Adult age estimation in a group of Thai population by Tooth coronal index of mandibular first molar from horizontal bitewing radiographs

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Abstract

Age estimation is the determination of an individual chronological age by using biological characteristics for both immigrant and criminal identification. Bitewing radiography is a widely used technique in dentistry. This study utilized a novel method using the tooth coronal index (TCI) as a key factor for estimating age in a group of Thai population from bitewing radiographs. A total of 120 bitewing radiographs of Thai individuals (60 males and 60 females) from 20 to 60 years old were collected. TCI was calculated using the crown heights and the pulp chamber heights of the first mandibular molar. Pearson's correlation coefficient represented the significant correlation between chronological age and TCI of mandibular first molars ($P < 0.001$). A positive correlation was presented with low strength ($r=0.365$). The predictive age model could not be developed from the relationship.

Keywords: *Forensic dentistry, Tooth coronal index, Mandibular first molar, Forensic anthropology*

1. Introduction

Forensic age estimation of unidentified bodies or skeletons is the traditional features of forensic science. The forensic examination helps identify a deceased person not only for a moral perspective but also for a legal and criminal aspect. The current globalization is associated with a huge migration movement, which makes the need for determining the individual age increased. Most of the cases are those who lack valid identifications, and their age needs to testify to serve the legal proceedings, subsidies, or humanitarian aid (Schmeling et al., 2007).

Age estimation is the process of using individual biometric traits to predict the individual's age. The human anatomical structures such as skeleton or tooth have been used to determining age. Dental age is considered to be closely related to the chronological age of the individual since tooth development shows less variability than other developmental structures and also low variability in relation to chronological age. Dental based age estimation methods based on the period of dental mineralization or demineralization including tooth wear (Brothwell D., 1989; Lovejoy, 1985; Miles, 1958), root dentine transparency (Bang, 1970; Drusini, 1991; Lamendin et al., 1992), tooth cementum annulation (Jankauskas et al., 2001; Wittwer-Backofen et al., 2004), racemization of aspartic acid (Ohtani et al., 1995; Ritz-Timme et al., 2000), apposition of secondary dentine (Drusini et al., 1997; Kvaal et al., 1995; Lopez-Nicolas et al., 1990).

While the age estimation in prenatal, neonatal, post-natal, children, and adolescents is considerably simple by determining the growth and development of teeth, the adult age estimation is more difficult when the development of permanent dentition completes with the eruption of the third molar at the age of 17-21 years. The methods for adult age estimation can be divided into three categories: morphological, biochemical, and radiological methods (Stavrianos et al., 2008; Panchbhai, 2011).

Oral radiology plays a principal role in forensic dentistry, according to the advantages of radiography, which are simple, non-invasive, repeatable, and can be applied both on living and the dead body. Age estimation could be performed by assessing the development of teeth, jawbones, the volume of the crown, pulpal cavity, and root of various teeth. The tooth area assessment from the radiograph is suggested as a practical method that determines the reduction in the size of the pulp cavity due to secondary dentin deposition, which relates proportionally to the age of the individual.

Tooth coronal index (TCI) is an adult age estimation method that is based on the correlation between the reduction of the coronal pulp cavity and the chronological age. TCI was calculated by using the lengths of the coronal pulp cavity and crown as variables. Ikeda et al. (1985) published the original paper of TCI and concluded that TCI was found to be an important parameter in adult age estimation. Drusini (2008) was published research using a panoramic radiograph to measure and calculate the TCI from mandibular premolars and molars of Caucasian individuals. It showed that there is no significant difference in the TCI between the first and second premolar and first and second molar (Drusini, 2008). Better correlations of the TCI of the molar group than the TCI of the premolar group were also mentioned in the study of Karkhanis et al. (2013).

Another key factor of the promising age estimation by a radiological method is the technique and quality of the radiograph. Many studies were published, challenging with various radiographic images both intraoral radiographs (Rajpal et al., 2016) and extraoral radiographs (lateral oblique radiographs (Moorrees et al., 1963), cephalometric radiographs (Rai et al., 2008), panoramic radiographs (Birchler et al., 2016). Bitewing radiograph is a standard technique that is routinely used for detecting interproximal dental caries and evaluating the height of alveolar bone (White, 2014). As a frequently used technique, bitewing radiography is easy to be taken and most likely to be found in a patient's dental record. Technically, the bitewing radiograph requires a central x-ray beam almost perpendicular to the plane of the imaging receptor with small vertical angulation (0-8 degree), which is placed parallel and very close to the examined tooth. As a result, the bitewing radiograph displays minimal distortion. Besides, the direct x-ray exposure and the resolution of the intraoral imaging receptor lead to highly detailed and accurate images (Kogon, 1996). Based on the advantages of bitewing radiographs, as mentioned above, bitewing radiographs can become a powerful tool for dental age estimation.

2. Objectives

To find the correlation between age and Tooth coronal index (TCI) of the mandibular first molar from bitewing in a group of the Thai population.

3. Materials and Methods

Subjects in this study were selected from the 120 patients (60 males and 60 females) who received horizontal bitewing radiographs of the molar area from 2015 to 2018 at the Oral and Maxillofacial Radiology Clinic, Faculty of Dentistry, Mahidol University, Bangkok, Thailand. The studied age range was 20-59 years and was divided into four age groups: 20-29 years, 30-39 years, 40-49 years, and 50-59 years. The radiographs were exported as a DICOM (Digital Imaging and Communications in Medicine) files. All the information that might allow the identification of the patient was eliminated before the examination.

The image analysis was performed by a 4-year experience dentist and a 10-year experience oral and maxillofacial radiologist in a radiographic interpretation room of the oral and maxillofacial clinic, faculty of dentistry, Mahidol university, using the 30-inch medical display (MDDC – 6430; Barco, Belgium) (resolution: 3280 x 2048 pixels). The observers were allowed to adjust the brightness and contrast of the images. The measurement calibration of 30 samples was performed before the image analysis. The TCI of 30 mandibular first molar in 30 horizontal bitewing radiographs were measured in 2 separate times by two observers. The TCI of mandibular first molar in the other 90 horizontal bitewing radiographs was measured by a 4-year experience dentist twice with a 1-month interval. The precision analysis was calculated by using the relative technical error of measurement (rTEM) and coefficient of reliability (R). Measurement error was determined to be within acceptable standards for all measurements (rTEM < 10%, R > 0.75).

Inclusion criteria:

1. The radiographs of the patients ranging from 20 - 59 years old were selected.
2. The entire crown and pulp chamber of mandibular first molars must be clearly seen.
3. The outline of the pulp chamber should be clearly seen.

Exclusion criteria:

1. The tooth with any pathology such as fractured, dental caries, or severe attrition
2. The tooth with a proximal filling
3. The tooth with large occlusal filling beyond the dento-enamel junction
4. The overlapping of proximal enamel beyond one-third of the enamel thickness
5. The tooth with malformation or developmental anomalies

Tooth-coronal index method (TCI)

The methodological approach in the present study follows the Tooth-coronal Index of Ikeda et al. (Ikeda et al., 1985). The crown height (CHm) and the pulp chamber height (PCHm) of the mandibular first molar was measured using a computer-aided drafting program (ADOBE Photoshop; Adobe Inc., United States of America). The crown height (CHm) was the perpendicular distance between the highest and lowest point of the crown area, and the pulp chamber height was the perpendicular distance between the highest and lowest point of the pulp chamber area (Figure 1). The crown height and the pulp chamber height was used to calculate TCI as follows:

$$TCI = (CHm \times 100) / PCHm$$

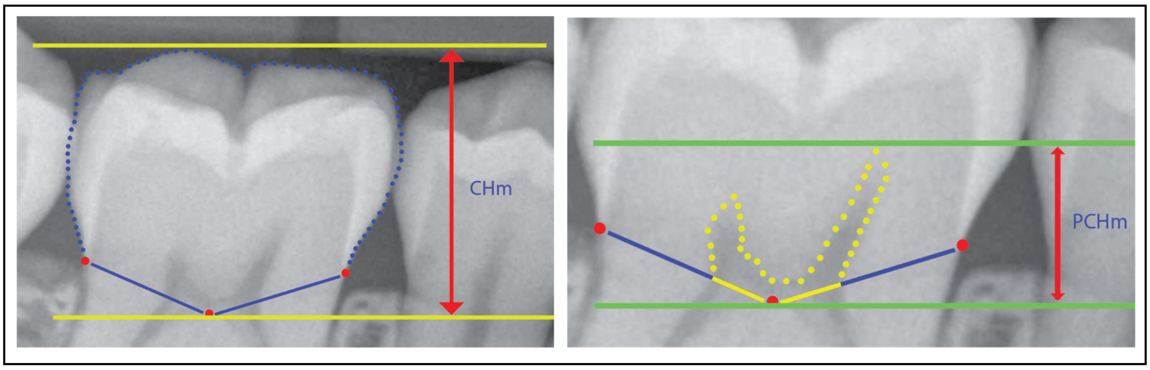

Figure 1 The crown height and the pulp chamber height of the right first mandibular molar

4. Results and Discussion

4.1 Results

There were no statistically significant difference between intra-observer (rTEM = 4.3%, R = 0.98) and inter-observer (rTEM = 9.3%, R = 0.98).

The extent of the TCI by age category were shows in Table 1.

Table 1 Comparison of crown height, pulp chamber height and tooth-coronal index in male and female subjects in different age groups

Age groups	Male		Female		Total		Parameters			Standard deviation
	No.	%	No.	%	No.	%	CHm	PCHm	TCI	
20-29	15	12.5	15	12.5	30	25.0	314.93	93.26	345.97	65.26
30-39	17	14.2	16	13.3	33	27.5	306.91	93.18	342.09	70.97
40-49	15	12.5	13	10.8	28	23.3	308.14	86.93	364.59	62.23
50-59	13	10.8	16	13.3	29	24.1	295.79	74.90	416.54	92.55

CHm: The mean of crown height in millimeter, PCHm: the mean of pulp chamber height in millimeter
TCI: Tooth-coronal index

The paired t-test showed no significant difference between the TCI of the right and left side of the same subject ($p > 0.05$). Independent t-test showed no significant difference in TCI between males and females ($p > 0.05$). There was a statistically significant correlation between chronological age and TCI by using Pearson's correlation coefficients ($r = 0.365$). The correlation model between chronological age and TCI was not found (Figure 2).

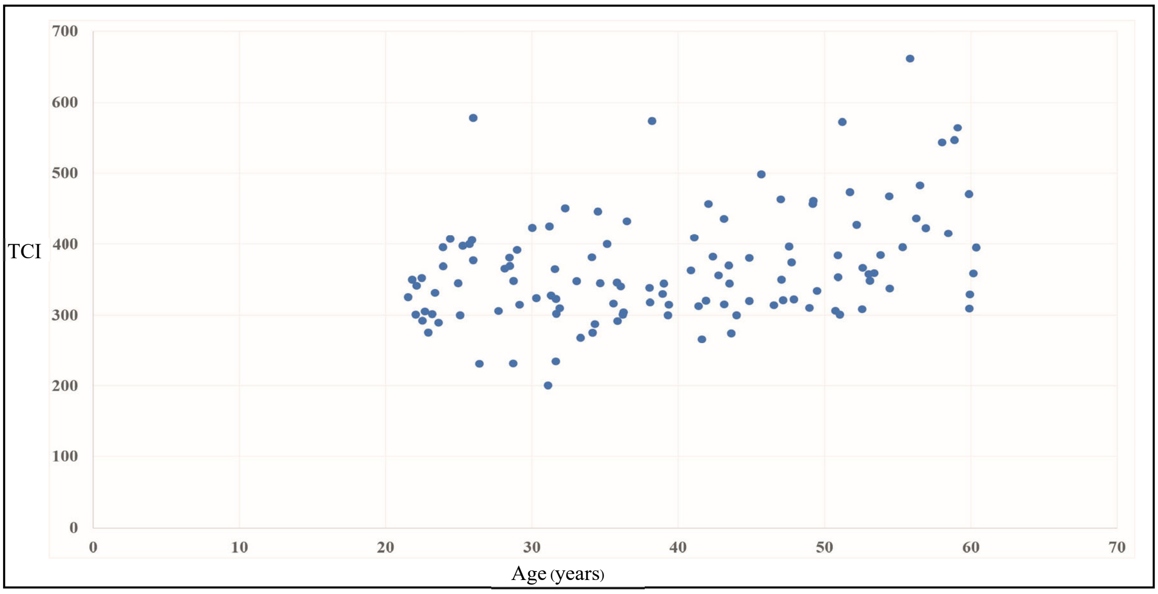

Figure 2 Scatterplot of age on TCI values for first molars

4.2 Discussion:

In this study, a bitewing radiograph was used for the first time as a major tool for measuring morphological parameters of teeth. A major advantage of bitewing radiographs is the accuracy of the anatomical structure. Because the vertical angulation of the X-ray beam is almost perpendicular (0-8 degree) to the teeth as well as the image receptor, the radiographs are less distortion when compared with panoramic and periapical radiographs. Another advantage of bitewing radiographs is that they provide a wide view of 2 to 3 adjacent teeth and opposite teeth, ensure a large amount of information to be observed. Certainly, the popularity and practical benefits of bitewing radiographs in dental practice promised that this would be a valuable tool in forensic dentistry.

Various studies were conducted on premolar and molar teeth to find the correlation between TCI and age. Talabani et al. (2015) found a correlation ($R^2 = 0.49$) between age and TCI for a mandibular first molar, similar results were reported in the studies by Igbigbi et al. (2005) ($R^2 = 0.54$), for premolars and molars. Godge et al. (2014) estimated chronologic age in south Asians using TCI on Panoramic and found that the correlation was significant for both genders in premolars and molars. This study was limited to the first molar because it was always present in bitewing radiographs. However, it cannot be denied that there could be a possible correlation between the TCI index of other molars or premolars with age.

There are several outliers (TCI> 500) that may have affected the results (Figure 2). The cause of this abnormality may be due to the complexity in the anatomical structure of the molar, which can increase measurement errors. Another point is that the outliers usually appeared in the oldest age group (age 50-59 years), which can be surmised that as the older the individuals, the faster the secondary dentin apposition process. A sharp drop in the pulp chamber height of the oldest group resulted in a sharp increase in TCI values. Increasing the number of sample sizes may contribute to the reduction of the influence of outlier factors.

The reference line of measurement may also affect the current result. In the previous study from Talabani showed a positive result and predictive value, even using fewer subjects (96 subjects) than our study (Talabani, 2015). Their reference line was the line connecting between the deepest mesial and deepest distal point of the enamel. In the current study, the reference line was the line connecting 3 points the deepest mesial point of the enamel, the deepest point of the floor of the pulp chamber, and the deepest distal point of the enamel (Figure 1). This difference affected CHm, PCHm, and TCI.

We suggest further studies should perform on a larger sample with multiple methods and multiple teeth. It may help to minimize measurement errors.

5. Conclusion

This study results had shown that there is a correlation between the TCI index of the first molars and the chronological age of adults. However, a regression model between the TCI and the age could not be established due to the small sample size. Combining the TCI index of the mandibular first molar with the TCI index of adjacent teeth may give better results.

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