Application of Cameriere Method for Age Determination in the Deutero-Malay Population

Akurasi Metode Cameriere untuk Estimasi Usia pada Populasi Ras Deutero Melayu di Indonesia

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Abstract

Cameriere introduced a method for determining human age based on the length and width of the open apex from seven permanent left mandibular teeth on a panoramic radiograph. Therefore, this study aims to produce a formula for age determination using Cameriere's method on panoramic radiographs in the Deutero-Malay subrace population. It was conducted using an analytical design on seven left permanent mandibular teeth from 240 panoramic radiographs with predetermined inclusion and exclusion criteria. The tooth length was measured from the incisal edge/cusp to the tip of the apex (L_{1-7}), then the width of the open apex was measured (A_{1-7}) in millimeters (mm) using open-source Fiji ImageJ. Furthermore, the value of x_{1-7} was obtained by dividing the width of the open apex (A_{1-7}) and tooth length (L_{1-7}), while s was obtained from the sum of x_1 to x_7. N0 is tooth with an apex tip that had closed perfectly. Data were collected and tabulated by gender (g) while the analysis was performed using a linear regression test with IBM statistical software, also, observer reliability was evaluated to determine the variability. The results showed a strong correlation between chronological age and Cameriere's method variables g, x_5, $N0$, s, and $s*N0$ (R=0.899) with the formula AGE = 10,845 + 0,140.g + 1,421. x_5 + 0,297.$N0$ – 1,284.s – 0,10.$s*N0$, R^2=0.807 and SEE=0.756. Based on the results, Cameriere's method can be used for age determination in the Deutero-Malay subrace population with panoramic radiographs.

Keywords: Cameriere method; age determination; mixed dentition; Deutero-Malay population

Abstrak

Cameriere memperkenalkan metode untuk menentukan usia manusia berdasarkan panjang dan lebar apeks terbuka dari tujuh gigi permanen mandibula kiri pada radiografi panoramik. Penelitian ini bertujuan untuk menghasilkan formula penentuan usia menggunakan metode Cameriere dengan radiografi panoramik pada populasi subras Deutero-Melayu. Desain studi analitik dilakukan pada tujuh gigi permanen rahang bawah kiri dari 240 radiografi panoramik sesuai kriteria yang sudah ditentukan. Pengukuran panjang gigi dilakukan mulai dari incisal edge/cusp hingga ujung apex (L_{1-7}), kemudian lebar open apex diukur (A_{1-7}) dalam milimeter (mm) menggunakan *open source* Fiji ImageJ. Selanjutnya nilai x_{1-7} diperoleh dari hasil pembagian lebar apeks terbuka (A_{1-7}) dan panjang gigi (L_{1-7}). Nilai s diperoleh dari penjumlahan hasil x_1 sampai x_7. *N0* adalah gigi dengan ujung apex yang telah tertutup sempurna. Data dikumpulkan dan ditabulasi berdasarkan jenis kelamin (g) dan dianalisis menggunakan uji regresi linier dengan perangkat lunak statistik IBM. Reliabilitas pengamat dievaluasi untuk mengetahui variabilitas pengamat. Terdapat hubungan yang kuat antara umur kronologis dengan variabel metode Cameriere (g, x_5, *N0*, s, dan $s*N0$) (R=0.899) dengan rumus AGE = 10,845 + 0,140.g

+ 1,421. x_5 + 0,297.$N0$ − 1,284.s − 0,10.$s*N0$ (R^2=0.807 dan *SEE*=0.756). Dalam penelitian ini, metode Cameriere dapat digunakan untuk penentuan usia pada populasi subras Deutero-Melayu menggunakan radiografi panoramik.

Kata kunci: Metode cameriere; penentuan usia; gigi campuran; populasi Deutero-Melayu

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INTRODUCTION

The age determination method is an essential factor for biological identification in forensics and dentistry.[1,2] Cameriere in 2006 introduced a new method based on the correlation between chronological age and open apex measurement of seven permanent left mandibular teeth using a sample of 455 children in Italy. A positive result was obtained with a median residual error of 0.035 years. It was more accurate than the age determination method proposed by Demirjian and Willem.[3,4]

Nair et al.[5] in Kerala and Valluri et al.[6] in Malaysia mentioned that age determination using Cameriere's method was carried out on children with mixed dentition stage. Another study by Honkala et al.[7] in Southeast Estonia stated that mixed dentition usually occurred in children aged 6-12 years. Therefore, Cameriere's method was conducted on children of this age range. The accuracy has also been tested in several populations worldwide.

Meanwhile, the radiographic method is a non-invasive technique for dental age determination. Previous studies including Cameriere et al.[3] in Italy, El-Bakary et al.[8] in Egypt, and Latić-Dautović et al.[9] in Bosnia and Herzegovina populations, adopted Cameriere's method for age determination using a panoramic radiograph. Some other studies also adopted panoramic radiograph, including Priya[10] that used Willems's method in India, Ebrahim et al.[11] which referred to Schour and Massler in India, and Mohammed et al.[12] in line with Demirjian's, Willems's, Nolla's, and Haavikko's method on the Indian populations. Consequently, panoramic radiographs can be used to determine the human age because it is practical, simple, and non-invasive. It also shows a wide range of bone and tooth structures, stages of eruption, and calcification of teeth.[13]

A software analysis measurement tool was used to analyze and improve the accuracy of various age determination methods. El-Bakary et al.[8] in Egypt used Image Tool, Penaloza et al.[14] in Australia, ITK-SNAP, while Balla et al.[15] in India used Adobe Photoshop 7. Fiji ImageJ has also been used for age determination on radiographic imaging in previous studies by Valluri et al.[6] in India and Mazzilli et al.[16] in the Brazilian population. Therefore, Fiji ImageJ has been accepted to assist in measuring age determination in various measurement methods.

Age determination using Cameriere's method has been conducted in various populations, including Fernandes et al.[17] in Brazil, Bagh et al.[18] in India, and Kumaresan et al.[19] in Malaysia. The previous study by Kumaresan et al. in Malaysia used the formula introduced by Cameriere in 2008 on the European population.[4,19] Due to the differences in the results obtained for various races, this study was conducted to produce a formula according to the data. Based on the literature search, the standard of age determination in Indonesia is unclear, especially in the Deutero-Malay subrace population which are spread over several tribes such as Aceh, Minangkabau, Riau, Bugis, Malay, Deli, Palembang, Jambi, Makassar, Bengkulu, Balinese, Sasak, Javanese, and Sundanese.[20] Therefore, this study aims to produce a formula for age determination using Cameriere's method on panoramic radiographs in the Deutero-Malay subrace population.

MATERIALS AND METHODS

This study was conducted analytically with a database of patients at the Department of Oral and Maxillofacial Radiology unit, Dental Hospital of Universitas Padjadjaran, Bandung, West Java, Indonesia, in 2018. A total of 240 panoramic radiographs comprising 120 males and 120 females were used with 1,680 left permanent mandibular teeth including central and lateral incisive, canine, first premolar, second premolar, as well as first and second molar in both genders (Table 1).

The inclusion criteria were panoramic radiographs with good quality, the age range between 6 to 12 years, completely developed teeth crowns, developing apex, and patients of the Deutero-Malay subrace. Samples that fulfill these criteria were clarified with informed consent and attached proof of Identity Card (IC) with two faithful generations of the Deutero Malay subject.

Patients with tooth anomalies such as hypodontia/hyperdontia, dental caries, attrition, abrasion, root dilaceration, tooth rotation, impaction, and supernumerary, as well as missing teeth due to agenesis or extraction were excluded. Other exclusion criteria include pathological conditions at the tooth apex including internal and external resorption of tooth roots, as well as periapical pathological conditions of abscess,

granuloma, and cyst.[6,21] Vatech Picasso Trio 2006 (Vatech DCT Pro®, Vatech, Suwon, Korea; scan parameters: 90 kVp, 10 mAs, and 12- x 8.5- cm Focal Through) was used to take all panoramic radiograph samples in JPG based on the information of the patient's gender and chronological age at the time of radiography exposure.

Seven permanent left mandibular teeth were measured to obtain the width of the open apex (*A*) and tooth length (*L*). Measurement of tooth length was carried out from the incisal edge/cusp to the tip of the apex (L_{1-7}), then the width was measured from the mesial to distal point at the end of the inner open apex (A_{1-7}) in millimeters (mm) using open-source Fiji ImageJ 1.34 (Fiji ImageJ, National Institute of Health, Bethesda, MD, USA) (Figure 1). The results were inputted in Microsoft Excel 2019 (Microsoft Excel, Microsoft Corporation, Redmond, Washington, USA).

Two observers namely Oral and Maxillofacial Radiologist were involved and measurements were carried out intra- and inter-observer. The 30 samples were measured intra-observer by the first observer with one repetition at three-week intervals. Meanwhile, in the inter-observer measurement, the first and second observers measure the same 30 samples simultaneously. To analyze the intra and inter-observer reliability, Cronbach's Alpha was used.

Multiple linear regression assisted with IBM SPSS 26.0 (IBM, Chicago, IL, USA) was used to evaluate the correlation coefficient (R), coefficient of determination (R2), and standard error of estimation (SEE) based on gender. The formula constants and coefficient values of each variable were obtained by entering the variables of Cameriere's (*A, L, x, N0, g, s, x_5*, and *s*N0*). *A* is the measurement of the width in the open apex from the mesial to distal point at the end of the inner part of the seven permanent teeth (A_i, *i*= 1...7), *L* is the tooth length (L_i, *i*= 1...7), *x* was obtained by dividing the width of the open apex (*A*) and tooth length (*L*) ($x_i = A_i/L_i$, *i*=1...7), *N0* is the total of teeth with the apex completely closed, *g* is the gender variable (*g* = 1 for male and *g* = 0 for female), *s* is the total of open roots ($x_1 + ... + x_7$), x_5 is the measurement of the left mandibular second premolar, and *s*N0* is the product of *s* and *N0*.[3]

This study was approved by The Ethics Committee, Faculty of Medicine, Universitas Padjadjaran, Bandung, West Java, Indonesia with registration numbers 138/UN6.KEP/EC/2021 on February 24th, 2021 and 241/UN6.KEP/EC/2021 on March 30th, 2021. Two ethical clearances were obtained because this study was conducted in two stages. The study was carried out from February to April 2021 at the Department of Oral and Maxillofacial Radiology unit at the Dental Hospital of Universitas Padjadjaran, Bandung, West Java, Indonesia.

RESULTS

A significantly positive result was obtained from the reliability test for intra- (*R*=0,998) and inter-observer (*R*=0,996) measurements, indicating that the first and second observers had the same measurement validity. The teeth length and width of the open apex had a significant correlation ($p<0.01$) with chronological age in both male and female groups.

Furthermore, the multiple linear regression test results showed the formula constants and coefficient values for each variable. The variable was adjusted to the formula published by Cameriere in 2006.[3] Cameriere's formula equation obtained in this study is as follows:

$$AGE = 10,845 + 0,140.g + 1,421.x_5 + 0,297.N0 - 1,284.s - 0,10.s\text{*}N0$$

The multiple linear regression equation results revealed the correlation coefficient (R = 0.899), the determination coefficient (R^2 = 0.807), with a standard error of estimate (SEE = 0.756) for both genders. The coefficient value of determination shows that Cameriere's variable had an effect on the chronological age of 80.7%, while the other 19.3% is influenced by other variables. The scatter graph shows that Cameriere's variables increased with chronological age (Figure 2).

DISCUSSIONS

Each ethnicity has unique dental characteristics, hence, there is a need for the same subject-dependent age determination method to increase accuracy.[22] Determining age with teeth is the most accurate, reliable, and fast method, particularly in children, and is also very important for various fields of study. There are different techniques for determining children's age including Cameriere's method.

The inter-observer measurements showed that the first and second observers had the same perception in measuring the length of teeth and width of the inner side open apex. Similarly, the intra-observer measurement results in the calculation of the first observer were stable. This is in line with a previous study by Cameriere et al.[4] conducted on the Italian, Spanish, and Croatian populations, Gulsahi et al.[21] in the Turkish, and El-Bakary et al.[23] in the Egyptian population who mentioned that the intra and inter-ob-

server validity, as well as, reliability showed excellent results. This implies that the open-source software Fiji ImageJ can help in analyzing the tooth length and open apex distance with consistent results.

Latić-Dautović et al.[9] on the children population in Bosnia and Herzegovina used Cameriere's method to obtain a different regression formula with an accurate age determination. Similarly, Cugati et al.[24] performed a linear regression on Malaysian samples to obtain the Cameriere formula. The results showed that differences in environmental, diet, growth rate, and ethnicity can affect the constants and coefficients of Cameriere's method variables. Differences in race and ethnicity were also found to influence the pattern of tooth calcification.[24] Therefore, the linear regression test was conducted in this study to obtain Cameriere's formula by measuring variables from the existing population.

The formula equation explained 80,7% (R^2=0,807) of the total deviation. This is consistent with a previous study by Cameriere et al.[3] in Italy, Spain, and Croatia, as well as Rai et al.[25] on the Indian population. This determination coefficient indicates that Cameriere's method variables can explain 80.7% of the variation in chronological age, while the rest 19.3% is defined by other factors. The standard error of estimate had a small value of 0.756 which implies that the regression model is good as a predictor of age.

A previous study by Rajpal et al.[26] in India used the periapical radiograph to determine age with the Kvaal method. However, this technique has limitations in measuring only one tooth. Meanwhile, the panoramic radiograph method can observe the structure of bones and teeth extensively and show the stages of eruption and calcification. This is in line with previous reports by Alghali et al.[27] in Malaysia which referred to Demirjian and Cameriere, Priya[10] in India with the Willems method, as well as Phillips et al.[28] in Africa through the Moorrees, Fanning, Hunt, Demirjian, as well as Goldstein and Tanner methods. The radiographic method is practical and non-destructive. Future studies need to consider determining age with this method using different types of radiographs to compare the accuracy.

The height and width of the open apex tooth were measured using Fiji ImageJ. It is an open-source software published in 2012 for analyzing biological images, calculating area and pixels, measuring distances and angles, manipulating contrast, edge detection, as well as median filtering.[29,30] Fiji ImageJ can be used as a valid and reliable measuring tool. The results obtained are different from Cameriere et al.[3] in Italy and Balla et al.[15] in the Indian population which used Adobe Photoshop 7. Fiji ImageJ is one of the newest open-source software and has been widely used in several studies, including Valluri et al.[6] in Malaysia and Mazzili et al.[16] in Brazil.

Based on the results, there are various advantages in this study such as the use of multiple linear regression to increase accuracy, as well as the application of Fiji ImageJ as an open software which can be easily obtained, simple to use, and practical. Certain limitations also need to be considered for future investigations. The quality of the radiographs, samples and the visual errors were beyond control, hence, it is recommended that further studies pay attention to them. This method can be used for males and females because there is no significant difference between gender groups. This study only used the age range of 6 to 12 years, therefore, future studies on other methods such as Willems' or Demirjian' for different ages are needed. Based on the literature search, similar studies on the Dutero-Malay subject are scanty, hence, this is a novelty study, especially on the Deutero Malay population.

Based on the results, the Cameriere method can be used for age determination in the Deutero-Malay subrace population with a panoramic radiograph.

ACKNOWLEDGMENTS

TABLES

Table 1. Distribution of samples according to age and gender

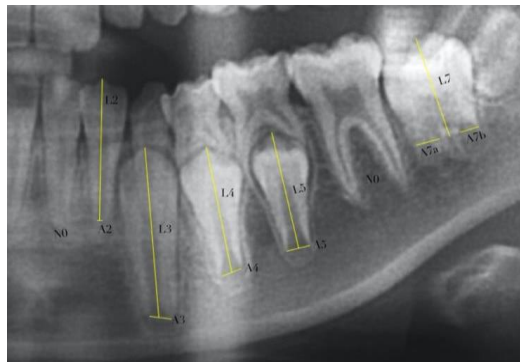| Age (years)	Female	Male	Frequency
6	7	15	22
7	27	19	46
8	28	28	56
9	19	26	45
10	17	15	32
11	15	6	21
12	7	11	18
Total	120	120	240

FIGURES

Fig. 1. The procedure in measuring the length of the teeth (mm) and the width of the open apex (mm). (L1-7) Measurement from the tip of the highest cusp/incisal to the tip of the apex. (A1-7) Measurement of side width in open apex. (N0) Teeth with completely closed apex
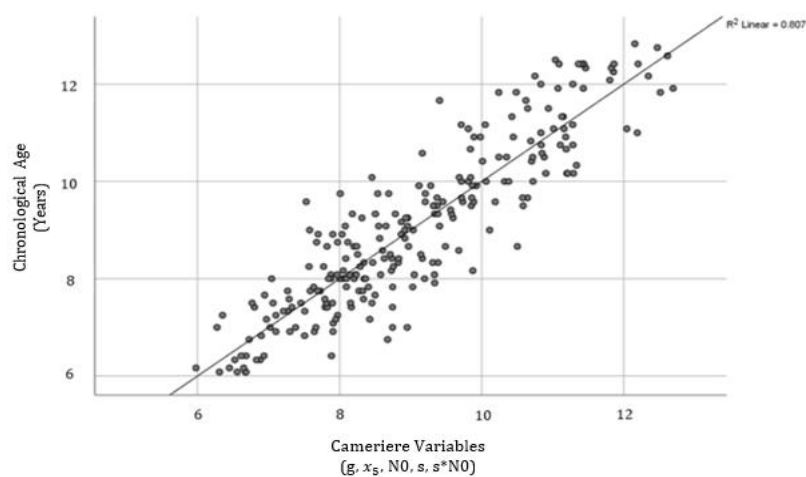
$R^2 = 0.807$

Fig. 2. The scatter graph shows the relationship between chronological age (years) and Cameriere variables (g, x_5, N0, s, s*N0)

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