CEPHALOMETRIC STUDY OF TREATED ORTHODONTIC PATIENTS WITH ACCEPTABLE ESTHETIC PROFILES COMPARED TO ADULT THAI NORMATIVE VALUES

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A Thesis Submitted in Partial Fulfillment of the Requirements
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การศึกษาค่าในการวิเคราะห์ภาพถ่ายรังสีกะโหลกศีรษะด้านข้างของผู้ป่วยจัดฟันไทยที่ได้รับการรักษาแล้วที่มีรูปด้านข้างของใบหน้าทียอมรับได้เปรียบเทียบกับค่าปกติของผู้ใหญ่ไทย

นายวิเศษสรรค์ พรศิริอนันต์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Thesis Title	CEPHALOMETRIC STUDY OF TREATED ORTHODONTIC PATIENTS WITH ACCEPTABLE ESTHETIC PROFILES COMPARED TO ADULT THAI NORMATIVE VALUES
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Field of Study	Orthodontics
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วัตถุประสงค์การศึกษา การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบตัวแปรจากภาพรังสีวัดกะโหลกศีรษะด้านข้างระหว่างกลุ่มที่มีรูปหน้าด้านข้างแบบปกติ แบบเว้าและแบบนูนที่สวยงามยอมรับได้ และระหว่างแต่ละกลุ่มกับค่าปกติของผู้ใหญ่ไทย

วัสดุและวิธีการ นำภาพเงาดำของรูปหน้าด้านข้างจากภาพรังสีวัดกะโหลกศีรษะด้านข้างหลังการรักษาของคนไข้จัดฟันอายุ 18-37 ปี จำนวน 303 ภาพ มาให้ทันตแพทย์จัดฟันชาวไทย 5 ท่านและผู้ป่วยที่อยู่ระหว่างได้รับการรักษาทางทันตกรรมจัดฟัน 15 ท่าน ให้คะแนนความพึงพอใจ ด้วยมาตราวัดลิเคิร์ท 5 ระดับ ภาพรังสี 207 ภาพที่ผ่านเกณฑ์คะแนนขั้นต่ำ 3 คะแนน จะถูกแบ่งเป็นกลุ่มรูปหน้าด้านข้างแบบปกติ แบบเว้า และแบบนูนที่ยอมรับได้ ทำการวัดค่าตัวแปรเนื้อเยื่อแข็ง 35 ค่า ตัวแปรฟัน 17 ค่า และตัวแปรเนื้อเยื่ออ่อน 34 ค่า ใช้สถิติการวิเคราะห์ความแปรปรวนทางเดียวร่วมกับการเปรียบเทียบเชิงพหุ หรือค่าสถิติการทดสอบแบบครัสคัล วอลลิสร่วมกับสถิติทดสอบแมน-วิทนีย์ยู เปรียบเทียบข้อมูลระหว่างกลุ่มรูปหน้าด้านข้างแบบปกติ แบบเว้า และแบบนูนที่ยอมรับได้ และใช้สถิติการทดสอบค่าทีของกลุ่มตัวอย่างกลุ่มเดียว หรือสถิติทดสอบวิลคอกซันสำหรับกลุ่มตัวอย่างกลุ่มเดียว วิเคราะห์ความแตกต่างระหว่างแต่ละกลุ่มเปรียบเทียบกับค่าปกติของผู้ใหญ่ไทย

ผลการศึกษา ลักษณะกระดูก กระดูกขากรรไกรบนถอยกว่าค่าปกติในทุกกลุ่มรูปหน้า ขณะที่กลุ่มที่มีรูปหน้าด้านข้างแบบเว้าที่สวยงามยอมรับได้มีกระดูกขากรรไกรล่างใกล้เคียง แต่คางยื่นกว่าค่าปกติ และกลุ่มที่มีรูปหน้าด้านข้างแบบนูนและปกติที่สวยงามยอมรับได้มีกระดูกขากรรไกรล่างและคางถอยกว่าค่าปกติ กลุ่มที่มีรูปหน้าปกติที่สวยงามยอมรับได้มีความสัมพันธ์กระดูกขากรรไกรและกระดูกเบ้าฟันใกล้เคียงค่าปกติเดิม กลุ่มที่มีรูปหน้าด้านข้างแบบเว้าที่สวยงามยอมรับได้มีแนวโน้มความสัมพันธ์กระดูกขากรรไกรและกระดูกเบ้าฟันชนิดที่ 3 ขณะที่กลุ่มที่มีรูปหน้าด้านข้างแบบนูนที่สวยงามยอมรับได้มีแนวโน้มความสัมพันธ์กระดูกขากรรไกรและกระดูกเบ้าฟันชนิดที่ 2 กลุ่มรูปหน้าด้านข้างแบบเว้าที่สวยงามยอมรับได้มีความสัมพันธ์ของกระดูกขากรรไกรแนวดิ่งใกล้เคียงค่าปกติ ส่วนอีก 2 กลุ่มมีแนวโน้มกระดูกขากรรไกรแบบสบเปิดกว่าค่าปกติ โดยเปิดมากกว่าในกลุ่มรูปหน้าด้านข้างแบบนูนที่สวยงามยอมรับได้

ลักษณะของฟัน กลุ่มที่มีรูปหน้าปกติที่สวยงามยอมรับได้มีลักษณะของฟันใกล้เคียงค่าปกติ กลุ่มที่มีรูปหน้าด้านข้างแบบเว้าที่สวยงามยอมรับได้มีฟันหน้าบนมีตำแหน่งยื่นและทำมุมยื่นกว่า มีฟันหน้าล่างมีตำแหน่งถอยและทำมุมถอยกว่า ขณะที่ในกลุ่มที่มีรูปหน้าด้านข้างแบบนูนที่สวยงามยอมรับได้มีฟันหน้าบนทำมุมถอยและมีตำแหน่งถอยกว่า มีฟันหน้าล่างมีตำแหน่งและทำมุมยื่นกว่าค่าปกติ

ลักษณะของเนื้อเยื่ออ่อน กลุ่มที่มีรูปหน้าปกติที่สวยงามยอมรับได้มีลักษณะใกล้เคียงค่าปกติ กลุ่มที่มีรูปหน้าด้านข้างแบบเว้าที่สวยงามยอมรับได้มีรูปหน้าด้านข้างแบนกว่า และกลุ่มที่มีรูปหน้าด้านข้างแบบนูนที่สวยงามยอมรับได้มีรูปหน้าด้านข้างแบบนูนกว่า กลุ่มที่มีรูปหน้าด้านข้างปกติและแบบเว้าที่สวยงามยอมรับได้ มีริมฝีปากบนยื่นและริมฝีปากล่างถอย ขณะที่กลุ่มที่มีรูปหน้าด้านข้างแบบนูนที่สวยงามยอมรับได้ มีรูปริมฝีปากบนและล่างใกล้เคียงค่าปกติ กลุ่มที่มีรูปหน้าด้านข้างแบบเว้ามีลักษณะคางยื่น กลุ่มที่มีรูปหน้าด้านข้างปกติมีลักษณะคางใกล้เคียงค่าปกติ ขณะที่กลุ่มที่มีรูปหน้าด้านข้างแบบนูนมีลักษณะคางถอย ในทุกกลุ่มรูปหน้าด้านข้างที่สวยงามยอมรับได้มีลักษณะจมูกยื่น และมีระยะระหว่างริมฝีปากบนและล่างน้อยกว่าค่าปกติ

สรุปผลการศึกษา รูปหน้าด้านข้างที่สวยงามยอมรับได้ 3 แบบ มีลักษณะกระดูก ฟัน และ เนื้อเยื่ออ่อน แตกต่างไปจากค่าปกติที่ใช้อยู่ในปัจจุบัน ในกลุ่มรูปหน้าด้านข้างปกติสามารถรักษาโดยอ้างอิงจากค่าปกติผู้ใหญ่ไทยได้ ลักษณะกระดูกค่อนไปทางแบบสบเปิดยอมรับได้ในทุกกลุ่มรูปหน้า ในกลุ่มที่มีรูปหน้าด้านข้างแบบเว้าที่สวยงามยอมรับได้สามารถจัดฟันหน้าบนทำมุมยื่นและตำแหน่งยื่น และจัดฟันหน้าล่างทำมุมถอยและตำแหน่งถอยกว่าค่าปกติของผู้ใหญ่ไทย ขณะที่กลุ่มที่มีรูปหน้าด้านข้างแบบนูนที่สวยงามยอมรับได้ ใช้หลักการตรงกันข้ามในการรักษา โดยสรุปเราควรประยุกต์ใช้เป้าหมายการรักษาที่แตกต่างกันตามค่ารังสีวัดกะโหลกศีรษะในแต่ละกลุ่มรูปหน้า เพื่อให้มีรูปหน้าด้านข้างที่สวยงามยอมรับได้

สาขาวิชา	ทันตกรรมจัดฟัน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2563	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6270029032 : MAJOR ORTHODONTICS
KEYWORD: ESTHETICALLY ACCEPTABLE PROFILE, CONCAVE PROFILE, CONVEX PROFILE, NORMAL PROFILE, LATERAL CEPHALOMETRIC RADIOGRAPH, CEPHALOMETRIC VALUES, ADULT THAI NORMATIVE VALUES, TREATED ORTHODONTIC PATIENTS
Visessan Pornsirianand : CEPHALOMETRIC STUDY OF TREATED ORTHODONTIC PATIENTS WITH ACCEPTABLE ESTHETIC PROFILES COMPARED TO ADULT THAI NORMATIVE VALUES. Advisor: JANETA CHAVANAVESH, D.D.S., M.Sc.

Objective: This study aimed to compare cephalometric variables between esthetically acceptable normal, concave, and convex profile groups as well as between each group and adult Thai normative values.

Materials and Methods: Three-hundred and three profile silhouettes from post-treatment lateral cephalometric radiographs of 18–37 year-old orthodontic patients were scored by 5 Thai orthodontists and 15 orthodontic patients. The Likert 5-point scale was used to judge the attractiveness. Two-hundred and seven radiographs passing the minimum score of 3 were divided into acceptable normal, concave, and convex profile (AN, ACC, ACV) groups. Thirty-five skeletal, 17 dental, and 34 soft tissue cephalometric variables were measured. One-way ANOVA and Multiple comparisons (Bonferroni) or Kruskal-Wallis H tests and Post Hoc tests with Mann-Whitney U tests were used to compare the data between AN, ACC, and ACV groups. One-sample t-test or One-sample Wilcoxon Signed Rank test were performed to analyze the difference between each group and adult Thai normative values.

Results: For skeletal part, maxilla was more retrusive in all groups compared the norms. While, ACC group had similar mandibular position, but more protrusive chin; and ACV and AN groups had more retrusive mandible and chin compared with the norms. ACC group presented skeletal and dental base Class III tendency, while ACV group showed skeletal and dental base Class II tendency. ACC had similar vertical relationship, while the others had open bite tendency, with more open bite in ACV group, compared with the norms.

For dental part, AN had similar dental characteristics compared with the norms. ACC group showed more protruded and proclined upper incisors, and retruded and retroclined lower incisors, while ACV group showed more retruded and retroclined upper incisors, and protruded and proclined lower incisors compared with the norms.

For soft tissue, AN group had similar soft tissue characteristics compared with the norms. ACC group had flatter profile, while ACV group had more convex profile compared with the norms. AN and ACC groups had more protruded upper lip and retruded lower lip, while ACV group had similar upper and lower lip position compared with Thai norms. ACC group had protruded chin, AN group had normal chin position, while ACV group had retruded chin. Prominent nose and more competent lip were presented in all groups when compared with the norms.

Conclusion: All three esthetically acceptable profile groups had some different skeletal, dental, and soft tissue characteristics from the present norms. For AN patients, orthodontic treatment could be planned based on previous Thai norms. Skeletal open bite tendency were acceptable in all groups. For the other profiles, orthodontic treatment could be performed with more protruded and proclined upper incisors and more retruded and retroclined lower incisors than the norms in ACC patients, and on the contrary treatment plan in ACV patients. In summary, different treatment goal based on cephalometric values for each lateral facial profile should be applied to achieve the esthetically acceptable facial profiles.

Field of Study:	Orthodontics	Student's Signature .....
Academic Year:	2020	Advisor's Signature .....

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Chapter 1

Introduction

1.1 Background and rationale

In early 1900s, orthodontic treatment planning was based on dental and skeletal components to have perfect alignment of teeth, an ideal dental occlusion and articulation with less emphasis on facial proportion and esthetics. The main diagnostic tools were dental casts and lateral cephalometric radiographs.[1, 2] However, many studies found that dependence on cephalometric analysis without clinical evaluation of the facial soft tissue was not adequate and may bring about esthetic problems.[3-7] Dental correction alone did not certainly obtain a good facial profile and may worsen esthetics.[3] Extraction of four first bicuspids resulted in 10-15% extremely retruded (dished-in) face after orthodontic treatment.[7] Although the goal of incisor positioning by placing lower incisor in front of the A-Pog line 1.5 mm. was achieved, the lip position still had large variation.[6]

The modern treatment goals of orthodontic diagnosis and treatment planning had been shifted to soft tissue paradigm, objectives and limitations of orthodontic and orthognathic treatments were determined by the soft tissue of the face, not by the teeth and bones[1, 2] Soft tissue should be analyzed for the correct assessment of an essential skeletal discrepancy as a result of individual difference in soft tissue thickness.[8] Several previous studies defined various soft tissue analyses in a lateral cephalometry, and recommended soft tissue normative values for clinical application[9] e.g. Downs[10], Steiner[11], Burstone[12], Ricketts[13], Holdaway[14], and Merrifield analyses.[4] In these analyses, however, there had not been an established gold standard for esthetic facial profile which may cause many treatments fail to achieve patient satisfaction.[15]

The most important motivating factor for patients seeking for orthodontic treatment was the improvement of dento-facial appearance and self-confidence.[8, 16] Moreover, a systematic review studying the reasons that people seek for orthodontic treatment indicated esthetics as the key motivational factor.[17] There were several factors affecting esthetic perception and preference of facial profiles. They were

various occupational backgrounds from laypeople to dental professions[15, 18], orthodontist to surgeon[19], as well as other factors which were age[15, 20], race[20-22], modernization[15], gender[15, 20], geographic area[23], socioeconomic status[23], education[18, 23, 24], and even facial profile category of the referees.[15, 20, 25]

Some previous studies revealed the agreement between facial attractiveness scores made from lateral cephalometric radiographs and those made from clinical photographs but inconclusive.[26-28] Correlations between cephalometric measurements (objective measurement) and rankings of facial attractiveness (esthetic perception) on clinical photographs at the end of treatment were less strong than had been expected.[29] The higher ranks for facial attractiveness on clinical photographs did not closely associate with the recommended cephalometric normative values, as well as lower facial attractiveness ranks did not associate with higher or lower cephalometric values either.[15, 29]

Nowadays, it became apparent that an excellent occlusion was unsatisfactory if the esthetic facial profile was not achieved. Since the traditional cephalometric norms were not established based on facial esthetics, orthodontic treatment based only on cephalometric standards without esthetic consideration of the face may not be adequate.[9] As we knew that modernization was one of the factors affecting esthetic preference of the patients,[15] several Thai cephalometric norms developed more than 20-30 years ago may be outdated. Therefore, in this study, we studied the cephalometric values of the treated orthodontic patients with acceptable esthetic facial profiles to create new cephalometric values as treatment goals for modern orthodontics in Thai adult patients.

1.2 Research questions

1.2.1 Were there any differences in the skeletal, dental, and soft tissue cephalometric values between patients with acceptable normal, convex, and concave facial profiles?

1.2.2 Were there any differences in the skeletal, dental, and soft tissue cephalometric values between patients with acceptable normal facial profiles and Thai normative values?

1.2.3 Were there any differences in the skeletal, dental, and soft tissue cephalometric values between patients with acceptable convex facial profiles and Thai normative values?

1.2.4 Were there any differences in the skeletal, dental, and soft tissue cephalometric values between patients with acceptable concave facial profiles and Thai normative values?

1.3 Research hypothesis

1.3.1 H0: The skeletal and soft tissue cephalometric values between patients with normal, acceptable convex, and acceptable concave facial profiles were similar.

H1: The skeletal and soft tissue cephalometric values between patients with normal, acceptable convex, and acceptable concave facial profiles were different.

1.3.2 H0: The skeletal and soft tissue cephalometric values between patients with normal facial profiles and Thai normative values were similar.

H1: The skeletal and soft tissue cephalometric values between patients with normal facial profiles and Thai normative values were different.

1.3.3 H0: The skeletal and soft tissue cephalometric values between patients with acceptable convex facial profiles and Thai normative values were similar.

H1: The skeletal and soft tissue cephalometric values between patients with acceptable convex facial profiles and Thai normative values were different.

1.3.4 H0: The skeletal and soft tissue cephalometric values between patients with acceptable concave facial profiles and Thai normative values were similar.

H1: The skeletal and soft tissue cephalometric values between patient with acceptable concave facial profiles and Thai normative values were different.

1.4 Research objectives

1.4.1 To compare means of skeletal, dental, and soft tissue cephalometric values between patients with acceptable normal, convex, and concave facial profiles.

1.4.2 To compare means of skeletal, dental, and soft tissue cephalometric values between patients with acceptable normal facial profiles and Thai normative values.

1.4.3 To compare means of skeletal, dental, and soft tissue cephalometric values between patients with acceptable convex facial profiles and Thai normative values.

1.4.4 To compare means of skeletal, dental, and soft tissue cephalometric values between patients with acceptable concave facial profiles and Thai normative values.

1.5 Conceptual framework

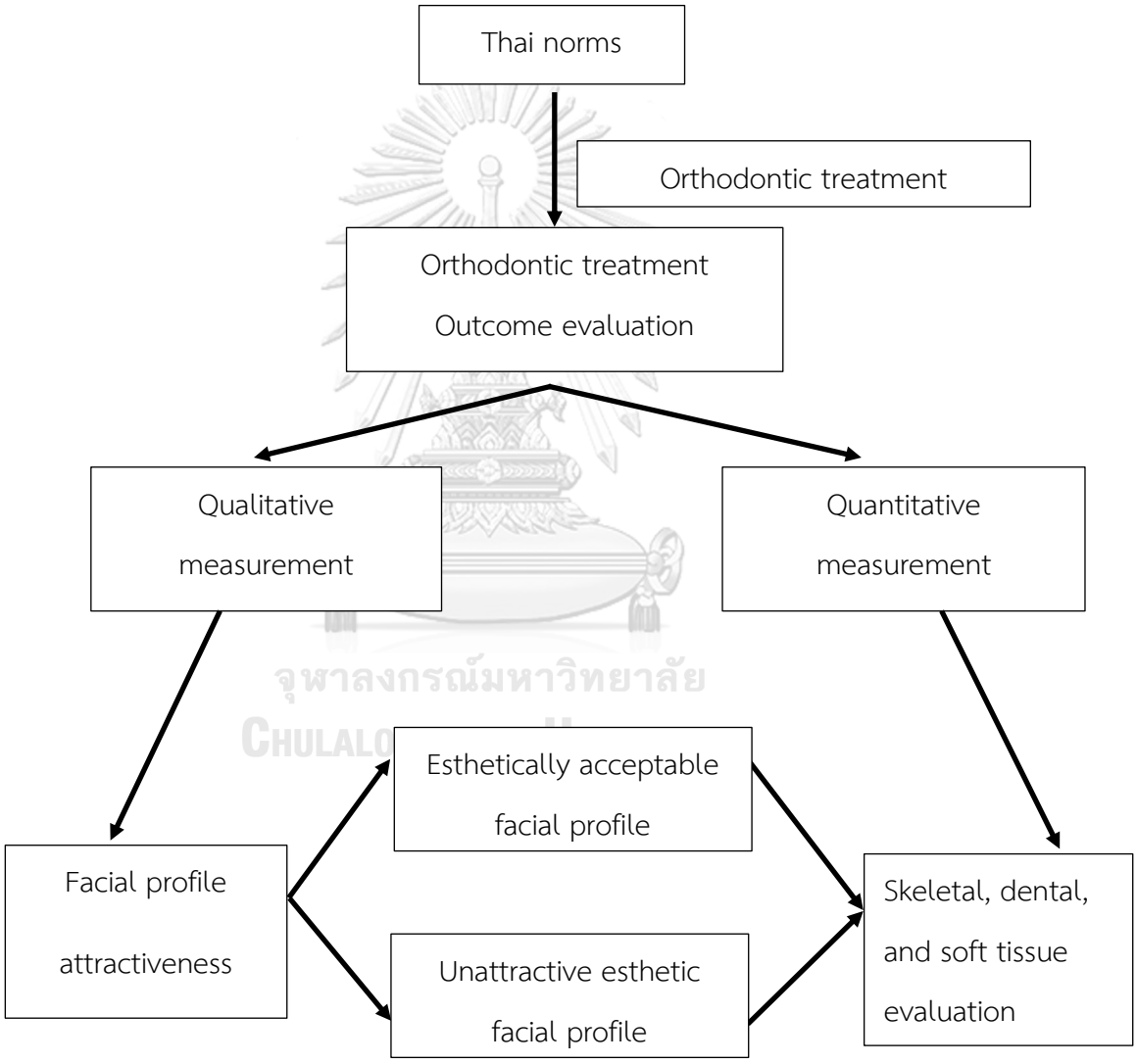

Figure 1 Conceptual framework of the present study

Chapter 2

Review literature

2.1 Esthetic perception

Beauty is universal. Every ethnic group had its esthetically strong and weak points, but on the whole, the most beautiful and attractive people of each and all races tended to look similar in terms of face shape, and harmonious delicacy of features, balance, and symmetry.[30]

Several facial profile attractiveness studies had various methods to create facial profile images, including computer-modified photographs, using computer software to create new images, or simple method such as silhouettes. Photographs, however, might lead to perception bias of race recognition and stereotyping.[31] Whereas Silhouettes could eliminate those biases.[32]

In the study of esthetic perception of facial profile, Thai patients considered a normal or slightly convex profile as the most attractive, and an extremely concave profile as the least attractive facial profiles.[25] This finding correlated with esthetic profile preference for the Japanese, an orthognathic profile was the most preferred and mandibular protrusion was the least favored profiles.[20] Moreover, a Class II profile or mandibular retrusion was more favored than a Class III profile or mandibular protrusion in Asian individuals.[20, 25] According to Suphatheerawatr et al study, the facial profiles with facial contour angle (FCA) within -8 to +12 degree from a normal facial profile photograph, which had FCA of 10 degree, or the facial profiles with FCA between 2-22 degree were considered as attractive.[25]

2.2 The history of soft tissue analysis

The importance of facial esthetics to orthodontic practice had its origins at the beginning of our specialty. In 1900, Angle E. H. believed that the harmonious face required a full complement of teeth. In early 1900s, Cryer M. and Case C. proposed that esthetic harmony of the face should be the most important objective in orthodontic treatment, and that extraction of teeth was sometimes necessary to achieve that goal. Afterward, Angle's reliance on non-extraction orthodontic

treatment was no longer reliable. Tweed's initial attempts to flatten profiles with marked bimaxillary protrusion seemed reasonable, but extraction in patients with mild protrusion to achieve the cephalometric goal of an upright mandibular incisor began to be questioned.[33] However, Tweed's principle correlated with the findings of a systematic review regarding esthetic perception changes in facial profile resulting from orthodontic treatment with extraction of premolars suggested that premolar extractions tended to be beneficial to the soft tissue structure in patients with greater lip protrusion and more convex facial morphologies.[34]

2.3 The previous soft tissue studies

Soft tissue measurement in cephalometric evaluation was firstly introduced in Downs' study.[10] The results of the study indicated that soft tissue did not follow the underlying hard tissue at all times.

E-line or esthetic line, the line drawn from the tip of nose to the chin, was firstly introduced in Ricketts' study[13] in Caucasian to determine the position of lip in relative with adjacent structures. Normative values of lower lip position for female adults and adolescences (age 12-14 years) are 4 $\pm$ 3 mm and 2 $\pm$ 3 mm, respectively. While standard values in male is slightly greater because of thinner lips.

H-line, the line drawn from upper lip to soft tissue pogonion, was proposed by Holdaway in the study of American population. This reference line was used to evaluate subnasale, upper and lower labial sulcus, and lower lip position. Both lips located on the H-line indicates perfect position of upper and lower labial sulcus. Moreover, the prominence of nose, the upper lip thickness at the level of point A, and the chin thickness at the pogonion point were also defined in this study. The angle between H-line and a line connecting soft tissue nasion and soft tissue pogonion or H-angle was also introduced. H-angle was associated with ANB angle. If ANB angle is 1-3 degree, H-angle should be 7-8 degree, lower lip would touch H-line and the nose tip would be 9 mm. in front of this line. H-angle directly changed with ANB angle.[14]

S-line, the line drawn from soft tissue pogonion to the midpoint of columella of the nose, was presented by Steiner in the study of Caucasian boy. The lips should be on S-line to represent the soft tissue profile harmonization.[11]

B-line, the line drawn from subnasale to soft tissue pogonion, was recommended by Burstone in the study of Caucasian. The positions of upper and lower lips approximately 3.5 and 2.2 mm anteriorly to this line were recommended. The position of the lips in relation to this line changed consequently to the tooth movement, which reflected the total esthetic. If anterior teeth retraction caused retrusion of the lips behind this line, and compromised esthetics, extraction should be avoided.[12]

Z-angle, the profile angle between the line drawn from soft tissue pogonion up to the most anterior point of lips (upper or lower lip which was more protruding will be used) and Frankfurt horizontal plane, was suggested by Merrifield in the study of Caucasian. The total chin thickness, the distance from pogonion to the covering of soft tissue, and upper lip thickness, prosthion to the most anterior point on the vermilion border of the upper lip, were variables that should be equal to or might be slightly greater than the total chin thickness. The upper lip should be on the profile line and lower lip may be on this line or slightly posterior to this line. Normal Z-angle is 80 $\pm$ 5 degree in adults and 78 $\pm$ 5 degree in adolescences (11-15 years).[35]

The accuracy of orthodontic diagnosis was discussed by Arnett and Bergman. They introduced a new facial and soft tissue cephalometric analysis (STCA) by augmenting cephalometric information with clinical facial profile analysis in the natural head position. The important soft tissue structures were measured in antero-posterior direction to the true vertical line through subnasale. The position of each structure relative to other structures might define the facial esthetics. Horizontal distance between two structures measured perpendicular to the vertical line indicated the harmonious values.[36-38]

2.4 The study of cephalometric measurements and the beauty of facial profile

Oh SH's study indicated the correlation between cephalometric measurements and facial attractiveness in Chinese and US patients after orthodontic treatment. They proposed 21 cephalometric variables which were considered to be strong indicators of facial attractiveness and esthetically related, including, 11 angular measurements, 9 linear measurements, and 1 ratio.[29]

Ghorbanyjavadpour F.'s study revealed the esthetic factors of profile silhouettes among the 39 cephalometric variables with the use of multivariate analysis. Profile silhouettes of 70 Iranians with Class I, good occlusion, and balanced faces were rated twice by 10 Iranian laypersons, and were given overall profile beauty scores. Cephalometric measurements were traced and assessed the effects of these variables (plus sex and age) on profile beauty scores.[23]

2.5 Normative cephalometric values in Thai population

There were several studies about normative cephalometric values in Thai patients, including Sorathesn K.[39], Dechkunakorn S.[40], Suchato W. [41], Chaiworawitkul M.[42], Ruksujarit T. [43], Nuntasukkasame A. [44], and Sutthiprapaporn P. [45] studies.

According to Sorathesn K. study, adult Thai cephalometric norms were proposed as a standard guideline for accurate treatment planning in Thai patients.[39] The inclusion criteria were Thai males (N=50) and females (N=50), aged over 18 years old (Non-growing patients), no history of orthodontic treatment, normal growth in maxillofacial region, and good intercuspation.[39]

Dechkunakorn S.'s study established the cephalometric norms for Thai adult in various lateral cephalometric analyses, comprising Down's analysis, Steiner's analysis, Tweed's analysis, Jarabak's analysis, Harvold's analysis, Ricketts' analysis, and McNamara's analysis. Forty-five Thai adults, mean age of 21.65 years old, with Class I molar relationship, normal overbite and overjet, proper tooth alignment or crowding less than 1 mm, and good facial profile and proportion, were included in the study.[40]

Suchato W.'s study recommended cephalometric values to diagnose and treat Thai patients properly. The author studied 100 Thai students aged 18-35 years old (the majority were between 18-22 years old with mean age of 22.02 years old) with full complete dentition, except third molar, Class I molar relationship with proper intercuspation, and no previous orthodontic treatment.[41]

Chaiworawitkul M.'s study established cephalometric norms of northern Thai adults with good facial profile and optimal natural occlusion. The inclusion criteria were Thai adults (N=70) aged 16-27 years old (mean age of 20 years old) with good occlusion, all permanent teeth were erupted, except third molars, no extensive restorations, Class I relationship of canines, premolars, and molars with 2-4 mm overjet and overbite, no more than 1 mm dental midline shift or posterior crossbite, crowding less than 2 mm, competent lips, normal function of lips and tongue, and no tongue-thrust habit, no protruded or retruded lip relative to the E-line.[42]

Ruksujarit T.'s study developed lateral cephalometric norms for 12–14 years old Thai girls and boys in Khon Kaen Province who had acceptable facial profiles. One-hundred and six girls and 67 boys with mean age of 13.1 and 13 years old, respectively, esthetically acceptable profiles, no more than 3 mm crowding or spacing of anterior teeth, 1-3 mm overjet and overbite, and no previous orthodontic treatment, were included in the study.[43]

Nuntasukkasame A.'s study introduced the cephalometric standard in Thai adults based on natural head position concept. The author studied 80 Thai adults with mean age of 23 years old, normal occlusion and dentofacial harmony.[44]

Sutthiprapaporn P.'s study introduced the cephalometric standard in Thai adults (age 18–37 years old) based on pleasing profile after orthodontic treatment. Post-treatment lateral profiles were transformed to black silhouettes and evaluated by 4 Thai orthodontists. The Likert 5-point scale was used to judge the attractiveness. Two hundred lateral cephalometric radiographs (100 males and 100 females) from the patients who had the pleasing profile were recruited. Seventy cephalometric

values were measured and analyzed. The esthetic lateral cephalometric values for Thai adults were proposed in this study.[45]

Chapter 3

Materials and Methods

3.1 Study design

Retrospective, cross-sectional, analytical study

3.2 Study population

Post-treatment lateral cephalometric radiographs of Thai orthodontic patients

3.3 Sample size

$$n = \frac{z^2_{1-\frac{\alpha}{2}}\sigma^2}{d^2}$$

Figure 2 Infinite population mean equation

According to the sample size estimation formula for testing infinite population mean from N4studies program, the standard deviation of the FCA angle from Sorathesn K. study[39] equal to 4, error equal to 0.5, and alpha equal to 0.05 were used. The total sample size was 246. However, the sample size was set at 300 for drop-out situation after scoring of profile silhouettes. Selection of sample was performed by purposive sampling method.

3.4 Inclusion criteria

- Post-treatment lateral cephalometric radiographs of completely treated orthodontic Thai patients from the Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University (During January 2007 – Until August 2020)
- Age ≥ 18-37 year old (non-growing patients)[39]
- Facial contour angle between 2 to 22 degree[25]

3.5 Exclusion criteria

- Poor lateral cephalometric radiographs quality
- Severe craniofacial disorders or craniofacial trauma
- Previous history of orthognathic surgery or cosmetic surgery (rhinoplasty, lip surgery, or chin correction)
- Serious medical condition

- Subjects with mentalis strain

3.6 Data collection and preparation

Facial contour angles (FCA) of each lateral cephalogram were measured twice by a single dentist, who had been trained and calibrated by the expert, using Adobe Photoshop CC 2019 software (Adobe System Inc., San Jose, CA) to minimize errors. Only radiographs with FCA between 2 to 22 degree were included in this study.

The outline of the soft tissue profile was traced via Adobe Illustrator 2019 software (Adobe System Inc., San Jose, CA), and converted into black silhouette against a white background via Adobe Photoshop CC 2019 (Adobe System Inc., San Jose, CA) by a single dentist. All profile silhouettes were displayed on 10.5 inches Apple iPad pro retina display with 2224 x 2668 pixels, 4:3 ratio (~264 ppi density) via goodnotes 5 application and google form online questionnaires since the outbreak of COVID-19 (Coronavirus disease 2019).

The final 303 profile silhouettes were divided into 6 sessions. Ten percent of profile silhouettes of each session were randomly selected via simple random sampling method and included into each session. The final profile silhouettes were 55 for session 1 to 5 and 58 for session 6. These duplicated profile silhouettes were used for inter-rater and intra-rater reliability tests.

3.7 Attractiveness score collection

A panel of Thai population without craniofacial deformities were selected by purposive sampling method. Five orthodontists (certified by the Fellow of the Royal College of Dental Surgeons of Thailand in Orthodontics, and aged between 30-40 years old) and fifteen laypersons (5 normal, 5 convex, and 5 concave facial profiles, and aged between 18-40 years old), a total of 10 males and 10 females, were invited to participate in this study. The soft tissue profiles of laypersons, who were orthodontic Thai patients from the Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University during August 2019 to September 2020, were classified based on FCA measurement from their lateral cephalometric radiographs according to Suphatheerawatr T. et al study[25] as normal (6 to 14 degree), concave (2 to <6 degree), and convex (>14 to 22 degree) facial profiles. All participants were asked to

rate the attractiveness score for each silhouette after the authors clearly explained the instruction of the questionnaires.

Each profile silhouette was presented to each rater for 5 seconds, without mentioning the subject's gender or age.[45] Only 55-58 silhouettes were scored per session to reduce fatigue[46], so each rater scored profile silhouettes for 6 sessions. Each silhouette was evaluated using Likert scale as very pleasant (5 points), pleasant (4 points), average (3 points), unpleasant (2 points), or very unpleasant (1 point). The scores given by all judges will be averaged, summed up, rounded, and assigned to each silhouette. Therefore, soft tissue profile attractiveness score of each subject will theoretically be a value from 1 to 5.

The profiles with scores $\geq$ 3 points were considered as esthetically acceptable. These esthetically acceptable profiles were then classified basing on their original FCA classification. Subjects with FCA 6 to 14 degree was classified as an acceptable normal profile group (AN), whereas the others with FCA 2 to <6 degree and >14 to 22 degree were categorized as acceptable concave (ACC) and convex (ACV) profile groups, respectively.[25]

3.8 Cephalometric Landmarks and measurements

The selected profile silhouettes were traced back for cephalometric values. Each cephalogram was traced and identified landmarks by a single dentist, who was trained and calibrated by the expert, via Adobe Illustrator 2019 software (Adobe System Inc., San Jose, CA). To improve the landmark accuracy, all landmarks were confirmed by an experienced orthodontist. If there were controversy regarding landmark positions, the correct landmarks were determined through discussion.

Eighty-six cephalometric measurements, including esthetically related cephalometric variables[9, 23, 29] were used. All cephalometric measurements were 35 hard-tissue measurements (21 angular, 12 linear, and 2 ratio measurements), 17 dental measurements (9 angular, 8 linear measurements), and 34 soft tissue measurements (6 angular, 28 linear measurements). The cephalometric landmarks were shown in Figure 1 and their definitions were described in Table 1. The cephalometric measurements were described in Table 2. The abbreviations in brackets are H: hard-tissue measurements, D: dental measurements and S: soft-tissue

measurements. The cephalometric variables with available Thai normative values were shown in Table 3.

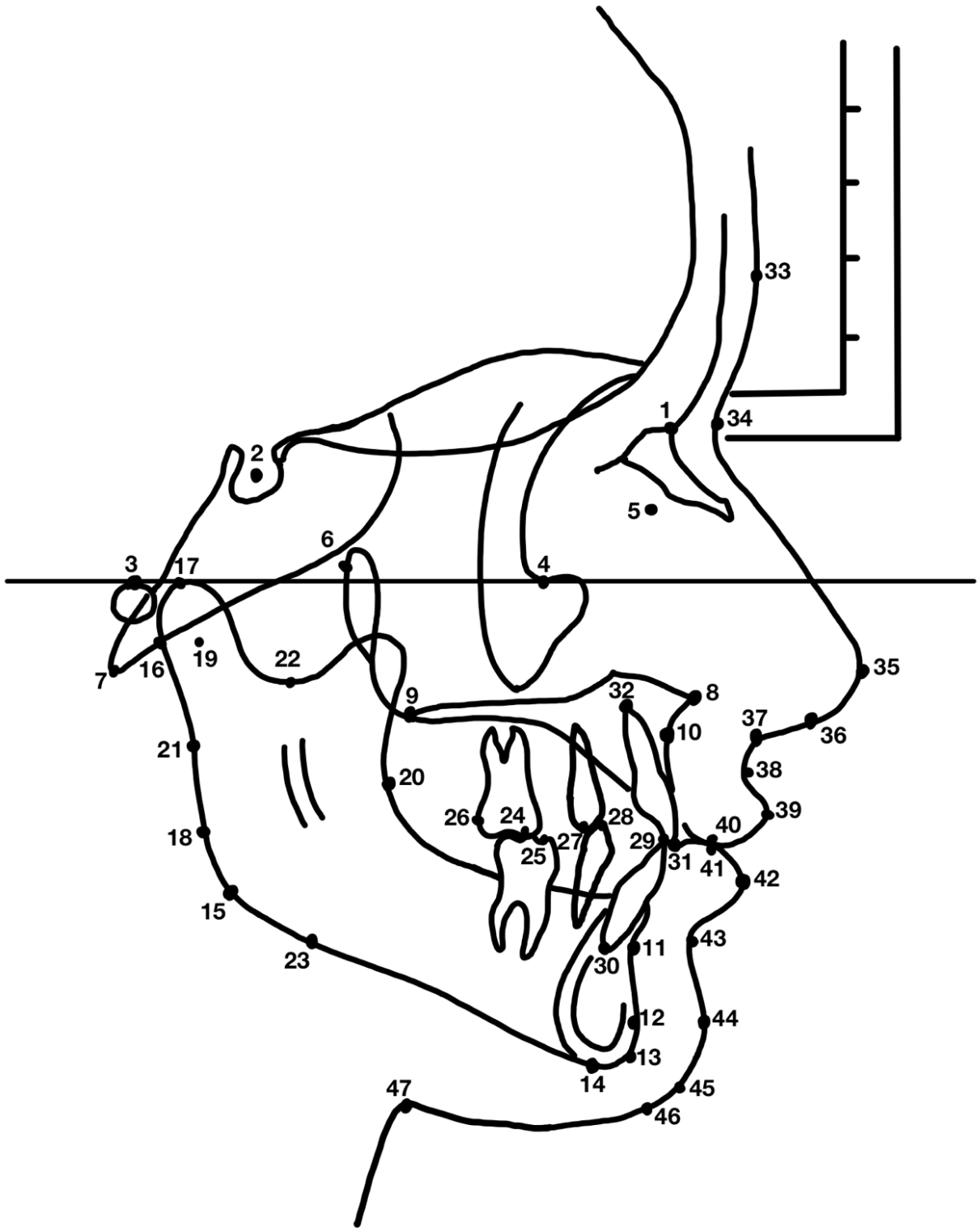

Figure 3 Sixty-two cephalometric Landmarks used in computing the 86 cephalometric measures. The horizontal lines showed the Frankfort horizontal plane (FH)

Table 1 Definition of cephalometric landmarks and reference plane

Landmarks	Definition
Skeletal landmarks	
1. Nasion (N)	the most anterior point of the frontonasal suture which joins the nasal part of the frontal bone and nasal bone or the intersection of the internasal suture with the nasofrontal suture in the midsagittal plane
2. Sella (S)	the center of the hypophyseal fossa or the center of the pituitary fossa of the sphenoid bone
3. Porion (Po)	the most superior point of the external auditory canal or the highest point of the ear canal
4. Orbitale (Or)	the most inferior point of the infraorbital rim or the lowest point of the external border of the orbital cavity
5. Eye point	the intersection of soft tissue glabella–posterior columella plane by a perpendicular line bisecting the eye
6. Pterygomaxillary fissure (Pt)	the most posterosuperior point of the pterygomaxillary fissure or the intersection of the inferior border of the foramen rotudum with the posterior wall of the pterygomaxillary fissure
7. Basion (Ba)	the most anterior point of the foramen magnum or the most inferior point of the occipital bone at the anterior margin of the occipital foramen
8. ANS	the tip of the anterior nasal spine
9. PNS	the tip of the posterior nasal spine
10. A point	the deepest point of the anterior border of the maxillary alveolar ridge concavity, between anterior nasal spine and the dental alveolus
11. B point	the deepest point of the anterior border of the mandibular alveolar ridge concavity along the anterior border of symphysis
12. Pogonion (Pg)	the most anterior point of the midsagittal symphysis
13. Gnathion (Gn)	the most anteroinferior aspect of the mandibular symphysis outline between pogonion and menton
14. Menton (Me)	the most inferior point of the symphysis
15. Gonion (Go)	the most convex point along the inferior border of the mandibular ramus
16. Articulare (Ar)	the point of intersection between the basisphenoid and the

	posterior border of the condylar head
17. Condylion (Co)	the most posterosuperior point on the outline of the mandibular condyle
18. Ramus point	the most posterior point up the border of the ramus
19. DC point	the center of the neck of the condyle on the Nasion-Basion line
20. R1 Mid ramus	The most concave point on the inferior of the ramus (Use to locate Xi point)
21. R2	the most convex point on the exterior border of the ramus along the vertical (Use to locate Xi point)
22. R3 Sigmoid notch	the most inferior border along the top of the ramus (Use to locate Xi point)
23. R4	the most superior border along the bottom of the ramus (Use to locate Xi point)
Dental landmarks	
24. U6 occlusal	the mesial buccal cusp tip of the maxillary molar
25. L6 occlusal	the mesial buccal cusp tip of the mandibular molar
26. U6 distal	the distal surface of the upper first molar, perpendicular to the occlusal plane
27. Upper first bicuspid U4	the buccal cusp tip of upper first premolar
28. Lower first bicuspid L4	The buccal cusp tip of lower first premolar
29. L1 Tip	the tip of the lower central incisor
30. L1 root	The root apex of lower central incisor
31. U1 Tip	the incisal tip of the upper central incisor
32. U1 root	the root apex of upper central incisor
Soft tissue landmarks	
33. Soft tissue Glabella (G')	the most anterior point of the soft tissue covering the frontal bone
34. Soft tissue Nasion (N')	the most concave point of soft tissue outline at the bridge of the nose
35. Pronasale (Pn)	the most anterior point of the nose (Tip of nose)
36. Columella (Cm)	the most anterior point on the columella of the nose
37. Subnasale (Sn)	the soft tissue point where the curvature of the upper lip connects to the floor of the nose

38. Soft tissue subspinale (SLS)	the most concave point of the upper lip between subnasale and the upper lip point (Soft tissue A point)
39. Upper lip (Ls)	the most anterior curve of the upper lip
40. Stomion superius (Stms)	the most inferior point of the upper lip
41. Stomion inferius (Stmi)	the most superior point of the lower lip
42. Lower lip (Li)	the most anterior curve of the lower lip
43. Mentolabial sulcus (ILS)	the most concave point of the lower lip between chin and lower lip point (Soft tissue B point)
44. Soft tissue pogonion (Pg')	the most anterior point of the soft tissue of the chin
45. Soft tissue gnathion (Gn')	the midpoint of the chin soft tissue outlines between soft tissue pogonion and soft tissue menton
46. Soft tissue menton (Me')	the most inferior point of the soft tissue of the chin from the lowest point of the outline of the mandibular symphysis
47. Throat point	the intersection of lines tangent to the neck and the throat
References planes	
Frankfort horizontal plane (FH)	the line connecting Porion and Orbitale

Table 2 Definition of cephalometric measurements

Cephalometric variables	Definition
Skeletal cephalometric measurements	
Antero-posterior analysis	
Cranial base	
1. SN (mm)	The anterior cranial base length, the distance between S and N
2. Anterior cranial base length (mm)	The distance from center of cranium (CC: the intersection of two planes between Ba-N and Pt-Gn) to N along Ba-N plane (CC-N)
3. FH-SN (°)	The anterior cranial base inclination, the angle between SN plane and FH plane
4. NSAr (°)	The saddle angle; the angle between SN plane and S-Ar plane
5. NS-Ba (°)	The cranial base angle; the angle between anterior and posterior skull

	base planes, representing skull base curvature
Maxilla	
6. SNA (°)	The angle formed by S, N, and A points indicating the sagittal maxillary position
7. SNO (°)	The angle performed by the intersection of SN plane and N-Or plane at N point
8. O-NA (mm)	The distance from Or measured perpendicular to NA plane
9. Maxillary depth (°)	The angle formed by FH plane to NA plane indicating the sagittal maxillary position (FH-NA)
10. A-NperpFH (mm)	The distance from point A to N perpendicular to FH plane
11. Co-A (mm)	The distance from Co to point A indicating the midfacial length
Mandible	
12. SNB (°)	The angle formed by S, N, and B point indicating the sagittal mandibular position
13. Facial depth (°)	The angle formed by the FH plane to NPg plane indicating the sagittal mandibular position (FH- NPg)
14. Pg-NperpFH (mm)	The distance from Pg to N perpendicular to FH plane
15. Co-Gn (mm)	The distance from Co to Gn indicating the mandibular length
16. N-Go (mm)	The distance from N to Go indicating the facial depth
Maxillomandibular (Mx-Md) relationship	
17. ANB (°)	The angle formed by A, N, and B indicating the skeletal relationship between the maxilla and mandible
18. Wits appraisal (mm)	The distance from the perpendicular lines from point A and B to the functional occlusal plane (AO-BO)
19. Cranial deflection (°)	The angle formed by Ba-N plane and FH plane (FH-BaN)
20. Convexity of point A (mm)	The distance from hard tissue point A to facial plane (N-Pg) (A-Npg)
Vertical analysis	
21. SN-OP (°)	The angle formed by SN plane and the functional occlusal plane (L6 occlusal-L4 buccal cusp)
22. SN-GoGn (°)	The angle formed by the SN plane and the Go-Gn plane indicating the facial growth
23. SN-MP (°)	The angle formed by SN plane and mandibular plane (Go-Me)

24. Mandibular arc (°)	The angle formed by condylar axis (Xi-DC) and corpus axis (PM-Xi) (XiDC-PMXi)
25. FH-PP (°)	The angle formed by the FH plane and palatal plane (ANS-PNS)
26. FMA (°)	The angle formed by the FH plane and mandibular plane (Go-Me) indicating the vertical mandibular growth (FH-MP) (Frankfurt Mandibular Plane Angle)
27. PP-MP (°)	The angle formed by the palatal plane (ANS-PNS) and mandibular plane (Go-Me) indicating the deep bite or open bite
28. NSGn (°)	The angle formed by the SN plane and the SGn plane indicating the vertical and anteroposterior mandibular growth
29. Lower face height (°)	The angle formed by the intersection of ANS-Xi and Xi-PM plane (PM-Xi-ANS)
30. LAFH (mm)	The distance from ANS to Me indicating the lower anterior facial height (ANS-Me)
31. UAFH/LAFH Ratio (%)	The ratio of the upper anterior facial height (linear distance between point N and ANS project line, measured in N-Me line) and LAFH (N-ANS/ANS-Me)
32. PFH:AFH (%)	The ratio of the posterior facial height and anterior facial height: the value of S-Go devided by N-Gn length (S-Go/N-Gn)
33. Ar-Go-Gn (°)	The gonial angle formed by the ramal plane and mandibular plane (Go-Gn) indicating the deep bite or open bite
Direction of growth	
34. Facial axis angle (°)	The angle formed by N-Ba and Ptm-Gn plane indicating the vertical or horizontal growth (BaN-PtmGn)
35. Posterior facial height (mm)	The distance from Go-Center of face (CF: the intersection between FH plane and the line perpendicular to FH plane pass to Pt point) (Go-CF)
Dental cephalometric measurements	
Maxilla	
36. U1-SN (°)	The angle formed by the upper incisor axis to the SN plane
37. U1-PP (°)	The angle formed by the upper incisor to the palatal plane
38. U1-NA (°)	The angle formed by the upper incisor to the NA plane
39. U1-NA (mm)	The distance from the Is to the NA plane
40. U1-APg (°)	The angle formed by the upper incisor to the APg plane
41. U1-APg (mm)	The distance from the Is to the APg plane

42. ADH (mm)	The distance from ANS to the Is perpendicular to the Incisal tip of the upper central incisor (U1 tip)
43. PDH (mm)	The distance from the occlusal plane pass through mesio-buccal cusp of the upper first molar to the inner border of the hard palate (U6 occlusal)
Mandible	
44. IMPA (°)	The angle formed by the lower incisor axis to the plane formed by the lower border of the mandible (Go-Me) (L1-MP) (Incisor Mandibular Plane Angle)
45. FMIA (°)	The angle formed by the FH plane and lowerincisor (L1-FH) (Frankfort Mandibular Incisor Angle)
46. L1-NB (°)	The angle formed by the lower incisor to the NB line
47. L1-NB (mm)	The distance from the Li to the NB plane
48. L1-Apg (°)	The angle formed by the lower incisor to the APg plane
49. L1-Apg (mm)	The distance from the Li to the APg plane
Maxillomandibular (Mx-Md) relationship	
50. Interincisal angle (°)	The angle formed by the upper and lower incisors axis (U1-L1)
51. Overjet (mm)	The distance from U1 tip to L1 tip measured parallel to the occlusal plane
52. Overbite (mm)	The distance from U1 tip to L1 tip measured perpendicular to the occlusal plane
Soft tissue cephalometric measurements	
53. FCA (°)	The angle formed by Ga', Sn and Pg' indicating the facial convexity (G'-Sn-Pg') (Facial Contour Angle)
54. NLA (°)	The angle formed by the line at Sn to the columella and a line from Sn to Ls (Nasolabial angle)
55. Upper NLA (°)	The angle formed by Sn to columella and the true horizontal plane
56. Lower NLA (°)	The angle formed by the true horizontal plane and a line from Sn to Ls
Upper lip	
57. E-line to upper lip (mm)	The distance from Ls to the esthetic line (the line extends from the Pn to Pg') (Ls to E-line)
58. Upper lip prominence (mm)	The distance from the Ls to a true vertical line passing through the Sn (Ls to SnV)
59. B-line to upper lip (mm)	The distance from Ls to the B -line (Sn-Pg') (Ls to Sn-Pg')

60. Ls to facial plane (mm)	the distance from the Ls to the facial plane (N-pg) and measured perpendicular to the facical plane (Ls-Npg)
61. Ls to G' V (mm)	The distance from the Ls to a true vertical line passing through the G'
62. Ls to N' V (mm)	The distance from the Ls to a true vertical line passing through the N'
63. H-angle (°)	The angular measurement of the H-line (the line drawn tangent to the soft tissue chin and the upper lip) to the N'Pg' line (N'-Pg', upper lip-Pg')
64. ULL (mm)	The distance from Sn to Stms (Sn-Stms) (Upper lip length)
Lower lip	
65. E-line to lower lip (mm)	The distance from Li to the esthetic line (the line extends from the Pn to Pg') (Li to E-line)
66. Lower lip prominence (mm)	The distance from the Li to a true vertical line passing through the Sn (Li to SnV)
67. B-line to lower lip (mm)	The distance from Li to the B -line (Sn-Pg') (Li to Sn-Pg')
68. Li to facial plane (mm)	the distance from the Li to the facial plane (N-pg) and measured perpendicular to the facical plane (Li-Npg)
69. Li to G' V (mm)	The distance from the Li to a true vertical line passing through the G'
70. Li to N' V (mm)	The distance from the Li to a true vertical line passing through the N'
71. LLL (mm)	The distance from Stmi to Me' (Stmi-Me') (Lower lip length)
Chin	
72. Soft tissue chin thickness (mm)	The chin thickness; the distance from Pg to Pg' (Pg-Pg')
73. Chin prominence (mm)	The distance from the Pg' to a true vertical line passing through the Sn (Pg' to SnV)
74. Pg' to facial plane (mm)	the distance from the Pg' to the facial plane (N-pg) and measured perpendicular to the facical plane (Pg'-Npg)
75. Pg' to G' V (mm)	The distance from the Pg' to a true vertical line passing through the G'
76. Pg' to N' V (mm)	The distance from the Pg' to a true vertical line passing through the N'
Nose	
77. Nose prominence (mm)	The distance from the Pn to a true vertical line passing through the Sn (Nose projection to SnV)
78. Nasal tip to facial plane (mm)	the distance from the nose tip to the facial plane (N-pg) and measured perpendicular to the facical plane (Pn-NPg)
Vertical analysis	
79. UFH (mm)	The distance from eye point to Sn (Sn-Stms) (Upper facial height)

80. LFH (mm)	The distance from Sn to Me' (Sn-Me') (Lower facial height)
Others	
81. Sn to H line (mm)	The distance from the Sn to H-line
82. ILS to H line (mm)	The distance from the ILS to H-line
83. Interlabial gap (mm)	The distance from Stms to Stmi (Stms-Stmi)
84. Mentolabial sulcus depth (mm)	The perpendicular distance from the ILS to the Li-Pg' line (+ve values if ILS beyond the Li-Pg' line and -ve values if ILS behind the Li-Pg' line)
85. TL (mm)	The distance from Throat point to Me' tangent to inferior border of mandible (Throat length)
86. LCTA (°)	The angle formed by the line from Throat point to Me' tangent to inferior border of mandible intersection with the line from Li to Pg' (Lip-Chin-Throat Angle)

Table 3 Cephalometric measurements and available Thai norms

Cephalometric measurements	SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
Skeletal cephalometric measurements						
Antero-posterior analysis						
Cranial base						
1. SN (mm)			✓	✓		✓
2. Anterior cranial base length (mm)			✓			
3. FH-SN (°)	✓					✓
4. NSAr (°)			✓	✓		✓
5. NS-Ba (°)				✓		✓
Maxilla						
6. SNA (°)	✓	✓	✓	✓		✓
7. SNO (°)	✓					
8. O-NA (mm)	✓					
9. Maxillary depth (°)			✓			✓
10. A-NperpFH (mm)			✓			✓

11. Co-A (mm)	✓		✓	✓		✓
Mandible						
12. SNB (°)	✓	✓	✓	✓		✓
13. Facial depth (°)			✓	✓		✓
14. Pg-NperpFH (mm)			✓			✓
15. Co-Gn (mm)	✓		✓	✓		✓
16. N-Go (mm)			✓			✓
Maxillomandibular (Mx-Md) relationship						
17. ANB (°)	✓	✓	✓	✓		✓
18. Wits appraisal (mm)	✓			✓		✓
19. Cranial deflection (°)			✓			
20. Convexity of point A (mm)			✓	✓		
Vertical analysis						
21. SN-OP (°)				✓		✓
22. SN-GoGn (°)		✓	✓	✓		✓
23. SN-MP (°)	✓			✓		
24. Mandibular arc (°)			✓			
25. FH-PP (°)						✓
26. FMA (°)			✓	✓		✓
27. PP-MP (°)		✓	✓	✓		✓
28. NSGn (°)		✓				✓
29. Lower face height (°)			✓			
30. LAFH (mm)			✓		✓	✓
31. UAFH/LAFH Ratio (%)		✓				✓
32. PFH:AFH (%)			✓			✓
33. Ar-Go-Gn (°)			✓			✓
Direction of growth						
34. Facial axis angle (°)			✓			✓
35. Posterior facial height (mm)			✓			
Dental cephalometric measurements						
Maxilla						

36. U1-SN (°)			✓	✓		✓
37. U1-PP (°)	✓			✓		✓
38. U1-NA (°)		✓	✓	✓		✓
39. U1-NA (mm)		✓	✓	✓		✓
40. U1-APg (°)			✓			✓
41. U1-APg (mm)		✓	✓			✓
42. ADH (mm)	✓				✓	✓
43. PDH (mm)	✓				✓	✓
Mandible						
44. IMPA (°)	✓	✓	✓	✓		✓
45. FMIA (°)			✓			✓
46. L1-NB (mm)		✓	✓	✓		✓
47. L1-Apg (°)		✓	✓	✓		✓
48. L1-Apg (mm)			✓			✓
49. IMPA (°)			✓	✓		✓
Maxillomandibular (Mx-Md) relationship						
50. Interincisal angle (°)		✓	✓	✓		✓
51. Overjet (mm)	✓		✓			
52. Overbite (mm)	✓		✓			
Soft tissue cephalometric measurements						
53. FCA (°)	✓					✓
54. NLA (°)	✓			✓		✓
55. Upper NLA (°)						✓
56. Lower NLA (°)						✓
Upper lip						
57. E-line to upper lip (mm)			✓	✓		✓
58. Upper lip prominence (mm)					✓	✓
59. B-line to upper lip (mm)						✓
60. Ls to facial plane (mm)		✓				
61. Ls to G' V (mm)						✓

62. Ls to N' V (mm)						✓
63. H-angle (°)		✓				✓
64. ULL (mm)	✓					✓
Lower lip						
65. E-line to lower lip (mm)			✓	✓		✓
66. Lower lip prominence (mm)					✓	✓
67. B-line to lower lip (mm)						✓
68. Li to facial plane (mm)		✓				
69. Li to G' V (mm)						✓
70. Li to N' V (mm)						✓
71. LLL (mm)	✓					✓
Chin						
72. Soft tissue chin thickness (mm)						✓
73. Chin prominence (mm)					✓	✓
74. Pg' to facial plane (mm)		✓				
75. Pg' to G' V (mm)						✓
76. Pg' to N' V (mm)						✓
Nose						
77. Nose prominence (mm)						✓
78. Nasal tip to facial plane (mm)		✓				
Vertical analysis						
79. UFH (mm)	✓					
80. LFH (mm)	✓					
Others						
81. Sn to H line (mm)						✓
82. ILS to H line (mm)						✓

83. Interlabial gap (mm)						✓
84. Mentolabial sulcus depth (mm)						✓
85. TL (mm)	✓					
86. LCTA (°)	✓					

✓ Available Thai cephalometric norms correlated with the reference cephalometric measurements

Available Thai norms references were SK, 1988: Sorathesn, K., 1988, SW: Suchato, W., 1984, DS: Dechunakorn, C., et al., 1994,

CM: Chaiworawitkul, M., 2008, NA: Nuntasukkasame, A., 2012, SP: Sutthiprapaporn, M., et al., 2020

The cephalometric measurements were performed by a single researcher. Ten percent of cephalometric radiographs were randomly selected via simple random sampling method, and re-measured by the same researcher and an experience orthodontist to assess the inter-examiner and intra-examiner reliability tests. Eighty-six cephalometric measurements were performed using Dolphin 3D software 11.9 premium (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA). The others 4 measurements, including Nasal tip to facial plane (mm), Ls to facial plane (mm), Li to facial plane (mm), and Pg' to facial plane (mm), were executed using image J software, version 1.47 (National Institutes of Health, Bethesda, Maryland, USA). The magnification factor was adjusted with a calibration process by identifying a known distance between two points (ruler 1 and ruler 2) on the cephalostat. Linear measurements were reported in millimeter (mm) with no magnification, angular measurements in degree (°) and facial height ratio in percentage (%). All data were recorded in numerical database and calculated by computer operations.

3.9 Statistical analysis

Intraclass Correlation Coefficient (ICC) was used to assess the intra- and inter-rater reliabilities, and intra- and inter-examiner reliabilities. Descriptive statistics was used to determine mean and standard deviation for each parameter. Normality test was verified by Kolmogorov–Smirnov test for AN group, and Shapiro-wilk test for ACC and ACV groups. The differences of cephalometric values between AN, ACV, and ACC groups were analyzed using one-way ANOVA (analysis of variance) test and multiple comparison (Bonferroni), while those between Thai norms [25, 39-42, 44, 45] and each

group were analyzed using one-sample t-test for most variables. Kruskal-Wallis H tests and Post Hoc tests with Mann-Whitney U tests, and one-sample Wilcoxon Signed Rank test were performed for non-parametric variables, including, N-Go, Mandibular arc, Posterior facial height, IMPA, FCA, Nasal tip to facial plane in ACC group; SN, FH-SN, Co-Gn, SN-GoGn, FMA, UAFH/LAFH ratio, Facial axis angle, PDH, Overjet, Overbite, FCA, and Interlabial gap in AN group; and SNO, N-Go, SN-PP, U1-SN, U1-PP, U1-NA (°), U1-NA (mm), U1-Apg(°), L1-Apg(°), U1-L1, Overbite, FCA, Li to G'V, and Pg' to G'V in ACV group.

All statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS 22.0; SPSS Inc., Chicago, IL, USA). The level of significance was determined at 0.05 significant level with 95% confidence interval. Two-sided P value was presented throughout.

The study protocol was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU2020-121), Thailand.

Chapter 4

Results

The original 303 profile silhouettes consisted of 100 males and 203 females, 63 concave (FCA 2 to <6), 173 normal (FCA 6 to 10), and 67 convex profiles (FCA >14 to 22). Two-hundred and seven profile silhouettes rated as esthetically acceptable comprised 61 males and 146 females, 31 acceptable concave profiles (FCA 2 to <6), 130 acceptable normal profiles (FCA 6 to 10), and 46 acceptable convex profiles (FCA >14 to 22). Means and standard deviations of age and attractiveness score were shown in Table 4. Intraclass correlation coefficient (ICC) of rater and examiner were shown in Table 5.

Table 4 Means and standard deviation of age and attractiveness score

Variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	23.36	4.564	23.03	3.692	23.86	4.835	22.17	4.127
Attractiveness score	3.22	0.413	3.19	0.402	3.24	0.428	3.17	0.283

Table 5 Intraclass correlation coefficient (ICC) of rater and examiner

	Raters		Examiners	
Variables	Intra-rater reliability	Inter-rater reliability	Intra-examiner reliability	Inter-examiner reliability
ICC	0.517-0.883	0.924	0998-1.000	0998-1.000
Interpretation	Moderate to good reliability	Excellent reliability	Excellent reliability	Excellent reliability

Table 6 Cephalometric values comparison among ACC, AN, and ACV and each group compared with available adult Thai norms

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Skeletal														
AP														
Cranial base														
1. SN (mm)	63.11	3.50	63.32	3.09	63.03	3.51	63.18	3.76				$72.0\pm3.4^{cc,N,cv}$		$66.8\pm3.8^{cc,N,cv}$
2. Anterior cranial base length (mm)	53.11	3.23	52.78	3.04	53.14	3.19	53.26	3.50			$55.1\pm3.88^{cc,n,cv}$			
3. FH-SN (°)	8.52	2.83	8.22	2.42	8.37	3.02	9.43	2.37	$6\pm3^{cc,N,cv}$					$6.9\pm3.1^{cc,N,cv}$
4. NSAr (°)	123.71	5.68	122.18^{a}	5.46	123.25^{a}	5.39	126.06^{b}	6.05			$122.1\pm4.61^{n,cv}$	$126.0\pm4.6^{cc,n}$		$122.1\pm5.1^{n,cv}$
5. NS-Ba (°)	129.47	5.29	128.25	5.11	129.28	5.36	130.83	5.03				$131.4\pm4.6^{cc,n}$		$126.9\pm5.0^{n,cv}$
Maxilla														
6. SNA (°)	83.11	3.48	83.80	4.26	83.04	3.36	82.87	3.25	$85\pm4^{n,cv}$	$84.2\pm3.58^{n,cv}$	$85.43\pm4.12^{cc,n,cv}$	83.6±3.4		$84.6\pm3.5^{n,cv}$
7. SNO (°)	59.62	4.26	61.21^{A}	4.33	59.24^{B}	4.01	$59.62^{A,B}$	4.72	$65\pm6^{cc,n,CV}$					
8. O-NA (mm)	11.25	2.06	10.61	2.02	11.43	1.99	10.54	2.24	$9\pm2^{cc,n,cv}$					
9. Maxillary depth (°)	91.70	3.33	92.01	2.88	91.41	3.54	92.30	2.90			$94.06\pm3.51^{cc,n,cv}$			91.6±3.1
10. A-NperpFH (mm)	1.64	3.32	1.84	2.77	1.37	3.56	2.27	2.88			$4.59\pm3.86^{cc,n,cv}$			1.6±3.2
11. Co-A (mm)	81.63	4.82	80.97	3.87	81.48	5.12	82.48	4.47	$90\pm3^{cc,n,cv}$		$93.39\pm4.95^{cc,n,cv}$	$93.3\pm3.9^{cc,n,cv}$		$84.2\pm5.0^{cc,n,cv}$

a, b, c: The small letters indicated One-way ANOVA and Multiple comparisons (Bonferroni) for the measurements with normal distribution.

A, B, C: The capital letters indicated Kruskal-Wallis H tests and Post Hoc tests with Mann-Whitney U tests with bonferroni multiple testing correction for the measurements without normal distribution.

cc, n, cv: The small letters One-sample t-test showed statistically significant difference between ACC, AN, and ACV and each Thai norm, respectively. (P-value < 0.05)

CC, N, CV: The capital letters One-sample Wilcoxon Signed Rank test showed statistically significant difference between ACC, AN, and ACV and each Thai norm, respectively. (P-value < 0.05)

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Skeletal														
Mandible														
12. SNB (°)	79.56	3.81	82.45^{a}	4.26	79.61^{b}	3.42	77.48^{c}	3.23	$82\pm3^{n,cv}$	$81.3\pm3.59^{n,cv}$	$81.59\pm3.69^{n,cv}$	$81.4\pm3.1^{n,cv}$		81.8 ± 3.8^{cv}
13. Facial depth (°)	88.50	3.55	91.38^{a}	3.02	88.39^{b}	3.51	86.87^{c}	2.80			$90.3\pm2.96^{n,cv}$	$89.8\pm2.6^{cc,n,cv}$		$89.5\pm3.4^{cc,n,cv}$
14. Pg-NperpFH (mm)	-2.93	6.73	2.45^{a}	5.57	-3.15^{b}	6.70	-5.91^{c}	5.37			$0.47\pm5.96^{n,cv}$			$-0.8\pm6.7^{cc,n,cv}$
15. Co-Gn (mm)	109.83	7.08	111.38^{A}	6.89	110.26^{A}	7.06	107.56^{B}	6.87	$119\pm4^{cc,N,cv}$		$121.38\pm6.69^{cc,N,cv}$	$125.8\pm5.6^{cc,N,cv}$		$121.0\pm7.5^{cc,N,cv}$
16. N-Go (mm)	109.44	7.24	108.57	7.80	109.50	7.05	109.85	7.52			$123.51\pm8.82^{CC,n,CV}$			$114.7\pm7.4^{CC,n,CV}$
Mx-Md relationship														
17. ANB (°)	3.55	2.06	1.35^{a}	1.92	3.43^{b}	1.69	5.37^{c}	1.46	$3\pm2^{cc,n,cv}$	$2.8\pm2.50^{cc,n,cv}$	$3.83\pm1.86^{cc,n,cv}$	$2.2\pm1.7^{cc,n,cv}$		$2.8\pm2.3^{cc,n,cv}$
18. Wits appraisal (mm)	-1.58	3.19	-3.89^{a}	2.74	-1.55^{b}	3.15	-1.00^{c}	2.69	$-3\pm2^{n,cv}$			$-1.7\pm2.4^{cc,cv}$		$-1.2\pm2.8^{cc,cv}$
19. Cranial deflection (°)	28.66	2.31	28.64	2.11	28.59	2.35	28.89	2.35			28.86±2.41			
20. Convexity of point A (mm)	3.19	2.36	0.59^{a}	2.17	3.02^{b}	1.82	5.43^{c}	1.75			$4.33\pm2.62^{cc,n,cv}$	$1.8\pm2.0^{cc,n,cv}$		

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Skeletal														
Vertical analysis														
21. SN-OP (°)	17.02	6.47	14.29^{a}	6.74	16.63^{a}	6.16	19.97^{b}	6.16				16.1±4.2^{cv}		14.3±5.3^{n,cv}
22. SN-GoGn (°)	32.52	5.88	29.18^{A}	6.33	32.74^{B}	5.66	34.13^{B}	5.42			29.55±5.4^{N,cv}	27.9±4.7^{N,cv}		30.0±6.2^{N,cv}
23. SN-MP (°)	35.17	5.93	31.81^{a}	6.44	35.42^{b}	5.73	36.74^{b}	5.39	33±5^{n,cv}	29.4±5.61^{cc,n,cv}		31.4±4.5^{n,cv}		
24. Mandibular arc (°)	34.16	5.30	37.67^{A}	4.66	33.70^{B}	5.13	33.13^{B}	5.33			41.82±4.72^{CC,n,cv}			
25. FH-PP (°)	1.20	3.27	0.52	2.95	1.15	3.15	1.82	3.73						0.8±2.9
26. FMA (°)	26.58	5.77	23.58^{A}	6.09	27.05^{B}	5.65	27.29^{B}	5.35			22.74±5.37^{N,cv}	23.6±4.0^{N,cv}		25.5±5.7^{N,cv}
27. PP-MP (°)	25.38	5.97	23.06	6.25	25.90	5.85	25.47	5.86		20.9±5.24^{n,cv}		22.1±4.4^{n,cv}		25.5±5.9^{cc}
28. NSGn (°)	69.86	3.75	66.65^{a}	3.92	69.96^{b}	3.40	71.77^{c}	3.19		67.7±3.29^{n,cv}				67.4±3.8^{n,cv}
29. Lower face height (°)	45.32	4.29	43.28^{a}	3.95	45.83^{b}	4.38	45.28^{a,b}	3.93			42.39±3.47^{n,cv}			
30. LAFH (mm)	64.41	5.42	62.91	5.87	64.74	5.40	64.50	5.10			70.66±5.76^{cc,n,cv}		70±4^{cc,n,cv}	67.5±5.5^{cc,n,cv}
31. UAFH/LAFH Ratio (%)	80.71	6.96	80.81	6.77	80.59	7.22	80.99	6.47		80.8±6.54				80.2±6.5
32. PFH:AFH (%)	65.83	4.77	67.57^{A}	5.49	65.83^{A,B}	4.57	64.66^{B}	4.54			66.82±5.29^{n,cv}			66.0±5.1
33. Ar-Go-Gn (°)	122.51	6.33	121.32	6.89	122.83	6.29	122.40	6.07			119.54±6.44^{n,cv}			120.3±6.2^{n,cv}
Direction of growth														
34. Facial axis angle (°)	86.60	4.15	89.90^{A}	4.11	86.42^{B}	3.96	84.89^{C}	3.47			86.63±3.79^{cc,cv}			88.0±4.4^{cc,N,cv}
35. Posterior facial height (mm)	62.70	6.03	62.78	6.98	62.82	5.84	62.31	5.99			73.22±7.37^{CC,n,cv}			

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Dental														
Maxilla														
36. U1-SN (°)	106.52	7.84	112.34^{A}	7.41	106.85^{B}	6.92	101.68^{C}	7.75			107.01±6.13^{cc,CV}	108.6±5.8^{cc,n,CV}		106.1±7.6^{cc,CV}
37. U1-PP (°)	116.31	7.82	121.09^{A}	7.22	116.37^{B}	7.48	112.94^{C}	7.58	119±5^{n,CV}			118.1±5.4^{cc,n,CV}		113.9±7.3^{cc,n}
38. U1-NA (°)	23.41	7.44	28.54^{A}	6.61	23.81^{B}	6.75	18.82^{C}	7.29		22.2±5.94^{cc,n,CV}	21.58±4.99^{cc,n,CV}	24.9±5.6^{cc,CV}		21.4±7.2^{cc,n,CV}
39. U1-NA (mm)	3.66	2.60	5.58^{A}	2.41	3.85^{B}	2.36	1.83^{C}	2.26		5.1±2.13^{n,CV}	3.39±1.99^{cc,n,CV}	6.2±2.6^{n,CV}		3.1±2.5^{cc,n,CV}
40. U1-APg (°)	30.20	5.71	29.83	5.55	30.24	5.47	30.32	6.53			30.46±4.91			25.7±5.7^{cc,n,CV}
41. U1-APg (mm)	6.19	1.92	6.12	2.00	6.22	1.90	6.17	1.98			6.31±1.89			4.8±2.3^{cc,n,cv}
42. ADH (mm)	27.23	2.79	26.45	2.92	27.37	2.72	27.35	2.89	29±3^{cc,n,cv}				29±1^{cc,n,cv}	28.0±3.1^{cc,n}
43. PDH (mm)	22.24	2.23	22.33	1.97	22.41	2.33	21.68	1.97	19±2^{cc,N,cv}				21±2^{cc,N,cv}	20.0±1.8^{cc,N,cv}
Mandible														
44. IMPA (°)	95.74	8.72	92.40^{A}	8.50	95.22^{A}	8.69	99.47^{B}	7.80	99±5^{CC,n}		97.26±5.97^{CC,n}	97.6±6.5^{CC,n}		90.1±8.7^{n,cv}
45. FMIA (°)	57.67	7.78	64.01^{a}	5.98	57.73^{b}	7.40	53.24^{c}	6.97			59.9±5.86^{cc,n,cv}			64.4±8.4^{n,cv}
46. L1-NB (°)	30.48	6.08	26.67^{a}	4.77	30.25^{b}	5.88	33.69^{c}	5.88		30.4±5.61^{cc,cv}	30.22±5.55^{cc,cv}	30.7±4.4^{cc,cv}		24.3±7.2^{cc,n,cv}
47. L1-NB (mm)	5.80	1.80	4.41^{a}	1.65	5.87^{b}	1.61	6.53^{b}	1.90		6.7±2.22^{cc,n}	6.42±2.13^{cc,n}	6.7±1.8^{cc,n}		4.4±2.4^{n,cv}
48. L1-Apg (°)	27.24	5.35	26.73	4.65	27.25	5.48	27.56	5.47			25.17±3.69^{n,CV}			22.9±5.8^{cc,n,CV}
49. L1-Apg (mm)	3.35	1.94	3.21	1.83	3.43	1.91	3.23	2.10			3.49±1.93	4.8±2.1^{cc,n,cv}		2.0±2.3^{cc,n,cv}
Mx-Md relationship														
50. Interincisal angle (°)	122.56	8.77	123.44	7.15	122.51	8.65	122.12	10.15		124.7±8.03^{n,CV}	124.36±7.56^{n,CV}	122.2±6.8		131.2±9.5^{cc,n,CV}
51. Overjet (mm)	2.95	0.67	3.13	0.64	2.89	0.61	2.98	0.82	2±1^{cc,N,cv}		2.68±0.63^{cc,N,cv}			
52. Overbite (mm)	1.56	0.96	1.44	0.69	1.54	1.00	1.67	1.00	2±1^{cc,N,CV}		1.71±1.06^{cc,N}			

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Soft tissue														
53. FCA (°)	10.65	4.41	4.14^{A}	1.36	10.01^{B}	2.25	16.84^{C}	1.98	9±5^{CC,N,CV}					171.9±5.2 Mean 8.1^{CC,N,CV}
54. NLA (°)	98.77	8.30	93.04^{a}	7.54	98.20^{b}	7.54	104.26^{c}	7.74	91±8^{n,cv}			95.0±8.6^{n,cv}		99.9±7.5^{cc,n,cv}
55. Upper NLA (°)	27.39	5.30	25.19^{a}	4.99	27.34^{a,b}	4.96	29.01^{b}	5.93						30.0±5.5^{cc,n}
56. Lower NLA (°)	71.83	6.35	68.14^{a}	4.36	71.36^{b}	5.98	75.65^{c}	6.68						69.9±6.5^{cc,n,cv}
Upper lip														
57. E-line to upper lip (mm)	-0.18	1.90	-1.10^{a}	1.51	-0.27^{a}	1.74	0.68^{B}	2.26			-1.23±1.91^{n,cv}	0.4±1.9^{cc,n}		-1.8±2^{cc,n,cv}
58. Upper lip prominence (mm)	4.96	1.96	6.54^{a}	1.65	4.97^{b}	1.72	3.86^{c}	2.07					5±1^{cc,cv}	4.7±1.6^{cc,cv}
69. B-line to upper lip (mm)	6.52	1.69	6.50	1.73	6.49	1.57	6.60	2.02						5.6±1.5^{cc,n,cv}
60. Ls to facial plane (mm)	20.65	2.85	18.64^{a}	2.92	20.40^{b}	2.45	22.69^{c}	2.68		21.9±2.85^{cc,n}				
61. Ls to G' V (mm)	10.12	4.44	8.65^{a}	4.58	9.92^{a,b}	4.16	11.65^{b}	4.79						9.5±4.9^{cv}
62. Ls to N' V (mm)	15.02	3.65	14.38	4.09	14.89	3.43	15.80	3.89						13.2±4.2^{n,cv}
63. H-angle (°)	17.84	3.21	15.36^{a}	2.53	17.45^{b}	2.63	20.64^{c}	3.24		13.6±3.83^{cc,n,cv}				13.8±3.6^{cc,n,cv}
64. ULL (mm)	21.51	2.00	20.92	1.96	21.60	2.00	21.64	2.00	23±2^{cc,n,cv}					23.1±2.3^{cc,n,cv}

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Soft tissue														
Lower lip														
65. E-line to lower lip (mm)	0.59	2.07	-0.20[a]	1.89	0.63[a,b]	1.91	1.03[b]	2.48			1.68±2.03[cc,n]	1.7±2.0[cc,n]		0.5±2.3[cc]
66. Lower lip prominence (mm)	1.23	3.24	4.45[a]	2.13	1.35[b]	2.74	-1.28[c]	3.15					2±2[cc,n,cv]	1.4±3.1[cc,cv]
67. B-line to lower lip (mm)	4.50	2.12	4.33	2.03	4.55	2.00	4.47	2.53						3.9±2.0[n]
68. Li to facial plane (mm)	17.83	2.59	16.63[a]	2.79	17.70[a]	2.44	19.00[b]	2.45		19.5±2.50[cc,n]				
69. Li to G' V (mm)	6.34	5.15	5.95	4.91	6.33	5.04	6.64	5.68						6.1±5.6
70. Li to N' V (mm)	11.37	4.34	11.77	4.34	11.43	4.23	10.91	4.69						9.8±4.9[cc,n]
71. LLL (mm)	43.48	3.54	42.39	3.97	43.76	3.60	43.40	2.93	46±2[cc,n]					44.5±4[cc,n,cv]
Chin														
72. Soft tissue chin thickness (mm)	11.79	1.89	11.84	2.13	11.77	1.77	11.80	2.06						11.8±1.7
73. Chin prominence (mm)	-5.59	4.53	0.20[a]	2.60	-5.47[b]	3.66	-9.83[c]	3.08					-5±3[cc,cv]	-3.8±5.1[cc,n,cv]
74. Pg' to facial plane (mm)	11.22	1.70	11.47	1.90	11.17	1.62	11.18	1.82		11.6±1.64[n]				
75. Pg' to G' V (mm)	-0.53	6.42	0.87	6.23	-0.43	6.26	-1.77	6.89						0.7±6.6[n]
76. Pg' to N' V (mm)	4.66	5.56	6.82[a]	5.46	4.84[a,b]	5.33	2.70[b]	5.73						4.5±5.9[cc,cv]

Cephalometric variables	Overall (N=207)		ACC group (N=31)		AN group (N=130)		ACV group (N=46)		SK, 1988	SW, 1984	DS, 1994	CM, 2008	NA, 2012	SP, 2020
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Soft tissue														
Nose														
77. Nose prominence (mm)	18.62	1.99	19.73^{a}	2.04	18.52^{b}	2.03	18.17^{b}	1.59						13.1±4.3^{cc,n,cv}
78. Nasal tip to facial plane (mm)	27.24	2.62	25.35^{A}	2.57	26.94^{B}	2.30	29.38^{C}	2.11		29.3±2.88^{CC,n}				
Vertical analysis														
79. UFH (mm)	45.00	3.46	43.70^{a}	3.79	45.06^{a,b}	3.49	45.70^{b}	2.96	48±3^{cc,n,cv}					
80. LFH (mm)	64.68	5.24	64.54	5.39	65.21	5.29	63.28	4.84	69±4^{cc,n,cv}					
Others														
81. Sn to H line (mm)	8.81	2.23	8.93	2.33	8.76	2.07	8.88	2.64						7.1±1.9^{cc,n,cv}
82. ILS to H line (mm)	3.97	1.31	4.10	1.00	3.88	1.35	4.16	1.39						4.4±1.3^{n}
83. Interlabial gap (mm)	1.35	2.16	1.35	1.60	1.30	2.12	1.48	2.60						2.5±1.7^{cc,N,cv}
84. Mentolabial sulcus depth (mm)	-7.51	3.65	-7.06	3.43	-7.61	3.53	-7.53	4.17						-5.2±1^{cc,n,cv}
85. TL (mm)	46.20	5.79	48.39^{a}	5.60	46.39^{a,b}	5.82	44.18^{b}	5.29	58±7^{cc,n,cv}					
86. LCTA (°)	100.79	6.42	97.96^{a}	6.43	100.10^{a}	6.28	104.61^{b}	5.12	115±7^{cc,n,cv}					

(Available Thai norms references were SK, 1988: Sorathesn, K., 1988, SW: Suchato, W., 1984, DS: Dechunakorn, C., et al., 1994, CM: Chaiworawitkul, M., 2008, NA: Nuntasukkasame, A., 2012, SP: Sutthiprapaporn, M., et al., 2020)

4.1. Comparison of the cephalometric measurements among 3 acceptable profile groups

Mean comparison between ACC and AN group represented significant difference on 15 measurements (NSAr(°), SNO(°), SNB(°), Facial depth(°), Pg-NperpFH(mm), ANB(°), Wits appraisal(mm), Convexity of point A(mm), SN-GoGn(°), SN-MP(°), Mandibular arc(°), FMA(°), NSGn(°), PFH:AFH(%), and Facial axis angle(°)) and no significant difference on 20 measurements of skeletal value. There were significant difference on 7 measurements (U1-SN(°), U1-PP(°), U1-NA(°), U1-NA(mm), FMIA(°), L1-NB(°), and L1-NB(mm)) and no significant difference on 10 measurements of dental value. There were significant difference on 10 measurements (FCA(°), NLA(°), Lower NLA(°), Upper lip prominence(mm), Ls to facial plane(mm), H-angle(°), Lower lip prominence(mm), Chin prominence(mm), Nose prominence(mm), and Nasal tip to facial plane(mm)) and no significant difference on 24 measurements of soft tissue value, relating to table 6.

Mean comparison between AN and ACV group represented significant difference on 15 measurements (NSAr(°), SNB(°), Facial depth(°), Pg-NperpFH(mm), Co-Gn(mm), ANB(°), Wits appraisal(mm), Convexity of point A(mm), SN-OP(°), SN-GoGn(°), SN-MP(°), Mandibular arc(°), FMA(°), NSGn(°), and Facial axis angle(°)) and no significant difference on 20 measurements of skeletal value. There were significant difference on 8 measurements (U1-SN(°), U1-PP(°), U1-NA(°), U1-NA(mm), IMPA(°), FMIA(°), L1-NB(°), and L1-NB(mm)) and no significant difference on 9 measurements of dental value. There were significant difference on 19 measurements (FCA(°), NLA(°), Upper NLA(°), Lower NLA(°), E-line to upper lip(mm), Upper lip prominence(mm), Ls to facial plane(mm), Ls to G' V(°), H-angle(°), E-line to lower lip(mm), Lower lip prominence(mm), Li to facial plane(mm), Chin prominence(mm), Pg' to N' V (mm), Nose prominence(mm), Nasal tip to facial plane(mm), TL(mm), and LCTA(°)) and no significant difference on 15 measurements of soft tissue value, relating to table 6.

Mean comparison between ACC and ACV group represented significant difference on 11 measurements (SNB(°), Facial depth(°), Pg-NperpFH(mm), Co-

Gn(mm), ANB(°), Wits appraisal(mm), Convexity of point A(mm), SN-OP(°), NSGn(°), PFH:AFH(%), and Facial axis angle(°)) and no significant difference on 24 measurements of skeletal value. There were significant difference on 7 measurements (U1-SN(°), U1-PP(°), U1-NA(°), U1-NA(mm), IMPA(°), FMIA(°), and L1-NB(°)) and no significant difference on 10 measurements of dental value. There were significant difference on 12 measurements (FCA(°), NLA(°), Lower NLA(°), E-line to upper lip(mm), Upper lip prominence(mm), Ls to facial plane(mm), H-angle(°), Lower lip prominence(mm), Li to facial plane(mm), Chin prominence(mm), Nose prominence(mm), and LCTA(°)) and no significant difference on 22 measurements of soft tissue value, relating to table 6. The predicted esthetically acceptable facial profiles based on established cephalometric values was shown in Figure 4.

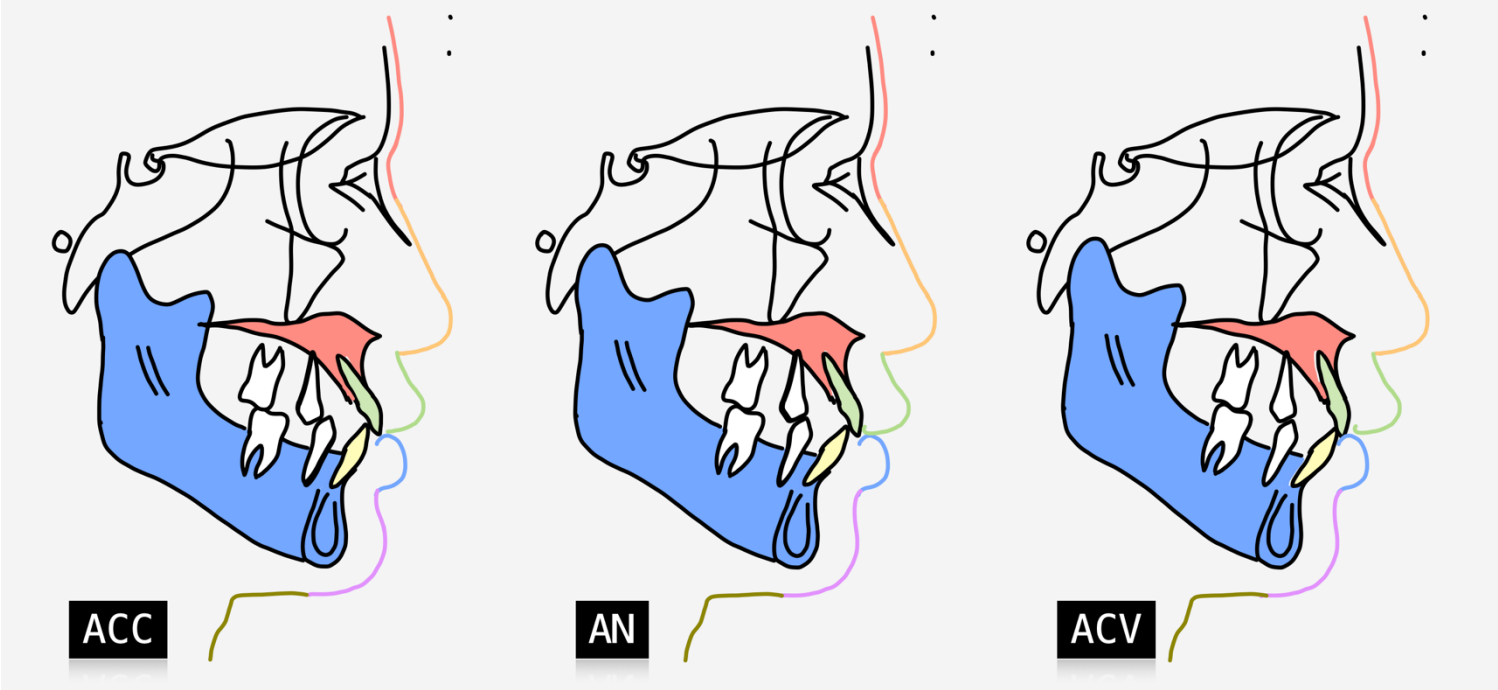

Figure 4 Predicted esthetically acceptable facial profiles based on established cephalometric values

The predicted esthetically acceptable profiles based on established cephalometric values in Figure 4 represented lateral facial profile contour of ACC, AN, and ACV groups.

ACC group showed skeletal Class III and dental base Class III tendency. Upper incisors were protruded and proclined while lower incisors were retruded and retroclined. Lateral profile was flat with protruded upper lip, retruded lower lip and competent lip. Chin position was protruded and the nose was prominent. AN group showed skeletal Class I or II and dental base Class I tendency, similar to dental characteristics in the norms. Lateral profile was straight with protruded upper lip, retruded lower lip and competent lip. Chin position was equal to Thai norms and the nose was prominent. ACV group showed skeletal Class II and dental base Class II tendency. Upper incisors were retruded and retroclined while lower incisors were protruded and proclined. Lateral profile was convex. Upper and lower lips were equal to Thai norms with competent lip. Chin position was retruded and the nose was prominent.

4.2. Comparison between each acceptable profile group and the available Thai norms

4.2.1. Comparison between acceptable normal profile group and the available Thai norms

Mean comparison between AN and available Thai norms represented significant difference on 32 measurements (SN(mm), Anterior cranial base length(mm), FH-SN(°), NSAr(°),NS-Ba(°), SNA(°), SNO(°), O-NA(mm), Maxillary depth(°), A-NperpFH(mm), Co-A(mm), SNB(°), Facial depth(°), Pg-NperpFH(mm), Co-Gn(mm), N-Go(mm), ANB(°), Wits appraisal(mm), Convexity of point A(mm), SN-OP(°), SN-GoGn(°), SN-MP(°), Mandibular arc(°), FMA(°), PP-MP(°), NSGn(°), Lower face height(°), LAFH(mm), PFH:AFH(%), Ar-Go-Gn(°), Facial axis angle(°), and Posterior facial height(mm)) and no significant difference on 3 measurements of skeletal value.

There were significant difference on all 17 measurements (U1-SN(°), U1-PP(°), U1-NA(°), U1-NA(mm), U1-APg(°), U1-APg(mm), ADH(mm), PDH(mm), IMPA(°), FMIA(°),

L1-NB(°), L1-NB(mm), L1-APg(°), L1-APg(mm), Interincisal angle(°), Overjet(mm), and Overbite(mm)) of dental value.

There were significant difference on 29 measurements (FCA(°), NLA(°), Upper NLA(°), Lower NLA(°), E-line to upper lip(mm), Upper lip prominence(mm), B-line to upper lip(mm), Ls to facial plane(mm), Ls to N' V(mm), H-angle(°), ULL(mm), E-line to lower lip(mm), Lower lip prominence(mm), B-line to lower lip(mm), Li to facial plane(mm), Li to N' V(mm), LLL(mm), Chin prominence(mm), Pg' to facial plane(mm), Pg' to G' V(mm), Nose prominence(mm), Nasal tip to facial plane(mm), UFH(mm), LFH(mm), Sn to H line(mm), ILS to H line(mm), Interlabial gap(mm), Mentolabial sulcus depth(mm), TL(mm) and LCTA(°)) and no significant difference on 5 measurements of soft tissue value, relating to table 6.

4.2.2. Comparison between acceptable concave profile group and the available Thai norms

Mean comparison between ACC and available Thai norms represented significant difference on 24 measurements (SN(mm), Anterior cranial base length(mm), FH-SN(°), NSAr(°),NS-Ba(°), SNA(°), SNO(°), O-NA(mm), Maxillary depth(°), A-NperpFH(mm), Co-A(mm), Facial depth(°), Pg-NperpFH(mm), Co-Gn(mm), N-Go(mm), ANB(°), Wits appraisal(mm), Convexity of point A(mm), SN-MP(°), Mandibular arc(°), PP-MP(°), LAFH(mm), Facial axis angle(°), and Posterior facial height(mm)) and no significant difference on 11 measurements of skeletal value.

There were significant difference on all 17 measurements (U1-SN(°), U1-PP(°), U1-NA(°), U1-NA(mm), U1-APg(°), U1-APg(mm), ADH(mm), PDH(mm), IMPA(°), FMIA(°), L1-NB(°), L1-NB(mm), L1-APg(°), L1-APg(mm), Interincisal angle(°), Overjet(mm), and Overbite(mm)) of dental value.

There were significant difference on 26 measurements (FCA(°), NLA(°), Upper NLA(°), Lower NLA(°), E-line to upper lip(mm), Upper lip prominence(mm), B-line to upper lip(mm), Ls to facial plane(mm), H-angle(°), ULL(mm), E-line to lower lip(mm), Lower lip prominence(mm), Li to facial plane(mm), Li to N' V(mm), LLL(mm), Chin prominence(mm), Nose prominence(mm), Nasal tip to facial plane(mm), UFH(mm), LFH(mm), Sn to H line(mm), Interlabial gap(mm), Mentolabial sulcus depth(mm),

TL(mm) and LCTA(°)) and no significant difference on 8 measurements of soft tissue value, relating to table 6.

4.2.3. Comparison between acceptable convex profile group and the available Thai norms

Mean comparison between ACV and available Thai norms represented significant difference on 32 measurements (SN(mm), Anterior cranial base length(mm), FH-SN(°), NSAr(°),NS-Ba(°), SNA(°), SNO(°), O-NA(mm), Maxillary depth(°), A-NperpFH(mm), Co-A(mm), SNB(°), Facial depth(°), Pg-NperpFH(mm), Co-Gn(mm), N-Go(mm), ANB(°), Wits appraisal(mm), Convexity of point A(mm), SN-OP(°), SN-GoGn(°), SN-MP(°), Mandibular arc(°), FMA(°), PP-MP(°), NSGn(°), Lower face height(°), LAFH(mm), UAFH/LAFH Ratio(%), PFH:AFH(%), Ar-Go-Gn(°), Facial axis angle(°), and Posterior facial height(mm)) and no significant difference on 3 measurements of skeletal value.

There were significant difference on all 17 measurements (U1-SN(°), U1-PP(°), U1-NA(°), U1-NA(mm), U1-APg(°), U1-APg(mm), ADH(mm), PDH(mm), IMPA(°), FMIA(°), L1-NB(°), L1-NB(mm), L1-APg(°), L1-APg(mm), Interincisal angle(°), Overjet(mm), and Overbite(mm)) of dental value.

There were significant difference on 22 measurements (FCA(°), NLA(°), Lower NLA(°), E-line to upper lip(mm), Upper lip prominence(mm), B-line to upper lip(mm) Ls to G' V(mm), Ls to N' V(mm), H-angle(°), ULL(mm), Lower lip prominence(mm), LLL(mm), Chin prominence(mm), Pg' to N' V(mm), Nose prominence(mm), UFH(mm), LFH(mm), Sn to H line(mm), Interlabial gap(mm), Mentolabial sulcus depth(mm), TL(mm) and LCTA(°)) and no significant difference on 12 measurements of soft tissue value, relating to table 6.

Chapter 5

Discussion

Only excellent occlusion was unsatisfactory if the esthetic facial profile was not achieved. It is an orthodontist's responsibility to treat these patients to reach their esthetic goals. Since the traditional cephalometric norms[39-42, 44, 45] were not established basing on facial esthetics, except for Sutthiprapaporn, M. study.[45] However, only certified orthodontists's esthetic perceptions were investigated in the previous study. According to Buranaprasertsuk P. Study [15], orthodontic patients' perception on facial profiles were slightly different from orthodontist perceptions. Moreover, modernization was one of the factors affecting esthetic preference of the patients,[15] several Thai cephalometric norms developed more than 20-30 years ago may be outdated. Therefore, in this study, we studied the cephalometric values of the treated orthodontic patients with esthetic facial profiles to create new cephalometric values as treatment goals for each facial profile type, especially for camouflage treatment in modern orthodontics in Thai adult patients with concave and convex profiles.

From Suphatheerawatr et al study [25], patients with FCA 2 to 22 degree were considered to be attractive, with FCA 10 to 14 degree as the most attractive profile. Hence, our study proposed the normal FCA values as 6 to 14 degree, whereas the patient with FCA 2 to <6 degree and >14 to 22 degree were considered as acceptable concave and acceptable convex profiles, respectively.[25]

Our study proceeded with several considerations. Only raters with ICC ≥ 0.5 each were included, and all raters were qualified at least moderate reliability levels [47] (moderate level for intra-rater reliability: 0.517-0.883). Our rating material was a profile silhouette converted from an original lateral cephalometric film from the orthodontic treated patient with adequate information on profile beauty. The importance of converting procedure was to minimize the effect of other facial features, e.g., hair style and color, facial makeup, eyes and eyebrows**,** which may considered as confounding factors for rating process.

In the process of rating, we divided the profile silhouettes into 6 sessions. Fifty-five profile silhouettes for session 1 to 5 and 58 for session 6. Each profile

silhouette was presented to each participant for 5 seconds. Therefore, each session may took around 4 minutes 30 seconds for the first 5 sessions and 4 minutes 45 seconds for the last session. Our method took almost doubling rating period of each session when compared with Sutthiprapaporn, M. study.[45] The fatigue in process of rating process of each rater was the issues in this situation. According to Ko, L. N. study[46], the primary-recency effect indicated that learner attention was explicit in the first 10 minutes, decreasing after every 10 minutes and gained the highest information at the beginning and the end of a session. Consequently a 5-minute period was adequate to retain the attention of each rater in each session.

According to the difference in data collection process, all profile silhouettes were displayed on Apple iPad pro retina display and google form online questionnaires. Originally, the authors designed the data collection and scoring via only iPad pro. Unfortunately, since the outbreak of COVID-19 (Coronavirus disease 2019), the data collection process must be transformed into online questionnaires. The reliability of the difference data collection process was concerned. Therefore, the authors performed ICC for different tools, and the result was 0.795 indicating good reliability.

According to the power of study, sample size estimation of our study was 246. However, the actual sample size in this study was 207 due to more number of drop-out profile silhouettes from attractiveness scoring procedure. The power of study was re-calculated using the formula for testing one population mean from N4studies program, the sample size equal to 207, reference value equal to 9, this value based on the mean of FCA angle from Sorathesn K. study,[39] mean and standard deviation equal to 10.65 and 4.41, this value base on our finding of FCA angle in overall group, and alpha equal to 0.05. The power of study was 1.000, which more than minimum requirement power of each study (0.8). Therefore, sample size of 207 was enough to detect the significant difference in this study.

The attractiveness score of each profile silhouette was 5-point Likert scale which similar to Ghorbanyjavadpour, F. study [23] and Sutthiprapaporn, M. study. [45] The attractiveness score of ≥ 3 (60%) was used to classify each profile as an esthetically acceptable profile in our study. This method was similar to that in

Sutthiprapaporn, M. study [45] , but different from Ghorbanyjavadpour, F. study [23] that required total score ≥ 40 from 50 (80%). According to this method, we could recruite more patients (N = 207). If we changed the criteria as in Ghorbanyjavadpour, F. study [23], the number of acceptable profile silhouettes would be only 45 (concave 6, normal 31, convex 8) which would not provide enough power of study to detect the significant difference.

The esthetically acceptable profile was classified basing on their original FCA classification. The profiles were classified as AN (FCA 6 to 14 degree), ACC (FCA 2 to <6 degree), and ACV (>14 to 22 degree) [25] for subgroup analysis of the cephalometric values among 3 acceptable profiles, which had never been established in previous Thai norms studies. [39-45] The authors aimed to establish the cephalometric values that represented each acceptable profile type as a target of cephalometric values in orthodontic camouflage treatment.

According to attractiveness score, AN group (3.22±0.413) was the most attractive facial profile and ACC group (3.19±0.402) was slightly more acceptable than ACV group (3.17±0.283). Interestingly, focusing on the ratio of acceptable profile in each group, AN group was still the most attractive facial profile (130/173 = 75% pass) but ACV group (46/67 = 69% pass) was extremely more acceptable than ACC group (31/63 = 49% pass). These findings were correlated to the study of Jarungidanan, P. study [31] which indicated that the straight profile was the most popular facial profile and convex profile was more acceptable than concave profile if there was equal deviation from the straight profile for both orthodontists and patients. Moreover, our results also correlate to Soh, J. study [19] which indicated that a normal facial profile was perceived to be highly attractive and a profile with a protrusive mandible was perceived to be the least attractive in Chinese subjects.

Skeletal analysis

All 3 acceptable profile groups of this study had shorter anterior cranial base length than Thai norms[40-42]. greater FH-SN than Thai norms[39, 45], and similar NSAr and NS-Ba to Thai norms[39, 42, 45].These results indicated that esthetically acceptable profiles had short anterior cranial base length and normal position of the condyle and mandible with respect to cranial base.

Maxilla and midface in all groups were slightly retrognathic and shorter than Thai norms.[39-42, 45] Although ACC group showed statistically significantly larger SNO(°) than AN and ACV groups, this cephalometric value may not be clinically significant because the difference was small, and O-NA(mm) were similar in all groups.

All 3 groups presented shorter mandible. AN and ACV groups showed more retrognathic chin and mandible, while ACC group had orthognathic mandibular position with more protrusive chin compared with Thai norms.[39-42, 45] Comparing among 3 groups, there was an increase in mandibular prognathism and chin protrusion from ACV, AN, to ACC group, which related to their lateral profile features.

Maxillomandibular relationship of ACC presented skeletal Class III and dental base Class III tendency, that of AN showed skeletal Class I or II and dental base Class I, and that of ACV showed skeletal Class II and dental base Class II tendency compared with Thai norms.[39-42, 45] These findings were in relation to their lateral profile features. Moreover, our wits appraisal demonstrated more dental base Class III tendency than American and Chinese.[29]

Vertical analysis found that AN and ACV showed greater skeletal openbite tendency, while ACC showed skeletal normal bite tendency compared with Thai norms.[39-42, 44, 45] Among 3 groups, ACV presented greater skeletal openbite tendency, whereas ACC showed the inverted resulted. However, both lower anterior face height and posterior facial height of all groups were shorter than Thai norms whereas other vertical cephalometric analysis indicated skeletal openbite. Therefore, skeletal openbite characteristics may resulted from the shorter PFH, not the longer anterior face height.

Direction of growth in all groups showed shorter posterior facial height when compared with Thai norms[40], indicated that esthetically acceptable profiles had vertical facial pattern or dolichofacial. Facial axis finding indicated that ACC showed more horizontal growth tendency, whereas ACV showed more vertical growth tendency than Thai norms.[40, 45]

Dental analysis

Upper incisor position and inclination of AN group were equal to most of Thai norms.[39-42, 45] However, more proclined and protruded upper incisors were presented

in ACC group, and more retroclined and retruded upper incisors were presented in ACV group when compared with Thai norm.[39-42, 45] In terms of upper incisor to APg both in degree and distance, these values were similar among the 3 groups, and equal to Thai norms.[42, 45] ADH showed shorter than Thai norms[39, 44, 45], whereas PDH showed greater than Thai norms[39, 44, 45], indicating that shorter anterior dental height and longer posterior dental height were considered to be esthetically acceptable.

Lower incisor position and inclination of AN group were equal to most of Thai norms.[39-42, 45] However, more proclined and protruded lower incisors were presented in ACV group, and more retroclined and retruded lower incisors were presented in ACC group when compared with Thai norm.[39-42, 45] In terms of lower incisor to APg both in degree and distance, these values showed greater degree and distance when compared with Thai norms.[40, 45] Our IMPA was equal to American [29] but smaller than Chinese [29], whereas L1-Apg in degree was greater than American but equal to Chinese [29] and L1-Apg in distance was smaller than Chinese [29] but greater than American. [29]

Maxillomandibular relationship showed similar interincisal angle, overjet, and overbite among 3 groups. Interincisal angle was slightly smaller than most of the Thai norms[39-42], and excessively smaller when compared with Sutthiprapaporn, M. study.[45] Overbite was slightly smaller and overjet was slightly greater than Thai norms[39, 40], indicating that slightly flared upper and lower incisors might gave the relative intrusion effect on reduced overbite and increased overjet.

Soft tissue analysis

The overall FCA in our study was slightly greater than Thai norms,[40, 45] indicated that slightly convex profile was preferable. Our esthetically acceptable profile was flatter than Iranian [23], American [29], and Chinese.[29] When compared among 3 groups, ACC group showed the smallest FCA, and ACV group showed the greatest FCA. When compared with Thai norms, ACC showed concave profile, AN showed straight profile, and ACV showed convex profile. Overall results indicated that obtuse NLA was considered more attractive. [29] Overall NLA showed greater than most of Thai norms[40, 42] except Sutthiprapaporn, M. study .[45] When compared among 3 groups, ACC group showed the smallest NLA and ACV group showed the

greatest NLA. When compared with Thai norms ACC group showed acute NLA, AN group showed normal NLA, and ACV group showed obtuse NLA. Upper NLA in all groups showed smaller than Thai norms, whereas Lower NLA showed smaller in ACC group and greater in AN and ACV groups. These findings indicated that ACV group presented obtuse NLA due to more retruded upper incisor and upper lip, whereas ACC group showed acute NLA due to more proclined upper incisor and upper lip. Our results was consistent with Chinese [29] but more acute than Iranian[23] and American. [29]

In aspects of upper lip position referred to E-line, facial plane, G'V, and H-angle, ACC and ACV groups showed the smallest and the greatest cephalometric values, respectively. However, upper lip position referred to SnV in ACC group showed the greatest cephalometric value. Comparing with Thai norms, ACC group showed protruded upper lip position when compared with E-line and SnV, whereas retruded position when compared with facial plane and G'V. AN group showed protruded upper lip position when compared with E-line, equal to Thai norms when compared with SnV and G'V, whereas retruded position when compared with facial plane. ACV group showed protruded upper lip position when compared with E-line and G'V, equal to Thai norms when compared with facial plane, whereas retruded position when compared with SnV. Our esthetically acceptable upper lip prominence was more protruded than Iranian [23], American [29], and Chinese.[29] H-angle was excessively greater than Thai norms in overall subjects which indicated more prominence of upper lip and more retrusive chin in an esthetically acceptable profile. Our results was consistent with Chinese [29] but greater than Iranian[23] and American. [29] . ULL of our study was similar to Iranian.[23] Even though, B-line to upper lip, Ls to N'V and ULL were significantly different from Thai norms, the difference only 1-2 millimeter may not be clinically significant.

In terms of lower lip position referred to E-line and facial plane, ACC and ACV groups showed the smallest and the greatest cephalometric values, respectively, while lower lip position referred to SnV showed the greatest cephalometric value in ACC group. However, lower lip position referred to B-line, G'V, and N'V, and LLL in all groups were similar. Comparing with Thai norms, ACC group showed protruded lower

lip position referred to SnV, whereas retruded position referred to E-line and facial plane. AN group showed equal lower lip position to Thai norms when compared with SnV, whereas retruded position when compared with E-line and facial plane. ACV group showed equal lower lip position to Thai norms when compared with E-line and facial plane, whereas retruded position when compared with SnV. Our lower lip prominence was more protruded than Iranian [23], American [29], and Chinese.[29] Even though, B-line to lower lip, Li to N'V and LLL were significantly different from Thai norms, the difference only 1-2 millimeter may not be clinically significant.

When compared chin position among 3 groups, ACV and ACC groups showed the most retruded and protruded chin referred to SnV and N'V, respectively. However, chin position referred to facial plane and G'V, and soft tissue chin thickness in all groups were similar. When compared with Thai norms, ACC group showed protruded chin tendency, AN group showed chin position equal to Thai norms, and ACV group showed retruded chin tendency. Our acceptable chin prominence was more protruded than American and Chinese.[29]

Comparing nose position referred to SnV among 3 groups, ACV and ACC groups showed the smallest and the greatest cephalometric values, respectively. However, ACV group showed the greatest nasal tip projection referred to facial plane. When compared with Thai norms, ACC and AN groups showed protruded nose referred to SnV, but retruded nose referred to facial plane. ACV group showed protruded nose referred to SnV, whereas similar nose position referred to facial plane when compared with Thai norms. Our findings may help improving the appearance either directly or indirectly by making the lips look less protruded in ACC group.[23] Our esthetically acceptable nose prominence was more protruded than Iranian [23], American [29], and Chinese.[29]

In terms of vertical analysis, ACC and ACV groups showed the smallest and the greatest UFH, respectively, whereas all groups showed similar LFH. When compared with Thai norms, all groups showed shorter UFH and LFH than Thai norms.

When compared other cephalometric values among 3 groups, ACV group showed the smallest TL and the greatest LCTA, but ACC group presented a contrary results. However, all groups showed similar Sn to H line, ILS to H line, interlabial gap,

and mentolabial sulcus depth. When compared with Thai norms, Sn to H line was greater than Thai norms[45] due to more protruded upper lip and more retrusive chin of our findings. Whereas interlabial gap, mentolabial sulcus depth, TL, and LCTA presented smaller than Thai norms, which indicated that more competent lip, deeper mentolabial sulcus, shorter TL and less obtuse LCTA would be an esthetically acceptable profile. Our esthetically acceptable interlabial gap was smaller than Iranian [23], whereas mentolabial sulcus depth was greater than Iranian. [23]

Clinical application

Only patients with initial FCA of 2-22 degree were suitable to use this study's cephalometric values as a treatment goal due to the inclusion criteria of our study. Patient with FCA different from our inclusion criteria may be difficult to achieve esthetically acceptable profile.[25] Therefore, those cases may not be a good candidate for orthodontic camouflage treatment.

Treatment plan for ACC group, skeletal normal bite or slightly skeletal open bite compared with Thai norms was acceptable. Mechanic for mandibular clockwise rotation which decrease chin prominence and increase facial height was acceptable, as long as LAFH and LFH were not exceed 64.41 ±5.42 and 64.68±5.24, respectively. Upper incisor could be more proclined and protruded while lower incisor could be more retroclined and retruded than Thai norms. Reduced FCA, acute NLA, protruded upper lip, retruded lower lip, protruded chin, and prominent nose was acceptable in ACC group.

Treatment plan for AN group, skeletal open bite compared with Thai norms was acceptable. Mechanic for mandibular clockwise rotation which slightly decrease chin prominence and increase facial height was acceptable, as long as LAFH and LFH were not exceed 64.41 ±5.42 and 64.68±5.24, respectively. Upper and lower incisor inclination and position, FCA, and NLA should be maintained equally to Thai norms. Upper lip could be maintained, or slightly protruded, while lower lip position could be maintained or slightly retruded compared with Thai norms. Slightly retrusive chin and prominent nose was acceptable in AN group.

Treatment plan for ACV group, skeletal open bite compared with Thai norms was acceptable. Mechanic for mandibular clockwise rotation which slightly decrease chin prominence and increase facial height was acceptable, as long as LAFH and LFH were not exceed 64.41 ±5.42 and 64.68±5.24, respectively. Upper incisor could be more more retroclined and retruded while lower incisor could be more proclined and protruded than Thai norms. Excessive FCA, obtuse NLA, equally upper lip and lower lip to Thai norms, retruded chin, and prominent nose is acceptable in ACV group.

However, all 3 groups shared similar upper and lower incisor position and inclination relating to A-Pg plane, upper and lower lip position relating to B-line and N'V, even though these values were significantly different from some of the previous Thai norms. Therefore, UI-APg in degree and distance, LI-APg in degree and distance, B-line to upper and lower lip, Ls and Li to N'V which did not show any significant difference among 3 profile types, may be used as universal treatment goals for all group to achieve esthetically acceptable profile. Whereas those significant difference of cephalometric variables shown among 3 profile types may be used as customized treatment goals for each profile type to provide more flexible values than the previous norms which based only on normal profile type.

There were some limitations of this study. Firstly, although we recruited the rater from various occupational background to decrease the differences in perceptional judgement, oral surgeons were not included as a rater. Although Soh, J. study [19] found a strong correlation in the profile assessment between orthodontist and oral surgeons, the other study found a difference in professional opinion showing that orthodontist preferred a flatter profile, whereas oral surgeons preferred a fuller normal Chinese profile.[19] It might affect the users' perception in case the cephalometric values from this study were being used by oral surgeons. Secondly, the present cephalometric values of acceptable profiles were studied only in rest position, thus, they may or may not be perceived as esthetically acceptable in posed smile. Thirdly, the data were only recruited from central region of Thailand and did not represent the nationwide. Our findings showed different cephalometric values comparing with another study of Thai norms which sample geographic area was one

of the factors to be concerned. Moreover, even though the orthodontist plan to move teeth to achieve the cephalometric treatment goals, it may not be possible because alveolar bone housing of the upper and lower incisors is one of the limitations of tooth movement. Therefore, further study should include oral surgeons, consider posed smile esthetics as one factor, and be performed as multi-center setting.

Chapter 6

Conclusion

Our study represented an esthetically acceptable profile of lateral cephalometric values in adult Thais and the recommended cephalometric values for each profile type. For skeletal part, maxilla was more retrusive in all groups comparing with the norms. ACC group had similar mandibular position, but more protrusive chin while ACV and AN groups had more retrusive mandible and chin comparing with the norms. ACC group presented skeletal Class III and dental base Class III tendency, AN group showed skeletal Class I or II and dental base Class I tendency, while ACV group showed skeletal Class II and dental base Class II tendency. ACC had similar vertical relationship, while the others had open bite tendency, ACV group showed the greatest open bite tendency compared with the norms.

For dental part, AN group had similar dental characteristics compared with the norms. ACC group showed more protruded and proclined upper incisors and retruded and retroclined lower incisors while ACV group showed more retruded and retroclined upper incisors and protruded and proclined lower incisors when compared with the norms.

For soft tissue, AN group had similar soft tissue characteristics compared with the norms. ACC group had flatter profile while ACV group had more convex profile compared with the norms. In ACC and AN group, upper lip was protruded and lower lip was retruded. In ACV group, upper and lower lip were equal to Thai norms while chin position was retruded. In AN group, chin position was equal to Thai norms, while protruded chin presented in ACC group. Prominent nose and more competent lip were presented in all groups when compared with the norms.

In clinical application, all 3 esthetically acceptable profile groups had some different skeletal, dental, and soft tissue characteristics from the previous norms. For AN patients, orthodontic treatment could be planned based on previous Thai norms. For the other profiles, orthodontic treatment in ACC patients could be performed with more protruded and proclined upper incisors and more retruded and

retroclined lower incisors than the norms, but with the contrary treatment plan in ACV patients. In summary, different treatment goal based on cephalometric values for each lateral facial profile should be applied to achieve the esthetically acceptable facial profiles.

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APPENDIX

Table 7 Normality test

Variables	ACC group[b] (N=31)	AN group[a] (N=130)	ACV group[b] (N=46)
Cephalometric variables Not normally distributed	N-Go (mm)	SN (mm)	SNO (°)
	Mandibular arc (XiDC-PMXi) (°)	FH-SN (°)	N-Go (mm)
	Posterior facial height (Go-CF) (mm)	Co-Gn (mm)	SN-PP (°)
	IMPA (L1-MP) (°)	SN-GoGn (°)	U1-SN (°)
	Facial Contour Angle (FCA) (G'-Sn-Pg') (°)	FMA (FH-MP(Go-Me)) (°)	U1-PP (°)
	Nasal tip to facial plane (Pn-NPg) (mm)	UAFH/LAFH Ratio (N-ANS/ANS-Me) (%)	U1-NA (°)
		Facial axis angle (BaN-PtmGn) (°)	U1-NA (mm)
		PDH (mm)	U1-Apg (°)
		Overjet (mm)	L1-Apg (°)
		Overbite (mm)	U1-L1 (°)
		Facial Contour Angle (FCA) (G'-Sn-Pg') (°)	Overbite (mm)
		Interlabial gap (Stms-Stmi) (mm)	Facial Contour Angle (FCA) (G'-Sn-Pg') (°)
			Li to G' V (mm)
			Pg' to G' V (mm)

a:Kolmogorov-Smirnov test P-value < 0.05, b:Shapiro-Wilk test P-value < 0.05

Table 8 Normality test of each variable

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	ProfileType	Statistic	df	Sig.	Statistic	df	Sig.
SN	Concave	.073	31	.200*	.985	31	.939
	Normal	.089	130	.013	.976	130	.022
	Convex	.086	46	.200*	.965	46	.177
Anterior Cranial Length	Concave	.095	31	.200*	.968	31	.476
	Normal	.052	130	.200*	.985	130	.173
	Convex	.084	46	.200*	.982	46	.688
FHSN	Concave	.149	31	.076	.944	31	.108
	Normal	.092	130	.009	.956	130	.000
	Convex	.100	46	.200*	.977	46	.491
SNAr	Concave	.144	31	.103	.932	31	.051
	Normal	.049	130	.200*	.987	130	.255
	Convex	.085	46	.200*	.971	46	.296
SNBa	Concave	.129	31	.200*	.949	31	.142
	Normal	.053	130	.200*	.992	130	.705
	Convex	.098	46	.200*	.981	46	.642
SNA	Concave	.115	31	.200*	.966	31	.410
	Normal	.071	130	.188	.985	130	.155
	Convex	.093	46	.200*	.981	46	.665
SNO	Concave	.082	31	.200*	.972	31	.583
	Normal	.062	130	.200*	.994	130	.853
	Convex	.104	46	.200*	.942	46	.023
ONA	Concave	.098	31	.200*	.980	31	.826
	Normal	.055	130	.200*	.987	130	.242
	Convex	.067	46	.200*	.966	46	.191
FHNA	Concave	.083	31	.200*	.989	31	.983
	Normal	.032	130	.200*	.996	130	.959

	Convex	.120	46	.093	.967	46	.208
ANaPerpFH	Concave	.114	31	.200*	.982	31	.863
	Normal	.035	130	.200*	.994	130	.898
	Convex	.109	46	.200*	.968	46	.237
CoA	Concave	.110	31	.200*	.966	31	.411
	Normal	.078	130	.051	.969	130	.004
	Convex	.109	46	.200*	.967	46	.219
SNB	Concave	.086	31	.200*	.978	31	.763
	Normal	.053	130	.200*	.993	130	.773
	Convex	.101	46	.200*	.960	46	.120
FHNPog	Concave	.152	31	.068	.947	31	.127
	Normal	.049	130	.200*	.989	130	.362
	Convex	.074	46	.200*	.985	46	.827
PgNaPerpFH	Concave	.144	31	.102	.948	31	.137
	Normal	.046	130	.200*	.988	130	.317
	Convex	.066	46	.200*	.985	46	.808
CoGn	Concave	.089	31	.200*	.990	31	.989
	Normal	.081	130	.038	.969	130	.004
	Convex	.095	46	.200*	.967	46	.219
NaGo	Concave	.181	31	.011	.793	31	.000
	Normal	.062	130	.200*	.990	130	.477
	Convex	.177	46	.001	.942	46	.024
ANB	Concave	.123	31	.200*	.944	31	.110
	Normal	.054	130	.200*	.994	130	.888
	Convex	.059	46	.200*	.990	46	.963
Wits	Concave	.107	31	.200*	.967	31	.439
	Normal	.053	130	.200*	.991	130	.538
	Convex	.094	46	.200*	.972	46	.339
Cranial Deflectio	Concave	.121	31	.200*	.957	31	.238
	Normal	.044	130	.200*	.990	130	.491

n	Convex	.105	46	.200*	.968	46	.238
ANPog	Concave	.113	31	.200*	.961	31	.307
	Normal	.055	130	.200*	.993	130	.804
	Convex	.095	46	.200*	.987	46	.887
SNOP	Concave	.109	31	.200*	.974	31	.640
	Normal	.058	130	.200*	.975	130	.016
	Convex	.125	46	.069	.973	46	.347
SNGoGN	Concave	.077	31	.200*	.993	31	.999
	Normal	.081	130	.036	.988	130	.302
	Convex	.096	46	.200*	.974	46	.389
SNMP	Concave	.074	31	.200*	.993	31	.998
	Normal	.069	130	.200*	.989	130	.400
	Convex	.075	46	.200*	.981	46	.656
MdArc	Concave	.172	31	.020	.921	31	.025
	Normal	.077	130	.058	.985	130	.162
	Convex	.121	46	.089	.955	46	.072
PPFH	Concave	.138	31	.139	.948	31	.134
	Normal	.034	130	.200*	.991	130	.590
	Convex	.085	46	.200*	.980	46	.624
FMA	Concave	.090	31	.200*	.978	31	.763
	Normal	.080	130	.040	.969	130	.005
	Convex	.094	46	.200*	.967	46	.221
PPMP	Concave	.102	31	.200*	.969	31	.489
	Normal	.050	130	.200*	.996	130	.969
	Convex	.070	46	.200*	.983	46	.740
SNGn	Concave	.095	31	.200*	.971	31	.541
	Normal	.033	130	.200*	.994	130	.835
	Convex	.077	46	.200*	.981	46	.631
Lower	Concave	.116	31	.200*	.968	31	.467
Face	Normal	.057	130	.200*	.986	130	.216

HeightXi	Convex	.091	46	.200*	.982	46	.698
LAFH	Concave	.089	31	.200*	.973	31	.602
	Normal	.042	130	.200*	.991	130	.552
	Convex	.080	46	.200*	.985	46	.812
UAHF/ LAFH ratio	Concave	.093	31	.200*	.976	31	.683
	Normal	.092	130	.009	.966	130	.003
	Convex	.104	46	.200*	.955	46	.076
PFH:AFH	Concave	.085	31	.200*	.978	31	.747
	Normal	.043	130	.200*	.986	130	.199
	Convex	.084	46	.200*	.985	46	.804
ArGoGn	Concave	.129	31	.200*	.932	31	.050
	Normal	.055	130	.200*	.988	130	.298
	Convex	.083	46	.200*	.961	46	.125
FacialAxis	Concave	.105	31	.200*	.955	31	.217
	Normal	.079	130	.044	.987	130	.266
	Convex	.074	46	.200*	.989	46	.946
Post Facial Height GoCF	Concave	.216	31	.001	.781	31	.000
	Normal	.078	130	.053	.984	130	.142
	Convex	.115	46	.154	.967	46	.206
U1SN	Concave	.098	31	.200*	.984	31	.910
	Normal	.037	130	.200*	.995	130	.912
	Convex	.097	46	.200*	.907	46	.001
U1PP	Concave	.107	31	.200*	.953	31	.184
	Normal	.057	130	.200*	.990	130	.480
	Convex	.094	46	.200*	.909	46	.002
U1NA degree	Concave	.164	31	.033	.955	31	.216
	Normal	.067	130	.200*	.995	130	.926
	Convex	.111	46	.198	.910	46	.002
U1NAmm	Concave	.093	31	.200*	.969	31	.488

	Normal	.062	130	.200*	.989	130	.374
	Convex	.131	46	.047	.932	46	.010
U1Apog degree	Concave	.100	31	.200*	.968	31	.474
	Normal	.042	130	.200*	.995	130	.944
	Convex	.105	46	.200*	.905	46	.001
U1Apog mm	Concave	.088	31	.200*	.986	31	.944
	Normal	.054	130	.200*	.988	130	.311
	Convex	.088	46	.200*	.975	46	.403
ADH	Concave	.095	31	.200*	.977	31	.723
	Normal	.045	130	.200*	.994	130	.897
	Convex	.082	46	.200*	.986	46	.864
PDH	Concave	.081	31	.200*	.983	31	.889
	Normal	.087	130	.018	.982	130	.078
	Convex	.080	46	.200*	.985	46	.792
U6PTV	Concave	.119	31	.200*	.960	31	.284
	Normal	.044	130	.200*	.995	130	.907
	Convex	.067	46	.200*	.989	46	.946
IMPA	Concave	.190	31	.006	.881	31	.003
	Normal	.049	130	.200*	.986	130	.184
	Convex	.082	46	.200*	.951	46	.050
FMIA	Concave	.124	31	.200*	.944	31	.106
	Normal	.051	130	.200*	.974	130	.015
	Convex	.097	46	.200*	.975	46	.403
L1NB degree	Concave	.105	31	.200*	.968	31	.479
	Normal	.066	130	.200*	.961	130	.001
	Convex	.102	46	.200*	.971	46	.305
L1NBmm	Concave	.092	31	.200*	.987	31	.961
	Normal	.049	130	.200*	.984	130	.122
	Convex	.051	46	.200*	.986	46	.849
L1Apog	Concave	.072	31	.200*	.977	31	.736

degree	Normal	.056	130	.200*	.961	130	.001
	Convex	.123	46	.081	.949	46	.042
L1Apog	Concave	.136	31	.153	.948	31	.141
mm	Normal	.060	130	.200*	.991	130	.585
	Convex	.096	46	.200*	.971	46	.298
U1L1	Concave	.079	31	.200*	.985	31	.938
	Normal	.070	130	.200*	.983	130	.116
	Convex	.112	46	.184	.884	46	.000
OJ	Concave	.123	31	.200*	.945	31	.112
	Normal	.094	130	.007	.966	130	.002
	Convex	.113	46	.178	.965	46	.180
OB	Concave	.147	31	.088	.946	31	.122
	Normal	.114	130	.000	.939	130	.000
	Convex	.176	46	.001	.859	46	.000
FCA	Concave	.148	31	.082	.890	31	.004
	Normal	.084	130	.024	.962	130	.001
	Convex	.098	46	.200*	.950	46	.048
NLA	Concave	.118	31	.200*	.958	31	.252
	Normal	.060	130	.200*	.991	130	.522
	Convex	.127	46	.059	.974	46	.395
Upper	Concave	.083	31	.200*	.977	31	.733
NLA	Normal	.069	130	.200*	.988	130	.303
	Convex	.104	46	.200*	.967	46	.223
Lower	Concave	.109	31	.200*	.939	31	.078
NLA	Normal	.041	130	.200*	.996	130	.984
	Convex	.106	46	.200*	.969	46	.256
UpperLip	Concave	.138	31	.142	.943	31	.103
toELine	Normal	.047	130	.200*	.992	130	.679
	Convex	.080	46	.200*	.985	46	.802
UpperLip	Concave	.114	31	.200*	.957	31	.244

toSnV	Normal	.049	130	.200*	.992	130	.651
	Convex	.113	46	.175	.974	46	.378
UpperLip toSnPg	Concave	.141	31	.117	.958	31	.266
	Normal	.063	130	.200*	.989	130	.373
	Convex	.117	46	.133	.970	46	.268
LstoNPog	Concave	.098	31	.200*	.950	31	.156
	Normal	.064	130	.200*	.990	130	.488
	Convex	.083	46	.200*	.965	46	.175
UpperLip toVG	Concave	.103	31	.200*	.975	31	.668
	Normal	.050	130	.200*	.995	130	.904
	Convex	.105	46	.200*	.965	46	.185
UpprLip toVN	Concave	.150	31	.072	.940	31	.082
	Normal	.063	130	.200*	.992	130	.641
	Convex	.092	46	.200*	.971	46	.311
HAngle	Concave	.139	31	.132	.961	31	.301
	Normal	.046	130	.200*	.993	130	.802
	Convex	.110	46	.200*	.971	46	.296
ULL	Concave	.087	31	.200*	.981	31	.840
	Normal	.068	130	.200*	.994	130	.834
	Convex	.113	46	.178	.970	46	.287
LowerLip toELine	Concave	.077	31	.200*	.970	31	.512
	Normal	.060	130	.200*	.992	130	.689
	Convex	.065	46	.200*	.992	46	.988
LowerLip toSnV	Concave	.132	31	.184	.955	31	.220
	Normal	.067	130	.200*	.987	130	.254
	Convex	.085	46	.200*	.982	46	.671
LowerLip toSnPg	Concave	.086	31	.200*	.976	31	.696
	Normal	.060	130	.200*	.988	130	.328
	Convex	.098	46	.200*	.982	46	.699
LitoNPog	Concave	.121	31	.200*	.959	31	.271

	Normal	.056	130	.200*	.993	130	.749
	Convex	.108	46	.200*	.970	46	.272
LowerLiptoVG	Concave	.085	31	.200*	.981	31	.831
	Normal	.038	130	.200*	.994	130	.834
	Convex	.138	46	.028	.948	46	.040
LowerLiptoVN	Concave	.093	31	.200*	.976	31	.685
	Normal	.032	130	.200*	.993	130	.741
	Convex	.108	46	.200*	.955	46	.074
LLL	Concave	.121	31	.200*	.952	31	.182
	Normal	.074	130	.077	.988	130	.292
	Convex	.063	46	.200*	.987	46	.893
Chin Thickness	Concave	.131	31	.191	.937	31	.069
	Normal	.049	130	.200*	.985	130	.151
	Convex	.107	46	.200*	.981	46	.662
PgtoSnV	Concave	.096	31	.200*	.964	31	.374
	Normal	.039	130	.200*	.991	130	.600
	Convex	.082	46	.200*	.985	46	.807
PgtoNPog	Concave	.131	31	.185	.955	31	.219
	Normal	.060	130	.200*	.977	130	.027
	Convex	.083	46	.200*	.981	46	.641
PgtoVG	Concave	.076	31	.200*	.975	31	.678
	Normal	.048	130	.200*	.989	130	.427
	Convex	.144	46	.018	.940	46	.020
PgtoVN	Concave	.107	31	.200*	.964	31	.376
	Normal	.045	130	.200*	.979	130	.041
	Convex	.109	46	.200*	.982	46	.678
NoseProminence	Concave	.143	31	.109	.941	31	.086
	Normal	.044	130	.200*	.993	130	.814
	Convex	.074	46	.200*	.987	46	.892
PntoNPog	Concave	.138	31	.137	.918	31	.021

	Normal	.059	130	.200*	.988	130	.302
	Convex	.061	46	.200*	.987	46	.887
UFH	Concave	.093	31	.200*	.964	31	.367
	Normal	.046	130	.200*	.992	130	.672
	Convex	.089	46	.200*	.978	46	.540
LFH	Concave	.117	31	.200*	.973	31	.594
	Normal	.039	130	.200*	.991	130	.615
	Convex	.065	46	.200*	.982	46	.679
Snto HLine	Concave	.107	31	.200*	.961	31	.317
	Normal	.072	130	.099	.985	130	.171
	Convex	.108	46	.200*	.969	46	.255
IStoHLine	Concave	.112	31	.200*	.983	31	.880
	Normal	.060	130	.200*	.990	130	.459
	Convex	.080	46	.200*	.972	46	.342
Interlabial Gap	Concave	.109	31	.200*	.979	31	.798
	Normal	.132	130	.000	.963	130	.001
	Convex	.172	46	.002	.923	46	.005
Mento Labial sulcus	Concave	.069	31	.200*	.967	31	.449
	Normal	.074	130	.079	.984	130	.122
	Convex	.062	46	.200*	.979	46	.556
TL	Concave	.076	31	.200*	.964	31	.365
	Normal	.042	130	.200*	.992	130	.665
	Convex	.126	46	.065	.965	46	.181
LCTA	Concave	.122	31	.200*	.941	31	.085
	Normal	.074	130	.079	.986	130	.215
	Convex	.080	46	.200*	.971	46	.289

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

VITA

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