นิพนธ์ต้นฉบับ ▪ Original Article

การประเมินอายุผู้ใหญ่ไทยโดยตรวจการโปร่งแสงของรากฟันและการถอยร่นของเนื้อเยื่อเกาะผิวฟัน

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Estimation of Thai Adult Age by Dental Root Translucency and Periodontosis

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หลักการและวัตถุประสงค์: เพื่อประเมินอายุผู้ใหญ่ไทยโดยตรวจการโปร่งแสงของรากฟันและการถอยร่นของเนื้อเยื่อเกาะผิวฟันเพื่อใช้ในศพนิรนาม

วิธีการศึกษา: การศึกษาภาคตัดขวางของฟัน 398 ซี่จากผู้ใหญ่ไทย 345 ราย ที่ทราบอายุจริง โดยวัดระยะการโปรงแสงของรากฟัน (t), ระยะการถอยร่นของเนื้อเยื่อเกาะผิวฟัน (p), และความยาวของรากฟัน(r) ด้วยเทคนิคของLamendin ข้อมูลเพศ อายุ ชนิดและตำแหน่งฟันถูกวิเคราะห์ด้วยสถิติเชิงพรรณนา ความสัมพันธ์ของอายุกับระยะของฟันถูกวิเคราะห์ด้วยค่าสหสัมพันธ์Pearsonและวิเคราะห์การถดถอยเชิงซ้อนที่ระดับนัยสำคัญ p<0.05

ผลการศึกษา: การโปร่งแสงของรากฟันและการถอยร่นของเนื้อเยื่อเกาะผิวฟันใช้ประเมินอายุผู้ใหญ่ไทยได้อย่างมีนัยสำคัญ (p<0.001) เมื่อวิเคราะห์การถดถอยเชิงซ้อนจะได้สมการประเมินอายุผู้ใหญ่ไทย = 16.038 + (0.572 x P) + (0.567 x T), เมื่อ (P = p*100/r, T = t*100/r) ค่าเฉลี่ยความคลาดเคลื่อน ±5.2 ปี และสมการของเพศชายและหญิง; อายุ = 13.816 + (0.669 x P) + (0.57 x T) และอายุ = 17.449 + (0.505 x P) + (0.567 x T) สมการแม่นยำในผู้ใหญ่อายุน้อย (20 – 50 ปี)

สรุป: ฟันหนึ่งซี่ใช้ประเมินอายุผู้ใหญ่ไทยได้โดยตรวจการโปร่งแสงของรากฟันและการถอยร่นของเนื้อเยื่อเกาะผิวฟันด้วยวิธีการอย่างง่าย

คำสำคัญ: อายุจริง, การประเมินอายุ, การโปร่งแสงของรากฟัน, การถอยร่นของเนื้อเยื่อเกาะผิวฟัน, ความยาวของรากฟัน

Background and Objective: To determine Thai adult age by analyzing dental root translucency and periodontosis for using in unknown dead body.

Methods: A cross-sectional study of 398 teeth from 345 Thai adult with known actual chronological age was conducted. The root translucency height (t), periodontosis height (p), and root height (r) were measured using the Lamendin's technique. Sex, age, tooth types and tooth positions were analyzed by descriptive statistics. The correlation between age and three tooth parameters were analyzed by Pearson's correlation and multiple regression analysis using statistical significance at p<0.05.

Results: Dental root translucency and periodontosis were able to estimate Thai adult age with statistical significance (p<0.001). The proposed equation derived from multiple regression analysis was Age = 16.038 + (0.572 x P) + (0.567 x T), where (P = p*100/r, T = t*100/r). The mean error was ±5.2 years. In addition, Thai formula for male and female were Age = 13.816 + (0.669 x P) + (0.57 x T) and Age = 17.449 + (0.505 x P) + (0.567 x T), respectively when sex was known. These Thai formulas showed a better precision in the young adult (20-50 years old).

Conclusion: Single tooth was able to estimate Thai adult age by using dental root translucency and periodontosis parameters in all tooth types and positions with a simple method.

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Keywords: chronological age, age estimation, dental root translucency, periodontosis, root height

ศรีนครินทร์เวชสาร 2562; 34(3): 226-231. ● Srinagarind Med J 2019; 34(3): 226-231.

Introduction

Identification of unknown person is an important issue in medico-legal cases. Fundamental human parameters including sex, age, ethnicity, and height are used in person identification. Age estimation in adulthood can be evaluated by anthropological profiles including pubic symphysis, sternal rib end of the 4th rib or cranial suture closure. In addition, the dental post-formation technique is also able to estimate adult age. The dental post-formation changes including attrition, periodontosis, secondary dentin, cementum apposition, root resorption, and root translucency are developed when the people are growing older as described in the six Gustafson's criteria[1]. According to the Lamendin's technique, two practical approaches were used for age estimation[2]. Firstly, root translucency is the phenomenon that results from the deposition of hydroxyapatite crystal within the dentin tubules over a period of time by beginning at the apex and transforming in a coronal direction since 20 years old. Root translucency is less influenced by external factors, and it is considered as the most accurate method for age determination in adult[3]. Secondly, the periodontosis can be used because the measurement is uncomplicated and the assessment of dental sections by the expertise is not required. The Lamendin's formula is proposed as Age = (0.18*P) + (0.42*T) + 25.53[2].

The dental post-formation changes vary in each population and are affected by cultural habits, diets, and other intra-individual factors. Lamendin et al.[2] applied their method to French populations while Prince DA and Ubelaker DH[4] applied the Lamendin's method to African and European populations and these studies produced the regression formulas for these populations. In Asia, the studies of adult age estimation using these dental features were conducted only in Indian and Malaysian populations[5-7]. Therefore, the authors intended to produce the specific formula to estimate adult age in Thai populations.

Methods

A cross-sectional study of Thai adult age estimation was conducted in 398 teeth extracted from 345 Thai adult without the underlying disease who visited the dentists in Phrachomklao hospital and Thayang hospital, Phetchaburi province for tooth extraction to get braces or denture wearing. The extracted teeth from Thai people whose age were ≥ 20 years old were recruited for this study. The data including patient identification numbers, age, sex, tooth types, and tooth positions were recorded by the dentists. The inclusion criteria were Thai adult who were ≥20 years old and had no underlying disease or routine medication. The exclusion criteria were dental diseases of the periodontal area and dental root including periodontitis and wisdom tooth. The diagnosis of these dental diseases was performed by the dentist before tooth extraction.

Using the Lamendin's technique was performed. Dental root translucency height (t), periodontosis height (p), and root height (r) were measured on the labial surface in perpendicular direction with a digital caliper in millimeters to 2 decimal places. The measurement was performed twice by both authors for all parameters. The average values from the measurement of both authors were used for analysis. Dental root translucency height was the measurement from the apex of root to the maximum height of translucency along the dental root. A black light-box was used to illuminate the translucency of the dental root. The periodontosis was the maximum distance between cementoenamel junction and the line of soft tissue attachment and was also determined by a smooth yellowish area of tartaric deposits below the enamel which had different color from the rest of the root. The measurement of periodontosis was performed promptly after tooth extraction. Root height was the measurement from the cementoenamel junction to the apex of root[2]. The measurement of these parameters were shown in Figure 1.

This study was carried out under the ethical approval from the Institutional Review Board (IRB) in Phrachomklao hospital, Phetchaburi province (Document Number13/2559 and 12/2560) and Phetchaburi provincial Public Health Office (Document Number 004/2560).

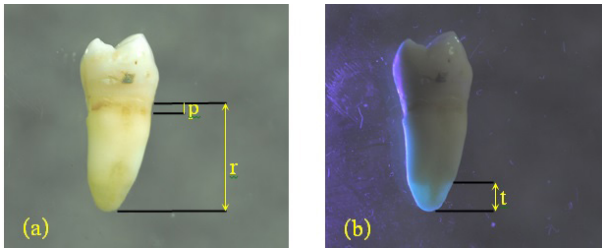

Figure 1 (a) Measurement of periodontosis height (p) and root height (r), (b) Measurement of the dental root translucency height (t).

Statistical Analysis

The statistical analysis was performed using SPSS Statistic® program for Windows Version 18.0. The fundamental data including chronological age, sex, tooth types, tooth positions, dental root translucency (T) (T = t*100/r), and Periodontosis (P) (P = p*100/r) were analyzed by descriptive statistics.

The correlation of Thai adult age with dental root translucency and periodontosis was assessed by Pearson's correlation and multiple regression analysis. Regression analysis was used for the evaluation of the estimated age from this Thai formula to predict the actual age. A p value of <0.05 was considered to be statistically significant.

Results

There were 398 teeth from 345 Thai adult subjects recruited in this study. There were 148 males (37.2%) and 250 females (62.8%). The age of subjects ranged from 20 years to 89 years and the mean age was 49 years old. The positions of these 398 teeth were divided into 210 maxillary teeth (52.8%) and 188 mandibular teeth (47.2%). The types of teeth were described as 110 incisors (27.6%), 50 canines (12.6%), 160 premolars (40.2%), and 78 molars (19.6%).

The dental root translucency and periodontosis were more progressing following the advanced age as described in Table 1.

Dental root translucency was significantly correlated with chronological age with high coefficient of determination ($p<0.0001$, $R^2 = 0.829$). The correlation between periodontosis and age was also statistically significant ($p<0.0001$, $R^2 = 0.611$) but the coefficient of determination was less than dental root translucency. When both factors were analyzed with multiple regression analysis for the adult age prediction, the coefficient of determination was stronger than the analysis by each parameter ($p<0.0001$, $R^2 = 0.871$). The proposed regression equation using both factors was demonstrated below.

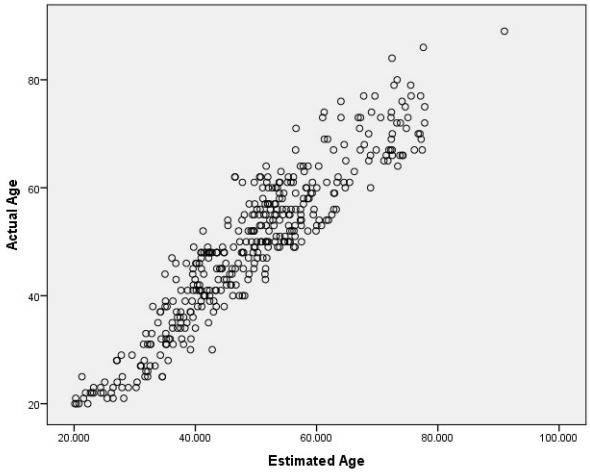

Figure 2 Estimated age from the new formula plotted against Actual age.

Table 1 Comparison of the mean of dental root translucency and periodontosis in each age range

Age ranges	Frequency (N)	Percent (%)	Dental root translucency (T) (T = t*100/r)	Periodontosis (P) (P = p*100/r)
20-29	45	11.3	9.677	10.269
30-39	54	13.6	20.892	16.468
40-49	97	24.4	29.518	20.428
50-59	103	25.9	42.472	24.351
60-69	65	16.3	52.380	27.977
70-79	30	7.5	68.227	28.277
80-89	4	1	75.153	34.840
Total	**398**	**100**	-	-

Thai Adult Age = 16.038 + (0.572 x P) + (0.567 x T) ;where (P = p*100/r, T = t*100/r)

The mean error between the actual and estimated age was ± 5.2 years. This formula provided better precision in the younger adult (20-50 years old) ($p<0.0001$, $R^2 = 0.793$) whereas the precision in the older adult was lower ($p<0.0001$, $R^2 = 0.605$). The correlation between actual age and estimated age was shown in the data plot in Figure 2. When the same variables were applied to the Lamendin's formula, the results were less accurate than the proposed Thai adult age formula ($p<0.0001$, $R^2 = 0.860$) (Table 2)

Table 2 Summary of factors that had the influence to estimate Thai adult age with p-value, R^2 by regression analysis, Pearson's correlation, and Standard error of the estimate

Factors	Frequency (N)	Percent (%)	p-value	R^2	Pearson's Correlation	Mean chronological age	Mean Estimated age	SE (years)
Lamendin's formula	398	100	<0.0001	0.860	0.927			5.829
Periodontosis (P)	398	100	<0.0001	0.611	0.782			9.037
Dental root translucency (T)	398	100	<0.0001	0.829	0.911			5.987
P & T	398	100	<0.0001	0.871	0.933			5.216
Sex								
Male	148	37.2	<0.0001	0.881	0.938			5.217
Female	250	62.8	<0.0001	0.867	0.931			5.198
Age								
20-50	214	53.8	<0.0001	0.793	0.890			4.202
>50	184	46.2	<0.0001	0.605	0.778			5.062
Types and Positions of teeth								
Maxillary teeth	210	52.8	<0.0001	0.863	0.929			5.315
Mandibular teeth	188	47.2	<0.0001	0.873	0.934			5.127
Types and Positions of teeth								
Maxillary central incisor	30	7.54	<0.0001	0.785	0.886	50.07	50.28	4.287
Maxillary lateral incisor	22	5.53	<0.0001	0.754	0.869	54.4	52.92	4.887
Maxillary canine	28	7.04	<0.0001	0.823	0.907	55.14	52.21	5.551
Maxillary first premolar	37	9.30	<0.0001	0.889	0.943	40.36	41.92	5.251
Maxillary second premolar	49	12.31	<0.0001	0.910	0.954	43.61	43.34	4.944
Maxillary first molar	13	3.27	<0.0001	0.862	0.928	47.56	47.71	3.598
Maxillary second molar	20	5.03	<0.0001	0.907	0.952	47.62	47.81	5.186
Maxillary third molar	11	2.76	<0.0001	0.961	0.980	38.41	41.22	3.114
Mandibular central incisor	28	7.04	<0.0001	0.918	0.958	49.77	50.50	3.823
Mandibular lateral incisor	30	7.54	<0.0001	0.780	0.883	55.00	52.93	5.243
Mandibular canine	22	5.53	<0.0001	0.691	0.831	55.32	53.12	6.049
Mandibular first premolar	33	8.29	<0.0001	0.944	0.972	49.97	49.73	4.260
Mandibular second premolar	41	10.30	<0.0001	0.798	0.894	48.49	47.34	5.557
Mandibular first molar	9	2.26	<0.0001	0.623	0.790	43.23	46.01	6.882
Mandibular second molar	8	2.01	<0.0001	0.829	0.910	48.35	50.37	5.340
Mandibular third molar	17	4.27	<0.0001	0.972	0.986	42.09	44.13	2.551

When each sex was separately analyzed, additional regression formulas were obtained for each sex with different coefficients of determination as described below. There was the same mean error of 5.2 years in both male and female formulas.

Thai Male Age = 13.816 + (0.669 x P) + (0.57 x T)
Thai Female Age = 17.449 + (0.505 x P) + (0.567 x T)
;where (P = p*100/r, T = t*100/r)

Both maxillary teeth and mandibular teeth provided equivalent precision in age estimation ($p<0.0001$, R^2 = 0.863 and 0.873, respectively) as described in Table 2.

Discussion

Strong correlations were found between dental root translucency and periodontosis parameters and chronological age in Thai population. Dental root translucency produced better accuracy compared to periodontosis consistent with the previous studies[3,8]. Dental root translucency was the best predicting variable because it was least susceptible to external factors[3,8]. The rate of periodontal attachment can be affected by crowding, hyperocclusion, and excessively poor oral hygiene. When combining these two variables to analyze for predicted adult ages in this study, the formula provided higher accuracy than using each variable alone and this result was consistent with the Lamendin's technique[2].

The ethnicity and sex are the two major factors for age estimation. The Lamendin's formula was generated from the French population[2]. When Prince DA and Ubelaker DH applied the method from Lamendin et al.[2] to the non-French population, the results showed the mean error of 8.23 years[4]. Thus, Prince and Ubelaker evaluated the effects of ancestry and sex by producing four regression formulas; Male African Ancestry, Male European Ancestry, Female African Ancestry, and Female European Ancestry[4]. These four formulas had been tested and compared with the Lamendin's formula in the Spanish population by Gonzalez-Comenares et al. and the results demonstrated that the method from Prince and Ubelaker provided better accuracy than the Lamendin's formula[9]. These results supported that ethnicity- and sex-specific formulas should be preferred in each population[9]. Therefore, the authors provided additional regression formulas for each sex for better prediction of Thai adult age. When compared to the Lamendin's formula, the results from Thai sex-specific formula produced higher accuracy and these findings confirmed that ethnicity and sex had a significant effect on age prediction.

The good accuracies of age estimation from the studies of Lamendin et al[2]., Prince and Ubelaker[4] and Pinchi et al.[10] were presented at the age of 40 - 70 years old, 30 – 69 years old, and 30-59 years old, respectively. However, Thai formulas from this study presented good accuracy in the young adult age of 20 - 50 years. The good accuracy was presented in the younger age group in this study because dental root translucency changed gradually and continuously in young adult while rapid and advanced root translucency was found in subjects over 50 years old and led to no difference within the older group.

Lamendin et al. found that the determination of adult age from single-rooted teeth and upper incisors showed a better age prediction than other teeth[2]. Solheim and Kvaal reported that mandibular central incisors provided more accurate estimation than maxillary central incisors[11]. In this study, not only single-rooted teeth but also multi-rooted teeth in all tooth positions were proven useful for age estimation in Thai population for the purpose of the age estimation of dead bodies. In addition, this study revealed that mandibular and maxillary teeth produced relatively equivalent accuracy. However, when overall teeth were considered in details, maxillary teeth mostly produced good accuracy whereas mandibular teeth produced varied accuracy. However, in the authors' opinion, all teeth could be used to assess Thai adult age because of small variations among tooth types which were consistent with the study of Solheim[12].

Currently, Cone Beam Computed Tomography (CBCT) is applied to assess the ages of teeth by evaluating the progressive change in pulp size due to secondary dentin apposition. Some studies used a CBCT scan to measure root translucency area[13]. This technique is non-invasive due to no requirement of tooth extraction or sectioning and can be used in the contemporary adult. However, this technique uses advanced mathematical calculations that require sophisticated and expensive equipment. In Asia, the studies using CBCT scan were initiated in Indian and Malaysian populations[5-7]. Therefore, the authors anticipate that this study results will be useful to develop the age estimation by CBCT method in Thailand in the future.

Conclusion

In this study, all teeth were found to be useful to estimate Thai adult age. Using a single tooth could provide good accuracy particularly in the young adult age of 20-50 years old. In case of known sex, sex-specific formulas were preferred for more accuracy. This technique is practical in Thailand because it is a simple method using uncomplicated equipment and the expertise to assess dental sections is not required. However, this study had relatively small sample size to generate regression formulas for individual tooth position and had some limitations from gender disproportion because of a smaller number of male cases.

Acknowledgment

The authors would like to express the sincere gratitude to Dr. Peerayuht Phuangphung and Dr. Vijarn Vachirawongsakorn from Department of Forensic Medicine, Siriraj Hospital, Mahidol University for their kindness in guidance to prepare the article. In addition, the authors were deeply grateful to all patients who had given their extracted teeth to this study, and also thankful to Department of dentistry, Phrachomklao Hospital, Phetchaburi Province and Department of dentistry, Thayang Hospital for supporting the authors in performing this study.

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