Research Article

The Reliability of Dental Age Estimation in Adults Using the Pulp/Tooth Ratio in Surabaya, Indonesia Population

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ABSTRACT

Objective: Age estimation is an essential aspect in forensic human identification, involving cases of unknown chronological age and determining the age of a dead person. The present study purposed to examine the accuracy of Cameriere's dental age estimation method for adults in Surabaya population.

Materials and Methods: 42 subjects participated in this study, and the measurement of pulp/tooth area was performed using Adobe Photoshop® CS6. Cameriere's formula was then applied to calculate the dental age (DA).

Results: The mean absolute error (MAE) of the dental age of all subjects was 7.23 years. The MAE value based on sexes showed that the female subjects (MAE = 6.15 years) had a higher accuracy rate than male subjects (MAE = 8.32 years). Based on the age groups in both sexes, the best MAE value was 4.92 years in the age group of 30-39 years.

Conclusion: The present study suggests that Cameriere's method for adults can be applied to estimate the DA of Indonesian population, and has an excellent level of reliability in females (30-39 years).

Keywords: Cameriere's method, Dental age estimation, Forensic identification, Radiographic

INTRODUCTION

There are several essential aspects in the field of forensic sciences that can be used to reveal individuals' identities, including sex, age, ethnicity, and biological profile. Age is a biological parameter that can be determined by calculating the chronological age and the physiological age.[1] The chronological age known based on the date of birth, while the physiological age is the age that reflects the aging of a person's body.[2,3] However, the chronological age solely could be inadequate to transmit the physiological information of a person, hence the biological age studies using various biomarkers and algorithm formulas are necessary to provide informations of human age.[4,5] Information about the human age is considered to be important in the field of law enforcement, post-mortem examinations, immigrant cases, and disputes over birth and criminal data.[6]

Various methods of age estimation, including skeletal, dental, and anthropological analysis have been established.[7] A previous study by Nolla et al., explains that dental age estimation methods show low variability as the calcification and the maturation of tooth are less controlled by environmental factors and more often by genes,

also tooth formation is less influenced by endocrinopathy and malnutrition.[8–10] Some of dental age estimation methods require an invasive procedure, such as Johanson (1971), Maples (1978), and Lamendin et al. (1992). In certain cases, apart from the high cost, this approach may be constrained by religious or ethical reasons.[11] Radiographic techniques in dentistry have been developed for non-invasive age estimation through continuous and regular secondary dentin formation, resulting in a narrowing of the pulp chamber with increasing age.[7,12]

Age estimation in adults is a challenging proceeding in the field of forensic sciences. Cameriere et al. (2007) have introduced a non-invasive dental age estimation method using periapical radiograph of canine tooth obtained from skeletons in the Museum of Anthropology, University of Bologna. Canines were chosen because they are often present in old age. Also, they are less likely to suffer wear than other anterior teeth.[7]

Indonesia is located in the *"ring of fire"* area which is prone to natural disasters, such as volcanic eruption, tsunamis, and floods.[13] In such situations, many peoples may become victims,

dead or alive. Therefore, an efficient identification method, include dental age estimation, is urgently needed in Indonesia. The present study aimed to examine the accuracy of Cameriere's dental age estimation method for adults in Surabaya population, which is categorized as Mongoloid race.

MATERIALS AND METHODS

This study was carried out at the Dental Hospital Universitas Airlangga, Surabaya under the approval of the Health Research Ethical Clearance Commission of Faculty of Dental Medicine Universitas Airlangga, number 424/HRECC.FODM/IX/2020. The subject of this study consisted of 42 patients (21 males, 21 females) who met the inclusion criteria:

- Males and females aged 20-60 years.
- Healthy lower canines without any pathological condition.
- Patients without orthodontic appliances.

All periapical radiographs were collected at the radiology center of Dental Hospital Universitas Airlangga Surabaya, and an indirect method of image digitization was used.

Each periapical radiograph image has been saved in a JPEG file format as defined in the original method by Cameriere. The JPEG files have been imported and processed in Adobe® Photoshop® CS6 software. Image adjustments such as brightness, contrast, and sharpness were made to ensure optimum measurement of each image. The polygonal lasso tool was used to trace the outline of the canine and the pulp structure, Figure 1. The measurement of the canine area and pulp area were recorded and evaluated using Cameriere's formula. According to Cameriere et al., dental age was calculated based on the ratio of pulp/tooth area (Figure 2) using the formula, as follows:

1. The formula for upper (x2) and lower (x1) canine:

$$Age = 114.624 - 431.183x_1 - 456.692x_2 + 1798.377x_1x_2$$

2. The formula for lower (x1) canine:

$$Age = 89.456 - 461.873x_1$$

3. The formula for upper (x2) canine:

$$Age = 99.937 - 532.775x_2$$

The estimated dental age (DA) was derived from the measurement of the pulp/tooth ratio in the Cameriere formula. These values were then tabulated in Microsoft Excel and compared to the actual age (AA) based on the date of birth of each subject. Descriptive statistics were used to evaluate the differences between DA and AA. The Pearson correlation test in IBM SPSS v.20.0 was performed to evaluate the correlation between DA and AA.

RESULTS

On the basis of the Lameshow formula for the determination of sample size, we enrolled 42 subjects (21 males, 21 females) aged 20 to 60 years to participate in this study. The information of each subject include sex, actual age (AA), dental age (DA), and AA-DA differences were tabulated in Microsoft Excel and statistically analyzed using IBM SPSS v. 20.0. AA-DA differences were calculated in order to evaluate the Mean Absolute Error (MAE). Subsequently, the Pearson correlation test was performed to analyze the degree of reliability of the Cameriere's method.

Overall Accuracy and Reliability Level

The overall MAE value of the Cameriere's method in this population was 7.23. The normality test was carried out to observe the distribution of the data, with $p=0.870$. The Pearson correlation test was conducted to evaluate the overall reliability level of Cameriere method in this study, with $p=0.013$, which means that AA was significantly correlated with DA, Table 1.

Accuracy and Reliability Level Based on Sex

The MAE value of Cameriere's method for male subjects in Surabaya population was 8.32, and the significance value of the normality test was $p=0.990$, which implies that the data was normally distributed. The results of the Pearson correlation test showed that the significance value was $p=0.632$. This indicates that DA and AA were not correlated and had a low reliability level for male subjects in Surabaya, Table 2.

The MAE value for female subjects was 6.15, and the data was normally distributed with $p=0.906$. The Pearson correlation test indicates that DA and AA were significantly correlated with $p=0.006$, and had a moderate reliability level for female subjects in Surabaya, $r=-0.576$.

Accuracy and Reliability Level Based on Age Range

The subjects of this study were divided into three age groups, 21-29 years (A), 30-39 years (B), and 40-50 years (C). Group A consisted of 22 subjects, group B consisted of 15 subjects, and group C consisted of 5 subjects, Table 3.

The MAE value for group A was 8.49, and the data was normally distributed, $p=0.974$. The significance value of the Pearson correlation test was $p=0.534$, which indicates that DA and AA were not correlated and had low reliability in the age group 21-29 years in Surabaya population.

The MAE value for group B was 4.92, and the normality test value was $p=0.986$, which implies that the data was normally distributed. The significance value of the Pearson correlation test was $p=0.010$. This suggests that there was a

clear correlation between DA and AA with a strong correlation.

The MAE value for group C was 8.62 with normal data distribution, *p=0.789*. The Pearson correlation test results showed that there was no correlation between DA and AA in the age range 40-50 years, *p=0.991*.

DISCUSSION

Teeth are considered to contribute to providing human life history because they are linked to the physiological changes of a person.[14] Various methods are used to discover the correlation between dental age and chronological age. In adolescents, tooth development is an outstanding physiological age predictor.[15] In children, Greene and Williams (2013) have divided the age estimation techniques into two subdivisions, using the atlas of tooth development and eruption as developed by AlQahtani et al. (2010), also using the structure and root resorption of primary teeth as developed by Moorrees et al. (1963). After the eruption of all permanent teeth, they experience physiological changes with an increase in secondary dentin deposits, which continue to occur throughout their lifetime. These may be a crucial factor in assessing the adult age estimation.[14] Using intraoral radiography, the dental maturation of individuals can be assessed using the eruption period and, the development of tooth calcification.[18]

The study of dental age estimation utilizes descriptive analysis to explore the accuracy level of the estimation and correlation test to assess the reliability of using Cameriere's method in Surabaya population. The accuracy level of the age estimation analysis can be reported as the standard error of estimation (SEE), mean absolute error (MAE), or standard deviation (SD).[19] Periapical radiographs were considered to be studied due to their ability to generate accurate images with minimal distortion.[20]

The results of the present study show that the MAE of the Cameriere dental age estimation method in Surabaya population, classified as Mongoloid, is 7.23 years old. The previous study by Cameriere et. al, 2007, showed that the value of the MAE was 4.38 years in the Caucasian population in Italy. Cameriere et al. (2009) carried out another study in Portugal and Italy in 2009 and obtained significantly higher accuracy, MAE=4.33 years. Another study by Jeevan et al. (2011), showed a MAE= 6.39 years in the Indian population. Although these studies had varying degrees of accuracy, errors of less than 10 years are acceptable in forensic age estimation.[23]

In this study, subjects were categorized based on sex and age range. Based on sex, the MAE value for females and males are 6.15 years and 8.32 years respectively. The result suggests that Cameriere's formula is more reliable for females subjects in Surabaya population. It has been thought that the degrees of attrition is more prominent in males than females.[24] Based on the age range, the group of 30-39 years old has the highest level of accuracy (MAE = 4.92 years). This result is narrowing the previous study in Mongoloid race by Jeevan et al. (2011), in which the highest level of accuracy was 2.7 years.

Dental age estimation using pulp/tooth area ratio is rarely conducted in the Indonesian population. Hidayat et al. (2018) performed a dental age estimation analysis using the pulp/tooth ratio parameter in CBCT image. The research used secondary data on the unspecific region of canines obtained from Dental Hospital of Faculty of Dentistry Padjajaran University, resulting in accuracy level of 8.4 years.

To assess if the ratio of the pulp/tooth area can be used for age estimation, the reliability or validity test need to be carried out.[22] Although the overall result of this study showed a correlation, the correlation was weak. Subjects are then grouped together to know which group had the greatest correlation. Based on sex, the female group had better reliability (*r=-0,576*) than the male group, which was even considered invalid (*p>0.05*). Based on age range, the pulp/tooth ratio with actual age in the 30-39 years age group was highly correlated (*r=-0,640*).

Different studies may result in different levels of accuracy. This is attributable to a variety of factors that lead to the outcome of the research. Factors such as tooth size variability in individuals, variations in secondary dentin apposition patterns, inconsistencies in the magnification of radiographic images, and human errors in the photo-taking process.[6] Other factors leading to pulp size variation include periodontitis, estrogen receptors that can increase dentin formation, tooth morphology, expression of genes in odontoblast, hormonal homeostasis, and occlusal strain.[26] Some studies may result in low levels of reliability, hence, the best method of observing age estimation is not to be concentrate solely on the accuracy level, but also on the amount of performance of estimation that the researcher has made in different populations.[10,27]

Besides, dental age estimation on females aged 30-39 years showed the highest levels of accuracy in this study (MAE 3.62 years). There was also a clear correlation between actual age and pulp/tooth ratio (*r=-0,852*). Based on the findings of this study, it can be concluded that the age estimation using pulp/tooth area ratio can be

applied accurately to females between 30 to 39 years of age.

CONCLUSION

Based on the analysis of this study can be concluded that the pulp/tooth ratio of mandibular canines can be used as a parameter for adult age estimation using periapical radiograph, especially in females between 30 to 39 years old, with a level of accuracy 3.62 years and an excellent level of reliability.

ETHICAL CLEARANCE

The ethical approval was obtained from Health Research Ethical Clearance Commission of Faculty of Dental Medicine Universitas Airlangga, number 424/HRECC.FODM/IX/2020.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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TABLE

Table 1: The value of the MAE, normality test, and correlation test for all subjects

Sample	n	MAE	Normality test		Correlation test		
			Sig. (2-tailed)	Explanation	Sig.(2-tailed)	Pearson Correlation	Reliability Level
Total	42	7,23	0,870	Normal	0,013	-0,382	Weak correlation

Table 2: The value of the MAE, normality test, and correlation test based on sexes

Sex	n	MAE	Normality test		Correlation test		
			Sig. (2-tailed)	Explanation	Sig.(2-tailed)	Pearson Correlation	Reliability Level
Male	21	8,32	0,906	Normal	0,632	-	No correlation
Female	21	6,15	0,990	Normal	0,006	-0,576	Moderate correlation

**Table 3: The value of the MAE, normality test, and correlation test based on the age range of subjects**

Age range	n	MAE	Normality test		Correlation test		
			Sig. (2-tailed)	Explanation	Sig. (2-tailed)	Pearson Correlation	Reliability level
20-29	22	8,49	0,974	Normal	0,534	-	No correlation
30-39	15	4,92	0,986	Normal	0,010	-0,640	Strong correlation
40-50	5	8,62	0,789	Normal	0,991	-	No correlation

FIGURE

Fig.1: An illustration of the selection of the pulp and tooth area
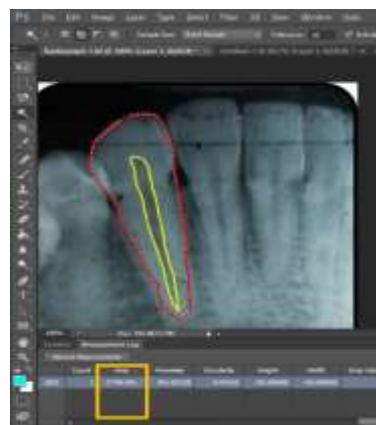
ig.2: The measurement of the pulp/tooth ratio using Adobe® Photoshop® software