ORIGINAL ARTICLE

# Adaptation of Demirjian's Method for Age Estimation via Third Molar Development Among Adolescents and Young Adults of Malay Ethnicity: A Preliminary Assessment

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## ABSTRACT

**Introduction:** Identification of remains recovered at advanced stages of decomposition can be problematic due to the lack of physical evidence. Nonetheless, human dentition is least susceptible to decomposition and as such carry a significant value in personal identification of decomposed remains. Demirjian's method of age estimation was developed specifically for children with developing dentition. In this article, a method on adapting the Demirjian's method for Malay ethnic-specific age estimation using the third molar development is presented. **Methods:** Orthopantomograms of Malay subjects aged 18 to 25 were obtained from UiTM Sungai Buloh. Total of 318 samples were taken, comprising of 123 and 195 images from male and female subjects. Development of right and left mandibular third molar was classified according to the eight stages of development as illustrated in Demirjian's method. Data obtained were subjected to statistical analysis such as descriptive statistics and analysis of variance. The intra- and inter-gender variation between left and right mandibular third molar was evaluated using independent student t-test and analysis of variance, respectively. **Results:** Intra-gender comparison analysis revealed a significant difference in the female and male with a p-value of 0.000 and 0.003, respectively. Regression equation to estimate age based on third molar development were formulated according to dental age and maturity score. **Conclusion:** The Demirjian's method was successfully adapted for age estimation of individuals of Malay ethnicity. These findings can help with victim identification in cases of poor skeletal framework recovery and highly decomposed remains.

**Keywords:** Demirjian, Malay, Third molar, Age estimation, Forensic odontology

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## INTRODUCTION

Forensic age-estimations are commonly requested in relation to age thresholds in criminal investigations, during immigration procedures, and for civil purposes. Teeth as an age indicator are one of the most common ways of determining a person's age, especially when it involves mass disaster where mass causalities can complicate and delay the identification process (1,2).

Although there have been a multitude of studies regarding the determination of age using dentition, studies have also indicated that ethnic differences between population groups affect the accuracy of such measurements. (3). Studies have shown variation within different subsets of a population, indicating that population and geographic regions may affect the accuracy of age determination (4) There are also many different methods for determining age using teeth, but in every method postulated, there was either under- or over-estimation of age (5) and ancestry played a role in contributing to the inaccuracy. According to statistics given by The World Bank (2018 est.), Malaysia constituted of Malay (50.4%), Chinese (20.8%), Indians (6.2%) and other (0.9%) ethnic citizens. Ancestry holds a big factor in rendering the methods inaccurate as for example, a teeth structure for a Caucasian male can be different from an Asian male even though they are of the same sex. Standards of morphological and morphometric sex differences in the teeth cannot be applied universally as it may differ with the population sample involved (6). The Malaysian population is extremely diverse, making age estimation much more complex.

Mass disaster such as tsunami, earthquake, hurricane and etc can happen in many countries including Malaysia. Therefore, it is important to have expert

odontologists in disaster victim identification. They help in looking through dental evidences for human identification. Mass disaster can be divided into 3 categories. The natural disaster, accidental disaster, and intentional mass disaster. Earthquake and hurricane can be categorized into natural disaster. Airplane crash and burning buildings can be categorized as accidental disaster. Example of intentional mass disaster can be bombing of buildings and terrorist attack (7).

Teeth is one of the hardest body parts where it can resist major heat and trauma. As physical features may fade as time pass, teeth will remain the same due to its heavily calcified teeth. It is possible that teeth can be preserved in many cases after days have pass (8). Right after human fingerprint and DNA, teeth is the most reliable tool in identification of human remains (9). Thus, proving the reliability and importance of teeth and body identification.

This research is valuable, especially in cases where age is unknown and requires determination. The aim of this research is to derive a new Malay sex-specific formula adapted from Demirjian's technique, for Malay respondents aged 18-25.

## MATERIALS AND METHODS

### Sample Selection

This research was a cross-sectional retrospective study, where 318 (n=138) orthopantomograms (OPGs) or commonly known as x-rays of teeth of both males and females of the Malaysian Malay population were obtained. The OPGs were observed and analysed based on the 8 stages of dental development (Figure 1) as defined by Demirjian et al. (10). The samples of OPGs were obtained from Universiti Teknologi MARA, Sungai Buloh, Selangor, Malaysia. Ethical approval was obtained from the ethics committees of both MSU Ethics Commitee (HE-MSU-011) and Universiti Teknologi MARA (600-IRMI(5/1/6), respectively.

### Inclusion and Exclusion Criteria

The sample OPGs chosen were those of Malaysian Malay individuals with a full complement of mandibular and maxillary third molars. Subjects chosen were physically healthy, well-nourished and had no history of any diseases that could affect the presence and development of third molars.

### Analysis

Scoring of 0 to 8 was given based on 8 stages of dental development for both left and right mandibular third molar teeth. The guideline for the scoring refers to the Demirjian method developed by Demirjian, Goldstein, and Tanner (10). Scoring for left and right mandibular third molar was combined for each age group and gender and graph were developed based on the data obtained. Data obtained were subjected to statistical analysis such as descriptive statistics and One-way analysis of variance (ANOVA). The significant of the developmental differences between left and right mandibular third molar between the same and different gender was evaluated using independent student t-test and ANOVA, respectively. Statistical significance was set at p=0.05. All data were analysed used Statistical Package for the Social Sciences (SPSS) Version 23.0, develop by IBM Corporation.

## RESULTS

The samples in this study were categorized according to age and gender (Table I, Figure 1), after which the Demirjian scoring was assigned for the left and right mandibular third molars in each OPG (Table II). There were a total of 8 different stages starting from A to H, each different level of development for the third molar.

One-way between groups ANOVA was conducted to determine significant difference between age groups. There was significant difference observed at ($p < 0.05$)

**Table I: Distribution according to age and gender.**

| Gender / Age (Years) | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Male | 10 | 7 | 10 | 14 | 26 | 14 | 24 | 18 | 123 |
| Female | 14 | 25 | 25 | 28 | 29 | 27 | 24 | 23 | 195 |
| Total | 24 | 32 | 35 | 42 | 55 | 41 | 48 | 41 | 318 |

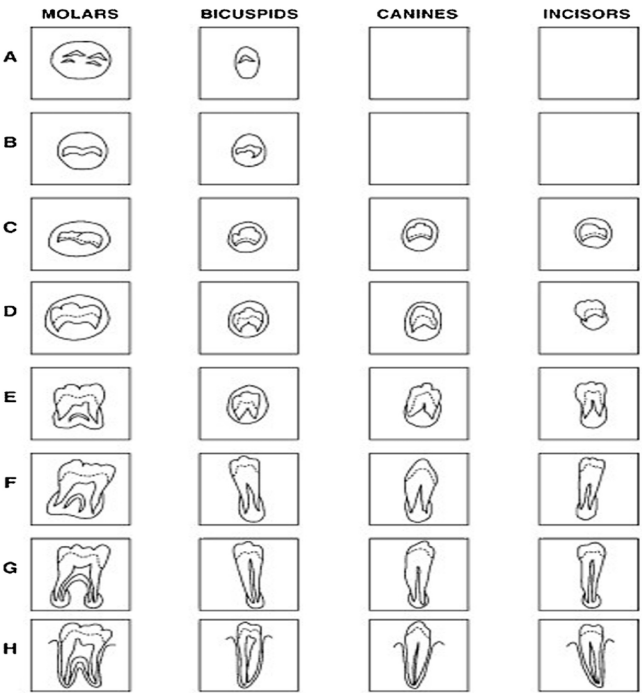


**Figure 1: Eight stages of tooth development based on Demirjian's method (Demirjian et al., 1973).** This figure was developed by Demirjian where tooth development is divided into 8 stages. There are 8 stages from stage A to stage H for molar teeth. Scoring will be given according to the development stage and the scoring will be used to create Demirjian's formula for Malay population.

**Table II: Frequency of the Demirjian's stages of mandibular third molar in males and females**

| Age | Demirjian's stages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | A | B | C | D | E | F | G | H |
| Mandibular Left Third Molar - Male | | | | | | | | | |
| 18 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 3 | 0 |
| 19 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 1 | 1 |
| 20 | 1 | 0 | 0 | 0 | 0 | 2 | 4 | 3 | 0 |
| 21 | 3 | 0 | 0 | 0 | 1 | 2 | 4 | 4 | 0 |
| 22 | 0 | 0 | 0 | 0 | 0 | 11 | 11 | 2 | 2 |
| 23 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 5 | 1 |
| 24 | 0 | 0 | 0 | 0 | 1 | 4 | 6 | 8 | 5 |
| 25 | 2 | 0 | 0 | 0 | 0 | 2 | 5 | 8 | 1 |
| Mandibular Right Third Molar - Male | | | | | | | | | |
| 18 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 2 | 1 |
| 19 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 2 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | 1 |
| 21 | 0 | 0 | 0 | 0 | 1 | 1 | 8 | 4 | 0 |
| 22 | 0 | 0 | 0 | 0 | 1 | 11 | 11 | 2 | 1 |
| 23 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 1 | 3 |
| 24 | 1 | 0 | 0 | 0 | 0 | 4 | 15 | 2 | 2 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 3 | 4 |
| Mandibular Left Third Molar - Female | | | | | | | | | |
| 18 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 2 | 0 |
| 19 | 0 | 0 | 1 | 2 | 3 | 4 | 5 | 8 | 2 |
| 20 | 0 | 0 | 0 | 0 | 1 | 4 | 11 | 7 | 2 |
| 21 | 1 | 0 | 0 | 0 | 1 | 8 | 7 | 9 | 2 |
| 22 | 2 | 0 | 0 | 0 | 2 | 8 | 11 | 4 | 2 |
| 23 | 1 | 0 | 0 | 0 | 2 | 8 | 8 | 5 | 3 |
| 24 | 3 | 0 | 0 | 0 | 0 | 9 | 6 | 5 | 1 |
| 25 | 3 | 0 | 0 | 0 | 0 | 3 | 4 | 5 | 8 |
| Mandibular Right Third Molar - Female | | | | | | | | | |
| 18 | 0 | 0 | 1 | 2 | 3 | 2 | 3 | 3 | 0 |
| 19 | 3 | 0 | 1 | 0 | 3 | 3 | 5 | 8 | 2 |
| 20 | 0 | 0 | 0 | 0 | 2 | 3 | 7 | 13 | 0 |
| 21 | 1 | 0 | 0 | 1 | 2 | 8 | 7 | 7 | 2 |
| 22 | 0 | 0 | 0 | 0 | 2 | 7 | 14 | 4 | 2 |
| 23 | 1 | 0 | 0 | 0 | 1 | 9 | 7 | 4 | 5 |
| 24 | 0 | 0 | 0 | 0 | 0 | 9 | 5 | 6 | 4 |
| 25 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 6 | 8 |

in [F(7, 230) = 3.200, p = 0.003] the male respondents (Table III). There was also significant difference at the p, 0.05 level for [F(7, 367) = 7.820, p = 0.000] for the female respondents (Table IV). Graph of age versus Demirjian's stages was plotted to obtain regression equation for male and female, seperately (Figure 2 - 3). The formula for male was y= 2.2476ln(x)-0.824 and female was y=0.1763x+2.1869 whereby y was Demirjian's stages and x was chronological ages.

**Table III: ANOVA test for male respondent**

| Demirjian's stages | Sum of Squares | df | Mean Square | F | Fig. |
|---|---|---|---|---|---|
| Between Groups | 21.579 | 7 | 3.083 | 3.200 | 0.03 |
| Within Groups | 221.568 | 230 | 0.963 | | |
| Total | 243.147 | 237 | | | |

**Table IV: ANOVA test for female respondent**

| Demirjian's stages | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 74.877 | 7 | 10.697 | 7.820 | 0.000 |
| Within Groups | 501.993 | 367 | 1.368 | | |
| Total | 576.869 | 374 | | | |

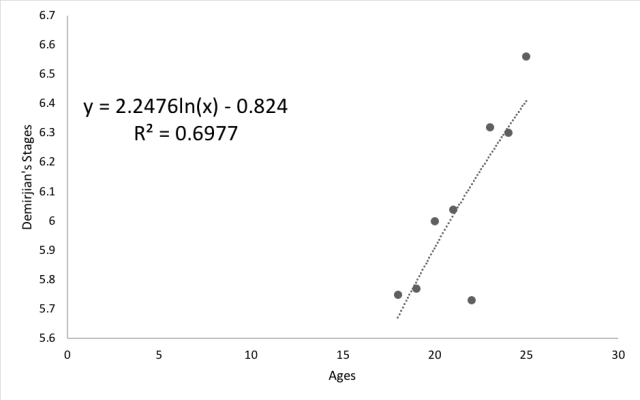


**Figure 2: Male Demirjian stages over ages graph.** The formula obtained was developed from the Malay male respondents.

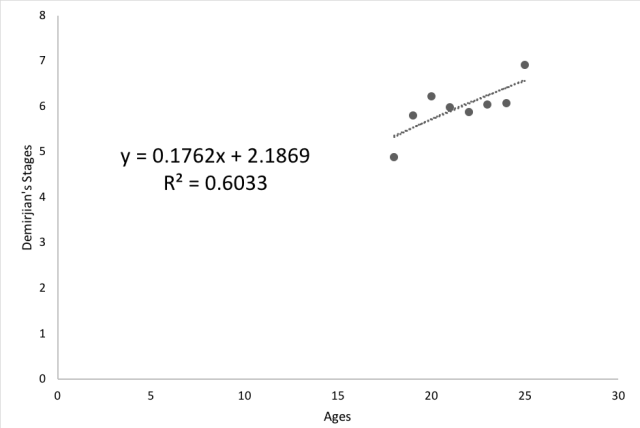


**Figure 3: Female Demirjian stages over ages graph.** The formula obtained was developed from the Malay female respondents.

## DISCUSSION

Obtaining chronological age from tooth development is a well-established procedure and can be very accurate excluding the exogenic factors such as those who suffer from diseases and malnutrition. The main interest in this research was the third molar because the third molar is the last to erupt. Furthermore, there is a unique advantage over other teeth because of its development tend to continue over a longer period and until a later age (11). Mineralisation for the third molar starts as early as 8.57 years old and apex closure was 21.96 years old (11). This finding enables researchers to use third molar for age estimation among older respondent. According to research done by Krogman in 1962, standards of morphological and morphometric sex differences in the teeth cannot be applied universally as it may differ with the population sample involved (6). Therefore, different age of maturity for third molar in different

race or ethnicity is expected. Findings from American anthropologist, (12) implied that primary races were divided into five major sub-races which are Caucasoid (White) race, Negroid (Black) race, Capoid (Bushmen/ Hottentots) race, Mongloid (Oriental/Amerindian) race, and Australoid (Australian Aborigine and Papuan) race. Different sub-races had different biological properties (13). Currently, primary races are commonly divided into 3 different major sub-races which are Caucasoid, Mongoloid, and Negroid. As different race will have different physical differences, this research focused on establishing the Demirjian's formula for the Malay ethnic in Malaysia.

Demirjian classified tooth development into 8 different stages and then, further divided into 2 main stages. The first four stages were the crown development stage and the last four stages are the root development stage. The p-value for both male and female respondents are lower than (p=0.05). Therefore, the result obtained from this research can be used to develop our own Malay-specific Demirjian's formula. The formula for male is y= 2.2476ln(x)-0.824 and female is y=0.1763x+2.1869. y is Demirjian's stages and x is chronological ages.

The finding of this study was consistent with that of previous work done. For instance, according to Bai, Mao, Zhu, and Wei (14), third molar genesis took place earlier in male respondent than the female respondent. In this research, male respondents were found to have earlier third molar genesis compared to the female respondents. When comparing crown completion, the Malay population may achieved that later (16 y) compared to other populations such as Japan, Iran, and Germany (15-17).

According to research done to the Iranian population, the first appearance of of third molar bud can happen around the age of 9 and the complete formation of crown can happen at the age of 14 (18). As for the Korean population, initial mineralization for third molar can occur as early as 8.75 years old and the average of crown completion is at 14.52 and 15.04 years old for maxillary and mandibular third molar, respectively (Jung et al., 2014). On the other hand, the German population did not reach the stage H of Demirjian's staging until the age of 18 (19). As for the central southern Chinese Han in Hunan Province, complete crown formation was observed to be at the age of 14 (20). Malay population will reach the crown completion before the age for 18. By the age of 18, Malay population will have reach the stage E which according to Demirjian' method, is the beginning of inter-radicular bifurcation formation (Demirjian et al., 1973).

## CONCLUSION

Through this study, it was shown that there were differences observable in third molar development among different races where the Malay population may achieve crown maturity in later age (16 y) compared to other previously studied populations. Thus the formula generated could possibly be applied to a Malaysian Malay population for simple age estimation (Male: y = 2.2476ln(x) - 0.824; Female: y = 0.1762x + 2.1869) where y is Demirjian's stages and x represents chronological age.

## ACKNOWLEDGEMENTS

This work was supported by the MSU Seed Research Grant SG-391-0916-HLS.

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