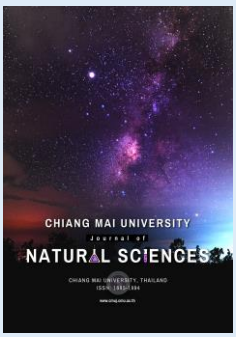

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Research article

Testing the Accuracy of an Age Estimation Method Using Radiographs of Permanent Mandibular Third Molar Teeth in a Thai Population

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Abstract The aim of this study was to test the accuracy of an age estimation method using the radiographs of permanent mandibular third molar teeth in a Southern Thai population. Digital panoramic radiographs of 480 Thai samples (240 males and 240 females) aged from 8 to 23 years were selected and divided into 16 age groups. The permanent mandibular third molar teeth were separated into nine developmental stages according to the Demirjian et al. classification. The developmental stage was evaluated and then converted into a developmental score. Accuracy of the dental age estimation was tested using regression equations according to the Duangto et al. study. Our results showed that dental age was close to the chronological age within one year for both sexes. In conclusion, the age estimation equations according to the Duangto et al. study provide an accurate age estimation in a Southern Thai population.

Keywords: Dental age estimation, Demirjian et al. classification, Mandibular third molar teeth, Thai population

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INTRODUCTION

Age estimation is an important procedure in forensic sciences for identification of missing persons and for determining the age of penalty in criminal liability (Ajmal et al., 2012). According to the criminal code of Thailand, the critical cut-off points of age for criminal liability are 10, 13, 15, 18, and 20 years. Therefore, an accurate age estimation method is needed in the interest of justice.

Presently, several age estimation methods are available such as the evaluation of skeletal maturity, expression of secondary sexual characteristics, and assessment of dental development. However, dental age estimation is a more accurate method because teeth are the strongest structures of the human body and tooth development is more affected by genetic factors and less affected by nutritional and environmental factors compared with other methods (Garn et al., 1965).

Development of the third molar teeth is the major approach for dental age estimation especially in children, adolescents, and young adults because the formation of the third molar teeth occurs later than the other teeth. The formation of third molar teeth begins as early as eight years old and root formation is complete at around 25 years of age. Radiographic age estimation from third molar development using the Demirjian et al. classification (Demirjian et al., 1973; Demirjian and Goldstein, 1976) has been widely used in several studies. Demirjian et al. employed changes of dental development to explain the stages of tooth development from the beginning of crown formation until closing of the root apices (Demirjian et al., 1973).

A previous study by Duangto et al. generated age estimation equations using third molar teeth in a Northern Thai population (Duangto et al., 2017). Nevertheless, there are ethnic differences in the chronology of third molar mineralization. Therefore, this study aimed to test the accuracy of an age estimation method using the permanent mandibular third molar teeth in a Southern Thai population.

MATERIAL AND MATHODS

This study was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Prince of Songkla University, Songkhla, Thailand (EC 6402-012). Digital panoramic radiographs were obtained from the Dental Hospital of the Faculty of Dentistry, Prince of Songkla University, Songkhla, Thailand. All digital panoramic radiographs were produced using the GXDP-700 PANOREX + cone beam machine (Gendex Dental Systems, Hatfield, PA, USA) between 2015 and 2021.

Digital panoramic radiographs of 480 Thai samples (240 males and 240 females) aged 8–23 years were selected using stratified random sampling and divided into 16 age groups (Table 1). The exclusion criteria included unclear panoramic radiographs, missing mandibular third molar teeth, pathologies of development of teeth and jaw bones, and systemic disease affecting the growth of teeth and jaw bones.

The permanent mandibular third molar teeth (teeth 38 and 48) were evaluated using nine developmental stages from 1 to H according to the Demirjian et al. classification (Demirjian et al., 1973). Each developmental stage was then converted into a development score (stage 1 = 1, stage A = 2, stage B = 3, stage C = 4, stage D = 5, stage E = 6, stage F = 7, stage G = 8, and stage H = 9) (Table 2). The development score was substituted into the regression equations according to the Duangto et al. study (Duangto et al., 2017) (Table 3). Finally, testing the age estimation equations was analyzed by evaluating the mean difference between the dental age and the chronological age and a 95% confidence interval (95% CI).

Table 1. Distribution of samples by age group and sex.

Age group (year)	Male (N =240) n	Female (N =240) n
8.00-8.99	15	15
9.00-9.99	15	15
10.00-10.99	15	15
11.00-11.99	15	15
12.00-12.99	15	15
13.00-13.99	15	15
14.00-14.99	15	15
15.00-15.99	15	15
16.00-16.99	15	15
17.00-17.99	15	15
18.00-18.99	15	15
19.00-19.99	15	15
20.00-20.99	15	15
21.00-21.99	15	15
22.00-22.99	15	15
23.00-23.99	15	15

Table 2. Definitions of tooth developmental stages according to the Demirjian et al. classification (Demirjian et al., 1973).

Stage	Score	Definition
1	1	Radiolucent bud is found, prior to mineralization.
A	2	Cusp tips are mineralized but have not yet coalesced.
B	3	Mineralized cusps are united so the mature coronal morphology is well-defined.
C	4	The crown is about half formed; the pulp chamber is evident and dentinal deposition is occurring.
D	5	Crown formation is complete to the dentinoenamel junction .The pulp chamber has a trapezoidal form.
E	6	Formation of the inter-radicular bifurcation has begun .Root length is less than the crown length.
F	7	Root length is at least as great as crown length .Roots have funnel shaped endings.
G	8	Root walls are parallel, but apices remain open.
H	9	Apical ends of the roots are completely closed, and the periodontal ligament has a uniform around the root.

Table 3. Age estimation equations according to the Duangto et al. study (Duangto et al., 2017) in both sexes.

Sex	Tooth	Equations
Male	38	y = 7.648 + 0.753x + 0.093x2
	48	y = 7.535 + 0.799x + 0.088x2
Female	38	y = 6.421 + 1.256x + 0.055x2
	48	y = 6.522 + 1.243x + 0.055x2

Note: y = dental age, x = the developmental score

A month after the first evaluation of all samples by the first observer, 100 digital panoramic radiographs were randomly chosen from all of the samples to test for the intra- and inter-observer agreements. The selected radiographs were assessed without information of age and sex by the first observer to test for intra-observer agreement and by the second observer to test for inter-observer agreement. Cohen's Kappa test was used to analyze the intra- and inter-observer agreements. Descriptive statistics with the mean and standard deviation of the chronological age in males and females, and the mean difference values were calculated. The 95% CI values (difference between dental age and chronological age) were used to test the accuracy of age estimation. The Wilcoxon signed rank test was used to compare the developmental stages between the left and right permanent mandibular teeth. The independent sample t test was used to compare the mean age between males and females in each stage. All statistical analyses were performed using IBM SPSS for Windows, Version 27, Chicago, IL, USA.

RESULTS

The Kappa values were 0.900 (tooth 38) and 0.911 (tooth 48) for intra-observer agreement, and 0.877 (tooth 38) and 0.867 (tooth 48) for inter-observer agreement. These values indicated almost perfect agreement according to the Landis and Koch guidelines (Landis and Koch, 1977).

The results showed that the mean error values were 0.39 years for tooth 38 and 0.35 years for tooth 48 in males and 0.48 years for tooth 38 and 0.47 years for tooth 48 in females. Moreover, the 95% CI using the difference values between dental age and chronological age showed that the lower bounds and upper bounds in teeth 38 and 48 were 0.22 to 0.57 years and 0.18 to 0.52 years for males, and were 0.30 to 0.67 and 0.28 to 0.66 years for females (Table 4).

Table 4. Mean error values and 95% confidence interval (95% CI) using the difference values between dental age and chronological age in teeth 38 and 48 for males and females.

Sex	Tooth	Mean dental age (year)	Mean chronological age (year)	Mean error (year)	SD	95% CI (year)	
						Lower	Upper
Male	38	16.37	15.98	0.39	1.38	0.22	0.57
	48	16.33	15.98	0.35	1.33	0.18	0.52
Female	38	16.49	16.01	0.48	1.45	0.30	0.67
	48	16.48	16.01	0.47	1.48	0.28	0.66

The developmental stage between teeth 38 and 48 was calculated using the Wilcoxon signed rank test. Our results showed no significant differences between teeth 38 and 48 in both males (P = 0.853) and females (P = 0.612).

Descriptive statistics of the chronological age in each stage compared between males and females for teeth 38 and 48 were shown in Tables 5 and 6, respectively. No significant differences of chronological age in each stage between males and females were detected, except the stage E of tooth 48 which found statistically significant difference between males and females (P = 0.041).

Table 5. Descriptive statistics of the chronological age between males and females for tooth 38.

Stage	Males			Females			*P* value
	n	Mean	SD	n	Mean	SD	
1	4	8.34	0.23	5	8.43	0.28	0.625
A	11	9.16	0.85	6	9.41	1.44	0.656
B	25	9.98	1.25	14	9.50	0.76	0.195
C	28	11.44	0.97	42	11.08	1.17	0.174
D	16	13.44	1.17	22	13.95	1.29	0.218
E	44	15.07	1.67	34	15.35	1.59	0.459
F	27	17.17	0.82	31	17.49	1.30	0.271
G	25	19.94	1.89	36	20.15	1.69	0.647
H	60	21.52	1.44	46	21.82	1.45	0.301

Note: n = number of samples, mean = mean age, SD = standard deviation, *Statistically significant difference using the independent sample t test (P <0.05)

Table 6. Descriptive statistics of the chronological age between male and female for tooth 48

Stage	Males			Females			*P* value
	n	Mean	SD	n	Mean	SD	
1	4	8.39	0.16	4	8.43	0.33	0.822
A	12	9.33	1.13	3	8.38	0.11	0.179
B	20	9.62	0.85	18	9.62	1.01	0.990
C	35	11.60	1.13	49	11.15	1.17	0.080
D	14	13.64	1.40	21	14.13	1.09	0.253
E	41	14.90	1.43	34	15.65	1.70	0.041*
F	28	17.24	1.18	31	17.57	1.42	0.345
G	27	19.55	1.58	33	20.20	1.72	0.141
H	59	21.68	1.43	47	21.77	1.47	0.752

Note: n = number of samples, mean = mean age, SD = standard deviation, *Statistically significant difference using the independent sample t test (P < 0.05)

DISCUSSION

Age estimation is an essential method in forensic sciences and clinical dentistry. Importance of age estimation includes assessing the status of living individuals without legal documents and the identification of unidentified dead victims (Khorate et al., 2014). Age estimation is also necessary in clinical dentistry for making a diagnosis, treatment planning, and treatment procedures (Prince and Ubelaker, 2002).

Currently, there are several methods for age estimation. Dental age estimation is a reliable method because teeth are the strongest biological structures, covered with soft tissue and jaw bones. Furthermore, the teeth are less influenced by the external environment, and they are corrosion resistant and do not

decompose up to 1,100°C (Merlati et al., 2002). However, skeletal age estimation often varies from nutritional, socioeconomic, and social conditions (Cardoso, 2007; Cameriere et al., 2007). Therefore, teeth are a suitable structure to confirm age.

Radiological dental age estimation methods have been generated from many researchers such as the Gleiser and Hunt method (Gleiser and Hunt, 1955), Moorrees et al. method (Moorrees et al., 1963), Demirjian et al. method (Demirjian et al., 1973), Kullman et al. method (Kullman et al., 1992), Köhler et al. method (Köhler et al., 1994), and the Kvaal et al. method (Kvaal et al., 1995). However, Demirjian et al. (Demirjian et al., 1973) presented a classification of dental development using radiographs including eight stages of the crown and root development. The Demirjian et al. stages are defined by changes in the shape of the tooth, independent of speculative estimations of lengths. Therefore, the Demirjian et al. classification method is simple and obvious (Lopez et al., 2013).

The third molar teeth are the last teeth to mature in the oral cavity. Compared to other teeth, development of the third molar teeth occurs over a longer period of time and begins as early as eight years of age. Complete root formation occurs at around 25 years of age (Dean, 2016). Olze et al. found no significant difference in mineralization between the upper and lower third molar teeth (Olze et al., 2004). In addition, the maxillary third molar teeth are often superimposed by the wall of the maxillary sinus, the zygomatic process, and the maxillary process of the zygomatic bone (de Oliveira et al., 2012). Therefore, our study only used the digital panoramic radiographs of the mandibular third molar teeth.

Previously, Lee et al. (Lee et al., 2011) and Ortega-Pertuz et al. (Ortega-Pertuz et al., 2018) reported that mean errors of dental age estimation method using dental radiographs within 0.5 to 1 year were acceptable in forensic sciences for age estimation. The mean errors in our study were within 1 year which could be concluded that the dental estimated age was close to the chronological age.

Formerly, several studies reported no significant difference between the developmental stages of teeth 38 and 48 (Soheim, 1993; Stavrianos et al., 2008; Mohammed et al., 2014). Our results also found no significant difference between teeth 38 and 48 because teeth 38 and 48 do not differ in development. Therefore, the age estimation equations of either teeth 38 or 48 can be used to estimate age.

CONCLUSION

The results of this study suggest that the age estimation equations according to the Duangto et al. study were found to be acceptable and accurate in a Southern Thai population. Our findings recommend that these equations be used for forensic and clinical purposes for age estimation, especially in Thai children, adolescents, and young adults.

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AUTHOR CONTRIBUTIONS

Conceptualization: Pornpat Theerasopon and Phuwadon Duangto. Data acquisition: Chairat Charoemratrote, Kanyathorn Tiansuwan, Natthanan srichaitan and Sichanad Norkaew. Data analysis or interpretation: Pornpat Theerasopon, Phuwadon Duangto, Natchalee Srimaneekarn, Kanyathorn Tiansuwan, Natthanan srichaitan and Sichanad Norkaew. Drafting of the manuscript: Kanyathorn Tiansuwan, Natthanan srichaitan, Sichanad Norkaew, Pornpat Theerasopon and

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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