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Validity of the Third Molar Age Estimation from Different Dental Age Estimation Surveys for Malays and Chinese in Malaysia- A Pilot Study

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ABSTRACT

This study aims to determine which age assessment data using the third molar development values (local or international) is suitable for estimating the age of Malays or Chinese in Malaysia. A sample of 60 panoramic images of Malays and Chinese aged between 13.58 to 21.25 years were selected. Different assessment surveys which included the studies by Yusof *et al.* (2015), Wilson (2005), Johan *et al.* (2012), Mincer *et al.* (1993), AlQahtani *et al.* (2010) and Gunst *et al.* (2003) were employed to estimate the age from the developing third molar on the panoramic images studied. The estimated ages were compared to the chronological age of the selected Malaysians. All the datas were then recorded on Microsoft Excel sheet. The two observers were then subjected to the Intraclass Correlation Coeffecient (ICC) inter-observer reliability test.The highest number of correspondence (65%) between the chronological and estimated age (within one year) was for the survey conducted by Wilson. With regards to ethnicities, 70% of Chinese matched the mean estimated age by Wilson while Malays showed a high correspondence for the study by Mincer *et al.* (63.3%). Furthermore the ICC reliability test showed strong agreement between the two observers. There were similarities between the Malay and Chinese population in the correspondence of the estimated age to the chronological age employing the different dental estimation surveys; in addition the study by Wilson and Mincer *et al.* yielded best matching for these Malaysians.

Keywords: Forensic Odontology, Third molar development, Dental age estimation, Malay, Chinese, Malaysian

INTRODUCTION

Forensic age estimation defines as an expertise in forensic medicine which aims to determine the chronological age of person of an unknown age involved in judicial or legal proceedings. Legal authorities in many countries are facing difficulties in determining the exact age of individual. Many researchers have come out with different methods for age estimation but there is no fool-proof method to universally determine the age in a standardized system (1).

Dental age estimation (DAE) is a procedure that uses dental growth as a measure to estimate age when the date of birth is unknown. The demands for accurate age estimation became increasingly crucial in the twentieth century where many cases involving unidentified persons remain unsolved because of lack of proper documentation. Furthermore cases of

a living individual who has no proof of identification but claim to be a minor to get social benefit are on the rise. In another popular crime-related situation, an adult will pretend to be a juvenile to escape harsher penalties for adult. According to the Age of Majority 1971(Act 21), any individual who committed very serious crimes and is above the age of eighteen is entitled for death sentence and corporal punishment as she/he has reached the age of majority (2). Moreover, the sexual partner of a girl below sixteen years can be charged for statutory rape of a minor even if there was mutual consent.

Edwin Saunders in 1837 was one of the first one who suggested that emergence of teeth in the oral cavity provided the most reliable guide to age estimation as compared to height during hiring of children for work (3). Later dental age estimation was performed by Greulich, Pyle. (1959)(4) and Moorrees *et al.* (1963)(5) by observing stages of tooth mineralization on radiograph. In 1973, Demirjian *et al.* started a new trend by using mandibular permanent teeth development from central incisor to second molar as parameters for age assessment (6). Demirjian conceived 8 stages developmental criteria starting from the first appearance of calcified cusp to the closure of root apex where tooth formation is categorized as completed.

There is still an issue to differentiate an adult from a juvenile as assessing any individual age 14 years and above is difficult, as most teeth have erupted into the oral cavity. The only teeth remaining are the third permanent molars. The third molar as we all know lacks reliability as biological marker for chronological age assessment. It is the most variable tooth in dentition with respect to size, time of eruption and time of formation (7). In addition, not every individual has all four third molars present as some may be congenitally missing. Moreover, this tooth has also a great tendency to exhibit impaction and malformation. However, because there is no other biological marker to estimate age after 14 years old, the third molar is the best option available. Many researchers have claimed the usefulness of their own third molar development surveys in determining juvenile versus adult status, in cases of a person suffering from amnesia and also in anthropological matters (8).

Based on the chronological table by Logan & Kronfield (1933), the first sign of calcification began at the age of 7 to 9 years old for maxilla and 8 to 10 years old for mandible while the third molar eruption occurs between ages of 17 to 21 years. However variations can happen (9). This “wisdom tooth” can erupt even when one reaches 30 years of age and researchers have noted that different populations have different age for third molar emergence (10).

There is a limited study of dental age assessment for the Malaysian population, presumably due to our country’s limited research output and unique multiracial or ethnic inhabitants. The ethnicities/ races are Malay, Chinese and Indian and other indigenous tribes which include Orang Asli, Iban, Kadazandusun, Muruts and many others. It is quite difficult to generalize the dental age estimation studies for all the races in Malaysia. Most of the studies by past researchers involved the Malay population, as they are the largest ethnic group in this country (Department of Statistic Malaysia 2014-2016). According to their demographic studies, Malays comprise 68.6% of the population, followed by Chinese (23.4%), Indians (7.0%) while others (1.0%) (11).

In this study we embarked to find out which dental age survey is suitable for the majority of Malaysians. The focus is on the two main ethnicities- Malays and Chinese as they come from the same Mongoloid (race) heritage. Although many notable researchers in this country and overseas have developed dental age estimation methods, there is still no studies done that validates which survey is suitable for estimating age of persons from the aforementioned ethnicities. Therefore, these selected number of age estimation surveys using third molars will be assessed to verify their data validity for application to Malays and Chinese.

MATERIALS AND METHODS

Digital panoramic images of 60 Malays and Chinese individuals (30 males and 30 females) were collected from Oral and Imaging Radiology Division, Faculty of Dentistry, University of Malaya for this study. The research was approved by the Medical Ethical Committee [DF OS1617/0041(U)], Faculty of Dentistry, University of Malaya. A major criterion for age estimation of living people is the use of dental panoramic images in the assessment of the teeth mineralization stage (12). It has been adopted by most investigators for their accessibility and ability to visualize all teeth on a single radiograph with minimal distortion (13). The exact chronological age of the patient was calculated from the date of birth and the date of the image (radiograph) taken. The ages of the patients ranged from 13.58 to 21.25 years old. The dental panoramic images were captured using an iPad Mini (Model A1432, Apple Inc., Foxconn, California, USA) and the images were transferred into a laptop (Sony VAIO Y Series VPCYB15AG, Sony, Beijing, China) for proper viewing and subsequent storing in CDs for record keeping.

The inclusion criteria for the images were that they were good quality dental panoramic images

and there must be no radiological evidence of any pathology or fracture in the mandible that could affect teeth development. This includes wisdom teeth that exhibit severe malposition, vertical and horizontal impaction and large carious lesion.

This study was performed by comparing the dental growth stage of an individual of known age against published reference data on dental developmental surveys. The comparison was conducted by two investigators. The following developmental surveys were selected;

1) **Yusof *et al.* (2015)** study scored the third molar development and eruption stages using the Gleiser and Hunt technique which was modified by Kohler *et al.* and Olze *et al.* technique respectively. The first technique is the ten developmental stages of the third molars and the second technique is the four third molar eruptional stages. Yusof *et al.* then yielded a Multiple Linear Regression (MLR) formula in obtaining the estimated age. Similarly all the 60 panoramic images were scored using the Olze *et al.* technique and Gleiser and Hunt technique modified by Kohler. Olze *et al.* (2010) used 605 panoramic radiographs of the First Nations people (Red Indians) of Canada. They scored the four third molar eruptional stages. The classification was; Stage A- Occlusal plane covered with alveolar bone; Stage B-Alveolar eruption; complete resorption of alveolar bone over occlusal plane; Stage C-Gingival emergence; penetration of gingiva by at least one dental cusp; Stage D- Complete emergence in occlusal plane (14).

   The scores were used in the MLR formula to get the estimated age.

Age = 9.6143 + 0.3700UL + 0.4987LR + 1.8005ur – 1.1022ul (1)

Age = 9.0252 + 0.838UR + 0.5461LR – 0.8163ur + 0.5584ul (2)

Figure 1: MLR ormula developed by Yusof *et al.* for age estimation.

   The MLR formula as shown in Figure 1 used abbreviations to calculate the estimated age, where UL is upper left third molar, LR is lower right third molar and UR is upper right third molar based on developmental scores. The ur is upper right third molar and ul is upper left third molar based on eruptional scores. Equations (1) and (2) refer to the formula for male and female children, respectively (15).

2) **Johan *et al.* (2012)** assessed the mineralization of both the lower third molars from 1080 panoramic radiographs of Northeast Malaysians (Malays) according to the eight grade scheme by Demirjian *et al.* (1973). The age prediction model was generated from the regression analysis (16). In our study, the 60 panoramic radiographs were scored according to Demirjian's classification and estimated age were obtained using the age prediction model generated by Johan *et al.*

3) **Wilson YP (2005)** conducted a study using 1224 panoramic radiographs of Malays, Chinese and Indians population from panoramic radiographs obtained from Faculty of Dentistry, University of Malaya. The third molar development were analyzed and scored using the Demirjian's method. Statistical tests using One-Way ANOVA and Odds Ratio were done and data were analyzed (17). The mean ages were obtained and tabled for each stage in every ethnic groups. For our comparative study, we scored the third molar development using the Demirjian's classification and the estimated age was obtained from the table in Wilson's thesis for Malays and Chinese.

4) **AlQahtani *et al.* (2010)** - In this technique the researchers used a cross-sectional, retrospective study of archived material. Developing teeth from 72 prenatal and 104 postnatal skeletal remains of known age-at-death were examined from collections held at the Royal College of Surgeons of England and the Natural History Museum, London, UK. Data were also collected from dental radiographs of living individuals (M 264, F 264). The tooth developmental and alveolar eruption stages of the right side of the jaw from each radiograph were recoded. Teeth development was assessed using the modified stages by Moorres *et al.* In selected cases, the tooth eruption stages in relation to bone level were assessed using the modified Bengston's stages. The atlas was developed for the combined gender and the median age was included (18). In our study, the development and eruption of the third molar on the right side of the jaw were observed on the panoramic radiographs and were scored according to the atlas drawn by AlQahtani *et al.* The estimated age were taken from the median age for each score.

5) **Mincer *et al.* (1993)** used the eighth grade scheme developed by Demirjian *et al.* to score the third molar development in 823

panoramic radiographs and some periapical films of White, Black and other Americans (19). A table with mean and median ages for third molar development was developed using the Demirjian's eight grade classification. In our study, third molar development were scored using the Demirjian technique and the estimated age were obtained from the table by Mincer *et al.* for the White Americans (i.e. mean age).

6) **Gunst *et al.* (2003)** evaluated the third molar development from the panoramic radiographs of Belgian Caucasians using the ten stage developmental scoring method by Gleiser and Hunt modified by Kohler *et al.* (1994). Multiple regression analysis was performed in order to obtain multiple regression formulae for dental age calculation (20). We scored the third molar development from the 60 panoramic iamges of Malays and Chinese in accordance to this technique and used the multiple regression formula obtained from Gunst *et al.* to get the estimated age for our study.

Each panoramic image was scored using the data, techniques, formulas etc. proposed by each researcher mentioned above and the estimated age was subsequently recorded in the Excel sheet. After the scoring was completed, the scored age was compared to the chronological age of the selected Chinese and Malays. The comparison yielded best correspondence of age estimation within six months and also one year to the chronological (actual) age. Both of the observers were involved in the images evaluation, with one observer responsible in scoring and calculating ages for the males, the other examiner was exclusively for the female samples (irrespective of ethnicity). After two weeks, forty randomized panoramic radiographs were selected and scored by the examiners for Intraclass Correlation Coeffecient inter-observer reliability test.

RESULTS

Inter-observer reliability test

The Intraclass Correlation Coefficient inter-observer reliability test showed strong agreement between the two observers. For the Olze *et al.* scoring technique, Intraclass Correlation showed an excellent score of 0.87. As for the scoring technique by Demirjian *et al*., Gunst *et al.* technique and AlQahtani *et al.* technique, each showed preferable Intraclass Correlation with scores as high as 0.947, 0.938 and 0.947 respectively.

Comparison of the chronological age with dental age estimated from different selected surveys

The chronological age of an individual was calculated from the date of birth (recorded in the identity card or birth certificate) and the date the panoramic image taken. The ages of individuals for this sample ranged from 13.58 to 21.25 years old (Table 1).

Table 1: Age and gender distribution of the sample.

Age group (years)	Number Male	Number Female
13-13.99	1	0
14-14.99	3	1
15-15.99	6	9
16-16.99	8	4
17-17.99	6	4
18-18.99	3	6
19-19.99	2	5
20-20.99	0	1
21-21.99	1	0

A higher number of correspondences for the survey conducted by Wilson (2005) where the estimated age of 39 cases were closely matching to the chronological age within one year (Table 2). This comprised of 65.0% of the total cases of 60 panoramic radiographs. The least accurate with less than half the total sample (46.7%) was observed in the age estimation employing multiple linear regression formula by Yusof *et al.* (2015). Others surveys showed correspondence in more than half the sample, with 51.7% for formula by Gunst *et al.* (2003), 53.3% for the technique by AlQahtani *et al.* (2010), 58.3% for the study by Johan *et al.* (2012) and with a reasonably good result from Mincer *et al.* (1993) where 60.0% of the cases had the estimated age corresponding within one year of the chronological age.

With regards to gender comparison, the highest score for the male was the studies by Wilson and Johan *et al.* where both had a percentage of 63.3% matches. While correspondence for the female the score showed more favourably towards the study by Wilson (66.7%).

There are also differences between the two ethnicities where the Malays showed higher percentage of correspondence for the study by Mincer

Table 2: The number of cases in which the estimated age corresponded within one year to the chronological age for each survey.

	One year correspondence						
	Yusof *et al.*	Wilson	Mincer *et al.*	Johan *et al.*	AlQahtani *et al.*	Gunst *et al.*	**Total**
Male	15	19	18	19	15	19	**30**
Female	13	20	18	16	17	12	**30**
Malay							
Male	7	9	9	11	7	9	**15**
Female	5	9	10	8	7	8	**15**
Chinese							
Male	8	10	9	8	8	10	**15**
Female	8	11	8	8	10	4	**15**
Total match (%)	46.7	65.0	60.0	58.3	53.3	51.7	**60**

et al. and Johan *et al.* with a percentage of 63.3%. Whereas, the Chinese showed 70% correspondence with the mean estimated age by Wilson - indicating this as the most favourable survey for the Chinese.

To be more detailed, for the Malay male, the study by Johan *et al.* showed a high score with 11 out of 15 cases, having age estimation which yielded the best to the actual age. As for Malay female, the mean age from the study conducted by Mincer *et al.* showed the highest percentage of correspondence (66.6%). For the Chinese population, the males yielded the best correspondence with the study by Wilson and Gunst *et al.* techniques - 10 out of 15 cases had the estimated age closer to the chronological age within one year whereas the Chinese female favoured better to the study by Wilson by presenting 73.3% correspondences.

Table 3 shows the number of cases which conformed within six months to the actual age was recorded for each survey. The result showed a similar pattern with that of the one year analysis table. In overall, the study by Wilson showed the highest percentage of correspondence (38.3%) of the estimated age to the actual age within six months.

The age estimation formula with the multiple linear regression formula by Yusof *et al.* and the age estimation study by AlQahtani *et al.* did not show a satisfying result, with only 30.0% and 28.3% of the cases yielding best correspondence to the estimated age respectively. As for the study by Johan *et al.* and Mincer *et al.*, each showed a percentage of 31.7% and 36.7% of cases where the estimated age conformed best within six months to the actual age.

With regards to gender, males are more favourable with the survey done by Wilson with 11 out of 30 cases having the estimated age correlated within six months to the actual age. Again with a percentage of 40.0% correspondence, females

Table 3: The number of cases in which the estimated age corresponded within six months to the chronological age for each survey.

	Six months correspondence						
	Yusof *et al.*	Wilson	Mincer *et al.*	Johan *et al.*	AlQahtani *et al.*	Gunst *et al.*	**Total**
Male	9	11	10	10	8	10	**30**
Female	9	12	12	9	9	10	**30**
Malay							
Male	4	5	7	6	2	3	**15**
Female	4	6	6	4	6	7	**15**
Chinese							
Male	5	6	3	4	6	7	**15**
Female	5	6	6	5	3	3	**15**
Total match (%)	30.0	38.3	36.7	31.7	28.3	33.3	**60**

showed a more positive result with the study by Wilson.

For the Malay population, the mean age from the study by Mincer *et al.* presented the highest correspondence with 43.3% of the estimated ages of the cases being accurate within the six months to the chronological age. As for the Chinese, Wilson presented the highest percentage of correspondence at 40.0%.

When detailing the results for the Malays, the estimated ages which corresponded better to the actual ages of Malay males is the study by Mincer *et al.* whereas Gunst *et al.* showed high correspondence for the Malay females with both studies, scoring 7 out of 15 cases. As for the Chinese, the males were more favourable to the study by Gunst *et al.* with 46.7% being matched to the actual age while the females showed a higher number for the study by Wilson and Mincer *et al.* with both scoring 6 out of 15 cases.

DISCUSSION

In this study, we compared six different dental age estimation surveys; Yusof *et al.* (2015), Wilson (2005), Johan *et al.* (2012), Mincer *et al.* (1993), AlQahtani *et al.* (2010), Gunst *et al.* (2003) to determine which study is most accurate to estimate the age of a Malay or Chinese of unknown age in Malaysia. The first three studies were on the Malaysian population while the rest were recognised international dental surveys used favourably for age estimation procedures. Based on the 95% confident interval of the Intraclass Correlation Coefficient estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.9 are indicative of poor, moderate, good, and excellent reliability respectively (21). The Intraclass Correlation Coefficient inter-observer reliability test showed excellent reliability with Demirijian *et al.* and AlQahtani *et al.* at 0.947, thereby indicating that the two observers had good correspondence in their findings.

A sample size of 60 panoramic images of Malays and Chinese (30 males and 30 females) aged between 13.58 to 21.25 years were obtained from the Oral and Maxillofacial Division, Faculty of Dentistry, University Malaya. This sample size was adequate for this pilot research as the authors were ascertaining the validity results of dental age estimation surveys and not creating their own. Researchers can now track the best method from the results obtained in this study for their future work. Moreover this exercise was time consuming as only excellent digital images with no pathologies affecting teeth developments were selected.

Yusof *et al.* incorporated Olze *et al.* eruption and Gleiser and Hunt 10 stages development model to derived a formula to estimate age for the Malay population. In our research, there was a lack of images that can strictly follow the criteria needed by Yusof *et al.* We decided to ignore 2 criteria mentioned in their research; firstly not to undertake age estimation if the third molar exhibited horizontal or vertical impaction and when the angulation between the long axis of third molar and long axis of second molar is more than 10 degree. Secondly, the available mandibular retromolar space needs to be measured in addition to third molar crown width. The ratio of retromolar space to crown width should be more than 1.1 (15). As these two criteria are difficult and complicated to follow during an actual case situation, we decided to ignore this prerequisite. Using Yusof *et al.* method, our studies found overestimation of dental age when compared with chronological age. Conversely, if we used purely the eruption score the dental age is expected to be underestimated in impacted third molar cases as impaction may result in delay of eruption. Yusuf *et al.* explained that the overestimation is due to the over-masking effect. In the formula the third molar development (TMD) and third molar eruption (TME) are combined and therefore information from TMD may mask the effect from TME. Thus, the TME effect will be suppressed (consequently age is overestimated).

Wilson's study stated that there is no difference in the third molar development between Malay and Chinese population which corresponded to our study where the two ethnicities showed only a small difference in number (about 10.0%). One shortcoming of Wilson's study is that she did not provide different tables of mean age for each gender. Despite this, it has been shown in our results that male and female exhibited the same percentage, at 60.0% correspondence. This high accuracy of dental age estimation within one year correspondence was observed amongst both Malays and Chinese. The higher accuracy is probably due to the studies done specifically for three ethnic groups in Malaysia (Malay, Chinese and Indian) instead of focusing only on one ethnicity. It is possible that the subtle differences were better recorded and analysed. As stated previously the two ages which hold significance in the Malaysian context were 16 years, in cases of statutory rape and 18 years for legal age of adult. In her studies Wilson stated that if the third molar development is at stage E and F (Demirjian's classification) they are more likely to be the age of 16 years old. As for the age of 18 years old, it is most likely to be at stage G and H. Our study also showed that Malays and Chinese with grade H in their third molar development were most likely to be above 18 years old as well.

Johan *et al.* research focused on Northeast Malaysian (Kelantan) Malay population. It was expected to have poor correspondence for Malaysian Chinese when compared with Wilson's study included this ethnicity. Although our study was mainly done on images from patients from central region of Malaysia (Selangor, Kuala Lumpur and Putrajaya), the result was good for the Malay population. Based on the one year analysis, the Malays showed higher percentage of correspondence at 63.3% to the survey done by Johan *et al.* Meanwhile the Chinese population also presented with a considerably good score of 53.3%. These findings showed that there were similarities in the timing of development of the third molar of Malays and Chinese.

Mincer *et al.* procured mean age benchmarks for American whites and Black. This is a national exercise in the USA and was supported by the American Board of Forensic Odontology. Surprisingly this age assessment has good accuracy for the Malaysian population, notably for the Malays with a percentage of 63.3% correspondence based on the one year analysis and 43.3% for the six months analysis. As for Chinese population, there are no differences for both genders at one year analysis with a score of 53.3% and as for the six months analysis, the score dropped remarkably at 30.0%. The high compatibility between Malay and American White makes this study suitable to be used for the Malays and cautiously employed for the Chinese.

AlQahtani *et al.* developed the atlas of human tooth development and eruption which combined the emergence and development of third molar on the right side of the jaw (18 and 48) for age estimation. This study was too detailed and complicated and yielded an average result in our study (53.0%). AlQahtani *et al.* dental age estimation is done for the general world population and it is not surprising that it produced less accurate results when we used the data for Malay and Chinese ethnicities.

Gunst *et al.* analyzed the third molar development in Belgian Caucasian individuals for both male and female gender. His study had strict selection criteria for parentage where only individuals with both father and mother were from the Belgian Caucasian origin were selected for the study. The result obtained was generally quite good for both Malays and Chinese at 51.7% for within one year correspondence, but it showed poor accuracy when used to estimate female Chinese with score of 26.7%. This lack of correspondence between female Chinese and female Belgians is probably due to different racial origin, one has Mongoloid heritage while the other is Caucasoid.

There is no single valid dental development survey for both the Malays and Chinese to determine age with certainty. The combination technique which incorporates the third molar eruption and development yielded poor result in our research. This can be seen from the survey data by Yusof *et al.* and AlQahtani *et al.* in our study. In addition, scoring by observation method seems to exhibit more accurate age estimation when compared with study that used formulas for calculation. The study conducted by Wilson, Johan *et al.* and Mincer *et al.* based on Demirijian's 8 stages of tooth development produced good results, indicating their suitability to be used for Malays and Chinese. It seems simpler method works best for the age estimation in these Malaysian populations.

CONCLUSION

From this investigation it can be concluded that when comparing the six different dental age estimation surveys, it is evident that there are similarities between the Malay and Chinese population in the accuracy of the estimated age to the chronological age (whether within one year or six months). In addition, Malays showed high correspondence to the study by Mincer *et al.* and the Chinese corresponded more toward the study by Wilson (within six months). It is evident that we need to develop more survey data which must be ethnic and gender specific to get higher accuracy. Lastly the age range scored must be at least be one year (not six months), taking into consideration the biological variation in teeth development.

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DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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