



Stages in third molar development and eruption to estimate the 18-year threshold Malay juvenile



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ABSTRACT

Age 18 years is considered as the age of majority by most countries. To ascertain the age of interest, both third molar development (TMD) and eruption (TME) staging scores are beneficial without needing multiple imaging modalities. This study aimed to assess the chronological course of TMD and TME in a Malay sub-adult population and evaluate predictions when specific stage(s) of TMD and TME have been attained that are pertinent to the age group of interest (<18 years or ≥18 years). A sample of 714 digital panoramic images for subjects stratified by age between 14.1 and 23.9 years was retrospectively collected. The techniques described by Gleiser and Hunt (modified by Kohler) and Olze were employed to stage TMD and TME, respectively. A binary logistic regression was performed to predict the 18-year threshold with staging score as predictors. Stages 4–6 (TMD) and A–B (TME) for males and stages 4 (TMD) and A (TME) for females were found to discriminate the <18-year group. For both genders, stages 9–10 (TMD) and D (TME) can be used as reference stages to estimate whether a subject is likely to be ≥18 years, with 94.74–100% and 85.88–96.38% correct predictions, respectively. Stages 4 (TMD) and A (TME) can also be used to identify juveniles (<18 years) with a high degree of correct predictions, 100%. The juvenility of an individual is easily anticipated by using the specific staging scores of both third molar variables (TMD and TME) without complex calculations.

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1. Introduction

The age of majority is the threshold of adulthood as conceptualised in law. It is the chronological moment when a child legally ceases to be considered a minor and assumes control over their possessions, actions and decisions, thereby terminating the legal control and legal responsibilities of their parents or guardians over and for them. The age of majority is a legally fixed age, concept or statutory principle, which may differ depending on the jurisdiction, and may not necessarily correspond to the actual mental or physical maturity of an individual (Steinberg, 2013).

In Malaysia, the legal age of majority is recognised as 18 years of age as stated in the Age of Majority Act 1971: “The minority of all males and females at the age of eighteen years and every such male and female attaining that age shall be of the age of majority” (Age of Majority Act, 1971). The age of criminal responsibility in most countries is also established at 18 years, and the law’s view of the criminal chastisements changes at this age. However, given the lighter sentences faced by juveniles compared to adults, the

current legal system is challenged by individuals who claim to be minors to escape harsher punishments. To increase the accuracy of age estimation in a criminal proceeding in determining whether an individual is of criminally responsible age and whether adult criminal law is applicable, multiple methods of age assessment are recommended taking the ethical and medico-legal aspects into account. The use of regression models such as multiple linear (Mohd Yusof, Cauwels, Deschepper, & Martens, 2015; Thevissen, Fieuws, & Willems, 2010), logistics (Acharya, Bhowmik, & Naikmasur, 2014; Guo et al., 2014), Bayesian (Thevissen et al., 2010) and principal component analysis (Mohd Yusof et al., 2015) has been performed to address the issue. This is in line with the updated recommendation by the members of the Study Group on Forensic Age Diagnostics (Schmeling et al., 2008). Therefore, the third molar provides a useful tool to assess individual’s chronological age based on the dental developmental age boundary. Plus, by using two staging criteria, third molar development (TMD) and eruption (TME), with the same radiograph, the exposure to radiation of living individuals can then be lessened. The use of TMD and TME as individual methods to estimate age has been well documented and there is a relatively high success rate in estimating age groups for children and sub-adults in different

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populations (Altalie, Thevissen, Fieuws, & Willems, 2014; Franco, Thevissen, Fieuws, Souza, & Willems, 2013; Guo et al., 2014; Olze, van Niekerk, Schulz et al., 2007; Olze, Peschke, Schulz, & Schmeling, 2008; Olze, Ishikawa et al., 2008; Ramanan et al., 2012; Yusof, Thevissen, Fieuws, & Willems, 2014).

The aims of this study are firstly, to assess the individual stages of TMD and TME in determining the chronological age of Malay sub-adults. Secondly, to evaluate the prediction of age using both third molar variables stages to discriminate the 18-year threshold.

2. Materials and methods

2.1. Patient selection

Digital panoramic images of 714 Malay individuals (341 males and 373 females) with known chronological age and gender were retrospectively collected for this study in the Oral & Maxillofacial Radiology unit in the Faculty of Dentistry of University Teknologi MARA (UiTM), Malaysia. The individuals were classified as Malaysian citizens and ethnically Malays based on retrieval of their identity cards. The ages of the sub-adults in this collected sample ranged from 14.1 to 23.8 years (Table 1). The youngest and oldest subjects were born in 1997 and 1988, respectively. The majority of individuals came as outpatients. Several selection criteria, such as good image quality and the visible absence of medical evidence or pathology affecting tooth development on the panoramic images, were imposed to prevent any confounders to the data.

2.2. Third molar scoring

Initially, TME and TMD were scored according to the Olze technique (Olze, van Niekerk, Ishikawa et al., 2007) and the Gleiser and Hunt technique (Gleiser & Hunt, 1955) as modified by Kohler et al. (Kohler, Schmelzle, Loitz, & Puschel, 1994), respectively. The former technique was devised from chronological descriptions of four-stage TMEs. The latter technique was formulated from ten developmental stages of third molar maturity using crown and root formation. After three weeks, 100 randomised panoramic images were scored by a second examiner (RW) and re-scored by the primary examiner (MYPMY). The panoramic images were kept without compression as JPEG files of size 2.5 Mb and dimension 2400 × 1280 pixels. Precautions to avoid bias included randomly re-labeling all images and all related information was made anonymous prior to data scoring. Images were assessed using Adobe® Photoshop® CS2 version 9.0 software (Adobe Systems Incorporated, San Jose, CA, USA), which allowed image to be enhanced and image quality to be improved during data collection. Ethics approval to perform this study has been obtained by the

Commission for Medical Ethics Ghent University Hospital (EC UZG 2013/146).

2.3. Statistical analysis

Inter-observer and intra-observer reliability was measured using kappa statistics. Correlations between developmental and eruption scores for third molars were calculated using the Spearman correlation test. The course of third molar variables pertinent to age is presented with descriptive statistics. Weighted means were calculated to represent an overall mean of all third molars for each stage. The sizes of the sample (n) were used as weights. Binary logistic regression analysis was applied to obtain a predicted probability between 0 and 1 (0–100%). The predicted probability (p) can be derived from the logit using the function $p = 1/(1 + ne^{-L})$, where L is the logit of the logistic regression formula (i.e., $L = \beta_0 + \beta_1 \times 1 + \beta_2 \times 2$). The binary responses for the logistic regression are <18 years and ≥18 years while the predictors are third molar staging scores (kept as a factor). The cut-off was arbitrarily chosen as 0.80 (80%), so a subject with a probability >0.80 (>80–100%) would be discriminated as <18 years or ≥18 years using the stages. All tests were performed using RStudio version 0.97.551 (© 2009–2012 RStudio, Inc.) and evaluated on a 0.05 significance level.

3. Results

The intra-observer and inter-observer analysis for third molar scoring yielded weighted kappa coefficients of 0.92 and 0.87, respectively. Significant Spearman correlation coefficients and high values for both TMD and TME scores reflected a strong dependency on each predictor. Both genders had more than a 90% correlation coefficient for all teeth with no indication of discrepancies for upper and lower or left and right third molars (Fig. 1).

Table 2 shows the details of each stage according to age means, standard deviations and third molar locations based on Olze's TME staging classification. The weighted means of stage A for both males and females are 15.22 and 15.39 years. Stage B varies from 16.20 to 16.99 years. Stages C and D exhibit a range of 18.06–20.77 years in males and 18.92–20.57 years in females, respectively. The weighted means for females are statistically higher than for males for stages B (95% CI 15.97–16.44 for males and 95% CI 17.03–17.55 for females; $p < 0.001$) and C (95% CI 17.70–18.42 for males and 95% CI 18.53–19.31 for females; $p < 0.001$) as shown by the error plot (Fig. 2).

The age distribution for TMD based on Gleiser and Hunt's staging criteria (as modified by Kohler) is shown in Table 3 for different stages and teeth. Fig. 2 demonstrates that there are relatively higher weighted means for females for stages 5, 6, 7 and 10 ($p < 0.001$). For males, stages A and B in Olze's TME staging system are in concordance with stages 4–7 in Gleiser and Hunt's TMD staging criteria (as modified by Kohler), being stage markers for <18 years. The same pattern is also observed in females except only stages 4 to 6 in TMD are included. The weighted means for these stages range from 15.22 to 17.66 years for males and 15.39 to 16.75 years for females. The means of the chronological ages increased with increasing stage for both TME and TMD, demonstrating that there was good agreement between the stages and the chronological ages of the subjects. In binary logistic regression analysis, stage D (TME) and stages 9–10 (TMD) can be used as reference stages to estimate whether a subject is likely to be equal to or over age 18, with 85.88–96.38% (Table 4) and 94.74–100% (Table 5) correct predictions, respectively, for both genders. Stages 4 (TMD) and A (TME) can also be used to identify juvenility (<18 years) with a high degree of correct predictions, 100%.

Table 1
Age and sample distribution of Malay sub-adults.

Age group	Males	Females	Total
14–14.9	21	20	41
15–15.9	37	39	76
16–16.9	31	34	65
17–17.9	29	41	70
18–18.9	30	41	71
19–19.9	38	46	84
20–20.9	43	40	83
21–21.9	36	32	68
22–22.9	46	42	88
23–23.9	25	34	59
Total	336	369	705

Age groups in years.

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