Comparative Assessment of Maxillary Central Incisor Position in Thai Females with Facial Harmony VS. Pre-Orthodontic Treatment

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Abstract

The antero-posterior (AP) position of maxillary central incisors (MCI) to the forehead profiles was described by L.F. Andrews as a useful method to assess attractiveness relative to the MCI position. The purpose of this study was to assess the AP position of the MCI in relation to forehead profile among Thai females and compare this MCI position between facial harmony (FH) and pre-orthodontic (pre-OD) groups. Out of 123 lateral smile profile photographs with MCI clearly visible of adult female volunteers (ages 18-30 years), 33 photographs with harmonious facial profiles were selected as the FH group. Thirty-three matched age and gender pre-orthodontic patient photographs were randomly selected as the pre-OD group. All photographs were consistently recolored, resized and rotated to estimated natural head position (ENHP). Landmarks of MCI position and forehead profile were located and measured. The mean distance between Forehead Anterior Limited Line and Dentition Anterior Limited Line (FALL-DALL distance) representing AP position of MCI was significantly different between the FH and pre-OD groups (-0.18±4.42 mm VS 3.49±3.35 mm respectively, p<.001). No significant differences were observed in forehead inclination between the two groups (12.80±5.69 degrees VS 15.05±3.48 degrees respectively, p=.058). There was a significant positive correlation between FALL-DALL distance and forehead inclination in the FH group (r=0.497, p=.003). The linear regression equation for prediction of MCI position (FALL-DALL distance) from forehead inclination was: FALL-DALL distance (mm) = (Forehead inclination (degree)x0.39) -5.76. To achieve facial harmony in orthodontic treatment planning, forehead inclination could be one of the important landmarks to determine the appropriate AP position of MCI.

Keywords: *Incisor/ Forehead/ Thai female/ Anteroposterior position/ The 6 Elements of Orthodontic Philosophy*

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Introduction

Appreciation of beautiful teeth has been widely recognized as one of attractiveness to people and increase self-esteem in many aspects. There is perception regarding an individual's potential for professional and financial success when one has nice smile and straight teeth.[1] Facial appearance becomes a major motivation for patients in pursuing orthodontic–treatment rather than functional considerations. Likewise, orthodontic treatment paradigm has been shifted to facial esthetics, importance in facial profile becomes equivalent to skeletal and dental bases for orthodontic diagnosis and treatment goals.[2,3] A number of methods for traditional cephalometric and soft tissue analysis have been proposed. Most cephalometric norms were based on samples considered as "normal" population which implied as a normal face, however, the norms are potentially unreliable because hard tissue is not consistently related to soft tissue of the face. The uses of internal osseous landmarks can be inconstant because of the error in landmarks identification and measurements as well as variables in racial backgrounds.[4,5]

In 2000, Andrew LF. introduced Six Elements of Orofacial Harmony as keys to obtain an ultimate result of facial harmony (FH).[6] Element II of the Six Elements of Orofacial Harmony focuses on the optimal position of the maxillary central incisors (MCI) in relation to forehead inclination. Unlike other structural landmarks, the forehead is relatively unchanged since the age of nine.[7,8] Therefore, forehead inclination was used to identify the proper antero-posterior (AP) position of the maxilla determined by the AP position of MCI under the condition that all teeth are correctly aligned in relation to the dental arch as of Andrew's Element I.

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Moreover, Andrews stated that Element II are "universal" meaning that they should work equally well for patients regardless of race, age, or gender.[6]

Current literatures have indicated variability in the proper AP position of MCI to the forehead profiles in various ethnic groups. From Element II, the AP position of MCI in FH people should be located between the Forehead Frontal Axis (FFA) point and glabella. This Element was supported by the studies in male and female Caucasians according to orthodontist point of view.[9,10] Similarly, Schlosser et al.[11] reported that Caucasian orthodontists and laypersons preferred normal to protrusive position of MCI. Another study in African Americans found that the optimal location of MCI was significantly anterior to glabella.[12] Moreover, Chinese orthodontists and laypersons favored protrusive and retroclined MCI than retrusive and proclined MCI.[13] On the other hand, Thai laypersons expressed partiality for normal and up to 3 mm retrusive over protrusive MCI positions.[14] This could lead to the assumption that acceptable facial harmony might not be a universal for all ethnic groups. Together with the fact that appropriate AP position of MCI among Thai females has not been observed. This study was designed to determine the ideal AP position of MCI in relation to the forehead profile in Thai females with FH and compare the ideal MCI position obtained with the AP position of MCI from pre-orthodontic (pre-OD) groups. In addition, the relationship between forehead inclination and AP position of MCI in FH group was investigated.

Materials and methods

Ethics approval and consent to participate. This study was granted the certificate of approval by the Ethics Committee on Human Research, Faculty of Dentistry/Pharmacy, Mahidol University in accordance with the Declaration of Helsinki (No. IRB2017/051.2609). All samples were verbally informed of the purpose of the study and signed the informed consent.

One hundred twenty-three Thai female participants aged between 18 to 30 years old with Thai or Chinese origins[15] were recruited from various sources such as modeling agencies, laypeople in the central business district, undergraduate dental students, and walk-in patients at the Orthodontic Department. Subjects' photographs in smiling profile were obtained with a DSLR camera and rotated to upright head position represented estimated natural head position (ENHP) by one investigator (NP), and were approved by two certified orthodontists (NS and RC).[9,16] All photographs were recolored in black-and-white format and distributed to a panel of six Thai professional practitioners comprising of two orthodontists, two maxillofacial surgeons, and two plastic surgeons, each of whom has more than 10 years of experience in their respective fields. Before assessment of FH, the photographs of the sample with good FH from pilot study with totally agreement of professional panels was kept and discussed for concept of FH. Each practitioner independently scored the photographs for FH then the photographs were classified according to panel agreement into three groups: Good facial harmony, average, and poor.

Of 123 photographs, only 33 photographs were rated by at least four out of the six practitioners as good facial harmony and assigned to be the FH group. The only exclusion criterion was poor quality of photograph which was insufficient for landmark locating.

For pre-OD group, 33 photographs were randomly selected from pre-treatment orthodontic records. The inclusion criteria of pre-OD group were 18-30-year-old Thai female with no specific skeletal, dental, or facial characteristics. The same exclusion criterion as FH group was applied. All pre-OD photographs were processed in the same fashion as FH group. All photographs were adjusted to the similar magnification with the approximated distance between trichion and incisal edge of the MCI as 138.41 mm. Landmarks for angular and linear measurements of MCI position and forehead inclination were identified and marked using ImageJ software (Version 2.0.0-rc-54/1.51h, Wayne Rasband, National Institutes of Health, USA). Images with ill-defined landmarks were excluded.

According to Andrews' Element II, the landmarks used for the forehead profile assessment were located.[17] Landmark definitions were shown in Table 1. Construction of superion and FFA point were shown in Figure 1. All of these points lied on the edge of the soft tissue in lateral profile. Then, 4 reference lines were constructed (Figure 2):

Table 1 Definition of landmarks

Landmarks	Definitions
Reference points	
1. Trichion	the hairline and the most superior aspect of the forehead when the forehead is of relatively flat contour
2. Glabella	the most inferior aspect of the forehead
3. Superion	the most superior aspect of the forehead when the forehead is either rounded or angular in contour
4. Forehead Frontal Axis point (FFA point)	the midpoint between trichion and glabella for foreheads with flat contour or the midpoint between superion and glabella for foreheads with rounded or angular contour
5. Frontal Axis point (FA point)	the midpoint between cervical and incisal edge of the central maxillary incisors
Reference Lines	
6. Forehead Inclination Line	glabella to the uppermost point of forehead (superion or trichion)
7. Forehead Anterior Limited Line (FALL)	vertical line passing through the FFA point
8. Glabella Vertical Line (GVL)	vertical line passing through the glabella
9. Dentition Anterior Limited Line (DALL)	vertical line passing through the FA point of MCI

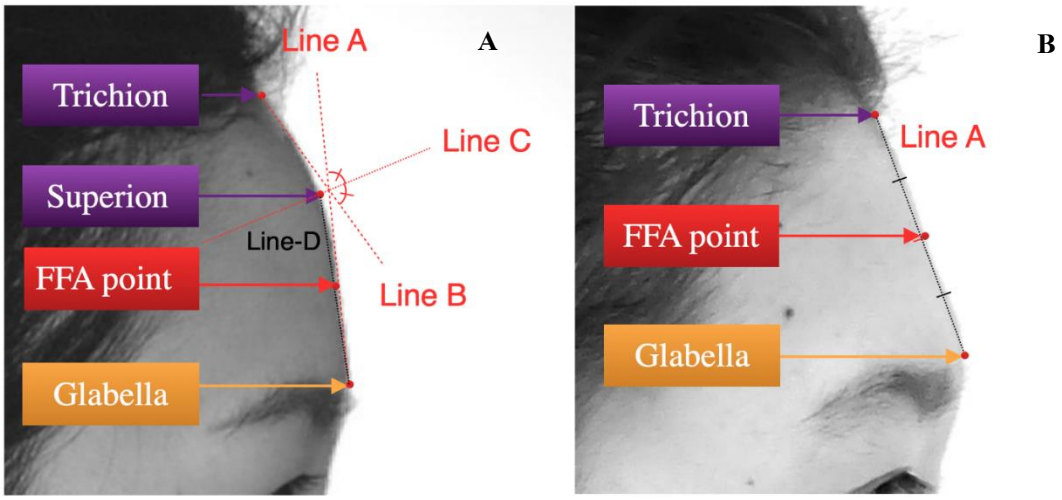

Figure 1 Construction of FFA point. **A, round and angular forehead**, Line A and Line B were drawn closely to the forehead inclination, superior from glabella and inferior from trichion respectively, two lines were crossed adjacent to the most curved part of forehead. Obtuse angle between Line A and Line B was measured and devided by two, Line C was drawn as an angle bisector. Superion was located at the point that Line C touched forehead. Line D was drawn between superion and glabella. Finally, the midpoint of Line D adjacent to forehead was the location of FFA point. **B, flat forehead**, Line A were drawn from glabella to trichion. FFA point was located at the midpoint between them and touched forehead.

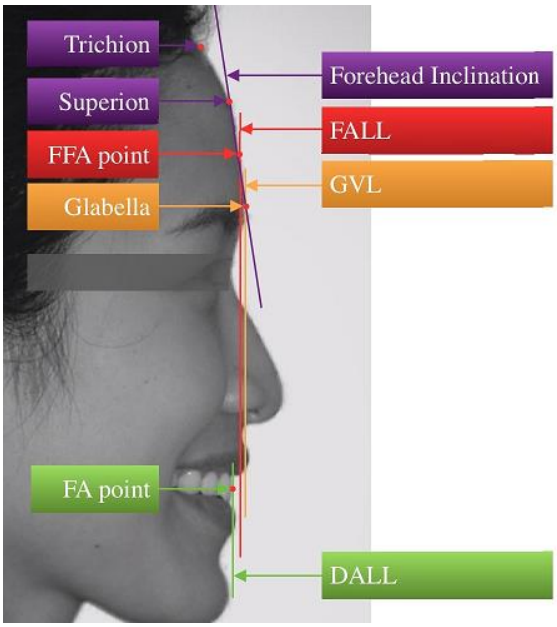

Figure 2 Reference lines; forehead inclination, FALL, GVL, and DALL. Landmarks points; trichion, superion, FFA point, glabella, and FA point.

AP position of MCI was studied in two aspects. Firstly, the AP locations according to the location of FA point of MCI were classified as located posterior to FALL, between FALL and GVL, or anterior to GVL. The number of FA point located in each group were calculated into percentage. Secondly, AP position of MCI represented as FALL-DALL distance was measured in millimeters. A positive value indicated DALL was anterior to FALL and negative value indicated DALL was posterior to FALL. Forehead inclination was measured as a sharp angle between forehead inclination line and GVL. Sample size was calculated using data from pilot study and independent t-test (two-tailed, α= 0.05, 1-β= 0.8). Adequate sample size was 26 per group.

Statistical analysis All statistical analyses were carried out using Statistical Package for Social Sciences (SPSS version 18, IBM Corp., Armonk NY, U.S.A.), with level of statistical significance set at $p<0.05$. The relationship of the AP location of MCI and two groups of studied population (FH VS pre-OD) was analyzed by Fisher's exact test. Comparison of means and standard deviations between FH and pre-OD groups for the FALL-DALL distance and angulation of forehead inclination were analyzed by two-tailed unpaired Student's t-tests. Regression analysis was used to determine the correlation between the FALL-DALL distance and forehead inclinations. Ten samples from both groups were randomly selected to test reliability of methodologies, all processes were repeated. The intra-examiner agreement between the first and second FH assessments was analyzed using paired t-test in FH group, measurements was analyzed using Bland-Altman plots in both FH and pre-OD groups.[18,19]

Results

A total of 66 samples consisted of 33 females with FH and 33 pre-OD patients aged range 20.00-29.50 and 18.58-29.50 years old respectively. There was no statistically significant difference in age between two groups. Ninety percent agreement was found between first and second FH assessments in FH group. All differences in measurements fell within non-significant limits, indicating that the data was homogeneous and reliable.

AP location according to the location of FA point of MCI

In the FH group, the locations of MCI were distributed almost equally between the location posterior to FALL and the location between FALL and GVL (54.5% and 45.5% respectively). No MCI location was located anteriorly to GVL. On the contrary, MCI locations in the pre-OD group were located between FALL and GVL as well as anterior to GVL (42.4% and 36.4% respectively), while 21.2% located posteriorly to FALL. (Figure 3)

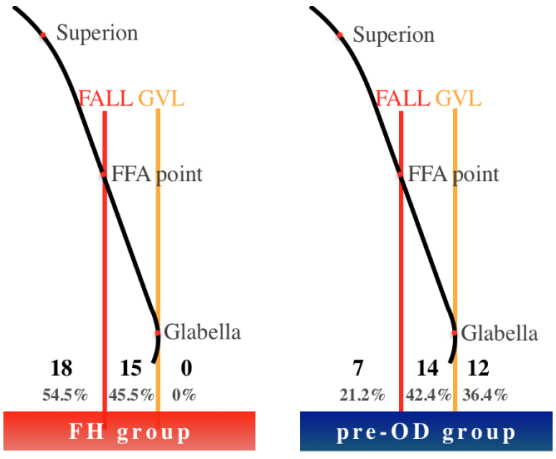

Figure 3 Distribution of the AP location of MCI relative to FFA point and glabella

As there was no subject with MCI located anterior to GVL in the FH group, Fisher's exact test was used to evaluate the relationship between the AP location of MCI and the two groups, which was found a significant correlation. It demonstrated a tendency of MCI locations in pre-OD positioned at anterior to FALL whereas MCI in the FH group was more likely to be located posteriorly to FALL ($p<0.01$) (Table 2)

Table 2 Distribution of the AP location of MCI relative to FALL in FH and pre-OD groups (Fisher's exact test: X2=7.791, p=0.005)

	Posterior to FALL	Anterior to FALL
FH group	18	15
pre-OD group	7	26

Comparing of FALL-DALL distance and forehead inclination

From Kolmogorov-Smirnov tests, normal distribution was found in FALL-DALL distance and the degree of forehead inclination in both FH and pre-OD groups ($p>0.01$). The means and standard deviations of each group were shown in Table 3. There was statistically significant difference in FALL-DALL distance between FH and pre-OD groups ($p<0.001$), but no significant differences for forehead inclination between 2 groups.

Table 3 Means and standard deviations of FALL-DALL distance and forehead inclination, * $p<0.05$

	FH group	pre-OD group
FALL-DALL distance, (mm)	-0.81±4.42*	3.49±3.34*
Forehead Inclination, (degree)	12.80±5.69	15.05±3.48

Relationship between FALL-DALL distance and forehead inclination

Regression analysis revealed a significant moderate positive correlation between the FALL-DALL distance and forehead inclination in the FH group ($r=0.497$, $p=0.003$), but no significant correlation was found in the pre-OD group ($p=0.447$). The equation denoting the relationship between the FALL-DALL distance and forehead inclination in the FH group was extracted from linear regression analysis (Figure 4) as follows:

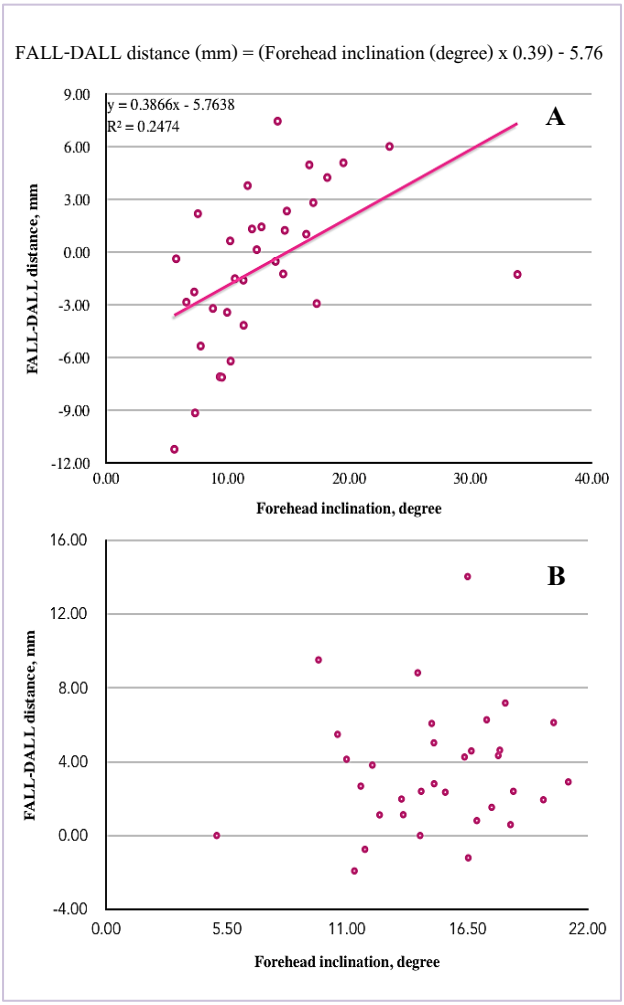

Figure 4 Linear regression analysis between the FALL-DALL distance and forehead inclination (A, FH group; B, pre-OD group)

Discussion

The aim of the study was to assess the AP position of MCI in relation to forehead profile among Thai females and compare the MCI position between FH and pre-OD groups.

According to the 6 Elements Orthodontic Philosophy by Andrews, AP position of MCI was considered to be an appropriate position of the maxilla for harmonious face. Six studies using same the reference landmarks reported that the ideal location of MCI was between FALL and GVL which represented 93% in Caucasian and 74% in Korean female samples.[9,20] However, this study showed different distribution in preferred MCI location of FH pattern (45.5% between FALL and GVL and 54.5% in posterior to FALL). Interestingly, all subjects in African American female

represented 100% anterior to GVL.[12] In contrast, this study found that no MCI location in FH group was located anterior to GVL which is consistent with Andrews' observation.[17] In comparing with half (54.5%) of FH in our study was located posterior to FALL, only 19% in Korean and 4% in Caucasian subjects were reported. Regarding to AP position of MCI related to FALL in millimeters, the FALL-DALL distance of FH group in this study was -0.81 mm, whilst the Korean, Caucasian and African American represented 1.38, 2.50, and 8.58 mm respectively. In our study, both MCI location and FALL-DALL distance demonstrated more retrusive position of MCI in Thai FH compared with other studies.[9,12,20] These may imply that ethnic plays an important role in determining appropriate MCI position for harmonious face.

Additionally, bimaxillary protrusion has often been judged to be undesirable in most Asian populations. The high prevalence of this facial profile in Thai populations which commonly leads to bicuspid extraction patterns to reduce facial convexity.[21,22] Studies conducted in Chinese and Japanese adults showed the general consensus from laypersons to dental professionals preferred bimaxillary retrusive profiles which were considered more attractive than those with bimaxillary protrusion.[23,24] This supported our findings in retrusive position of MCI.

In comparing between FH and pre-OD groups, the AP position of MCI, measured by FALL-DALL distance, exhibited distinctly different. The FH samples had MCI position 0.81 mm behind FALL, while in pre-OD MCI was located 3.49 mm in front of FALL. Unlike forehead inclination, the mean value was not found to be statistically different between two groups. These findings were in good agreement with previous studies in Caucasian and Korean females.[9, 20]

In this study, a positive correlation between the FALL-DALL distance and forehead inclination ($r = 0.497$, $p = 0.003$) was found, which can be translated into the linear regression equation: FALL-DALL distance (mm) = (Forehead inclination (degree) x 0.39) - 5.76. From this equation, it can be calculated that a forehead inclination of 15 degrees would produce an MCI position which coincides directly with the FALL. For every degree of increased forehead inclination rotated in a counter-clockwise manner, the estimated AP position of the MCI would move 0.39 mm more protrusive, but never pass GVL. As there were no differences in forehead inclination values between the FH and pre-OD groups, this equation might be used to define the proper AP position of the MCI for Thai females. Further study in Thai males is required to extend and compare these findings.

Our study is an early attempt to apply the 6 Elements Orthodontic Philosophy of Andrews in a group of Thai females with FH. Moreover, FH was assessed by panel of experts in both medical and dental fields which could control sample selection bias. As FH in various ethnic groups are vastly different, our findings could be applied for orthodontic treatment guideline related to orofacial harmony. The limitation in this study is that identification and measurement of photographic landmarks could cause minor systematic errors. This problematic method could be improved by using standardized photographs with subject positioned in a natural head orientation. However, it was unlikely that we can perform direct measurement in person from the subject. Lastly, the suggested equation should be used with caution in extreme forehead inclination case.

Conclusions

- There was a significant relationship between facial harmony and the anteroposterior location of MCI in relation to FALL in Thai females. The appropriate MCI location was distributed almost equally at between FALL and GVL (45.5%) and posterior to FALL (54.5%).

- Comparing between facial harmony and pre-orthodontic females, there was significant difference in anteroposterior position (FALL-DALL distance) of MCI, but no significant difference in forehead inclination.

- There was a significant correlation between anteroposterior position of MCI and forehead inclination in Thai females with facial harmony (Linear regression equation: AP position of MCI (mm) = (Forehead inclination (degree) x 0.39) - 5.76). Therefore, measurement of forehead inclination could be essential to determine the optimal AP position of MCI for facial harmony in orthodontic treatment planning.

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การศึกษาเปรียบเทียบตำแหน่งของฟันตัดหน้าบนระหว่างหญิงไทยที่มีใบหน้าสมส่วนและผู้ป่วยก่อนการรักษาทันตกรรมจัดฟัน

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บทคัดย่อ

การศึกษาในครั้งนี้มีวัตถุประสงค์เพื่อเปรียบเทียบความสัมพันธ์ของตำแหน่งในแนวหน้า-หลังของฟันตัดหน้าบนกับหน้าผากระหว่างกลุ่มตัวอย่างหญิงไทยที่มีใบหน้าสมส่วน (Facial Harmony, FH) และกลุ่มตัวอย่างผู้ป่วยหญิงก่อนรับการรักษาทันตกรรมจัดฟัน (pre-OD) โดยศึกษาภาพถ่ายใบหน้าด้านข้างขณะยิ้มเห็นฟันตัดหน้าบนชัดเจน จากอาสาสมัครจำนวน 123 ราย ประเมินความสมส่วนของใบหน้าด้านข้างได้กลุ่ม FH จำนวน 33 ราย และทำการสุ่มตัวอย่างกลุ่มผู้ป่วยหญิงก่อนรักษาทันตกรรมจัดฟัน ได้กลุ่ม pre-OD จำนวน 33 ราย โดยภาพถ่ายทั้งหมดถูกปรับขนาดและหมุนเพื่อประมาณตำแหน่งศีรษะตามธรรมชาติ (Estimated Natural Head Position) แล้วจึงกำหนดจุด และวัดค่าต่าง ๆ โดยพบว่าค่าเฉลี่ยระยะห่างในแนวหน้า-หลังของฟันตัดหน้าบนกับจุด FFA point มีความแตกต่างกันระหว่างกลุ่ม FH และ pre-OD (-0.18±4.42 มิลลิเมตร และ 3.49±3.35 มิลลิเมตร ตามลำดับ, p<.001) ในขณะที่พบความแตกต่างอย่างไม่มีนัยสำคัญในมุมลาดเอียงในแนวดิ่งของหน้าผาก (Forehead inclination) ระหว่างกลุ่ม (12.80±5.69 องศา และ15.05±3.48 องศา ตามลำดับ, p=.058). นอกจากนี้ยังพบความสัมพันธ์ระหว่างระยะห่างในแนวหน้า-หลังของฟันตัดหน้าบนกับจุด FFA point และมุมลาดเอียงในแนวดิ่งของหน้าผากในกลุ่มควบคุม (r=0.497 และ p=.003) จากผลการศึกษาสามารถสรุปได้ว่ามุมลาดเอียงในแนวดิ่งของหน้าผากอาจใช้เป็นจุดอ้างอิงสำคัญในการหาตำแหน่งในแนวหน้า-หลังที่เหมาะสมของฟันตัดหน้าบนในกลุ่มหญิงไทย เพื่อช่วยในการวางแผนการรักษาทันตกรรมจัดฟันให้ผู้ป่วยมีใบหน้าสมส่วน

คำไขรหัส: *ฟันตัด/ หน้าผาก/ หญิงไทย/ ตำแหน่งหน้า-หลัง/ ปรัชญาการจัดฟัน 6 องค์ประกอบ*

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