Chronological Age Estimation Base on Third Molar Development from Panoramic Radiograph in Thai Population

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Abstract

The purpose of this study was to assess the chronological age based on the developmental stages of third molars in Thai population by using Demirjian's classification system.
The sample consisted of 1,729 digital panoramic radiographs from Thai subjects aged between 9.26 and 25 years. Statistical measures were calculated at stages A – H in males and females for both impacted and non – impacted third molars.

The present study showed that females reached the completion root formation earlier than males both maxillary and mandibular third molars. At the age 18 years, for maxillary third molars, formation of the inter-radicular bifurcation has begun (stage E). However, at the same age for mandibular third molars, stage E was only found females, whereas stage F (root length is at least as great as crown length and have funnel-shaped endings)was found in males.

The determined probability of Thai individual being younger or older than 18 years for legislation might be valuable in future forensic practice.

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Introduction

Age estimation is very important in forensic medicine because of its application to unidentified cadavers and human remains, as well as remains lacking documentation of age.[1] The international and interdisciplinary study group on forensic age diagnostic for age estimation in living individualsrecommended that every expert opinion comprises three independent parts contributed by forensically experienced experts of the relevant disciplines, including physical examination, X-ray examination of the left hand by a radiologist, and dental examination with the determination of the dentition status and X-ray examination of the dentition.[2] It is generally accepted that dental development is the most reliable method in estimating the chronological age of adolescents and young adults. The radiographic assessment of the degree of third molar formation is a major part for forensic age estimation, additionally, the third molar possesses a unique advantage over other teeth because its development tends to continue over a longer period and until a later age and assumes great forensic importance.[3]

There were several methods to assess dental development in the past.[4-10] Compared to other methods, the eight-stage scheme designed by Demirjian et al[11] obtains the highest value in both observer agreement and correlation between chronological age and estimated age and is widely used for its simplicity, accuracy and objectivity.[3] Recently, numerous studies have been undertaken to estimate dental age according to third molars and provided reference data of different ethnic groups for comparative studies and age estimation of juveniles and adolescents. Although many studies have evaluated the usefulness of third-molar mineralization as a reliable indicator of age estimation in different population[12-17], the influence of geographic origin on the development rate has not been sufficiently analyzed. Moreover, the development of each individual can be affected by genetic, nutritional, climate, hormonal, and environmental factors.[18]

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Previous studies have shown that dental development varies slightly among dissimilar populations, making population-specific studies necessary, and studies of different ethnic populations have yielded varied age estimations.[12-14] We hypothesize that Thai population have a different rhythm of third molar mineralization from that of population in the countries from which the standards were derived. To our knowledge, there was a few reports about age estimation in Thai population.[17,22]

However, one of these reports[17], the authors assessed third-molar development by using a modified scoring technique, the 10-point developmental scoring, which was proposed by Gleiser and Hunt[9] and modified by Kohler et al.[10] The other report were performed only in the mandibular third molars of Thai population in the different region of Thailand. Therefore, this study will be performed to assess chronological age estimation based on developmental stages of maxillary and mandibular third molars in lower north part Thai population by using Demirjian's classification system.

Materials and methods

Samples

In this retrospective study, the study sample was chosen from Thai outpatients who visited Dental Hospital, Faculty of Dentistry, Naresuan University, and underwent panoramic radiograph examination between August 2014 and January 2016. All Panoramic radiographs were digitally generated on a Kodak 9000c Digital Panoramic and Cephalometric System (Carestream Health Inc., Rochester, NY, USA). A total of 1,729 digital panoramic radiographs of 549 male and 1,180 female Thai subjects age between 9.26 and 25 years were examined. The inclusion criteria are the availability in their clinical records of a panoramic radiograph of adequate quality, and no history of medical or surgical disease that could affect the presence and development of third molars. Exclusion criteria included image deformity affecting third molar visualization or panoramic radiograph showing obvious dental pathology related to the third molars. The chronological age, converting to a decimal age, was based on the date of the panoramic radiograph and the date of birth. This study was approved by the Naresuan University Institutional Review Board (COA No. 046/2015).

Developmental stage assessment method

The Demirjian's classification system is used to evaluate the developmental stage of the third molars on the panoramic radiograph as shown in Figure 1, and 2, Demirjian's classification system distinguished eight stages of crown and root development (stage A-H). Stages A, B, C, and D represented crown formation from the appearance of the cusp to the crown completion, and stages E, F, G, and H showed representative root formations from radicular bifurcation to apical closing.

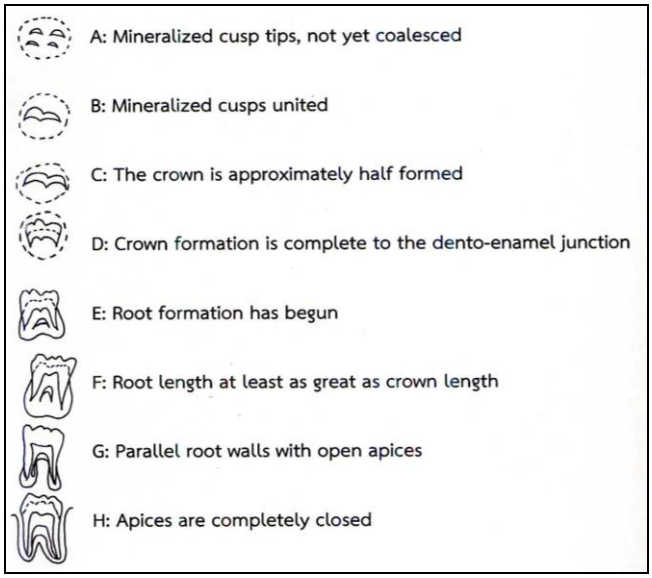

Figure 1. Schematic drawing of the developmental stages of third molars.

Assessment of the study sample

All of the digital radiographs are viewed on the 21 inches LCD monitor, with resolution of 1600x1200 pixels (Dell LCD monitor, Dell Optiplex 990, Dell Inc., Penang, Malaysia). The assessment is performed by one oral and maxillofacial radiologist. With an interval of two months, 100 randomly chosen panoramic radiographs are graded by a second observer and re-scored by the main one for testing intra-observer agreement.

Statistical analysis

Descriptive statistics are obtained by calculating the means, standard deviations and range of the patients' chronological age at eight stages of third molar development. Statistical analysis is performed with the Mann-Whitney U-test and the Wilcoxon test for gender and age. Regression analysis is performed to assess the

correlation between the third molar development and chronological age. Cohen's kappa test is performed to calculate the intra- observer agreement. All the data are analyzed using the SPSS software package (SPSS for Windows, version 17.0, Chicago, IL, USA). Statistical significance is defined as $P < 0.05$.

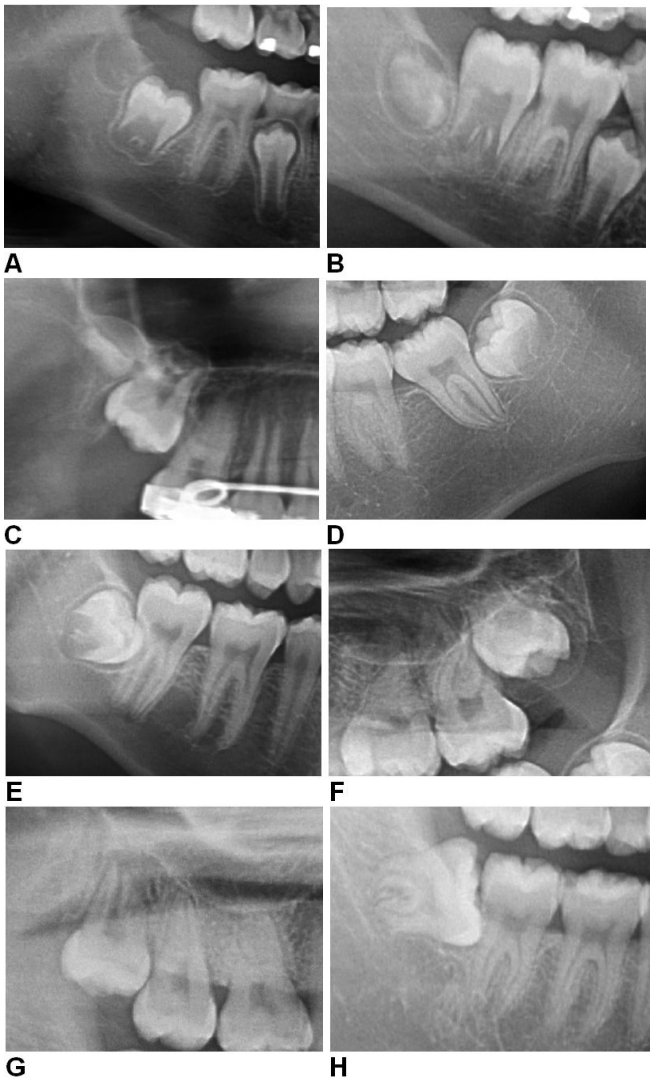

Figure 2. Cropped panoramic radiographs show developmental stages of third molars. A, stage A: cusp tips are mineralized but have not yet coalesced. B, stage B: mineralized cusps are united so the mature coronal morphology is well-defined. C, stage C: the crown is about half formed, the pulp chamber is evident and dentinal deposition is occurring. D, stage D: crown formation is complete to the dentino-enamel junction. The pulp chamber has a trapezoidal form. E, stage E: formation of the inter-radicular bifurcation has begun. Root length is less than the crown length. F, stage F: root length is at least as great as crown length. Roots have funnel-shaped endings. G, stage G: root walls are parallel, but apices remain open. H, stage H: apical ends of the roots are completely closed, and the PDL has a uniform width around the root.

Results

Repeated scorings of 100 panoramic radiographs indicated excellent intra – observer agreement (0.94). The subjects included in the present study composed of 1,729 patients, 31.75 % (n = 549) were males and 68.25 % (n = 1,180) were females, the mean age was 20.19±3.43 years and the age range from 9.26 to 25years. Distributionof third molar analyzed was shown in Table 1. The number of teeth, minimum, maximum, and mean values with standard deviation for the mineralization age of teeth 18, 28, 38, and 48 were shown in Tables 2, 3, 4, and 5, respectively.

The root formation of 18, 28, 38, and 48 were completed (stage H) at the mean age range of 21 and 22 years. At the age 18 years, for maxillary third molars, formation of inter – radicular bifurcation has begun (stage E). However, these were not found in mandibular third molars of male patients (Tables 4 and 5).There was significant difference between the mean age of males and females in stage E of mandibular third molars, which was higher in females (Tables 4 and 5).

The data showed that most of the stages males reached the indicated ages (18 years) earlier than females, and that the probabilities differ also between the maxilla and mandible. No statistically significant differences in mineralization age of third molars between maxilla and mandible and between sides for each genders.

Discussion

Currently, there are several methods for age estimation, dental age estimation by using panoramic radiographic examination is more reliable than skeletal indicators, such as cervical vertebrae and hand wrist bones.[18,19] Aves Ferreira et al[20] reported the use of multiple linear regression method to estimate age by measurements in dry adult human skulls. They concluded that this method was not accurate for age estimation and that were not observed

evidences of positive association between age and variables tested. Teeth are the strongest structures in the human body, protected by the soft and hard tissues of the face, and are highly resistant to external factors such as decomposition processes and extreme temperatures.[21] Therefore, teeth are good indicator for age estimation.[22]

Third molar mineralization stage is one of the most useful tools to assess the chronological age, especially in unknown victims or legal purposes. Nowadays, the Demirjian's classification is one of the most frequently applied radiological methods.[1] This system is based on a definitive anatomical shape and shows very goodintra – and inter – examiner agreements. These allow for better reproducibility.[13,23]

Recently, for different ethnic groups, many reports have been published about the evaluation of third molar development.[3,12-16] The present study was performed to add reference data for forensic application about third molar mineralization in a group of Thai population. We evaluated third molar mineralization stage in 9.26 – to 25 – year – old population by using Demirjian's classification. Even though wide age range, there was a clear correspondence between the mineralization stage and the age of the subject. There were many studies reported reference data for age estimation by using Demirjian's classification of third molar development. However, these data were different between populations.[12-16]

In Thailand, the Criminal Code states that "For any person over 15 years of age but not yet 18 years of age, it shall reduce the scale of punishment as provided for such offence by one – half (section 75)".[22] Therefore, accuracy of age estimation methods for suspects with unknown chronological age is needed in the interest of justice.[24] From a medico - legal aspect, we decided to estimate the probability of an adolescent being older than 18 years, which indicates adulthood status in our country. According to our findings, mineralization stage A, B, C, and D indicated that the person in question is younger than 18 years and would therefore fall under juvenile legislation. However, caution may be necessary in the forensic application because these possibilities were created from the representative survey.

In the present study, cusp tips mineralization (stage A) initiated at 9.75 years of age. Jung & Cho[24] observed that the third molar began to calcify at 7 years of age, which was earlier than our study. We found that the crown completion (stage D) was found at the mean age of 15.47 years. Compared with the results of other populations, it was earlier than Turkish[12] and Saudi populations[13], and later than Korean population.[24] Duangto et al[21] found that lower third molar crown formation in Thai population was completed at the mean age of 14.10 years, which was earlier than our results (15.50 years). The reason of different result even though same country may be the difference in region of the subjects.

According to our data, root formation was completed (stage H) earliest at the age of 16.08 years. This is about 3 years earlier than the study by Duangto et al in northern Thai[22], 2 years earlier than Turkish[12], and 1 year earlier than Korean populations.[24] Olze et al.[16] analyzed mineralization stages of third molars on subjects aged between 12 and 30 years on the basis of Demirjian's classification. They found that at the mean age of 18 years, crown formation is complete to the dentino-enamel junction (stage D) for both maxilla and mandible. Their study results, however, different from ours, which was found stage E in maxilla (both males and females) and mandible (females) at the mean age of 18 years. Jung & Cho[24] evaluated developmental stages of the third molars in Korean population using modified Demirjian's classification. They reported that at the age of 18 years or older, the patients exhibit stage G, which was older than Thai (the present study) and Japanese population.[16] There was no statistically significant difference in the chronology of maxillary and mandibular third molars in the present study. This finding was consistent with the study in Japanese by Olze et al.[16]

Cantekin et al[12] analyzed cone-beam computed tomography (CBCT) image of third molar morphology as age estimation. They indicated that CBCT was superior to panoramic images in dental age assessment according to Demirjian method. Regarding the socio-economic status of the population in developing countries such as Thailand, panoramic radiograph is the most reliable and appropriate in evaluation of the teeth and related structures including jaw bones, and also age assessment by determination of third molar development. The other important

aspect to consider is the treatment planning of impacted third molar which was appropriate developed and should be removed. Panoramic radiographic evaluation is helpful to determine impacted third molar developmental stage, pattern of impaction, which will be useful for the surgeon to avoid postoperative complications such as pain, swelling, trismus, alveolitis, nerve damage, infection, and anxiety.[25]

Conclusions

The data from the present study may provide Thai references for third molar examination for the purpose of forensic investigation. The determined probability of Thai individual being younger or older than 18 years for legislation might be valuable in the future forensic practice.

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Declaration of Interest

The authors report no conflict of interest.

	18	28	38	48	Total
Male	483	477	485	490	1,935
Female	1,022	1,020	1,015	1,026	4,083
Total	**1,505**	**1,497**	**1,500**	**1,516**	**6,018**

Table 1. Distribution of third molars.

Stage	Male					Female					
	Number	Min	Max	Mean	SD	Number	Min	Max	Mean	SD	*P*
A	1	-	-	9.75	-	2	9.26	10.48	9.87	0.57	NS
B	3	9.75	14.08	11.91	0.54	3	9.50	13.50	11.50	0.51	NS
C	5	10.42	17.33	12.53	0.48	10	10.75	16.08	13.42	0.46	NS
D	16	11.25	20.00	15.23	0.49	26	11.83	21.17	15.84	0.48	NS
E	27	13.17	22.17	18.53	0.41	94	13.42	22.25	18.59	0.41	NS
F	32	15.75	22.08	19.17	0.43	105	15.42	24.50	19.76	0.42	NS
G	62	15.83	24.42	19.55	0.40	253	16.42	22.25	20.00	0.39	NS
H	866	16.08	25.00	21.75	0.49	529	16.08	23.83	21.69	0.49	NS

Table 2. Mineralization age of 18.
SD: standard deviation, P: P value, NS: not significant.

Stage	Male					Female					
	Number	Min	Max	Mean	SD	Number	Min	Max	Mean	SD	*P*
A	-	-	-	-	-	1	-	-	9.69	-	NS
B	3	9.75	12.08	10.92	0.55	2	9.50	12.50	11.00	0.52	NS
C	3	10.42	11.92	11.25	0.48	7	10.75	12.08	11.42	0.47	NS
D	14	11.83	21.25	15.63	0.48	24	11.25	19.33	15.12	0.48	NS
E	31	13.17	22.25	18.52	0.44	94	13.42	23.42	18.62	0.43	NS
F	30	15.75	22.08	19.19	0.40	115	15.42	24.50	19.76	0.41	NS
G	59	15.83	22.92	19.47	0.40	246	16.42	22.25	20.05	0.40	NS
H	337	16.42	25.00	21.75	0.47	538	16.75	23.83	21.65	0.47	NS

Table 3. Mineralization age of 28.
SD: standard deviation, P: P value, NS: not significant.

Stage	Male					Female					
	Number	Min	Max	Mean	SD	Number	Min	Max	Mean	SD	*P*
A	3	9.75	12.17	10.95	0.45	9	9.75	11.58	10.87	0.43	NS
B	3	11.42	12.08	11.69	0.51	5	10.67	13.50	11.80	0.49	NS
C	4	10.42	16.75	12.23	0.53	4	10.75	16.17	12.66	0.52	NS
D	13	11.83	18.75	15.83	0.45	34	10.75	18.00	16.28	0.45	NS
E	19	15.00	20.17	17.23	0.41	70	14.75	23.50	18.71	0.42	< 0.05
F	23	16.00	22.08	18.99	0.40	81	15.42	23.08	19.44	0.41	NS
G	56	15.83	22.92	19.08	0.39	244	16.17	22.25	19.88	0.38	NS
H	364	16.42	25.00	22.00	0.49	568	17.00	23.83	21.53	0.49	NS

Table 4. Mineralization age of 38.
SD: standard deviation, P: P value, NS: not significant.

Stage	Male					Female					
	Number	Min	Max	Mean	SD	Number	Min	Max	Mean	SD	*P*
A	3	9.75	12.17	10.95	0.48	7	9.75	12.58	10.63	0.46	NS
B	4	11.42	12.33	11.85	0.53	4	11.17	12.50	11.80	0.52	NS
C	3	10.42	14.92	12.31	0.53	4	10.83	13.17	12.23	0.51	NS
D	13	11.83	22.92	14.52	0.44	34	10.75	21.67	15.35	0.44	NS
E	19	15.00	22.17	17.49	0.43	70	14.75	21.42	18.69	0.42	< 0.05
F	24	16.17	23.33	19.30	0.40	91	15.42	22.83	19.69	0.41	NS
G	49	15.83	22.17	19.98	0.37	246	16.17	22.25	19.82	0.37	NS
H	374	17.58	25.00	21.89	0.49	573	17.00	22.25	21.5	0.49	NS

Table 5. Mineralization age of 48.

SD: standard deviation, P: P value, NS: not significant.

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