

Accuracy of age estimation method by panoramic radiographic examination in paediatric dental patients: A diagnostic study in Indonesia

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ABSTRACT

Introduction: Cases of violence and criminality in children continue to increase, with implications for the increasing need for identification measures, especially for living victims for judicial or law enforcement purposes. Teeth are one of the indicators that determine a child's identity. The methods often used to estimate a child's age through dental radiographic examination during the period of deciduous and mixed teeth are the Al Qahtani, Demirjian, and Blenkin & Evans methods.

Materials and Methods: An analytical cross-sectional study was conducted. The children's ages were estimated using dental examination and 103 digital panoramic radiographs. Descriptive statistics, normality test followed by difference test based on five parameters: p-value Wilcoxon test, Intraclass Correlation Coefficient (ICC), Spearman correlation coefficient, and Bland–Altman analysis by looking at % out of Limit of Agreement and looking at Mean Difference.

Results: Wilcoxon's p-value showed that Blenkin's method and Demirjian's method vs. chronological age were significantly different, whereas Al Qahtani's method was not significantly different. The Demirjian method had the highest ICC. Spearman's correlation coefficient was strongly correlated between Blenkin's and Demirjian's methods and the chronological age ($r \geq 0.8$). The Bland–Altman analysis showed that the Demirjian Method had the best % out of LOA = 5.8, while the Al Qahtani Method had the most minor differences.

Conclusion: The Demirjian method showed results closest to the patient's chronological age.

KEYWORDS:

Children, chronological age, crime and violence, estimation method

INTRODUCTION

Recently, news on crimes against children has become rampant. Almost every day, there is a lot of news in the media and perceptions from the community that reports

incidents of violence, kidnapping, abuse, neglect of children, and others. According to the World Health Organization (WHO), violence against children is an act of mistreatment or mistreatment of children in the form of physical, emotional, or sexual harm; neglect of care; and exploitation for commercial interests that are real or not, which can endanger their health, survival, dignity, or development. The potential for violence against children includes physical, emotional, sexual, and economic violence. In 2023, the Ministry of Communication and Information, along with the Indonesian Child Protection Commission, stated that Indonesia was in a child abuse emergency.^{1,2}

Age identification is widely used in paediatric dentistry, forensics, anthropology, archaeology, and orthodontics. Age determination in live child individuals is generally used for various purposes such as 1) identification of unknown individuals at the scene of a crime or accident; 2) estimating the chronological age of children with missing or doubtful birth certificates; 3) falsification of working age, marriage age, and athlete's age; 4) guardianship of children; 5) immigration; 6) rape; and 7) legal evidence to determine whether a person is legally a child or an adult, where there are different legal and judicial processes for children and adults.^{3,4} Treatment planning and prognosis of a particular orthodontic treatment depends mainly on the age of the teeth. Chronological age (CA) can also be used as an essential indicator to determine abnormal eruption sequences to implement preventive measures.^{5,6}

Forensic dentistry is a branch that uses teeth for identification and judicial or law enforcement. Teeth are used as a medium of identification because they are the hardest part of the body and are resistant to degradation, decomposition, chemical influences, and high-temperature influences. Dental maturity is considered a more accurate indicator of biological maturity in children, because it is least affected by nutritional and endocrine status. A widely researched method for estimating dental age is to analyze tooth growth on radiographs. This method was chosen because it is easy to perform and non-invasive, especially in estimating the age of living individuals.⁷⁻¹⁰ Various methods are currently used to predict age, such as skeletal maturation, physical examination using anthropometric measurements, and

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dental examination. Human skeletal growth and maturation are unique to each individual, but dental examination techniques are considered the best in assessing true chronological age, especially during the age range when teeth are undergoing morphological development.¹¹⁻¹³ It is known that different genetic and environmental factors may cause individuals of the same chronological age to have other body characteristics and developmental levels. Therefore, before using an age estimation method for legal purposes in any population, it is essential to validate the accuracy and applicability of the technique in a specific population.^{14,15}

To the best of our knowledge, no clinical study has officially stated the most appropriate age estimation method for child identification in Indonesia. As long as we are in the field of forensic odontology, there is no consensus among forensic odontology practitioners on the dominant age estimation method for Indonesian children. Previous studies have only compared several methods with their respective advantages and disadvantages; therefore, there is no answer in cases that require age estimation in Indonesia. Some adopted methods used for age estimation through radiographic examination of children's teeth in the deciduous and mixed phases include the Al Qahtani, Demirjian, and Blenkin and Evans methods. The author hopes to answer the question of using one of the most appropriate age estimation methods for Indonesian children. By knowing the most suitable method and achieving high accuracy, the success of the work carried out can be achieved optimally. Therefore, this study aimed to evaluate the accuracy and applicability of three established dental age estimation methods in an Indonesian paediatric population.

MATERIALS AND METHODS

This study was approved by the Ethical Committee of Health Research, Faculty of Dentistry, Universitas Trisakti, Jakarta, Indonesia (046/S3/KEPK/FGK/7/2024).

Study Design

An analytical study with a cross-sectional design was conducted between October and December 2024. The study was designed to estimate the age of paediatric patients through a dental examination on digital panoramic radiographs by comparing the measurement results using the Al Qahtani, Demirjian, and Blenkin & Evans methods to the patient's chronological age. Panoramic radiographs were obtained from paediatric patients at the Radiology Installation of the Dental and Oral Hospital (RSGM), Faculty of Dentistry, Trisakti University.

Sample Size and Data Collection

Based on our calculations, the minimum sample size for this study was 73. The panoramic radiographs examined were panoramic radiographs of paediatric dental patients who came to the RSGM Faculty of Dentistry, Trisakti University, from September 2023 to September 2024.

The study inclusion criteria were panoramic images of healthy individuals, no systemic disease, children aged 0-16 years, no orthodontic treatment, no bilateral anomalies or

pathology in the maxillofacial region, history of trauma, and no bilateral permanent tooth loss, caries, restoration, root canal treatment, or apical pathology. The exclusion criteria were as follows. incomplete tooth seeds in region 3 and poor quality panoramic radiography results.

A competent forensic odontologist performed the measurements using these three methods. All measurement results were recorded and matched with the patients' chronological age according to the hospital's Medical Record data.

Procedures of Age Estimation^{8,10}

Demirjian Method

First, the gender of the subjects was identified. The method relies on a panoramic radiograph of the left mandibular permanent teeth, from the central incisor to the second molar. Next, we assessed the tooth maturation stages of each tooth to convert them into the Demirjian maturation score according to the sex-specific table. The scores were then calculated to obtain the Total Demirjian Maturation Score, which was converted according to the Demirjian age estimation table.

Blenkin Evans Method

First, the gender of the subjects was identified. The method relies on a panoramic radiograph of the left mandibular permanent teeth, from the central incisor to the second molar. We then assessed the tooth maturation stages of each tooth, similar to the Demirjian Classification of maturity, to convert it into the Blenkin maturation score according to the sex-specific table. Next, we calculated the scores to obtain the Total Maturation Score and converted the score according to the age estimation table.

Al-Qahtani Method

This method uses atlas and presents reference images for each age group from birth to 23 years. First, the tooth development stages include crown formation, tooth positioning in relation to the alveolar bone, root formation, and apical closure of each tooth on one side of both jaws. Then, we matched the development stages assessed on panoramic radiographs with the Atlas. Next, we determined the age range that represents the best match between the radiograph and the Atlas.

Statistical Analysis

Data cleaning and tabulation were performed using Microsoft Excel, which was then exported to the Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, version 25.0). Descriptive statistics were used to display the characteristics of the study participants, followed by a normality test. T-tests were conducted to compare the measurement results of the three methods on the CA of patients, based on five parameters: Wilcoxon Signed-Rank Test, Intraclass Correlation Coefficient (ICC), Spearman correlation coefficient, and Bland-Altman analysis by looking at % out of Limit of Agreement (% out of LOA) and looking at mean difference.

A Wilcoxon test was conducted to determine whether there was a significant difference between chronological age and

the measurement results of the age estimation method. The ICC is a reliability test between two observations: CA-Blenkin, CA-Demirjian, and CA-Al Qahtani. Spearman's Correlation was then used to determine whether there was a linear relationship between the variables CA-Blenkin, CA-Demirjian, and CA-Al Qahtani. The % of LOA was used to calculate the percentage of extreme measurement results from the total sample.

RESULTS

A total of 103 digital panoramic radiographs of pediatric patients were obtained at an oral hospital. Table I presents the range (minimum and maximum), standard deviation of chronological age, and the three methods measured.

Table II shows the results of the age difference test on CA against the other three age estimation methods using non-parametric tests, namely the Wilcoxon signed-rank paired test and the Spearman correlation coefficient. Other tests are ICC (Intraclass Correlation Coefficient), Bland-Altman (% of the Limit of Agreement), and mean differences.

Wilcoxon's p-value shows that Blenkin's Method and Demirjian's method vs. CA are significantly different, meaning that the median ages in Blenkin's method and Demirjian's method median vs. CA are significantly different. However, in Al-Qahtani, the median age was not significantly different from the median CA. The ICC test showed that all three methods were either very good or excellent. Excellent when ICC was > 0.75 . (Ref Christine Konieczka et al). However, the Demirjian method had the highest ICC value (ICC = 0.8).

The Spearman correlation coefficient strongly correlated with the Blenkin and Demirjian methods for chronological age ($r \geq 0.8$). The Bland-Altman analysis shows that all methods have a percentage of the Limit of Agreement below 10%, and the Demirjian Method has the smallest percentage LoA; therefore, it can be said to be better. Bland-Altman analysis shows a gray belt, which means that the observation points (one point is one sample) are within the tolerance limit. This belt was formed based on data variation; the more varied it is, the wider it will be. The minimum to maximum range is wider, meaning that it is more varied. Bland-Altman analysis assesses the range of the upper and lower limits. What is essential in Bland Altman's analysis is the percentage of observations outside the tolerance limit, which is called the %out of the Limit of Agreement (%out of LoA).

Analysis using Mean Differences shows that the Al Qahtani Method has the smallest mean difference value (closest to chronological age) compared to the other two methods. Demirjian showed the highest ICC. ICC = reliable when ≥ 0.75 , and in Al Qahtani or Demirjian all above 0.75. Regarding the size of the numbers, it cannot be compared; the important thing is that the interpretation if above 0.75 is said to be reliable.

DISCUSSION

Age determination is a major concern in both medical and legal procedures. Dental age identification is an important

procedure in clinical science, forensics, and legal procedures. As we know, cases of crimes and violence against children tend to increase annually. Therefore, indirectly, the need for age estimation through dental examinations of children for law enforcement purposes has also increased, especially in living individuals. In this situation, the role of pedodontists and forensic odontologists becomes essential, and, of course, adequate knowledge is needed. This study was conducted in Jakarta, the largest metropolitan city in Indonesia with the highest population heterogeneity. Many people from various regions and almost all ethnic groups live in Jakarta.^{16,17}

The radiographic method is simple, rapid, economical, and minimally invasive for age identification. It can be used as a diagnostic tool to estimate the age of the deceased or living subjects in all communities. However, radiographic examination still has some ethical considerations regarding the side effects of X-rays.^{8,9,18,19} This study used existing digital panoramic radiographs of the patients, which were only used in this study. It did not perform Direct radiographic photographs of the patients were not obtained. Panoramic radiographs were obtained from patients treated at the study hospital. This was chosen to minimize exposure to the subjects.

Teeth are an essential parameter that can be used for age estimation. This is because teeth have morphological characteristics that differ with age due to processes such as enamel and dentin calcification, crown development, and root development until they are fully formed. Forensic odontologists play an essential role in determining the unknown fetal age in cases of premature birth and abortion. Primary tooth mineralization starts at 6 to 7 weeks intrauterine, and with the help of histological methods, tooth mineralization can be observed up to 12 weeks before it is detected by radiographs.^{8,9}

The t-test of this study shows that the Blenkin-Evans method does not have the best value for all parameters used. Although they met the standard criteria for these parameters, they did not achieve the best value. Each dental age estimation method is developed based on individuals from different ethnic backgrounds. The Blenkin-Evans Method was adapted from the Demirjian Method to suit the Australian pediatric population.^{10,11,20,21} However, research conducted by Sahin in the pediatric population of Turkey (2025) showed that the Blenkin-Evans method gave the closest results to chronological age compared to other methods. Different genetic and environmental factors can cause individuals with the same CA to have different body characteristics and developmental levels.^{22,24}

Of the five parameters of this study, the Al-Qahtani Method has the best value in 2 parameters. Al-Qahtani explained the development of teeth and their eruption rate in one region in the upper jaw and one area in the lower jaw in each individual with an age range of 6-23 years. The obstacle to the Al-Qahtani method is that the Al-Qahtani method diagram is only based on the development of the second and third molar teeth, which can affect the age results of the study due to the different developmental states of the third molar teeth. Al Qahtani et al. published a new dental-age assessment method in 2010. The London Atlas is an

illustrated textbook that assesses each tooth's formation and eruption stages and then matches it to one of 31 age-category illustrations representing tooth formation and eruption. The London Atlas was initially tested on British and Bangladeshi ethnic subjects and was shown to be more precise than the Schour, Massler, and Ubelaker methods, and potentially more accurate than Demirjian calculations.^{5,23}

This study indicates that the Demirjian method has the best value among the three parameters. This shows that the age estimation results of the Demirjian Method are the closest to the actual chronological age of the patient. The advantages of the Demirjian Method include detailed calculation of the maturity level of each tooth and the conversion of the number from the Demirjian maturation score, which leads to a number that will be converted to the age from the Demirjian Table. The Demirjian Method is much more complex and detailed than other age estimation methods that use the atlas of dental development stages.²⁴⁻²⁶

The results of this study are also in line with research by Kotecha, who found that the most widely accepted system is the system developed by Demirjian, which assesses children's dental development individually. The stages of the left mandibular tooth formation (excluding the third molars) were evaluated. Individual scores for each of the seven stages were summed, and these were converted into a single dental age representing the average age of the child with that score. However, research conducted by Pliska et al. in 2024 showed that the Willems Method was more accurate than the Demirjian Method. In this case, the estimation results of the Demirjian method exceed the chronological age. Based on these points, it can be said that the Demirjian Method is not highly correlated when used in different populations.^{3,5,24} This study was conducted in Jakarta, the capital city with the highest heterogeneity in Indonesia, but it does not rule out the possibility that there are tribes or ethnic groups that do not live in Jakarta, but in other regions within Indonesia.

CONCLUSION

After using the Al-Qahtani, Demirjian, and Blenkin methods and performing statistical analyses, the study concluded that the Demirjian Method measurement results are closest to the chronological age of children in the Indonesian child population.

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