -0.02 ± 1.18 in the female group.[12]

In Kumaresan et al.'s study,[14] which was carried out on the Malaysian population, the Demirjian method in the male and female groups overestimated the ages by 0.98 ± 1.29 and 0.97 ± 1.12 years, respectively. Meanwhile, the Willems method overestimated the ages by 0.55 ± 1.40 years for the male group and 0.53 ± 1.20 for the female group.[14]

However, the study on the South China population by Yang et al.[6] discovered that the Demirjian method was more precise than the Willems method. Demirjian's method underestimated the ages by -0.03 ± 1.20 in the male group and overestimated by 0.03 ± 1.05 years in the female group. The Willems method overestimated the ages by 0.44 ± 1.15 years for the male group and 0.54 ± 1.08 years for the female group.[6]

The disparity in results between this study and other studies could be attributed to biological variations due to ethnic differences. Furthermore, sample size and statistical approach of the age range could also lead to a difference in results.[6] These differences may also occur due to differences in the level of dental development in different populations.[10] This can be attributed to differences in genetic factors in each population that will affect the growth and development of teeth.[5]

According to Mohammed et al.,[15] sample size, different age groups, statistical methodologies, and the accuracy of the methods tested can affect the results of age estimation. In addition, differences in results can also occur due to the influence of lifestyle, nutrition, and dietary habits as an example of environmental influences.[7]

Based on this study, Willems' dental age estimation method was found to be more precise than the Demirjian method in both sexes, and it may be applicable to children in Surabaya, Indonesia. In forensic science, dental age estimation research is very important in order to determine the most reliable method to be applied to a certain population. However, we propose additional research to achieve more precise estimates of different demographic groupings and ethnicities.

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