The Correlations between Soft and Hard Tissues Measurements in Convex Profile Patients

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์ เพื่อสำรวจลักษณะรูปแบบของโครงสร้างเนื้อเยื่ออ่อนและหาความสัมพันธ์ระหว่างโครงสร้างเนื้อเยื่ออ่อนและเนื้อเยื่อแข็งในคนไทยเพศหญิงกลุ่มหนึ่งอายุระหว่าง 18-44 ปี คัดเลือกภาพรังสีกะโหลกศีรษะด้านข้างของผู้ป่วยก่อนเริ่มการรักษาทางทันตกรรมจัดฟัน จากคลินิกทันตกรรมจัดฟัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ จำนวน 130 ภาพ มีรูปร่างใบหน้าด้านข้างอูม ลอกลายภาพรังสี กำหนดจุดอ้างอิงโดยผู้วิจัยคนเดียว และวัดค่าเซฟาโลเมตริกต่างๆของภาพรังสีทั้งหมด โดยใช้โปรแกรม Dentofacial planner plus version 2.02 สำรวจลักษณะใบหน้าด้านข้างจากโครงสร้างเนื้อเยื่ออ่อน วิเคราะห์ความแตกต่างระหว่างค่าเซฟาโลเมตริกของโครงสร้างเนื้อเยื่อแข็งที่พบในโครงสร้างเนื้อเยื่ออ่อนแต่ละกลุ่ม จากกลุ่มตัวอย่างพบว่า ลักษณะรูปร่างใบหน้าด้านข้าง 3 อันดับแรกที่พบมากที่สุด คือร้อยละ 40.8 มีตำแหน่ง Sn ยื่น มากกว่าปกติร่วมกับ Pg' อยู่ในตำแหน่งปกติ ร้อยละ 21.5 มีตำแหน่ง Sn ปกติร่วมกับมีตำแหน่ง Pg' อยู่หลังกว่าปกติ และร้อยละ 15.4 มีตำแหน่ง Sn ยื่นกว่าปกติร่วมกับตำแหน่ง Pg' อยู่หลังกว่าปกติ โครงสร้างเนื้อเยื่อแข็งที่พบมีความแตกต่างระหว่างกลุ่มของเนื้อเยื่ออ่อนในทิศทางเดียวกัน แต่จะไม่แตกต่างกันเมื่อวัดโครงสร้างเนื้อเยื่อแข็งด้วยค่าความยาวขากรรไกรบน (Co-A)และความยาวขากรรไกรล่าง (Co-Gn) ความผิดปกติของเนื้อเยื่ออ่อนที่พบจะมีความสัมพันธ์กับการวิเคราะห์ลักษณะเนื้อเยื่อแข็งด้วยการวัดค่า A-Nperp และ Pg-Nperp มากที่สุดซึ่งมีระนาบแฟรงค์เฟิร์ตเป็นระนาบอ้างอิงที่ใช้วัดอันเดียวกัน ปัญหาความสวยงามของเนื้อเยื่ออ่อนที่พบอาจไม่มีลักษณะที่สอดคล้องไปกับการวิเคราะห์ลักษณะโครงสร้างเนื้อเยื่อแข็งจากภาพรังสีกะโหลกศีรษะด้านข้างเสมอ และการประเมินโครงสร้างทั้งสองส่วนควรใช้วิธีการวัดที่มีเส้นอ้างอิงเดียวกัน

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ABSTRACT

The aim of the study was to investigate characteristics of soft tissue profile and relationships of soft and hard tissues measurements in a group of Thai females with convex facial profile. Pretreatment of lateral cephalograms of 130 females with convex profile, age range 18-44 years old, were utilized in this study. All films were traced and digitized by one investigator. Tracings were measured for soft and hard tissue cephalometric parameters by a software program (Dentofacial planner plus version 2.02). The three most common anteroposterior characteristics of convex facial profile were anterior Sn position combined with normal position of Pg' (40.8%), normal position of Sn with posterior position of Pg' (21.5%), and anterior Sn position with posterior Pg' position (15.4%). Hard tissue measurements were correspondent with soft tissue measurements, except measured with Co-A and Co-Gn. Soft tissue profile evaluation in convex patients were most related with hard tissue measured by A-Nperp and Pg-Nperp. Soft tissue esthetic problems may not represent with abnormality of hard tissue value. Soft and hard tissue evaluation, if it is necessary to be performed, should be made together with same reference line.

Keywords: Cephalometric, facial profile, convex, soft tissue

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Sajjaporn Pakanant

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LIST OF ABBREVIATIONS

deg.	=	Degree
FCA	=	Facial contour angle
FH	=	Frankfort Horizontal plane
FMA	=	Frankfort mandibular plane angle
G′	=	Glabella
Gn	=	Gnathion
Gn′	=	Soft tissue gnathion
Go	=	Gonion
mm.	=	Millimeter
MP	=	The mandibular plane
MxDpt	=	Maxillary Depth
N	=	Nasion
Nperp	=	Nasion perpendicular
Or	=	Orbitale
Po	=	Porion
Pg	=	Pogonion
Pg′	=	The soft tissue pogonion
S	=	Sella Turcica
Sn	=	Subnasale

CHAPTER 1

INTRODUCTION

Background and rationale

The objective of orthodontic treatment is not only well-aligned dental arches in an optimal occlusal relationship, but also a well-balanced and proportional face that is esthetically pleasing.

Since 1999, the soft tissue paradigm was introduced by Ackerman, Proffit and Sarver[1] for orthodontic treatment planning. Clinicians must establish treatment plans for the dentition and facial skeletal changes based on harmony of soft tissue outcomes.

From the orthodontic viewpoint, a person's facial type is best described by the relative antero-posterior relationship of the forehead, middle face (maxilla) and lower face (mandible). The contours of the face reflect the underlying facial skeleton, so skeletal disproportions inevitably affect the facial soft tissues. The more retrognathic and convex a face is, and the greater the antero-posterior differential between maxillary and mandibular denture bases are.

Convex profile is a common characteristic found in Class II malocclusion which is not a single clinical entity but as the outcome of numerous combinations of skeletal and dental components.[2] Variable characteristics of class II malocclusion can be related to maxillary skeletal protrusion, maxillary dentoalveolar protrusion, mandibular dentoalveolar retrusion, or mandibular skeletal retrusion.[2,3]

Besides clinical examination of facial soft tissue, cephalometric analysis is one of useful diagnostic tools for evaluating soft tissue characteristics that correlate to the underlying skeletal and dentoalveolar structure. Understanding the correlations of hard and soft tissue facial structure will be the useful baseline data in orthodontic treatment planning according to soft tissue paradigm.

Definition of key term

Lateral cephalometric radiograph: A radiograph of the head taken with the x-ray beam perpendicular to the patient's sagittal plane. The beam enters on the patients right side, with the film cassette adjacent to the patient's left side. The distance between x-ray source and the midsagittal plane of the subject is either 5 feet or 150 cm. The distance between the midsagittal plane of the subject and the film is 13 cm. The head is held in Frankfort horizontal plane parallel to the floor.

Cephalometric tracing: An overlay drawing produced from a cephalometric radiograph by copying specific outlines from it with a lead pencil onto acetate paper, using an illuminated view-box. Tracings are used to facilitate cephalometric analysis.

Review of Literatures

The orthodontic specialty has been at the forefront in the assessment of the facial soft-tissue profile from the use of lateral cephalometric radiographs that provide many analyses.[4-11]

Since the establishment of orthodontic specialty over 100 years ago, orthodontic theory and practice have been based on the Angle paradigm. The goal of treatment was to produce perfect occlusion of all the teeth, and facial beauty was thought to follow. Although relying on cephalometric dentoskeletal analysis for treatment planning can sometimes lead to esthetic problems especially when orthodontist try to predict soft tissue outcome using only hard tissue normal values, the basic idea that the dentofacial skeleton determined the goals of treatment remained intact.

Current concepts of the soft-tissue paradigm focus the diagnosis and treatment of dentofacial problems on the soft tissues of the faces rather than on dentoskeletal structures, has emerged in orthodontics and orthognathic surgery.[12] The dentoskeletal structures of the face are like the scaffold over which the soft tissue drape.[13] Proffit et al.[14] have led the way in the emergence of this paradigm shift. Clinicians must establish treatment plans for the dentition and facial skeletal changes based on their desired soft tissue outcomes. After that, an important aspect of orthodontic diagnosis and treatment depends on placing the dentition in the skeleton to achieve maximum soft-tissue esthetics.

Facial profile assessment

Sarver and Jacobson[15] refer to the esthetic portion of orthodontic diagnosis and treatment as "enhancement of appearance". They outline the diagnosis and treatment planning of appearance into three major areas that serve as a framework for systematic evaluation of the esthetic needs of each particular patient. In the macroesthetics encompasses the face in all three planes of space. There are frontal, oblique and profile view. The profile characteristics are evaluated in natural head position. Facial profiles can be found in straight, concave or convex. Lip, chin and nose are important in profile evaluation. The assessments of profile consist of proportion of vertical facial thirds, nasolabial angle, nose projection, lip projection, labiomental angle, chin projection, lip chin throat angle, chin-neck length and chin-neck angle (cervicomental angle). The profile evaluations of miniesthetic are overjet and incisor angulation.

Frankfort horizontal plane and Sella-nasion line

Frankfort horizontal plane (FH) has been generally recognized as the reference plane for the skull and hass proven to be of much value to orthodontists. With the introduction of the cephalogram, the anterior cranial base represented by the sell-nasion line (SN) gained great significance.

The relationship between two reference planes was demonstrated in 1957 by Daugaard-Jensen, who registered in her collective an almost constant mean angle of 7 degree during growth.[16]

The relationship of these 2 reference planes was shown to increased during growth by a mean of 3.1 degree.[17] A broad variation in the FH-SN angle was found in difference group of samples, indicating that this angle is characteristic for each person and remains virtually constant on average during growth.

Soft tissue cephalometric measurements

Facial harmony: The first in harmony examinations. The upper face, midface and chin are related via the facial angle (G'-Sn-Pg'). The facial angle by itself, does not identify the source of disharmony but does measure the product of all other factors.

Dental and skeletal normals or averages were established for the general population.[4, 18, 19] It became convenient to define facial beauty based on these normals, and this had inherent problems[20, 21] for the following reasons:

- An assumption was made that if the dental and skeletal values were normal, the face would also be normal. Studies[22, 23] have shown that there is no correlation for this.
- The normals were obtained from patient samples which included individuals with malocclusions. The findings were not based on ideal faces and occlusions.
- The position of the dentition within the skeletal pattern was related primarily to cranial base structures. While these references were helpful in normal facial patterns, the cranial landmarks themselves (for examples sella. Porion and orbitale) showed significant variability of position in patients with more severe facial disharmony, and the landmarks were often difficult to locate.

Lateral cephalometric radiographs routinely used in orthodontic diagnosis. Dentoskeletal and facial profile measurements are important information in treatment planning for individual patient.

A cephalometric evaluation of craniofacial complex requires a plane of reference from which to assess the location of various anatomical structures. Traditional two planes have been used, namely the Sella-nasion (SN) plane and the Frankfort horizontal (FH) plane. SN plane may provide erroneous information if the inclination of this plane is either too high or too low. A sella turcica positioned to a great extent superiorly or inferiorly would account for a low or high inclination of the SN plane, respectively.

Frankfort horizontal plane has also been used extensively in cephalometry. Despite the difficulty in locating porion reproducibly, the Frankfort horizontal has been advocated to more accurately represent the clinical impression of jaw position.[24]

As an alternative, Legan and Burstone[25] suggest using a constructed horizontal. This is a line drawn through nasion at an angle of 7 degrees to the SN line. This constructed horizontal tends to be parallel to true horizontal. However, in cases in which SN is excessively angulated, even the constructed horizontal would not approximate true horizontal, in which case an alternative reference line must be sought. (Fig.1)

Another approach involves obtaining the cephalogram with the head in the natural head position.[26] This approach offers the advantage that natural head position approximates the position in which clinical judgments are made. Its drawbacks include strict adherence to technique and difficulty in conducting studies where cephalograms have been obtained from various facilities.

Evaluation of facial profile in cephalometric is proposed by many authors. They have suggested utilizing soft tissue analysis as a reliable guide for occlusal treatment and attendant soft tissue changes.[9, 10, 25, 20-23, 27-30]

Facial convexity

In 1980, Legan and Burstone[25] designed soft tissue cephalometric analysis to determine what would be most desirable in facial esthetics. Typically, the overall facial demonstrates mild convexity. The angle of facial convexity, or facial contour angle is formed by the line glabella (G′) to subnasale (Sn) and the line Sn to soft tissue pogonion (Pg′). A clockwise angle is positive and a counterclockwise angle is a negative. As the positive angle increased, the profile becomes more convex, suggest in a Class II skeletal and dental relationship. However, the angle of facial convexity is not a specific to the location of the deformity. (Fig.1)

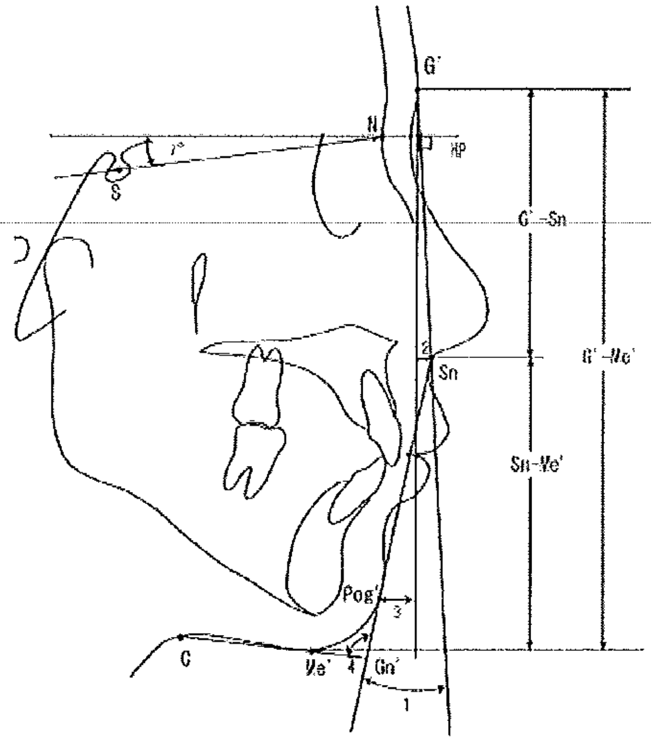

Fig.1 Legan-Burstone soft-tissue analysis of facial form: 1,Facial convexity angle (G-Sn-Pg'); 2, maxillary prognathism (G-Sn); 3, mandibular prognathism (G-Pg'); 4, lower face throat angle (Sn-Gn'-C); vertical height ratio, G-Sn/Sn-Me'; lower vertical height-depth ratio, Sn-Gn'/C-Gn'; horizontal reference plane (HP), constructed by drawing a line through nasion (N) 7° up from the sella (S)-N line.

The profile angle was used to assess convexity or concavity of the facial profile. According to Bergman[8], a Class I subject presented an angle range of 165 – 175 degrees. This decreased in Class II and increased in Class III. The last part of the facial harmony evaluation assesses the upper face, midface, and chin which are related via the facial angle (G'–Sn–Pog'). The forehead is compared to two specific points, the upper jaw (G'–A') and chin (G'–Pg'). Arnett *et al.*[31] indicated that these three measurements give the broad picture of facial balance. It was determined that the standard value for facial angle, glabella'–A point', and glabella'–pogonion' is 167.00 ± 5.18, 6.60 ± 1.55, and 1.97 ± 5.37 mm, respectively. All full facial harmony measurements showed no significant gender dimorphism.

Burstone[27] measured facial convexity in young adult whites, the facial contour angle was 11.3°. In study of Sorathesn[32] in Thai, facial contour angle of adult normal profile were 9 ± 4 degrees in male and 9 ± 5 degrees in female.

Subnasale and Chin position

Gonzales-Ulloa[33] suggested dropping a vertical line (Zero-meridian line) to evaluate the position of the chin. The vertical line is constructed through soft-tissue glabella and perpendicular to the Frankfort horizontal. They stated that in most faces considered to be "beautiful" the soft-tissue chin fell on this vertical plane.

In 1972, Andrews[34] proposed a method to determine ideal anteroposterior (AP) jaw position, which in turn optimizes the esthetics of the soft tissue profile. The frontal plane is used with the forehead inclination to locate the goal anterior limit line (GALL), which is then used to measure the quality of the AP positions of the jaws. The AP position of the GALL changes according to angulation of the forehead, so that a steeply angulated forehead will have a more anteriorly placed GALL, and a flat forehead will have a more posteriorly positioned GALL. The rationale for using the forehead to determine the goal for the maxillary incisors includes the concept that, in persons with facial harmony, there is a correlation between the prominence and the inclination of the forehead and the AP positions of the teeth and jaws.

Andrews[34] also favors the forehead as a stable landmark because, unlike internal radiographic landmarks, it is a part of the face, and its relationship to the incisors is predictable and repeatable. He concludes that people, trained or untrained, are sensitive to the incorrect A-P relationship of the maxillary incisor to the forehead and that this is the method that society unconsciously uses in determining profile acceptance. If this is true, disrupting a harmonious forehead-to-incisor relationship should yield uniform profile rejection among orthodontic professionals and lay judges.

Legan and Burstone[25] used a line perpendicular to the horizontal plane (HP), which dropped from glabella and the relationship of the maxilla and mandible are related to it to determine whether the problem is maxilla or mandible. The distance to subnasale from this vertical line measured parallel to the horizontal plane describes the amount of maxillary excess or deficiency in the anteroposterior dimension.

The position of soft tissue pogonion is also measured parallel to HP from the perpendicular line dropped from glabella. This measurement gives an indication of mandibular prognathism or retrognathism; that is, as the magnitude of mandibular deficiency becomes more severe, the more negative the measurement G'-Pg'(HP) becomes. However, this measurement must be evaluated in conjunction with others to distinguish between microgenia, micrognathia, or retrognathia. In other words, if Pg' is positioned posteriorly, further examination is necessary to determine whether the cause is a small hard tissue chin, small mandible, average-sized mandible positioned posteriorly, thin soft tissue chin, or a combination of these.

Normal values of horizontal distance from a vertical perpendicular dropped from the glabella to subnasale and soft tissue pogonion are 6 ± 3 and 0 ± 4 mm., respectively.

Scheideman, et al.[35] studied the anteroposterior points on the soft tissue profile below the nose. They dropped a true vertical plane from the natural head position through subnasale and measured lip and chin relationships to this line. They also assessed vertical soft tissue relationships of the face.

The soft tissue cephalometric analysis(STCA) of Arnett, *et al.*[31] is a radiographic analysis that correlates various facial hard- and soft-tissue structures that determine balance and harmony as well as to a true vertical line (TVL), in both the sagittal and vertical planes. It also emphasizes the importance of clinical facial assessment of the patient, to augment and elucidate cephalometric findings.

The harmony values were created to measure facial structure balance and harmony. Harmony or balance between different facial landmarks is an important component of beauty. It is the position of each landmark relative to other landmarks that determines the facial balance. Harmony values represent the horizontal distance between 2 landmarks measured perpendicular to the true vertical line. Harmony values examine four areas of balance: intramandibular parts, interjaw, orbits to jaws, and the total face. The following harmony groupings are essential to excellent dentofacial outcomes.

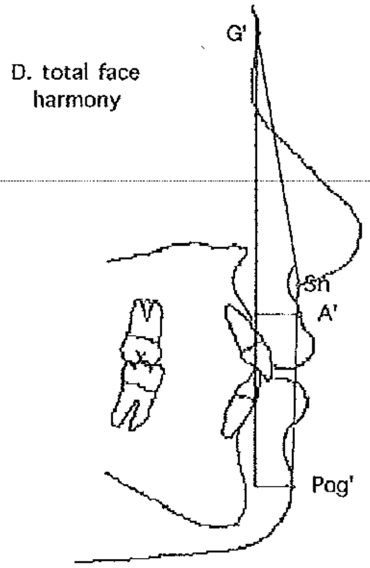

Fig. 2 Total face harmony by Arnett, *et al*[31].

All values are calculated from the horizontal difference between points as calculated from the TVL. Total face harmony: relationships between the forehead, upper jaw, and lower jaw that determine balance are measured, facial angle (G′-Sn-Pg′), forehead at glabella to upper jaw at soft tissue point A, and forehead at glabella to lower jaw at Pg′. (Fig.2)

Relationship between soft tissue and the underlying dentoskeletal structures

Both the soft-tissue structures and the skeletal determine facial harmony and balance.[36] However, most of the visual impact of the face is provided by the structure of the overlying soft tissues and their relative proportions.[37, 38]

Riedel[39] was one of the first to directly investigate the relationships between the morphology of the lips and the underlying dentoskeletal structures. His sample included a variety of occlusions, and the average subject age of 19 years is well past the age for significant growth. He considered the soft tissue profile to be related to the underlying dental and skeletal structures, and also stressed the importance of individual variation.

Park and Burstone[23] studied the relationship between the soft tissue profile and hard tissue standards. Their subjects were randomly selected with lower incisor placed about 1.5

mm. anterior to A-Pg line. They found that there was a big variation of lip protrusion between 5-10 mm. relative to Subnasale-Pogonion line, even though the lower incisors were in same position.

Saxby and Freer[40] concluded that the position of the lower incisor was more important that its inclination to reflect with lower lip convexity and soft tissue-B-point. Overbite was most correlated with the horizontal position of soft tissue B-point, and slightly correlated with the position of soft tissue-A-point, while overjet was considerably related only with upper lip convexity. Correlations with the angulation and position of the upper incisors suggest that they are very important determinants of the associated soft tissue morphology.

Kasai[41] found that soft tissue profile would not totally respond to the underlying skeletal changes during orthodontic treatment. He agreed with Saxby and Freer that the stomion and lower lip changes correlated with the hard tissue changes, whereas the upper lip and soft tissue chin were dependent on the position of the jaws. However, other components of soft tissue profile seemed to be independent of changes of the dentoskeletal structures.

Bergman[8] presented a cephalometric-based facial analysis. Relying solely on skeletal analysis, assuming that the face will balance if the skeletal and dental cephalometric values are normalized, may not yield the desired soft tissue outcome. Thus good occlusion does not necessarily mean good facial balance.

Bittner and Pancherz[42] studied the relationship between the facial morphology and malocclusion. Large overjet (more than 5 mm.) would be easily recognized from the facial photographs, while overbite, openbite, and negative overjet could not be detectd at all from photographs. Sagittal position of the maxilla was determined reliably except in the group with retrognathic maxilla, whereas it was difficult to categorize the sagittal position of the mandible from the pictures in three groups with normal, prognathic, and retrognathic mandible. They concluded that the sagittal and vertical intermaxillary tooth and jaw mal-relationships only partly affected the facial esthetics.

Errors of measurement

Systematic error (or bias): systematic error which implies a bias in the recording and measuring system to produce difference from the true ones. It can arise in obtaining lateral cephalometric radiographs if the geometry of the system varies and no compensation is made. When two series of radiographs are measured by different persons who have different concepts of a particular landmark, there will again be a systematic error. This can happen when more than one observer is involved, but it can arise over a period of time if a single observer's practice changes with experience. Thus, one series of measurements may differ systematically from a series made at a different time. Randomization of record measurement is one of the most important methods of avoiding bias.

Random error: random errors can arise as a result of variations in positioning of the patient in the cephalostat. Soft-tissue points in particular are affected by the way the patient is posed. Variations in film density and sharpness also lead to random errors. Perhaps the greaest source of random errors is difficulty in identifying a particular landmark or imprecision in its definition. Many landmarks are difficult to identify, and the observer's opinion about the exact location of the point may vary at random. For example, if pogonion is defined as the most anterior point on the bony chin with no control over the orientation of the head, random errors will again be introduced. A number of attempts have been made to improve the precision of definitions, but the problem remains and must be recognized.

The purpose of the research

To investigate craniofacial morphology and relationship between soft and hard tissues using lateral cephalometric analyses in Thai patients with convex profile.

Significance of the study

1. Know about characteristics of structure and correlation of soft and hard tissue measurements in convex profile Thai patients.
2. To be useful data in diagnosis and treatment planning of convex profile patients.
3. To be fundamental knowledge for a further study regarding to craniofacial structure in convex profile patients.

CHAPTER 2

MATERIALS AND METHODS

Samples

All pretreatment lateral cephalometric radiographs of female non-growing patients (≥18 years old) used in this study were taken from files of Orthodontic Clinic of the Faculty of Dentistry at Prince of Songkla University over the year 1987-2008.

The criteria for selection of the subjects

1. Good quality of the radiographs which were sufficient to allow landmarks identification.
2. No previous orthodontic treatment.
3. Radiographs with relax of upper lip, lower lip and soft tissue chin
4. Normal facial profile patients (use as a norm of soft tissue profile)

   The sample had to have the facial contour angle (FCA) which was in range one standard deviation less and more than the mean FCA of Thai norm. According to Sorathesn[32] the FCA norm was 9±4 degrees in male and 9±5 degrees in female; therefore, the selected FCA was in range 5-13 degrees in male and 4-14 degrees in female.
5. Convex facial profile patients

   The sample had to have the facial contour angle which was at least one standard deviation more than the mean FCA of normal facial profile.

Cephalometric tracing

All lateral cephalometric radiographs were traced and digitized by one investigator. Each radiograph was traced on a sheet of 0.003 inch acetate paper with a sharp-edge black pencil (0.35 mm.) and a viewing box. The location of each landmark was indicated by a single fine pencil dot. When bilateral structure gave rise to double images, the mid-point by estimation or construction, as appropriate, was chosen. Soft and hard tissues landmarks that were used in this study illustrated in Fig. 2 and Table 1-3. Reference planes were illustrated in Fig. 3 and Table 4.

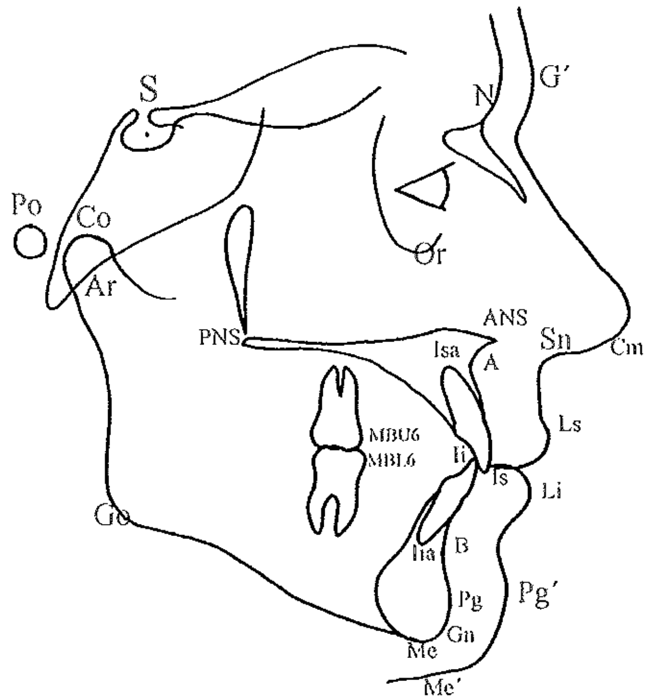

Fig. 3 Soft and hard tissue landmarks

Table 1 Soft tissue landmarks

No.	Soft tissue landmarks	Definitions
1	Glabella (G′)	The most prominent point in the midsagittal plane of forehead.
2	Subnasale (Sn)	The point in the midsagittal plane where the base of the collumella of the nose meet the upper lip (midsagittal).
3	Soft tissue pogonion (Pg′)	The most anteriorly positioned point of the soft tissue chin.

Table 2 Skeletal landmarks

No.	Skeletal landmarks	Definitions
1	Sella (S)	The midpoint of the cavity of sella turcica.
2	Nasion (N)	The anterior point of the intersection between the nasal and frontal bones.
3	Point A (A)	The most posterior point on the anterior surface of the maxilla.
4	Point B (B)	The most posterior point on the anterior surface of the symphyseal outline.
5	Orbitale (Or)	The lowest point on the inferior rim of the orbit.
6	Pogonion (Pg)	The most anterior point of the contour of the chin.
7	Gonion (Go)	The point on the contour of the mandible determined by bisecting the angle formed by the mandibular and ramal planes.
9	Condylion (Co)	The most posterosuperior point on the head of the condyle.
10	Porion (Po)	The most superiorly positioned point of the external auditory meatus (Anatomical porion).

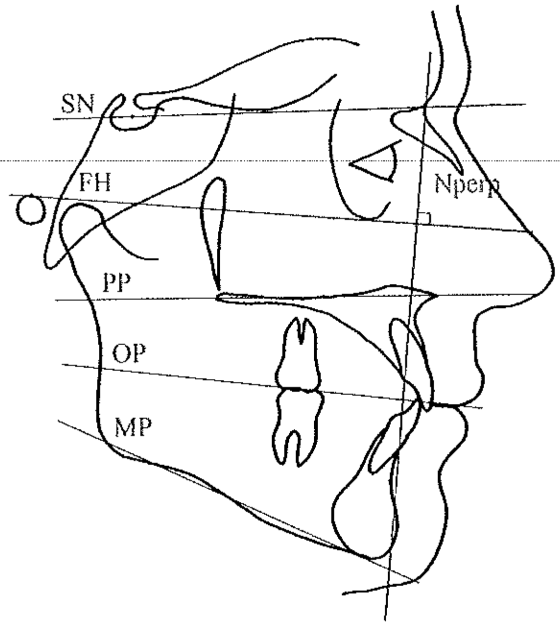

Fig. 4 Reference planes: SN, FH, PP, OP, MP and Nperp

Table 3 Definition of reference lines and planes

No.	Lines	Definitions
1	Frankfort Horizontal plane (FH)	Plane extending from anatomic porion to orbitale.
2	Mandibular plane (MP)	A line that connects Go to Me.
3	SN plane (SN)	A line that connects to N to S.
4	NA line (NA)	A line that connects N to A.
5	NB line (NB)	A line that connects N to B.
6	Nasion perpendicular (Nperp)	A vertical line constructed perpendicular to the Frankfort horizontal plane and extended inferiorly from Nasion.
7	Glabella perpendicular (G'perp)	A vertical line constructed perpendicular to the Frankfort horizontal plane and extended inferiorly from Glabella.

Cephalometric measurements

The positions of the landmarks on tracings were digitized with a transparent pad and commercial cephalometric program (Dentofacial planner plus version 2.02). Thirteen of dentoskeletal and three of soft tissue variables were determined, measured. Angular and linear measurements were illustrated in Fig. 3-7 and Table 4.

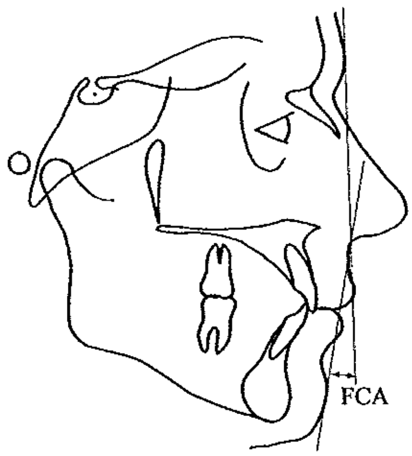

Fig. 5 Facial contour angle

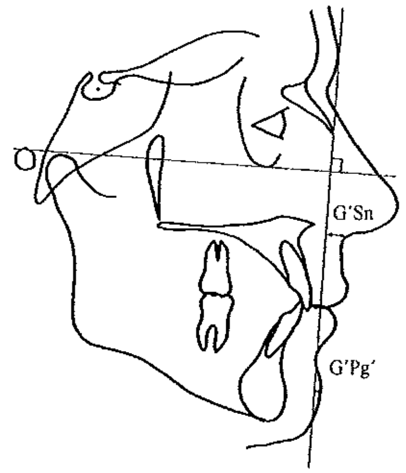

Fig. 6 G′Sn and G′Pg′measurements

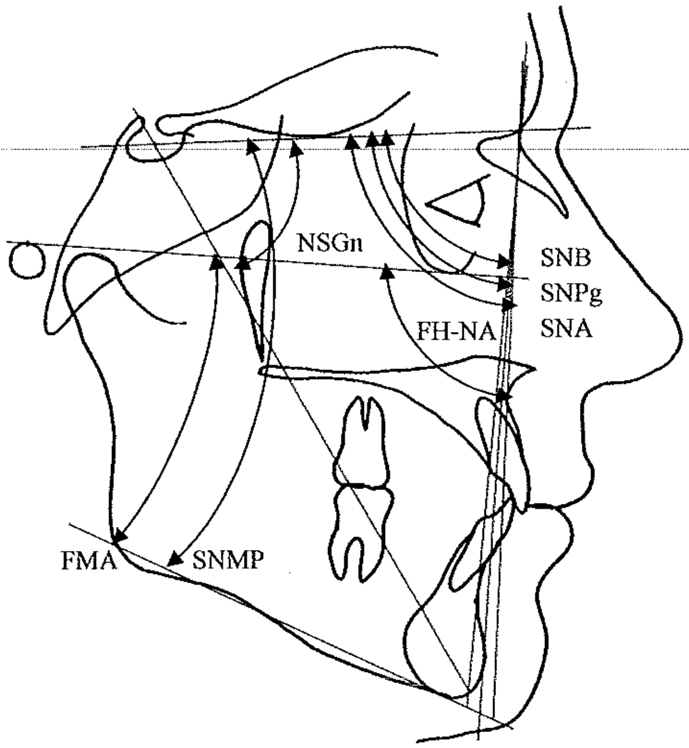

Fig. 7 Angular measurements

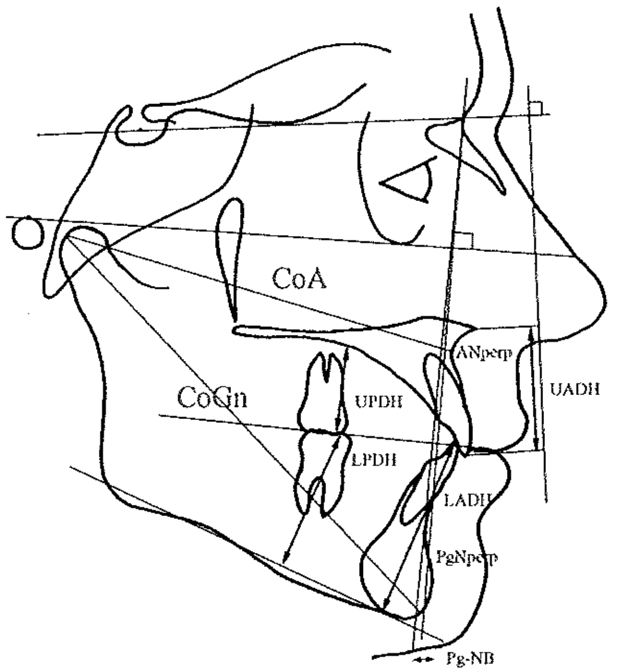

Fig. 8 Linear measurements

Table 4 Cephalometric measurements in this study

Measurements	Definitions
Maxilla	
SNA (deg.)	The angle formed by the intersection of SN and NA.
Co-A (mm.)	The linear measurement from condylion to A-point.
FHNA (deg.)	The angle of an intersection between FH line and NA line.
A-Nperp (mm.)	The distance from point A to Nperp.
Mandible	
SNB (deg.)	The angle formed by the intersection of SN and NB.
SNPg (deg.)	The angle formed by the intersection of SN and NPg.
Pg-Nperp (mm.)	The distance from pogonion to Nperp.
Pg-NB (mm.)	The shortest distance from Pg to NB.
Co-Gn (mm.)	The linear measurement from condylion to gnathion.
Intermaxillary	
ANB (deg.)	The angle formed by the intersection of NA and NB.
Vertical skeletal	
SNGoMe (deg.)	The angle formed by the intersection of SN and MP.
FMA (deg.)	The small angle where the FH line intersects the mandibular plane(MP).
NSGn (deg.)	The angle formed by the intersection of SN and SGn.
Soft tissue	
G'-Sn (mm.)	The distance parallel to FH from subnasale to perpendicular line dropped from glabella.
G'-Pg' (mm.)	The distance parallel to FH from soft tissue pogonion to perpendicular line dropped from glabella.
FCA	The angle formed by the upper facial plane and the lower facial plane.

Adjustment of different magnification

There were 37 radiographs of 161 used radiographs that showed the magnification of 8%. The others revealed 10% of magnification. Equalization of different magnifications for all radiographs was adjusted. The linear measurements affected by magnification need to be calculated before data analysis. The linear measurements of radiographs used in the study were corrected from the 8% and 10% magnifications.

Reliability of the measurement

In order to determine whether the measurements were reproducible they were checked for reliability. To check for intra-judge reliability, 20 radiographs were selected at random from the observation group for retraced and remeasured after 2 weeks interval. Then, the error of measurements was calculated according to Dahlberg's formula.

$$ME = \sqrt{\frac{\sum d^2}{2n}}$$

where d is the difference between pairs of the first and second measurements and n is the number of pairs.

Normal facial profile patients

Group of normal facial profile was measured and used as norm for divide convex facial profile. Thirty one of lateral cephalometric radiographs of females were used to investigate normal position of subnasale (Sn) and soft tissue pogonion (Pg$'$). Cephalometric variables used in this group were facial contour angle (FCA), distance of G$'$-Sn and distance of G$'$-Pg$'$. Distances of Sn and Pg$'$ from vertical line from glabella perpendicular to Frankfort horizontal plane in normal profiles were used to divide convex profile patients to subgroups.

Soft tissue characteristics of convex profile patients

Pretreatment of lateral cephalometric radiographs were selected by facial contour angle greater than 12 degrees. All of radiographs of convex profile were divided by range of G'-Sn and G-Pg' from normal profile samples. The criteria were:-

Three types of subnasale positions

Sn1 when distance of G'-Sn is much more than mean+1SD

Sn2 when distance of G'-Sn is in range of mean±1SD

Sn3 when distance of G'-Sn is less than mean-1SD

Three types of soft tissue pogonion positions

Pg'1 when distance of G'-Pg' is much more than mean+1SD

Pg'2 when distance of G'-Pg' is in range of mean±1SD

Pg'3 when distance of G'-Pg' is less than mean-1SD

In any individual convex profile had combination of one type of subnasale and one type of soft tissue pogonion position. Each of them was grouped.

Statistical analysis

The purpose of this study was to describe and analyze craniofacial morphology of adult Thai subjects in convex facial profile. The soft tissue variables of this study were FCA, G'Sn distance and G'Pg' distance. The relationship of soft tissue profile and underlying hard tissue was studied by statistical analysis.

The SPSS version 13.0 program was used to perform the following calculations:

1. Descriptive statistics (mean and standard deviation) of cephalometric measurements were calculated in each of the various cephalometric measurements.

2. Pearson correlation coefficient was used to determine correlations between soft and hard tissues measurements.
3. ANOVA and Tukey test were used to determine significant differences of hard tissue among individual groups of soft tissue at a significance level of $P < 0.05$.

CHAPTER 3

RESULTS

General information of Thai female convex profile patients

From 6, 158 initial lateral cephalometric films of patients in orthodontic clinic at the Faculty of dentistry, Prince of Songkla University since 1987-2008, there were 150 radiographs of adults (>18 years old) with facial contour angle more than 12 degrees. All subjects (20 males and 130 females) were between 18-44 years old. The mean and standard deviations of FCA, G'-Sn, G'-Pg' in female with convex facial profile subjects were presented in Table 5.

Table 5 Means and standard deviations of age and FCA in both sexes.

Sex	Number	Age (year)	Facial contour angle (FCA)		
		Mean(SD)	Mean(SD)	Min.	Max.
Female	130	23.4(5.4)	17.96(3.00)	13.2	26.7
Male	20	22.3(3.4)	19.85(4.40)	12.6	25.4

The intra-observer reproducibility for the angular and linear measurements ranged from 0.49 to 0.97 degree and from 0.56 to 1.12 mm, respectively (Table 6). Means of standard error of angle and linear measurements were 0.70 degree and 0.84 mm.

Due to small number of male samples compared to female samples, only the female samples were studied.

Table 6 Method error of the angular measurements according to Dahlberg's formula.

Variables	Method error (deg.)
FCA	0.97
SNA	0.66
SNB	0.67
ANB	0.72
SNPg	0.70
FH-NA	0.77
FMA	0.70
SNGoMe	0.72
NSGn	0.72

Table 7 Method error of the linear measurements according to Dahlberg's formula.

Variables	Method error (mm.)
G'-Sn	0.91
G'-Pg'	1.12
A-Nperp	0.86
Pg-Nperp	0.78
Co-A	0.56
Co-Gn	0.82
Pg-NB	0.83

Means, standard deviations, minimum and maximum value of soft tissue measurements of all convex samples were shown in Table 8.

Table 8 Means, standard deviations, minimum and maximum values of soft tissue measurements in female convex profile samples.

Variables	N	Mean	S.D.	Min.	Max.
FCA	130	17.96	3.00	13.2	26.7
G'-Sn	130	10.97	3.56	2.7	18.6
G'-Pg'	130	1.19	6.45	-17.4	16.5

Normal facial profile patients

Thirty one of lateral cephalometric radiographs of females were measured for the normal distances of G'-Sn and G'-Pg'. Mean and standard deviation of FCA was 9.58±1.60 deg. Means and standard deviations of G'-Sn and G'-Pg' were 7.27±1.77 mm. and 3.53±2.76 mm. respectively (Table 9). These normal values were used to divide convex profile patients into subgroups.

Table 9 Means, standard deviations, minimum and maximum of variables in female normal profile patients

Variables	N	Mean	S.D.	Min.	Max.
Age	31	21.19	1.87	18	27
FCA (deg.)	31	9.58	1.60	6	13
G'-Sn (mm.)	31	7.27	1.77	4	11
G'-Pg' (mm.)	31	3.53	2.76	-1	9

Types of Sn and Pg' Position

All of radiographs of convex profile were divided by normal range of G'-Sn and G'-Pg'. Following groups of Sn and Pg':

Three types of subnasale positions

Sn1 = G'-Sn > 9 mm. (representing anterior position of Sn)

Sn2 = G'-Sn 5-9 mm. (representing normal position of Sn)

Sn3 = G'-Sn < 5 mm. (representing posterior position of Sn)

Three types of soft tissue pogonion positions

Pg'1 = G'-Pg' > 7 mm. (representing anterior position of Pg')

Pg'2 = G'-Pg' 1-7 mm. (representing normal position of Pg')

Pg'3 = G'-Pg' < 1 mm. (representing posterior position of Pg')

Amount, percent, means and standard deviations of each group of Sn and Pg' were illustrated in Table 10 and 11.

Table 10 Means, standard deviations, number and percent of G'-Sn in each groups of Sn.

Groups of Sn	G'-Sn Mean(SD) (mm.)	n	Percent
Sn1	12.79(2.23)	92	70.8
Sn2	7.35(1.20)	30	23.1
Sn3	3.56(0.70)	8	6.1

In female convex profile, it's found that the most Sn position was anteriorly about 71%, normal position of Sn 23% and a little of posterior Sn (6 %).

Table 11 Means, standard deviations, number and percent of G'-Pg' in each groups of Pg'.

Groups of Pg'	G'-Pg' Mean(SD) (mm.)	n	Percent
Pg'1	10.39(2.19)	19	14.6
Pg'2	4.19(2.29)	55	42.3
Pg'3	-4.88(3.89)	56	43.1

From Table 11, the position of Pg' found with normal position was nearly with Pg' retrusion (42.3 and 43.1%), while convex profile with anterior position of Pg' was found at least (14.6%).

Convex profile soft tissue characteristics

Six characteristics of convex profile were found due to combined type of positions of subnasale and soft tissue pogonion shown in Table 12 and 13.

Table 12 Frequency of males and females in any 6 characteristics of convex facial profile

Variables	N=150	Sn1Pg'2 n = 58	Sn2Pg'3 n = 31	Sn1Pg'3 n = 27	Sn1Pg'1 n = 20	Sn3Pg'3 n = 12	Sn2Pg'2 n = 2
Male	20	5	3	7	1	4	0
Female	130	53	28	20	19	8	2

In group of female, percentages of the three most common characteristics of convex profile, Sn1Pg'2, Sn2Pg'3 and Sn1Pg'3 were shown in Table 13. The most frequent found convex profile characteristic in female was Sn1Pg'2 (40.8%) followed by Sn2Pg'3 (21.5%). Sn1Pg'3 and Sn1Pg'1 were found in almost the same frequency of 15.4 and 14.6% respectively. Sn2Pg'2 was the least frequent found of 1.5%.

Among Sn1 group, Sn1 was usually come with Pg'2 and less match with Pg'3 and Pg'1. In Sn2 group, only 2 types of Pg' (Pg'3 and 2) were found without any sample show Sn2 with Pg'1. However Sn2Pg'3 (21.5%) was found far more frequent than that of Sn2Pg'2 (1.5%). For Sn3 group, only Sn3Pg'3 was found with a few number of 6.2%.

Table 13 Percentage of 6 characteristics convex facial profile in females (N=130).

Groups	Frequency	Percent
Sn1Pg'2	53	40.8
Sn2Pg'3	28	21.5
Sn1Pg'3	20	15.4
Sn1Pg'1	19	14.6
Sn3Pg'3	8	6.2
Sn2Pg'2	2	1.5

Correlations between soft and hard tissue measurements

All samples in this study were test correlations between position of subnasale and soft tissue pogonion with hard tissue measurements.

Correlations between G'-Sn and maxillary measurements were shown in Table 14. The correlation was found most with A-Nperp (0.823). Maxillary depth was correlated with G'-Sn distance in the second (0.748) and followed with SNA (0.483). While the Co-A measurements was small correlated with measured G'-Sn in this study (0.110).

G'-Pg' measurement in 130 females convex profile was most correlated with Pg-Nperp measurement (0.929). SNB and SNPg measurements were correlated with G'-Pg' in the nearly value of correlation coefficient (0.556 and 0.603). Co-Gn measurement was correlated with 0.275 and Pg-NB had smallest correlation with G'-Pg' distance (0.170). (Table 15)

Table 14 Pearson correlation coefficient between G'-Sn and maxillary measurements

Maxillary measurements	SNA	FHNA	A-Nperp	Co-A
G'-Sn N = 130	0.483**	0.748**	0.823**	0.110

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

Table 15 Pearson correlation coefficient between G'-Pg' and mandibular measurements

Mandibular measurements	SNB	SNPg	Pg-NB	Pg-Nperp	Co-Gn
G'-Pg' N = 130	0.556**	0.603**	0.170	0.929**	0.275**

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

Different of maxillary skeletal measurements in 3 types of subnasale position

All three maxillary measurements in Sn1 group had statistically significant differences with measurements in Sn2 and Sn3, while hard tissue measurements of maxilla between Sn2 and Sn3 were not significant different.

The difference among 3 groups of Sn also showed in hard tissue analysis (Table 14, 15). The hard tissue analysis can best exclude hard tissue of Sn1 out of hard tissue of Sn2 and 3 but cannot detect the difference between hard tissue of Sn2 and 3.

No any hard tissue analysis effectively categorized hard tissue maxillary protrusion along with soft tissue analysis.

Table 16 Means and standard deviations of maxillary measurements and results of ANOVA at significant level 0.05

Groups of G'-Sn N = 130	Sn1 n = 92	Sn2 n = 30	Sn3 n = 8	ANOVA P value
SNA Mean(SD)	86.19(3.74)	83.39(3.21)	82.78(3.82)	0.000
A-Nperp Mean(SD)	7.64(2.83)	2.65(1.93)	1.25(2.92)	0.000
FHNA Mean(SD)	96.89(3.00)	92.48(1.97)	91.19(2.75)	0.000
Co-A Mean(SD)	93.09(4.20)	90.98(4.17)	95.00(8.74)	0.034

Table 17 Means and standard deviations of maxillary measurements and results of Tukey test in SNA, A-Nperp and FHNA.

Groups of G'-Sn N = 130	SNA Mean±SD	A-Nperp Mean±SD	FHNA Mean±SD
Sn1 (n=92)	86.19±3.74	7.64+2.83	96.89±3.00
Sn2 (n=30)	83.39±3.21	2.65±1.93	92.48±1.97
Sn3 (n=8)	82.78±3.82	1.25±2.92	91.19±2.75

*significance different at P < 0.05

Different of mandibular skeletal measurements in 3 types of soft tissue pogonion position

Regarding mandibular measurements, all variables, except for Pg-NB, showed a statistically significant difference among groups (Table 16, 17).

Mandibular measurements between Pg'1 and Pg'3 were statistically significant differences. The measurements between Pg'2 and Pg'3 were statistically significant differences except Co-Gn. Only Pg-Nperp can categorize hard tissue pogonion into different 3 groups along with soft tissue pogonion.

Table 18 Mean and standard deviation of maxillary measurements and results of ANOVA at significant level 0.05

Groups of G'-Pg' N = 130	Pg'1 n = 19	Pg'2 n = 55	Pg'3 n = 56	ANOVA P value
SNB Mean(SD)	81.12(3.76)	79.23(2.82)	76.63(3.47)	0.000
SNPg Mean(SD)	81.42(2.82)	79.65(2.83)	76.54(3.47)	0.000
Pg-Nperp Mean(SD)	6.10(2.51)	0.39(3.33)	-8.58(4.29)	0.000
Pg-NB Mean(SD)	0.58(1.84)	0.17(1.73)	-0.22(1.65)	0.174
Co-Gn Mean(SD)	121.08(4.37)	118.30(5.02)	116.41(5.66)	0.003

Table 19 Means and standard deviations of mandibular measurements and results of Tukey test

Groups of G'-Pg' N = 130	SNB Mean±SD	SNPg Mean±SD	Pg-Nperp Mean±SD	Co-Gn Mean±SD
Pg'1 (n=19)	81.12±3.76	81.42±3.20	6.10+2.51	121.08±4.37
Pg'2 (n=55)	79.23±2.82	79.65±2.83	0.39±3.33	118.30±5.02
Pg'3 (n=56)	76.63±3.47	76.54±3.47	-8.58±4.29	116.41±5.66

*significance different at P < 0.05

Differeent of hard tissues in three most common characteristics of convex profile

Hard tissue measurements of the three most common characteristics of convex profile were test differences among groups and shown in Table 18.

Group1 (Sn1Pg'2) had significant more maxillary protrusion than the other groups. SNA in group I was significant higher than group II and III. A-Nperp and FHNA were significant differences in all three groups with the highest value at group I, then II and III respectively. Co-A was insignificant difference among groups.

The least mandibular retrusion found in group I, while more retrusion of mandible found in group II and III with comparable values. SNB, SNPg and Pg-Nperp in group I were significant higher than group II and III. Co-Gn was not significant difference among 3 groups.

The most severe Class II relationship (ANB) found in group III while the least found in group II. However the different found only between group II and III.

Vertical skeletal measurements among 3 groups were not significant different except FMA in group I was statistically significant higher than group III only.

Table 20 Means and standard deviations of hard tissue measurements with ANOVA and Tukey test for differences in three most common characteristics of convex profile

Measurements	Group I (Sn1Pg'2) n = 53		Group II (Sn2Pg'3) n = 28		Group III (Sn1Pg'3) n = 20		ANOVA	Tukey test Significance (*)		
	Mean	SD	Mean	SD	Mean	SD	P value	I vs II	II vs III	I vs III
Maxilla										
SNA	86.32	2.93	83.47	3.17	84.21	4.10	0.001	*	NS	*
A-Nperp	7.64	1.95	2.51	1.88	5.07	2.73	0.000	*	*	*
FHNA	96.92	2.72	92.36	1.95	94.68	2.49	0.000	*	*	*
Co-A	93.05	4.10	91.14	4.26	92.98	4.61	0.141	NS	NS	NS
Mandible										
SNB	79.27	2.81	77.06	3.48	76.43	3.67	0.001	*	NS	*
SNPg	79.72	2.82	77.13	3.56	76.3	3.62	0.000	*	NS	*
Pg-Nperp	0.38	3.39	-8.35	4.10	-7.12	3.77	0.000	*	NS	*
Co-Gn	118.44	5.02	116.54	5.33	116.85	6.05	0.246	NS	NS	NS
Intermaxillary										
ANB	7.05	1.41	6.42	1.90	7.78	2.20	0.031	NS	*	NS
Vertical										
FMA	29.29	4.62	28.89	4.62	25.65	5.68	0.017	NS	NS	*
SNGoMe	38.45	5.70	39.00	5.36	36.03	5.52	0.162	NS	NS	NS
NSGn	70.66	3.75	71.09	3.84	69.88	2.85	0.518	NS	NS	NS
FHSN	9.16	2.74	10.11	2.99	10.38	2.18	0.144	NS	NS	NS

*Significant difference at P < 0.05

CHAPTER 4

DISCUSSION

General information of female convex profile

The number of non-growing female patients in orthodontic clinic, the faculty of dentistry, Prince of Songkla University since 1987-2008 was more than male about 6 times. Esthetics is probably the most important factor bring patient seeking orthodontic treatment.

Samples used in this study were only females. Due to too small numbers of male of only 20, we decided to exclude male samples from this study. Moreover, most of the sagittal and vertical linear measurements in Chung and Wong's study[43] showed significant sex differences-males had larger dimensions than females. Similar findings were reported by Sinclair and Little.[44]

Reliability of measurements

Bettagel[45] suggested that the error of measurement is of importance and concluded that Dahlberg's estimation is mathematically the soundest method to evaluate measurement error. Measurement errors in this study were acceptable range when compare with other studies[46, 47]. Facial contour angle was the most error of angle measurement in this study. G'-Sn and G'-Pg' were the most error linear measurements. Soft tissue measurements were more error than hard tissue but there were insignificant in clinical assessment.

Normal facial profile patients

The inclusion criteria were based on soft tissue profile without consideration of malocclusion. From both male and female there were insignificant different in amount of FCA. When there are normal facial contour angle there will be balance of anteroposterior discrepancy of maxilla and mandible also effect the soft tissue profile by position of subnasale and soft tissue pogonion. In study of Lagan and Burstone they used horizontal line that minus SN plane 7 degrees as a reference line to measure the position of Sn and Pg' from glabella parallel to this line. There would be effect of inclination of SN plane that different among each person make this reference line not able to represent true horizontal plane. Mean and standard deviation of G'-Sn and G'-Pg' were 7.27±1.77 mm. and 3.53±2.76 mm. respectively (Table 8). These normal values were used to divide convex profile patients to subgroups.

Caucacian's adult standards by Legan and Burstone[25] had smaller normal value of G'-Sn (6±3 mm.) and G'-Pg'(0±4 mm.) when compared with this study. There are silmilarly of reference plane in Legan and Burstone's and this study. Caucacian have more retrusion of subnasale and soft tissue pogonion than Thai female.

When considering the facial contour angle, there were facial contour angle less than in Caucacian's norm (12±4 degree) but coincide with Sorathesn (9±4 degree). Thai female have less different of subnasale and soft tissue pogonion than Caucasian's. In another word, the Caucasian female is more convex than Thai female.

Convex facial profile in a group of Thai females

Considering only the position of subnasale, the most common subnasale position found in Thai female convex patients was protrusion according to the protrusive Sn of more than 9 mm anterior to the glabella.

Soft tissue cephalometric analysis proposed by Burstone[27], the evaluation of maxilla position from position of subnasale assumed that when subnasale is protrusion more than norm with one standard deviation, the maxillary skeletal is protrusion. Also a group of Thai females with convex profile frequently had maxillary protrusion.

The Sn3 group with G'-Sn less than 5 mm had convex profile when combined with only retrusion of soft tissue pogonion position.

In group of soft tissue pogonion position, Pg'2 and Pg'3 were similarity percentage found in all convex samples in this study. Females with convex profile 43.1 percent had retrusion of soft tissue pogonion and 42.3 percent had normal position of soft tissue pogonion.

Unfortunately, up until now, there has been no Asian Class II profile study investigated, so that the comparison between our study and the others cannot be discussed.

Correlations between soft and hard tissue measurements

The hard tissue measurements which were highly correlated with soft tissue measurements in convex profile patients in this study were A-Nperp and Pg-Nperp for maxillary and mandible measurements respectively. If there was high value of G'-Sn distance the hard tissue should be measured with A-Nperp, there will show the discrepancy of structure in the same direction. Like with the G'-Pg' measurement which had the same direction of anteroposterior position of chin and position of mandible with Pg-Nperp measurement.

Maxillary and mandibular lengths which were small correlated with subnasale and soft tissue pogonion anteroposterior position may had error from the identifying of condylion landmark. Condylion landmark is the bilateral structure and must be tracing with averaged two sides of mandibular condyle. However these measurements are not in the horizontal distance like the Frankfort horizontal plane, the effect of vertical skeletal component should be considered.

There were moderate correlations of measurements which had reference plane with SN plane and method of measurement with angle. Angular measurements with SN reference line may be affected by the inclination of SN, the anteroposterior position of nasion[48], so the correlations of these angles and soft tissue measurements were lower than with the linear measurements.

Hard tissue differences in Sn1, Sn2 and Sn3

From 3 types of subnasale position, hard tissue measurement of group Sn1 was significantly higher than the other two groups. The mean differences between G'-Sn of Sn1 and Sn2 (5.44 mm.) and between A-Nperp of Sn1 and Sn2 (4.99 mm.) were almost the same values. Because of using of Frankfort horizontal reference line in both hard and soft tissue measurements, these differences almost equal.

When we tested the different of maxillary skeletal measurements in groups of subnasale position, there were significant differences between groups in SNA, A-Nperp and FHNA. Sn1 subjects showed significantly higher SNA, A-Nperp and FHNA than Sn2 and Sn3 subjects. Co-A did not show significant difference in three groups. Maxillary length or Co-A did not show significant difference between groups of subnasale position. This can prove that the hard tissue may not have the same mal position as the soft tissue or the hard tissue measurements have problem to detect its own mal position. Co-A failed to exhibit the difference among 3 groups of Sn so that the Co-A may not appropriate to diagnose the maxillary position for soft tissue correction.

Hard tissue differences in Pg'1, Pg'2 and Pg'3

G'-Pg' between groups had different distances nearly to different distances measured for Pg-Nperp, the explanation is same to what prior discussed for Sn.

There were significant different between Pg'1 and Pg'3 in all hard tissue measurements except Pg-NB. This indicated that Pg-NB may not be a good measurement to locate the position of Pg. Anteroposterior mandibular measurements between Pg'1 and Pg'2 were not significant difference, but there was significant difference between both of them when measured with Pg-Nperp. This reveals that Pg-Nperp has higher potential to detect the different among these 3 groups. From the data, the mean of soft tissue different between Pg'1 and Pg'2 from Pg-Nperp of 6.2 mm. was considerably high, while the angle measurements (SNB, SNPg) had only about 2 degrees difference. These can conclude that linear measurement of Pg-Nperp represents the same direction as that of soft tissue Pg does.

Hard tissue differences in convex profile characteristics

There was different of subnasale position between group II and III while the SNA measurements cannot express the differences of hard tissue. Amount of SNA angle may be affected by inclination of anterior cranial base or anteroposterior position of Nasion. Individual patient has each characteristic of FHSN angle.[44] Patient with high inclination of SN plane tendency to have smaller angle formed by SN plane, for example SNA and SNB. SNA in group II and III should different, because of both groups were divided by different position of subnasale, but SNA in both were not siginificant different. When test the different of FHSN between 2 groups, there was not significant different (P=0.71).

There was variation of soft tissue thickness in each patient. It may be affected from variation of soft tissue thickness from point A to subnasale. When measured the thickness of soft tissue from point A parallel with Frankfort horizontal plane to subnasale, there was not significant different of soft tissue thickness in 3 characteristics of convex profile patients (Table 19).

However, the position of point N in anteroposterior may affect amount of SNA. If there is forward position of N point, the SNA angle will be small than SNA with backward of point N.

In addition, A-Nperp and Pg-Nperp may be affected by position of N point in the same manner. If there is forward point N, there will be smaller linear measurement of distance of A-Nperp and higher distance of Pg-Nperp. Following the hard tissue measurements may bring to inappropriate treatment plan if we compare with norms which were from samples with different inclusion criteria selected.

The soft tissue evaluation in this study was based on position of glabella and Frankfort horizontal plane. If position of glabella is more forward, subnasale and soft tissue pogonion will be more retrusion. Hard tissue linear measurement which based on point N (A-Nperp and Pg-Nperp) may be not correspondent with soft tissue measurement if there is large different of distance between glabella and point N. But in this study, the different of distances between point N and glabella in three group characteristics were not significant different (Table 19).

Another interesting point is the difference of A point position between group I and III which have same Sn1, this can assume that both groups have Sn protrusion but group I has more protrusion than group III.

Three characteristics of female convex profile presented with two types of soft tissue pogonion positions. Group I had normal soft tissue pogonion position while group II and III had soft tissue pogonion retrusion. All mandibular measurements indicate the mandibular position in the same direction as the soft tissue mandible. The retrusions of Pg from group II and III are the same.

Table 21 Means and standard deviations of soft tissue thickness of A-Sn and N-G' and ANOVA among three groups

Soft tissue thickness	Group I Sn1Pg'2(n=53)	Group II Sn2Pg'3(n=28)	Group III Sn1Pg'3(n=20)	ANOVA (P value)
A-Sn	13.32(1.67)	13.59(1.72)	13.81(1.70)	0.518
N-G'	8.30(1.34)	8.93(1.11)	8.13(1.88)	0.090

Significant at 0.05 level

Compared to cephalometric norms

To examine whether the underlying hard tissues were mal position as indicated as the soft tissue profile does, the cephalometric analysis were compared with the previous studies' Thai norms.

From Table 20, in Sn1 group with expected maxillary protrusion as its soft tissue protrusion, however, no Thai norm diagnosed the A point position as maxillary protrusion. For Sn2 group, normal maxillary protrusion should be presented as its soft tissue well located. All Thai norms showed maxillary normal position as expected. For Sn3 group, only A-Nperp and FHNA can indicate maxillary retrusion. From this all information, we can conclude that Thai hard tissue norms cannot be used as diagnostic tools for the correction of soft tissue malposition. The treatment plan based on soft tissue measurement should be introduced and placed in higher priority than hard tissue measurement.

From table 21, we looked for hard tissue with the same malposition as the soft tissue based on Thai norm. Only Pg-Nperp diagnoses the mandular position in the same direction as the soft tissue.

It probably assumed that esthetic of soft tissue profile not correspondent with hard tissue diagnosis. Reliance on cephalometric analysis and treatment planning to norms sometimes leads to esthetics problems[9, 22, 29, 30]. The assumption that bite correction, based on cephalometric standards, leads to correct facial esthetics is not always true and may, in some instances, lead to less than desirable facial outcomes[9, 22, 29, 30].

Table 22 Compared Means and standard deviations of maxillary measurements with Thai norms

Thai norms (Female)	SNA[49]	A-Nperp[50]	FHNA[50]	Co-A[49]
Mean(SD)	85.02(3.73)	4.82(3.1)	94.36(3.0)	90.16(3.48)
Range	81.29-88.75	1.72-7.92	91.36-97.36	86.68-93.64
Sn1 (n=92)	86.19(3.74)	7.64(2.83)	96.89(3.00)	93.09(4.20)
Sn2 (n=30)	83.39(3.21)	2.65(1.93)	92.48(1.97)	90.98(4.17)
Sn3 (n=8)	82.78(3.82)	1.25(2.92)	91.19(2.75)	95.00(8.74)

Table 23 Compared means and standard deviations of mandibular measurements with Thai norms

Thai norms (Female)	SNB[49]	SNPg[50]	Pg-Nperp[50]	Pg-NB[50]	Co-Gn[49]
Mean(SD)	81.78(3.28)	81.67(3.73)	0.63(4.96)	-0.09(1.41)	118.96(3.96)
Range	78.5-85.06	77.94-85.4	-4.33-5.59	-1.5-1.32	115-122.92
Pg'1 (n=19)	81.12(3.76)	81.42(3.20)	6.10(2.51)	0.58(1.84)	121.08(4.37)
Pg'2 (n=55)	79.23(2.82)	79.65(2.83)	0.39(3.33)	0.17(1.73)	118.30(5.02)
Pg'3 (n=56)	76.63(3.47)	76.54(3.47)	-8.58(4.29)	-0.22(1.65)	116.41(5.66)

Clinical application and suggestion

This data imply that the major problem in Thai convex profile female is the maxillary protrusion. The most frequent found convex profile patient is a group with Sn1Pg'2 or maxillary protrusion combined with normal mandible. This general information can be used as a guideline for focusing on specific treatment techniques aiming to solve Class II maxillary protrusion.

This study supports using linear measurement to evaluate soft tissue profile combined with linear measurement of hard tissue profile. So the result of soft tissue pattern will be correspondence with hard tissue value then the treatment plan would not be misled.

Limitation of the study

There were limitation of small sample size and study in a group of female only. Frankfort horizontal plane may not represent facial profile compared to natural head position of patient.

Suggestions

In evaluation of soft tissue profile along with hard tissue measurements, these study found that using Frankfort horizontal plane in measurements the Sn and Pg' position were highly correlated with A-Nperp and Pg-Nperp respectively. The hard tissue value will be correspondent with soft tissue value when measured by using the same reference line.

It should design further study with natural head position which can provide accurate esthetic problem of individual patient. Cephalometric norms of hard tissue are not a good standard of treatment plan when focusing of esthetic outcome of soft tissue profile. The soft tissue changes after the treatment compared to the hard tissue changes should be performed to achieve more information for treatment planning and prediction.

CHAPTER 5

CONCLUSIONS

A group of Thai female with convex facial profile can be found in three most common characteristics of soft tissue profile:

1. Anterior position of subnasale with normal position of soft tissue pogonion
2. Normal position of subnasale with posterior position of soft tissue pogonion
3. Anterior position of subnasale with posterior position of soft tissue pogonion

Soft tissue esthetic problems may not represent with abnormality of hard tissue value. Soft and hard tissue evaluation, if it is necessary to be performed, should be made together with same reference line.

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