Accuracy of Different Dental Age Assessment Methods to Determine Chronological Age among Malay Children

Ahmad Faisal Ismail1*, Afizuddin Othman1, Nazih Shaaban Mustafa2, Muhamad Ali Kashmoola2, Basma Ezzat Mustafa3, Mohd Yusmaidil Putera Mohd Yusof4

1Department of Paediatric Dentistry, Orthodontics and Dental Public Health, Kulliyyah of Dentistry, International Islamic University Malaysia, Malaysia
2Department of Oral and Maxillofacial Surgery and Oral Diagnosis, Kulliyyah of Dentistry, International Islamic University Malaysia, Malaysia
3 Department of Fundamental Dental and Medical Sciences, Kulliyyah of Dentistry, International Islamic University Malaysia, Malaysia
4Center of Oral and Maxillofacial Diagnostic and Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Malaysia

*drfaisal@iium.edu.my

Abstract. Willems method is the most common method used for dental age assessment among Malaysian children. London Atlas method was recently introduced in 2010 and there was no study conducted using this method for Malaysian children. This study was conducted retrospectively by analyzing 150 digital dental panoramic tomograms of 5-, 10- and 15-year-old healthy Malay children attending Faculty of Dentistry, International Islamic University Malaysia within the period from 2012 to 2016. The mean age estimated using Willems method and London Atlas method were compared to the mean chronological age. All data were analysed using RStudio software. The results of the study showed that intra- and inter-examiner reliability were 0.75 and 0.82, respectively. The mean chronological age for 5-, 10- and 15-year-old groups were 5.49, 10.22 and 15.39, respectively. Significant differences were observed for 5- and 10-year-old groups between London Atlas method (P<0.05) and Willems method (P<0.05) when compared to chronological age. However, no significant difference was observed for 15-year-old group (P>0.05). Willems method is more accurate in determining chronological age for the 5- and 10-year-old groups compared to London Atlas method.

1. Introduction
Chronological age (CA) is defined as the age of a person from the date the person was born. It is one of the most noticeable attribute of all human beings apart from sex and race. It is significant in most societies for events such as school attendance, employment, marriage, birth of first child and retirement [1]. Age determination is very important in forensic odontology and medico-legal purposes as this can aid in the identification of age at death of a deceased person such as in the setting of a crime investigation or mass disaster such as in flood, tsunami and plane crash [1].

In the wake of recent issues of migration and adoption, age determination is really important for lawyers and immigration officers where the birth date is unknown and unreliable [2]. In dental field, age determination aids in the management of developing occlusion in relation to the maxillofacial growth of a children that can assist orthodontist and also paediatric dentist for their treatment planning [3].
Age of an unknown person can be assessed by correlating the physical, skeletal, and dental maturity of an individual. There are various methods to determine age of a human such as the estimation of dental age which is the most accurate, reliable and fast method. Dental age can be assessed either using tooth eruption date or the progress of tooth mineralization or calcification. It will be impossible to use the eruption of teeth in age determination on skeletal remains in forensic. Tooth calcification is superior to tooth emergence in determining age since calcified teeth are extremely durable where they often survive conditions which consume all other human tissues.

Since the development of dental radiograph, non-invasive, simple technique used in daily dental practice has been employed in age determination. Although different types of radiography have been proposed, dental panoramic tomogram (DPT) have been utilized by most authors due to their accessibility and possibility of visualization of all teeth. It will be impossible to use the eruption of teeth in age determination on skeletal remains in forensic.

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Several methods have been proposed that were utilizing DPTs with Demirjian and Willems method has been the most commonly applied. Demirjian method describes the tooth development clearly with diagrams and radiographic images, which has been the main advantage of the method compared to others. This method also evaluates the development of tooth based on eight stages (A to H) of mineralized dental tissues and closure of apex. Several studies have been conducted to determine the chronological age of Malaysian children using these methods. The results of the majority of the studies using Demirjian method exhibited overestimation of dental age, meanwhile Willems method showed higher accuracy in determining the chronological age of Malaysian children.

London Atlas is another method to determine dental development and eruption with more detail tooth stage descriptions, clear illustration of both internal and external features of each tooth, adequate and representative sample size and age variation for each tooth stage. This method is validated on skeletal remains and dental radiographs of known age individuals and proved to be the most accurate method to estimate age from developing teeth. However, there has been no study yet conducted to assess the accuracy of London Atlas in determining chronological age with other methods among Malay children.

The objectives of the study were to compare the accuracy of two different methods of dental age estimation and to validate the most accurate method in determining chronological age among Malay children with the hypothesis that London Atlas method is more accurate than the Willems method.

2. Method

2.1. Data collection

This retrospective study analyzed 150 digital dental panoramic tomograms (DPTs) of patients taken at the Faculty of Dentistry, International Islamic University Malaysia (IIUM), Kuantan campus, Malaysia within the period from 2012 to 2016. After obtaining approval from the IIUM Research Ethic Committee (IREC No. 565), the examiners underwent a forensic dentistry workshop and calibration assessment. The developmental stage of the seven permanent teeth from the second molar to the central incisor in the left mandible were assessed according to the method proposed by Willems and London Atlas of Tooth Development and Eruption.

The teeth were rated in the following order: Second molar, first molar, second premolar, first premolar, canine, lateral incisor and central incisor. The rating was assigned according to the written criteria of Willems method dental development stage. The teeth was compared with the radiograph images and descriptions for each stage as described in London Atlas. The 150 DPTs were retrieved from Planmeca Romexis® imaging software in Joint Photographic Experts Group (JPEG) format without compromising the quality of the image. The DPTs were labelled to each specific identification (ID) to avoid bias during analysis of the developmental stages of the teeth.
2.2. Reproducibility of measurements
A total of 20 DPTs were assessed twice in two weeks interval after a period of calibration for intra- and inter-examiner reliability assessment. The DPT used for reliability assessment were excluded from this study.

2.3. Inclusion and exclusion criteria
The inclusion criteria were good quality image of dental panoramic radiograph of healthy, non-syndromic Malay children aged 5-5.99, 10-10.99 and 15-15.99-year-old. Children with history of dental anomalies, orthodontic treatment and/or medically compromised were excluded from the study. Radiographs with distortion, low quality image such as overlapping, under- or over-exposure, or under or over-development of the film were also excluded.

2.4. Statistical analysis
Chronological age of the patient was calculated by subtracting the date of birth from the date that the DPT was taken. The age was then converted to year to one decimal point. The developmental stage of each of the seven teeth was converted to a maturity score according to Willems and London Atlas. The data obtained from the two methods were analyzed and compared using RStudio software.
Following normal distribution, One-way ANOVA test was conducted to compare means of variables. A p-value of less than 0.05 was considered as statistically significant.

3. Results and Discussion
The inter-examiner and intra-examiner reliability were calculated at 0.82 and 0.75, respectively. The mean chronological age and estimated dental age using Willems method and London Atlas method for different age groups were shown in Table 1. Mean chronological age for 5-year-old group was 5.49, for 10-year-old group was 10.22 and for 15-year-old group was 15.39.

Table 1. Mean age for chronological age (CA), Willems method (WM) and London Atlas Method (LAM). Ismail et al

| Age group      | N | Mean CA  | Mean WM  | Mean LA  | p-value |
|----------------|---|----------|----------|----------|---------|
| 5 year-old     | 50| 5.49 (0.32) | 5.84 (0.45) | 5.90 (0.33) | 0.04*   |
| 10 year-old    | 50| 10.22 (1.53) | 10.12 (1.67) | 10.09 (1.34) | 0.03*   |
| 15 year-old    | 50| 15.39 (1.44) | 15.55 (1.30) | 15.11 (1.35) | 0.08    |

* Significant difference at p<0.05

For Willems method, there were overestimation of age for 5-year-old and 15-year-old groups with mean of 5.84 (CA=5.49) and 15.55 (CA=15.39), respectively. Meanwhile, there was underestimation of age for 10-year-old group with mean of 10.12 (CA=10.22).

For London Atlas method, there were underestimation of age for 10-year-old and 15-year-old groups with mean of 10.09 (CA=10.22) and 15.11 (CA=15.39), respectively. However, there was overestimation of age for 5-year-old group with mean of 5.90 (CA=5.49).

The age differences between chronological age, Willems and London Atlas methods for each age group were shown in Table 2 and Table 3. For the Willems method, there was overestimation of the chronological age as indicated by the negative sign which were -0.35 and -0.16 for 5 and 15-year-old groups, respectively. However, there was underestimation for the 10 years old group with mean chronological age was 0.10.

For London Atlas method, there was underestimation of the chronological age for 10- and 15-year old group which were 0.13 and 0.28, respectively and overestimation of the age for 5 years old group which was -0.41. Significant differences were observed between Willems method and London Atlas method for 5-year-old (p<0.05) and 10-year-old (p<0.05) groups with no significant difference was observed in 15-year-old group (p>0.05).

In study by Nik et al [1], there was underestimation of 10 and 15 years old age groups with mean of 0.1 and 0.7 respectively but with overestimation of 5 years old age group with mean of 0.6 using
Willems’ method. In similar study by Mani et al [10], there was overestimation of 10 years old age group with mean of 0.26 and also underestimation of 15 years old age group with mean of 0.03 reported. In subsequent study by Yusof et al [11] based on the prediction using both Belgian (Willems’ method) and Malay children’s model, overestimation was observed both 5 and 10 years old. In 5 and 10 years old male (0.61 and 0.71 respectively), the mean for the estimated age was higher than female (0.20 and 0.38 respectively) in the same age groups. For 15 years old group age, there was no significant difference between Willems method and London atlas method. This may due to growth has significantly ceased or slowed down during this age time [2].

For the current study on Willems method, there was overestimation of 5-year-old group and underestimation of 10-year-old group. This was supported by the findings reported by Nik et al [1] For 15-year-old group, there was overestimation of age with no significant difference from the actual CA. The differences may be due to inclusion of other contributing factors of development such as gender, race and population [1].

For the London Atlas method [8], there was underestimation of 10- and 15-year-old group with overestimation on 5-year-old group. The significant difference was probably due to the study being tested on Caucasian population [12].

Both Willems and London Atlas methods overestimated the age for 5-year-old group. This can be explained due to differences in dental development during primary dentition stage between Malay and Caucasian population, in which our study reported that both Willems and London Atlas methods tend to overestimate the Malay population.

On the other note, both methods were reported to underestimate the 10-year-old group. During this mixed dentition stage, the Malay population showed to have increase development rate compared to Caucasian population. There were significant differences for 5- and 10-year-old group with p-value of 0.04 for 5-year-old and 0.03 for 10-year-old group when compared between the 2 methods. However, no significant difference for 15-year-old group was observed, with p-value of 0.08. This may be due to the growth has ceased or slowed down during this time of age group [3].

Dental panoramic radiograph (DPT) have been used by most authors because of its accessibility and the possibility to visualize the overall dentition. Besides, in children, difficulties in obtaining intraoral radiographs without having distortion is the main factor that DPT is a preferred tool in age estimation in children [1], [6], [12].

There were several methods have been developed for dental age estimation, however, the most common method used which also have become the benchmark for the age estimation is the Demirjian method where they have studied a large samples of 1446 males and 1482 females of French-Canadian origin [6]. However, our study revealed that there was overestimation of the Dermirjian method in estimating the age of the children including few studies that were conducted in Malaysia [1], [3], [10]. Willems method has gain some popularity among the researchers as it was a modified version of Demirjian method. Numerous studies that used Willems method showed a more consistent accurate result compared to other methods [1], [7], [10]. A recent systematic review and meta-analysis study on performance of Willems’ method in children revealed that Willems’ method accurately estimated age for less than one year with majority of primary studies reported less than six months on error rate based on different populations, investigators and age groups [13].

4. Conclusion
Our study concluded that Willems method is more accurate in estimating the age of Malay children of 5-year-old and 10-years-old group. However we observed no significant difference between Willems method and London Atlas method for 15-years-old group.

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