Dental age assessment based on the radiographic visibility of the periodontal ligament in lower third molars in a Thai sample

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The authors declare that they have no conflict of interest.

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ABSTRACT

The objective of the present study was to analyze the radiographic visibility of the periodontal ligament in completed root formation lower third molars in a sample of lower northern Thai population. Digital panoramic images from 800 patients with ages ranging from 16 to 26 years were used in this study. The visibility status of the periodontal ligament of lower third molars with completed root formation including apical closure was assessed. For each stage, the minimum age, maximum age, median, mean, and standard deviation were calculated. The minimum age found in stage 0 was 16.17 years in males and 17.00 years in females. Stage 1 was first achieved at the age of 16.17 years in males and 17.08 years in females. The earliest onset of stage 2 was 17.00 years in males and 18.17 years in females. The incidence of stage 3 was first observed at 19.17 years in males and 18.83 years in females. It may be concluded that the radiographic visibility of the periodontal ligament in lower third molars may be a useful approach in the dental age assessment in a Thai population. In case the periodontal ligament visibility is found to be in stage 2, it may be confirmed that the individual is at least 18 years of age.

INTRODUCTION

Forensic age assessment is a significant task in chronological age prediction for legal reasons, including immigration, individual identification, and sentencing in most jurisdictions.[1] A new guideline on best practice for age assessment was published as a result of multi-partner cooperation between the Ministry of Justice, the Ministry of Solidarity and Health, the Ministry of the Interior and the Ministry of Territorial Cohesion and relations with local and regional authorities.[2] In Thailand, the lawfully considered age limits are 10, 13, 15, 18, and 20 years. The international and multi-disciplinary study group on forensic age diagnostics (AGFAD) suggests chronological age evaluation processes involving three independent factors, including a physical examination, radiographic examination of the hand, and a dental examination. If skeletal development of the hand is completed, further radiography or CT examination of the clavicle's sternal extremity should be carried out.[3] The main indications for assessing chronological age based on teeth are the tooth mineralization stages.[4] In Thailand, there were studies on the root mineralization of third molars. These studies reported that mineralization of lower third molar roots could be completed over the age of 18.[5] However, it is still difficult to

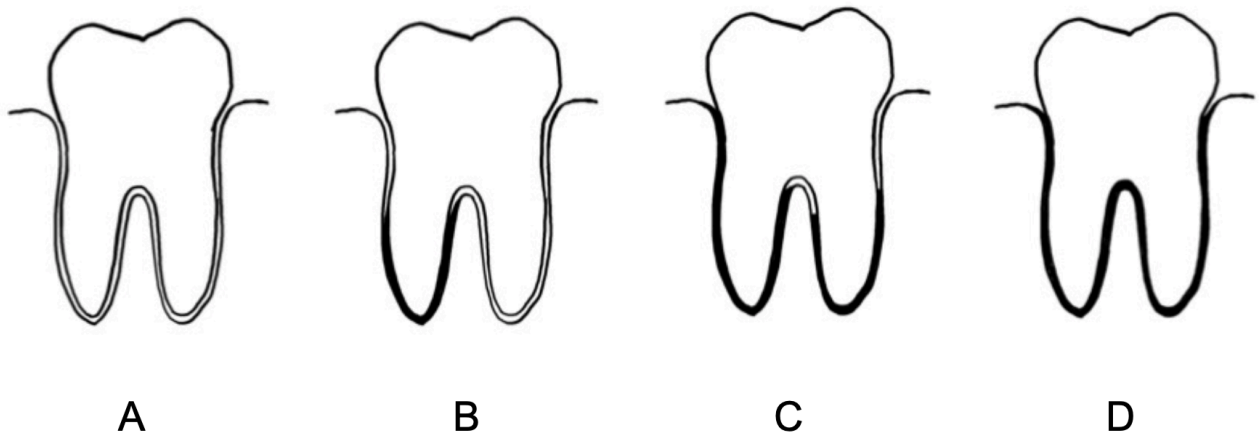
prove beyond reasonable doubt that a person is over 18 years of age. It would be advantageous to find a dental method after the third molar root formation was completed. Periodontal ligament (PDL) is the tooth supporting structure that is composed of strips of fibrous connective tissue and attaches tooth cementum to the alveolar bone. Periodontal ligament width could be changed because of age or tooth function. Olze et al.[6] first described the radiographic visibility of the periodontal ligament in the completed root formation of lower third molars for forensic age estimation in a German population. In addition, there are papers based on the radiographic visibility of the periodontal ligament in northern Chinese[1], Portuguese[7], and UK-Caucasian[8] populations. These previous studies described this method as a potential age estimation criterion after completed root formation. The present study was conducted to analyze the periodontal ligament visibility of completed root formed lower third molars in a sample of panoramic radiographs from Thailand and compare with the other ethnic samples.

MATERIAL AND METHODS

The institutional ethics committee approved the present study (IRB No. P10068/63). Digital panoramic images from 800 patients with ages ranging from 16 to 26 years were used in this study. The panoramic radiographs were taken between 2018 and 2020.

The visibility status of the periodontal ligament of left and right lower third molars with completed root formation including apical closure was assessed using the following four stages described by Olze et al.[6]-(Figure 1):

Figure 1. Schematic drawings of the radiographic visibility of periodontal ligament in lower third molars; (A) stage 0 (B) stage 1 (C) stage 2 (D) stage 3



Stage 0: The PDL is visible along the full length of all roots.

Stage 1: The PDL is invisible in one root from the apex to more than half of the root.

Stage 2: The PDL is invisible along almost the full length of one root or part of the root in two roots or both.

Stage 3: The PDL is invisible along almost the full length of two roots.

All of the digital panoramic radiographs were evaluated by an oral radiologist, with more than 10 years of experience. The lower third molars with fused roots or narrowed furcation were not determined. The patient's age, sex, and stage of radiographic visibility of the PDL were recorded using Microsoft Excel tables. Statistical analysis was performed using SPSS Statistics version 17. Each patient's age was the difference between the date of panoramic radiographic examination and the date of birth and recorded as years and 1/100 of years. The minimum age, maximum age, median, mean, and standard deviation were calculated for each stage.

The inter-observer agreement was assessed by the random selection of 100 panoramic radiographs and examined by two examiners. To assess intra-observer agreement, the same 100 radiographs were evaluated by the first examiner after a 1-month interval. Kappa statistics were performed to calculate the intra- and inter-observer agreement

RESULTS

A total of 746 digital panoramic images (299 males and 447 females), aged 16 to 26, were recruited for the present study (Table 1).

Table 1. Age distribution of the subjects

Age (years)	Sex		Total
	Male	Female	
16	3	0	3
17	32	22	54
18	28	29	57
19	54	100	154
20	29	96	125
21	43	60	103
22	20	49	69
23	20	23	43
24	25	25	50
25	25	26	51
26	20	17	37
Total	299	447	746

There were 54 panoramic radiographs (7.24%) that could not be assessed because of fused roots or narrowed furcation. The minimum age, maximum age, median, mean, and standard deviation of radiographic visibility of the periodontal ligament for tooth 38 and 48 in both sexes were shown in Table 2. The minimum age found in stage 0 was 16.17 years in males and 17.00 years in females. Stage 1 was first achieved at the age of 16.17 years in males and 17.08 years in females. The earliest onset of stage 2 was 17.00 years in males and 18.17 years in females. The incidence of stage 3 was first observed at 19.17 years in males and 18.83 years in females.

The medians were varied in each stage. For stage 0, it ranged from 18.75 to 19.46 years. The medians of stage 1 varied between 20.33 and 20.58 years. For stage 2, the medians were between 21.42 and 22.92 years. The medians of stage 3 were between 20.58 and 23.83 years. Regarding the mean age of the stages of periodontal ligament visibility on panoramic radiographs of teeth 38 and 48, it was not statistically significant different both in males and females (Table 3). Table 4 demonstrated the distribution of periodontal ligament visibility stages on panoramic radiographs between adults and minors.

Table 2. data for the stages of periodontal ligament visibility on panoramic radiographs of teeth 38 and 48 in males and females

	Tooth	Stage	n	Min	Max	Median	Mean	SD
Males	38	0	51	16.42	25.00	18.75	18.94	1.62
		1	107	16.17	26.67	20.58	21.04	2.23
		2	90	17.00	26.92	22.92	22.83	2.28
		3	11	20.33	26.92	23.42	23.39	2.56
	48	0	45	16.17	24.00	18.83	19.09	1.59
		1	114	16.42	26.67	20.58	21.13	2.40
		2	94	18.83	26.92	21.92	22.78	2.44
		3	16	19.17	26.92	23.83	23.28	2.80
Females	38	0	70	17.00	26.92	19.46	19.72	1.91
		1	180	17.08	26.92	20.46	21.00	2.10
		2	132	18.58	26.92	21.42	21.98	2.15
		3	6	19.67	26.50	20.46	21.40	2.54
	48	0	67	17.00	26.17	19.42	19.83	1.98
		1	164	17.08	26.92	20.33	20.86	1.93
		2	145	18.17	26.92	21.67	22.26	2.43
		3	6	18.83	24.33	21.29	21.36	2.00

Table 3. Data on the mean age of the stages of periodontal ligament visibility on panoramic radiographs of teeth 38 and 48 in males and females

		Mean age		*p* Value
		Tooth 38	Tooth 48	
Males Stage	0	18.94	19.09	0.66
	1	21.04	21.13	0.77
	2	22.83	22.78	0.89
	3	23.39	23.28	0.92
Females Stage	0	19.72	19.83	0.73
	1	21.00	20.86	0.54
	2	21.98	22.26	0.30
	3	21.40	21.36	0.97

Table 4. Distribution of periodontal ligament visibility stages on panoramic radiographs between adults and minors

	Tooth	Stage	n	< 18 Years	≥ 18 Years
Males	38	0	51	16	35
		1	107	6	101
		2	90	1	89
		3	11	0	11
	48	0	45	12	33
		1	114	10	104
		2	94	0	94
		3	16	0	16
Females	38	0	70	12	58
		1	180	9	171
		2	132	0	132
		3	6	0	6
	48	0	67	15	52
		1	164	6	158
		2	145	0	145
		3	6	0	6

The intra- and inter-observer agreement were 0.874 and 0.739, respectively. These values are considered to be almost perfect for intra-observer agreement and substantial for inter-observer agreement.

DISCUSSION

According to the civil and criminal laws, 18 years of age is of legal relevance in Thailand. We analyzed the radiographic visibility of the periodontal ligament in lower third molars from a sample of the Thai population to determine if this methodology could be used to exclude subjects under 18 years of age. There are some methods to estimate the chronological age, including assessing the development of third molars on panoramic radiographs[4] and assessing clavicular ossification.[9] However, not many forensic odontologists are familiar with the clavicular assessment. Therefore, only a few studies have been published focusing on age estimation based on clavicular epiphysis.[10, 11] According to the dental age estimation study based on third molar development from panoramic radiographs in the Thai population, the root formation is completed around 22 years. However, in many cases, the root formation is completed before the age of 18 years.[4] Therefore, the alternative method is necessary to assess whether the victim or the suspect has reached 18 years of age.

Our investigation showed that from stage 2, almost all individuals were over 18 years of age, which is not in line with previous studies. Olze et al.[6] proposed the periodontal ligament visibility status in the lower third molars as a characteristic for dental age estimation after complete mineralization of the root. Their study included 1198 panoramic radiographs from Germans with ages between 15 and 40 years, the minimum age for stages 1-3 was over 18 years of age. In 2014, Sequeira et al.[7] studied 487 panoramic images of Portuguese subjects aged between 17 and 31 years. They concluded that stage 3 could be used in estimating males over 21 years of age, whereas for females, other techniques were suggested. Guo et al.[1] studied the radiographic visibility of the periodontal ligament in lower third molars of a Chinese population. They concluded that if stage 1 was determined, it was possible to prove that an individual was already 18 years of age. Timme et al.[12] assessed 2346 panoramic images in Germans and proved that stages 1 and 2 can be used to explain that individuals are older than 18 and 21 years of age, respectively.

However, our study's result was in accordance with Lucas et al.[8], who studied a UK Caucasian cohort of 2000 subjects with ages between 16 and 25 years. The authors renamed stages 0, 1, 2, and 3 to A, B, C, and D to better represent the data's categorical nature. They concluded that both in males and females, the presence of stages C and D could help accurately determine whether an individual was over 18 years.

The authors evaluated 746 radiographs of a Thai population selected from the age of 16 to 26 years, which covered the period of third molar root formation completion. The results showed that the minimum and the median ages of the individuals increased with the stages, except for stage 3 in females, which may be caused by the small number of cases. We found stage 2 first appeared at the age around 18.15 years, which is similar to that of Portuguese[7], but about 5 years younger than that of Chinese[1] and German populations.[12] The mean age of the 4 stages of periodontal ligament visibility on panoramic radiographs of teeth 38 and 48 were not statistically significant different both in males and females. Even distribution of the number of subjects in each age group may be helpful in the significance of these parameters.

The subjects in the present study were selected based on age, without the other factors such as the socio-economic status. It may be that the difference in the minimum age of different populations were caused by different origins. In 2020, Guo et al.[13] first developed a new stage classification without considering the periodontal ligament visibility status between the roots of the lower third molars, which could not be classified in many cases because of fused roots or narrowed furcation. This new criterion can be effectively used in forensic age estimation. In the present study, we found that the visibility status of 54 panoramic radiographs (7.24%) could not be classified to any stage because of fused roots or narrowed furcation, which could be considered as one of the limitations of the study. The dental age assessment using radiographs is a valid method of forensic age estimation.[14] Further study should be performed to determine whether the new classification by Guo et al is also applicable to a Thai population. According to the inter-observer error results, it can be concluded that

dental age estimation should only be performed by properly trained personnel.[13]

CONCLUSIONS

Based on the results of the present study, radiographic visibility of the periodontal ligament in lower third molars may be a useful approach in dental age assessment in the Thai population. In case the periodontal ligament visibility is found to be in stage 2, it may be confirmed that the individual is at least 18 years of age. Further studies are needed to prove the relationship between ethnicity and the stage of periodontal ligament visibility on panoramic radiographs.

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