How to Identify Soft Tissue Profile for Orthodontic Diagnosis

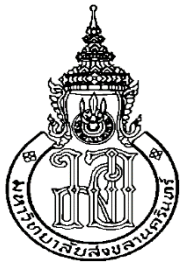
Piyanart Songkongka

A Thesis Submitted in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Oral Health Sciences

Prince of Songkla University

2017



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Major Program	Oral Health Sciences

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This is to certify that the work here submitted is the result of the candidate's own investigations. Due acknowledgement has been made of any assistance received.

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(Miss Piyanart Songkongka)

Candidate

I hereby certify that this work has not been accepted in substance for any degree, and is not being currently submitted in candidature for any degree.

……Signature

(Miss Piyanart Songkongka)

Candidate

ชื่อวิทยานิพนธ์ การประเมินเนื้อเยื่ออ่อนของผู้ป่วยเพื่อใช้ในการวินิจฉัยทางทันตกรรมจัดฟัน
ผู้เขียน นางสาวปิยนาฏ สงคงคา
สาขาวิชา วิทยาศาสตร์สุขภาพช่องปาก
ปีการศึกษา 2559

บทคัดย่อ

การประเมินเนื้อเยื่ออ่อนจากใบหน้าด้านข้างเป็นขั้นตอนสำคัญที่ใช้ในการวางแผนรักษาทางทันตกรรมจัดฟันเพื่อให้ได้ผลลัพธ์ที่ดีมีความสวยงามของใบหน้า **วัตถุประสงค์** เพื่อสร้างเครื่อง มือทางคลินิกที่ใช้ประเมินเนื้อเยื่ออ่อนได้อย่างมีประสิทธิภาพ พร้อมทั้งหาค่ามาตรฐานของคนไทย และเพื่อเปรียบเทียบการใช้เครื่องมือนี้กับเครื่องมือที่มีอยู่เดิมและความคิดเห็นของผู้เชี่ยวชาญ **วิธีการวิจัย** การศึกษาตอนที่ 1 กลุ่มตัวอย่างประกอบด้วยเพศหญิง 39 คนอายุเฉลี่ย 24.5 ปี และเพศชาย 31 คนอายุเฉลี่ย 25.4 ปี ที่ได้รับการยอมรับจากผู้เชี่ยวชาญอย่างน้อย 4 ใน 5 คนว่ามีลักษณะใบหน้าด้านข้างที่ดี ทำการบันทึกภาพใบหน้าด้านข้างในตำแหน่งศีรษะธรรมชาติเพื่อนำมาประเมินเนื้อเยื่ออ่อนโดยใช้เส้นแนวดิ่งจริงที่ลากผ่านปีกจมูกที่สร้างขึ้นมาใหม่เป็นเส้นอ้างอิง ค่าเฉลี่ยจากการศึกษาตอนที่ 1 ถือเป็นค่ามาตรฐานของคนไทย การศึกษาตอนที่ 2 เป็นการพิสูจน์การนำไปใช้งานของเครื่องมือนี้ว่ามีความเหมือนหรือแตกต่างอย่างไรกับความคิดเห็นของผู้เชี่ยวชาญและเครื่องมือที่มีอยู่เดิม โดยเลือกกลุ่มตัวอย่างเพศหญิง 18 คน เพศชาย 18 คน ที่มีลักษณะใบหน้าด้านข้างแบบต่างๆมาบันทึกภาพใบหน้าด้านข้าง ใช้เส้นแนวดิ่งจริงที่ลากผ่านปีกจมูก เส้นแนวดิ่งจริงที่ลากผ่าน Sn E line และความคิดเห็นของผู้เชี่ยวชาญในการประเมินเนื้อเยื่ออ่อน ใช้สถิติ Kappa หาความสอดคล้องจากการใช้วิธีการต่างๆ **ผลการศึกษา** เส้นแนวดิ่งจริงที่ลากผ่านปีกจมูก มีความสอดคล้องกับเส้นแนวดิ่งจริงที่ลากผ่าน Sn มากกว่า E line และเมื่อเปรียบเทียบกับความคิดเห็นของผู้เชี่ยวชาญพบว่า เส้นแนวดิ่งจริงที่ลากผ่านปีกจมูกมีความสอดคล้องกับความคิดเห็นของผู้เชี่ยวชาญมากที่สุด รองลงมาคือเส้นแนวดิ่งจริงที่ลากผ่าน Sn และสุดท้ายคือ E line โดยเส้นแนวดิ่งจริงที่ลากผ่านปีกจมูกมีความสอดคล้องกับความคิดเห็นของผู้เชี่ยวชาญมากกว่าเส้นแนวดิ่งจริงที่ลากผ่าน Sn ในตำแหน่งริมฝีปากบนของทั้งเพศหญิงและชาย และตำแหน่งคางในเพศชาย สำหรับ E line นั้นเส้นแนวดิ่งจริงที่ลากผ่านปีกจมูกมีความสอดคล้องกับความคิดเห็นของผู้เชี่ยวชาญมากกว่าในทุกตัวแปร คือตำแหน่งริมฝีปากบนและล่างของทั้งสองเพศ **สรุป** เส้นแนวดิ่งจริงที่ลากผ่านปีกจมูกเป็นอีกทางเลือกหนึ่งสำหรับใช้ในการประเมินเนื้อเยื่ออ่อนจากลักษณะใบหน้าด้านข้างในทางทันตกรรมจัดฟัน

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Major Program Oral Health Sciences

Academic Year 2016

ABSTRACT

In the present day, esthetics is the main motivation that brings the patient seeking orthodontic treatment. Soft tissue analysis is a tool in planning orthodontic treatment to obtain not only good function but also improve facial attractiveness, psychosocial status and quality of life. **Objectives:** To create a clinical diagnostic tool for soft tissue analysis and determine norms for Thai adult males and females together with comparing this tool with the currently used soft tissue analyses and the expert opinion. **Materials and Methods:** Part 1 The TVL through alar was chosen as a reference line in this study. 39 females and 31 males (mean age 24.5 and 25.4 years) with a good facial profile and were accepted by at least 4 of 5 orthodontists were selected. The profile photos of all subjects were taken in natural head position. The soft tissue measurements using TVL through alar were done to determined norms for Thai adult males and females.Part2 To test the effectiveness of the new diagnostic tool by comparing with the expert opinion (which was regarded as gold standard) and the currently used soft tissue analyses. The profile photos of 18 females and 18 males with any profile type were taken. The soft tissue profiles of these subjects were diagnose with the TVL through alar, TVL through Sn, E line and the expert opinion. Kappa analysis was used to determine the agreements among these methods. **Results:** The agreements of our tool with TVL through Sn were higher than the agreements of our tool with E line. When compare these 3 analyses with the expert opinion, the agreements of expert opinion with our tool was the highest, following by the agreements of expert opinion with TVL through Sn. And the last was the agreements of expert opinion with E line. The experts agreed with our tool more than the TVL through Sn for upper lip in both sexes and chin in males. They also agreed with our tool more than E line for upper and lower lips in both sexes. **Conclusions:** The TVL through alar is an alternative diagnostic tool for clinical soft tissue evaluation in orthodontic treatment.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisor, Assoc.Prof.Dr.Chairat Charoemratrote for his continuous support, motivation, and guidance for this research.

My sincere thanks also to Assist.Prof.Dr.Sukanya Tianviwat for her good suggestions and comments in research methodologies. Assist.Prof.Dr.Udom Thongudomporn, Doctor Arthit Sittipornchai, Doctor Nuengrathai Yodthong and Doctor Siriporn Panitjitboon for their suggestions and provide help in sample selection.

I would like to thank the experts who were involved in the questionnaire for this research project. Without their passionate participation and input, this research could not have been successfully conducted.

The special thanks to all of Orthodontic staff, Orthodontic residences, Orthodontic clinic and Audiovisual Unit, Faculty of Dentistry at Prince of Songkla University for the support throughout the period of this study.

Last but not the least, I would like to thank my family, my parents and my sister for always supporting me throughout my years of study and always gives me the greatest love.

Piyanart Songkongka

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et al	=	and others
mm	=	millimeter
deg.	=	degree
NHP	=	natural head position
NHO	=	natural head orientation
Fig.	=	figure
TVL	=	true vertical line
THL	=	true horizontal line
Sn	=	subnasale
ULA	=	upper lip anterior
LLA	=	lower lip anterior
Sm	=	supramentale
Pg’	=	soft tissue pogonion
Prn	=	pronasal
NLA	=	nasolabial angle
MLA	=	mentolabial angle

CHAPTER 1

INTRODUCTION

Background and rationale

Goals for successful orthodontic treatment are function, esthetics and stability. But in the present days, esthetics is the most important factor bring the patient seeking orthodontic treatment [1-3]. In the past, orthodontic treatment emphasizes on the dental and skeletal components to have ideal dental occlusion. We pay less attention to facial proportions and esthetics. So the important diagnosis tools were dental casts and lateral cephalometric radiographs.[4]

As time passed, it became clear that even an excellent occlusion was unsatisfactory if it was not achieved of proper facial proportions. Since the traditional cephalometric measurements do not provide all answer to the esthetic consideration of face. Orthodontics treatment based on cephalometric standards without examination of the face is not adequate. Unfortunately, reliance on cephalometric analysis and treating to the numbers sometimes cause esthetic problems[5-10]. Lead to the changes in the goals of orthodontic treatment, which are focus on facial proportions and the impact of the dentition on facial appearance. Treatment plan approach also change from obtaining ideal dental and skeletal relationships and assume the soft tissue will be harmony and balance to plan ideal soft tissue relationships and then place teeth and jaws as needed to achieve this.[4, 11]And increasing focus on facial clinical examination rather than examination of dental casts and radiographs leads to a different approach to obtaining important diagnostic information. So the clinical soft tissue analysis of the face is very essential because the precise soft tissue evaluation leads to the accurate diagnosis and successful treatment.

Many researchers have defined various methods for soft tissue analysis in the lateral cephalometry. Such as Downs[12], Steiner[13], Burstone[14], Ricketts[15], Holdaway[16], Merrifield[7] and Canut[17]. Additionally, there has been increasing recognition that facial esthetics should be assessed in relation to natural head position (NHP) on photographic records. As the study of Bass[18, 19], Stoner[20], Neger [21], Fernandez-Riveiro *et al* [22, 23] and Arnett and Bergman [24]. The natural

head position is a standardized orientation of the head with eyes focused on a distant point at eye level[25]. Many reserchers [26-29] claimed that natural head position should be the head position of preference for profile evaluation because it reflects the everyday true life appearance of people and good reproducibility. A further advantage of natural head position is that it provides the use of extracranial reference line as true vertical and true horizontal lines.

Although there are many soft tissue analyses, These analyses have some problems. According to the study of Oh *et al.*[30], there was less association than expected between objective measurements on the lateral cephalograms (which including many soft tissue analyses) and clinicians' rankings of facial attractiveness on clinical photographs at the end-of-treatment. And the higher rank for facial attractiveness on photographs did not closely associated with the ideal value of the cephalometric measures, whereas both higher and lower values for the cephalometric measures did not associated with lower photo attractiveness ranks either. The problems in the soft tissue analyses that we currently use such as,

Patient's position is not represent true facial profile if we analyze soft tissue in lateral cephalometric radiograph that set the Frankfort Horizontal plane parallel to the ground

High variation of reference line, such as intracranial reference line.

Reference point is not on the normal structure such as chin on retrognathic mandible, Sn on maxillary retrusion

Reference point is unstable(change during treatment) such as chin, Sn Sm. Or there is large variation such as tip of nose. (The standard deviation of nose length is twice as great as the standard deviation that are estimates of variation in lip protrusion.[14])

Lead efforts to create a new diagnostic tool in orthodontics to evaluate soft tissue profile with the proper reference line in this study.

Literature reviews

The importance of soft tissue analysis

Nowadays, esthetics is the most important factor that why people seeking orthodontic treatment. According to Lew[1], improvement of dento-facial appearance and self-confidence were mentioned as the most important motivating factors (80 percent) for patient in orthodontics treatment. And the study of Wedrychowska[3] presents that enhancement in dental aesthetics was the main motivational factor for the children (29–48 percent), their parents (54 percent), and adult patients (55 percent) who seeking orthodontic treatment. Furthermore, a systematic review about the motivational factors of people for orthodontic treatment shows that 13 articles included in this review identified aesthetics as the key motivational factor.[2]

By the early 1900s, orthodontic treatment emphasized on the dental and skeletal components to have ideal dental occlusion, perfectly alignment of teeth and ideal articulation. But less attention on facial proportions and esthetics. Believe in that when this ideal dental occlusion occurs, the face should also be in perfect harmony and balance. So the important diagnosis tools were dental casts and lateral cephalometric radiographs.[4, 11]

Orthodontics treatment based on cephalometric standards without clinical evaluation of the facial soft tissue was not adequate. Dependence on cephalometric analysis and planning the treatment with these may bring about esthetic problems[5-10]. Many findings could explain for the inadequacy of cephalometry. Burstone[5] showed that only the dental correction did not certainly obtain the good facial balance and may lead to esthetic problems. Drobocky [6]studied 160 cases with four 1st bicuspid extraction and found that 10% to 15 % of cases showed the extremely retruded (dished-in) face after orthodontic treatment. Park and Burstone [8]found grossly different among the profiles of 30 patients who had the position of lower incisor in front of the A-Pog line1.5 mm. (This position of the lower incisor is believed to be the key for getting a well balance facial profile.) Although the goal of incisor positioning was achieved, the lip protrusion still had large variation. So bringing into question on the using of this relationship between the incisor and A-Pog line as the esthetic guideline. Furthermore, study of Oh *et al.* [30] found that the association between the measurements of the lateral cephalometric radiograph (which including soft tissue analysis) and the facial attractiveness ranking by the clinicians from the clinical

photographs were less than expected. Another reason of cephalometric inadequacy in orthodontic diagnosis and treatment planning was the use of cranial base as the reference line to measure the facial profile, this may lead to the false findings. Michiels[31] verified the validity of many cephalometric standards which used to evaluated facial profiles by the study of 27 nonorthodontic classI patients. He concluded that the cephalometric measurements relating cranial base landmarks were imprecise in evaluating the real clinical profile.

Until now, it became clear that even an excellent occlusion was unsatisfactory if it was not achieved of proper facial proportions. Lead to the changes in the goals of orthodontic treatment, which are to focus on facial proportions and the impact of the dentition on facial appearance. The increased focus on facial clinical examination rather than examination of dental casts and radiographs leads to a different approach to obtaining important diagnostic information and that information is used to develop treatment plan. It is the orthodontist's task in diagnosis and planning the treatment within the patient's limit of soft tissue adaptation and soft tissue contour. It also relates very much to why patients seeking orthodontic treatment and what they expect to gain from it. So the soft tissue facial analysis is important, as it leads to the precise diagnosis and treatment planning.

The previous soft tissue analysis

Downs[12] began to include measurement of soft tissues into cephalometric analysis, by using the filters in the radiographic technique. Therefore the soft tissues could be seen in the radiograph. The purpose was to know the relation of soft and hard tissues. And he concluded that the soft tissue did not follow the underlying hard tissue at all times.

In about the same period, Ricketts[15] introduces the line from the tip of nose to the chin to determine position of lip in relative with neighboring structures. This line was named the esthetic line or E line. And his later study[9] shows that the lower lip position in female adults should be located average 4 mm behind this line, with a standard deviation (SD) of 3 mm. But in adolescences or patients with the age around 12-14 years, the lower lip position was accepted to be 2 mm behind this line, with a standard deviation (SD) of 3 mm. And the upper lip is slightly more posterior to the E line than the lower lip. But in male, the range was slightly greater because of the thinner lips.

Holdaway[16] presented soft tissue analysis by means of the H-line which was drawn from upper lip to the soft tissue pogonion. The evaluation of subnasale, upper and lower labial sulcus position and lower lip position could be done by this reference line. Perfectly both lips should be on the H-line. He also defined the prominence of nose, the upper lip thickness at the level of point A, and the chin thickness at the pogonion point. Moreover he created the H-angle. This angle made by the H-line and soft-tissue Na-Pg' line. H-angle associated with the ANB angle If the ANB angle is 1 - 3º, this angle should be 7 - 8º, the lower lip touch the H-line and the nose tip was in front of this line 9 mm. If the ANB angle is lesser or greater than normal, the H-angle should direct change to the ANB angle.

Steiner[13] presented a harmonize soft tissue profile by using a S-line from the soft tissue pogonion to the midpoint of columella of the nose, the lips should be on this reference line.

Burstone[14] estimated the position of the lips by use of the B-line runs from the subnasale to the soft tissue pogonion as he believed that this plane has less variation in the area of the face. And suggested that the upper lip is approximately 3.5 mm and the lower lip 2.2 mm anteriorly to the Sn-Pg' line. The lip position in relative to B-line was meaning in soft tissue analysis. The position of the lips in relation to this line changed according to the tooth movement and consequently the total aesthetic as well. In cases of the retraction of the front teeth caused retrusion of the lips to be posterior to this line, extraction should be avoided.

Merrifield[7] draw the profile line from the soft tissue pogonion up to the most anterior point of lips (it could be the lower or upper lip which was most protruding). The angle between the profile line and the Frankfurt horizontal plane called Z-angle. He also measured the total chin thickness (the bony part of the chin located in front of the NB-line towards the pogonion and the covering of soft tissue) and upper lip thickness (prosthion to the most anterior point on the vermilion border of the upper lip). He concluded that these 2 variables should be equal or the chin thickness might be slightly greater. The lip rposition could be evaluated in relation to the profile line. The upper lip should be on the line, the lower lip may be on the line or slightly posterior to the profile line. In adult, the normal Z angle is 80 $\pm$ 5 degrees. In adolescences (11-15 years), the normal Z angle is 78 $\pm$ 5 degrees.

Canut [17]presented a soft tissue analysis which evaluates the nose, lips and chin to the Sn-Sm line and the nasolabial sulcus depth, which were called the nasolabial aesthetic

sigma. In the literature Canut's line is still referred to as the "Juanita line" due to his name Juan Canut.

Gonzales-Ulloa and Stevens[32] introduced the line of zero meridian, which is vertical on the Frankfurt horizontal, crosses through the soft tissue nasion. They suggest that in the harmonize facial profile the chin should lie on that line.

Bass[18, 19]described the upper incisor position as a key for orthodontic treatment. The radiograph and photographic records were taken in the natural head position. The true horizontal was used as a reference line. And a perpendicular line to the true horizontal was used to determine the ideal position of the upper incisor, soft tissue pogonion, and the lips. He also suggested the display of 2 to 3 mm of the upper incisor below the interlabial gap.

In contemporary orthodontics, soft tissue analysis on photographs was developed. A method was also developed of linear and angular soft tissue profile analysis on photographs. In 1955, Stoner [20] evaluating facial profile by the method of photometric analysis. His offered is one method of assessing the disharmonies of facial balance and establishing criteria for determining the extent of change in the facial profile due to orthodontic treatment.

Neger [21] formulated a technique for soft-tissue profile analysis on the consideration of practicality, simplicity, accurateness and clinical application. His method was angular measurement on photogrammetric analysis. In his study, he focused on the upper lip, the lower lip, chin and using Frankfort horizontal plane as the main reference line.

Fernandez-Riveiro *et al.* [22, 23]standardized photographic technique and studied the profiles of subjects between 18 and 20 years old (50 male and 162 female) in a natural head position by the method of linear photogrammetric analysis to determine the mean soft tissue profile of the young adult white male and female. For the linear variables they concluded that sexual dimorphism existed in the area of the lips, nose and chin. They also studied angular photogrammetric analysis of the soft tissue profile of 275 individuals (67 males and 208 females) to define the average soft tissue facial profile. The results showed sexual differences in some measurements.

Arnett and Bergman[33, 34]discussed about the accuracy of orthodontic diagnosis and also suggested the solution to the this problem. They presented an organized, comprehensive clinical facial analysis. 19 facial traits were selected for this investigation. Both frontal and profile

views of the patient were used to identify the problems in 3 planes of space for orthodontic diagnosis and they also discussed about the soft tissue changes associated with orthodontic and surgical treatments of malocclusion. In addition, Arnett et al. [24] introduced a new facial diagnostic tool as the soft tissue cephalometric analysis (STCA) by augment cephalometric information with clinical facial profile analysis in the natural head position. In his study, he focus on 5 different but interrelated areas; the dentoskeletal, the soft tissue, facial lengths, true vertical line projections and harmony of facial parts. The important soft tissue structures were measured in antero-posterior direction to the true vertical line through subnasale. (They also suggested that in case of maxillary retrusion which could be defined by clinical and cephalometric findings, the true vertical line should move slightly forward from subnasale in order to use it as the reference line.) And the harmony of facial parts were measured by the harmony values. This was the position of each structure relative to other structures that defined the facial esthetics. Harmony values showed the horizontal distance between 2 structures measured perpendicular to the true vertical line. They also presented the treatment guidelines the orthodontist and surgeon about incisor and occlusal plane angulations that influence facial outcome.

Natural head position

In the 1950s, the idea of natural head position (NHP) was presented in orthodontics by Downs[12], Bjerin[35], and Moorrees and Kean[28]. It is a standardized and reproducible position of the head in an upright posture, the eyes focused on a point in the distance at eye level, which implies that the visual axis is horizontal.[25]

In the 1860s, in craniometric studies, craniologists attempt to orient the skull in a way of the natural head position of the living. Many horizontal or vertical reference plane was used to determine natural head position, but preference was given mostly to the horizontal plane. After extensive consideration, an agreements was reached finally at the World Congress on Anthropology in Frankfurt am Main, Germany in 1884 to take the plane from left porion to left orbitale which was called "Frankfort horizontal plane" as the best compromise plane for orientate skull. Nevertheless, orthodontists dealing with living subjects have used this plane in cephalometric analysis. Until 1956, Downs[12] described that sometimes patients had facial profile which they obviously did not possess when use Frankfort plane as a reference plane in

cephalometric analysis. The differences between facial profile from lateral cephalogram and photographic disappeared when the Frankfurt plane was not horizontal, but tilted up or down while the patient was looking at a point in the distance at eye level in natural head position. In addition to the study of Bjerin[35], the great variation in the relation of Frankfort and sella turcica-nasion (SN) plane (the two general reference plane) to the true horizontal plane of head indicated the suitability of taking into facial profile analysis. The standard deviations of the Frankfort horizontal variation in relative to the true horizontal were 4.6 and 4.3 degrees in the standing and sitting positions respectively, for the sella turcica-nasion plane the corresponding data were 4.0 and 4.4 degrees. Compare to the natural head position that got from different occasions varied from time to time within the approximate limits 2.7 degrees (standing) and 3.2 (sitting). The head position was therefore fairly constant. According to Solow and Tallgren[36], they compare the reproducibility between two methods to obtain natural head position. It was 2.48 degrees in the self-balance position and 1.43 degrees in the mirror position.

Moorrees and Kean[28] suggested to use natural head position for obtaining cephalometric radiographs and use the true vertical line as reference. When compare this method with the routine used of reference lines such as the Frankfort horizontal or nasion-sella turcica, it was more reliable. Since the biologic variation of the intracranial lines studies (SD ranges from 3.55 to 6.69 degrees) was greater than the variation found in recording natural head position (SD = 1.54 degrees). Similar to Lundstrom and Lundstrom[27], they supported to use the natural head position for cephalometric analysis of dentofacial anomalies. As the fact that the natural head position represents a realistic appearance and the repeatability of the natural head position was close to 2 degrees, compared with variation of 3 cephalometric reference lines (sella-nasion, basion-nasion, and porion-orbitale) to the true horizontal plane ranges from 4.5 degrees to 5.6 degrees.

Cooke and Wei [26] reported the reproducibility of the natural head position close to 2° on repeated radiographs. The reproducibility was better (1.9°) with patients looking at a mirror, than without a mirror (2.7°). They also investigated the use of ear post, and commented that no significant difference in the reproducibility was found between the natural head position recordings taken with and without ear posts.

Pereira *et al*.[37]studied the repeatability of the natural head position in children by

The photograghs. They concluded that there were no significant differences in the natural head position within a fifteen day interval whether using a cephalostat or not. The natural head position was evidenced to be a technique with good reproducibility in children.

Moreover, Peng and Cooke[38] studied the longitudinal reproducibility of natural head position. The five to ten minutes reproducibility was 1.9 degrees and the five year reproducibility was 3.0 degrees. After the fifteen year, the reproducibility was 2.2 degrees. As time pass, the individual variability of natural head posture repeatability was slightly increased. However, the variance of natural head posture after fifteen years (4.8 degrees) remains significantly less than the variance of intracranial reference planes to the true vertical (25 degrees to 36 degrees). In the same way as Cooke[39], he reported the outcomes of a five year longitudinal study assessing the reproducibility over time of natural head position in the lateral cephalogram. The reproducibility of natural head position deteriorated over time then exhibited signs of steadying after one to one and a half years. The 1 to 2 hours and 3 to 6 months reproducibility was 1.93 degrees and 2.34 degrees respectively. After 5 years, the reproducibility was 3.04 degrees. The standard deviation of the SN to true vertical angulation was more than the natural head position variability as 2.61 degrees after 1 to 2 hours, 3.16 degrees after 3 to 6 months, and 4.20 degrees after 5 years. Cephalometric analyses based on natural head position thus remain valid over time.

Even though the natural head position was confirmed to be reliable in the sagittal plane, but in the coronal and axial planes have not been proven. With an increasing interest in 3-dimensional craniofacial analysis, Weber *et al*.[40] evaluated the reproducibility of natural head position in the sagittal, coronal, and axial planes with 3-dimensional imaging over time. They found no statistically significant differences between the 5 time points in any of the 3 planes of space. Nevertheless, a statistically significant difference was found between the mean angular deviations of 3 reference planes. The coronal plane had the least variation over time, followed by the axial and sagittal planes.

Methods to obtain natural head position according to literature review of Nuntasukkasame *et al.* [41] concluded that there were 3 concepts to bring subjects into natural head position.

1. The position of head was defined by means of external reference such as a mirror. In the literature it is still referred to as the mirror methods. Subjects were asked to look into their own eyes in the mirror that located at their eyes level.[27, 28, 35]

2. The position of head was defined by the subjects own feeling of a natural head balance which was called the self-balance position. This method was introduced by Solow and Tallgren[36] in 1971 cited from the study of Molhave about the orthoposition. (a physiologic position of the head, when taking the first step forward from the standing to a moving or walking posture.) This position was obtained by letting the subject walk slightly on the spot. The achievement of the self-balance head position was facilitated by letting the subject tilt his head forwards and backwards with decreasing amplitude until he felt that a natural head balance was reached. However Solow and Tallgren found that the reproducibility of the mirror methods was better than the self-balance method, leading to the combination of the mirror and the self-balance method by letting the subject do the self-balance head position and then looking into the his own eyes in the mirror.[26, 42]

3. The natural head orientation (NHO) concept. It was the head orientation of the subject perceived by the clinician's experience, as same as the natural head position, the subject was looking at a distant point at eye level in a standing, relaxed body and head posture. This concept was shown in the study of Lundstrom *et al.*[43] in 1995 to correct the unavoidable error during the registration of the natural head position by the subject. They also reported a high correlation (r=0.82-0.96) among investigators in orientating the subjects' profile photographs in approximated natural head position. Furthermore, investigators showed good correlation (r=0.57-0.84) in head orientation after a three week interval. Mean differences for the same period varied between 0.1 and 2.9 degrees. The validity of natural head orientation was also encouraged by a panel investigation.

Objectives of this study

1. To create a new diagnostic tool for clinical soft tissue profile evaluation in orthodontic treatment and determine norms for Thai adult males and females

2. To compare the new diagnostic tool with the soft tissue analyses that we currently used.

3. To compare the new diagnostic tool and the soft tissue analyses that we currently used with the expert opinion.

Significance of the study

To provide the new diagnostic tool for soft tissue analysis that can evaluate soft tissue profile precisely, be practical, relates to natural head position, and can be done clinically in every visit. So the orthodontists can use this tool to plan the treatment and evaluate it to obtain the successful outcomes

CHAPTER 2

MATERIALS AND METHODS

Part 1 : To create the new diagnostic tool and establish norms for soft tissue measurements in Thai males and females

First, we developed the new tool to evaluate soft tissue profile with the proper reference line. This proper reference line was created base on

1. The reference line is the extracranial line and related to natural head position, such as true vertical line. Because it represents a realistic appearance of people in everyday life and reproducible.

2. The reference point is on the normal structure (for example, not on the chin in retrognathic mandible), stable (less change during treatment) and less variation.

So the reference point should not be the chin because it's position may be abnormal (in prognathic or retrognathic mandible) and less stable as it change during treatment.

It should not be the supramentale because it less stable as it change during treatment.

It should not be the subnasale because it's position may be abnormal (in prognathic or retrognathic maxilla) and less stable as it change during treatment.

And It should not be the tip of nose because it is high variation as Burstone said "the standard deviation of nose length is twice as great as the standard deviation that are estimates of variation in lip protrusion."[14])

In this study, we chose the most posterior point of alar for the reference point as its position is not on the abnormal structure, stable and less variation. [44, 45]

3. Clinical evaluation during treatment can be done. Because orthodontic treatment is a dynamic process and the adaptation in soft tissue may vary between individuals. So soft tissue analysis in this study would be the clinical tool to evaluate the patient's soft tissue for every visit.

4. Focus on lower facial area which are most esthetic matters that affected by orthodontic treatment.

5. It must be practical and easy to use.

In conclusion, we selected the true vertical line through the most posterior point of alar for the reference line in the new diagnostic tool. Because this line meet all the requirements for proper reference line.

Second, we determined norms for the new soft tissue analysis in Thai adult males and females. Purposive sampling of male and female non growing person (male 21-35,female 18-35) with a pleasing and balanced profile from the personnel or students at Prince of Songkla University until samples consist of 60 males and 60 females. These samples were judged by 5 orthodontists, Only the person who was accepted by at least 4 of 5 orthodontists that had good facial profile were included as the subjects in part 1.

The profile photos of all subjects were taken for soft tissue profile analysis according to the protocols.

Photographic setup

The records were taken in natural head position. Each subject stand on a line on the floor, framed by a vertical scale divided in 1-cm segments allowed measurements at life size. Subjects were asked to relax, and walk a few steps, stand at rest facing the camera, and look into his or her own eyes in the mirror. The lips were also relaxed, adopting their normal position during the day. Glasses were removed, and the subject's forehead, neck, and ears were clearly visible during the record.

The camera, canon D600, a 100-mm macro lens and a primary flash was used in its manual position, the shutter speed was 1/200 second, and the opening of the diaphragm was f/20 ,ISO 200.

The landmarks and reference lines

Table 1 Soft tissue landmarks

No.	Soft tissue landmarks	Definitions
1	Subnasale (Sn)	The point where the upper lip joins the columella
2	Upper lip anterior (ULA)	The most anterior point of the upper lip
3	Lower lip anterior (LLA)	The most anterior point of the lower lip
4	Supramentale (Sm)	The deepest point of the inferior sublabial concavity
5	Soft tissue pogonion (Pg')	The most anterior point of the chin
6	Alar	The most posterior point of the alar contour of nose in the profile view
7	Pronasal (Prn)	The most prominent point of the tip of the nose

Table 2 Reference lines

No.	Lines	Definitions
1	TVL through alar	True vertical line through the most posterior point of alar
2	THL through Sn	True horizontal line through subnasale
3	THL through Sm	True horizontal line through supramentale

Table 3 Linear and angular measurements

No.	Measurements	Definitions
	Linear measurements (mm)	
1	Sn - TVL through alar	The distance from Sn to TVL through alar
2	ULA - TVL through alar	The distance from ULA to TVL through alar
3	LLA - TVL through alar	The distance from LLA to TVL through alar
4	Sm - TVL through alar	The distance from Sm to TVL through alar
5	Pg'- TVL through alar	The distance from Pg' to TVL through alar
	Angular measurements (deg.)	
1	Nasolabial angle (NLA)	The angle formed by the intersection of Sn-ULA to THL through Sn
2	Mentolabial angle (MLA)	The angle formed by the intersection of Sm-LLA to THL through Sm

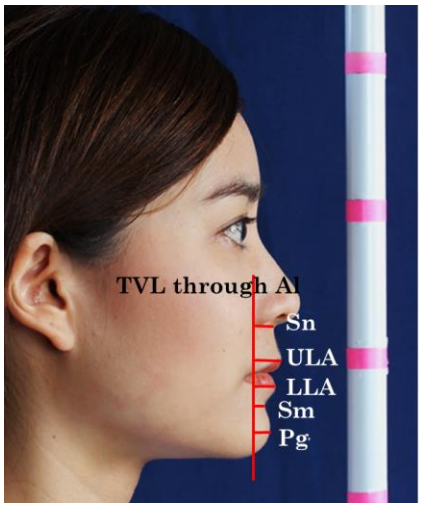

Fig. 1 5 linear measurements

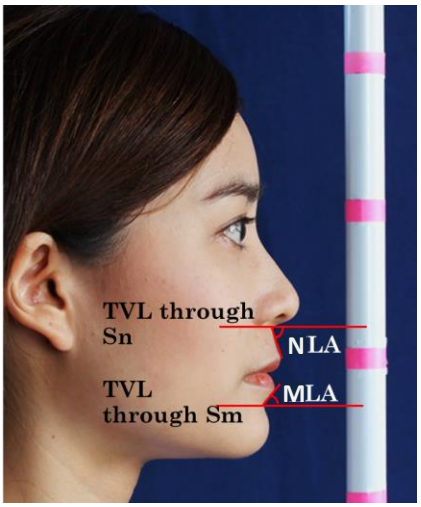

Fig. 2 2 angular measurements

The landmarks and reference lines were located on a digitized image to obtain all measurements by the computer program (Image J) and by one investigator. A descriptive statistics analysis of the measurements were carried out. Sexual dimorphism were evaluated by the Student t

test. The internal reliability of the method were analyzed by using Dahlberg's formula to determine the difference between 2 measurements at an interval of 2 weeks. For this purpose, 20 randomly selected records were remeasured.

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

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

The data from the measurements of samples with a pleasing and balanced profile were used as the norms for the new soft tissue analysis in Thai adult males and females.

Part 2: To test the effectiveness of the new diagnostic tool (compare with the currently used soft tissue analyses and the expert opinion which are regarded as gold standard)

Samples consist of 18 males and 18 females non growing person (male 21-35 years, female 18-35 years) with any type of facial profile from the personnel or students at Prince of Songkla University. The profile photo of all subjects were taken with the same protocols as part 1. The photographs and the questionnaire were sent to the 25 experts in order to diagnose the soft tissue profile of each subject by judge. The criteria for select the experts were

Having 5 years experiences in orthodontic treatment at least

Having a qualification of diplomate of Thai board orthodontics or equal

Graduating from varieties of university (Thailand, aboard)

Having different work place (university, hospital, private practice)

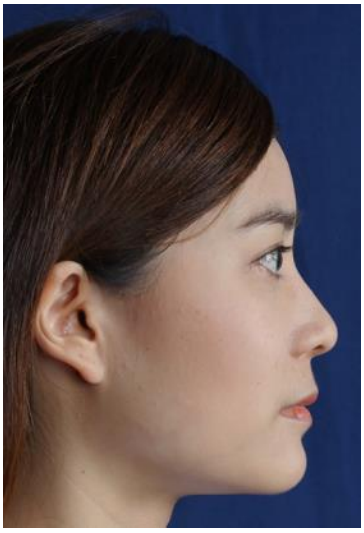

Fig. 3 Photo in questionnaire

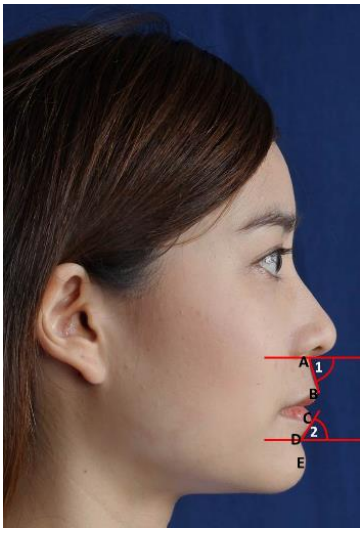

Fig. 4 Photo which define the points and angles in questionnaire

กรุณาวงกลมล้อมรอบคำตอบที่ตรงกับความคิดเห็นของท่านมากที่สุดเมื่อพิจารณาจากรูปภาพที่ให้มา

1. ท่านคิดว่าตำแหน่งริมฝีปากบนบริเวณจุด A มีลักษณะเป็นอย่างไร
   Retrude **Normal** **Protrude**

2. ท่านคิดว่าตำแหน่งริมฝีปากบนบริเวณจุด B มีลักษณะเป็นอย่างไร
   Retrude **Normal** **Protrude**

3. ท่านคิดว่าตำแหน่งริมฝีปากล่างบริเวณจุด C มีลักษณะเป็นอย่างไร
   Retrude **Normal** **Protrude**

4. ท่านคิดว่าตำแหน่งริมฝีปากล่างบริเวณจุด D มีลักษณะเป็นอย่างไร
   Retrude **Normal** **Protrude**

5. ท่านคิดว่าตำแหน่งคาง (E) มีลักษณะเป็นอย่างไร
   Retrude **Normal** **Protrude**

6. ท่านคิดว่าขนาดของมุมหมายเลข 1 ซึ่งแสดงถึงลักษณะของริมฝีปากบนเป็นอย่างไร
   Acute **Normal** **Obtuse**

7. ท่านคิดว่าขนาดของมุมหมายเลข 2 ซึ่งแสดงถึงลักษณะของริมฝีปากล่างเป็นอย่างไร
   Acute **Normal** **Obtuse**

Fig. 5 Questionnaire

Photos of all subjects in part II (18 males and 18 females) with the 7 variables were measured by the computer program (Image J) and by one investigator as same protocols as part 1. The measurement values were interpret into the diagnosis such as the protruded upper lip, the normally positioned lower lip by using the 3 analyses consist of E line, true vertical line through subnasale and true vertical line through posterior point of alar (the new tool). Norms for these analyses are Thai norms according to Dechkunakon *et al*. for E line[47], Nuntasukkasame. for true vertical line through subnasale[48] and the data from part I of this study for true vertical line through posterior point of alar.

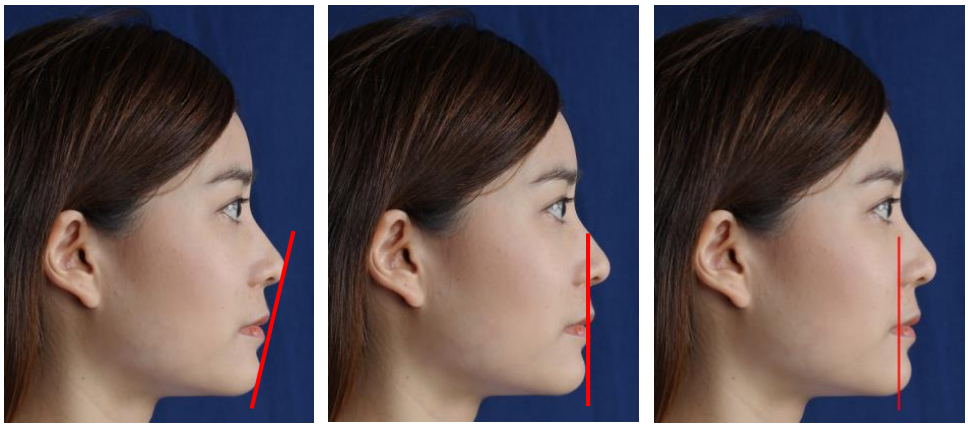

Fig. 6 3 analyses consist of E line, true vertical line through subnasale and true vertical line through alar (from right to left).

Kappa analyses were used to determine the agreements between

the new diagnostic tool (TVL through alar) and the TVL through Sn,

the new diagnostic tool (TVL through alar) and E line,

the expert opinion and the new diagnostic tool (TVL through alar),

the expert opinion and the TVL through Sn,

the expert opinion and the E line.

For this purpose, kappa analyses were used in each variable and separate between male and female. The interpretation of kappa values were done according to Landis and Koch's guideline [49] as shown in Table 4.

Table 4 Landis and Koch's guideline for the interpretation of kappa values

	Interpretation
< 0	Poor agreements
0.01 – 0.20	Slight agreements
0.21 – 0.40	Fair agreements
0.41 – 0.60	Moderate agreements
0.61 – 0.80	Substantial agreements
0.81 – 1.00	Almost perfect agreements

Additionally, sensitivity and specificity of the new diagnostic tool in each variable were evaluated by using the expert opinion as the gold standard.

CHAPTER 3

RESULTS

Part 1: Norms for soft tissue measurements in Thai males and females using the new diagnostic tool, TVL through alar.

From 120 subjects, 60 females and males, 39 females and 31 males with a pleasing and balanced profile were selected as judged by 80 percent agreements of 5 orthodontists. The mean age of subjects was 24.5 years in females and 25.4 years in males. On the basis of soft tissue landmarks measured on these subjects, Norms and standard deviations for soft tissue measurements in males and females using TVL through alar were established. Male soft tissue measurement average values were greater than the females in all variables. And the upper lip was more protrusive than the lower lip around 2 mm in relation to TVL through alar in both sexes. Statistical analysis of the differences between males and females was done with the Student's t-test. A level of significance of 5% was assigned and P values were determined. Statistical analysis revealed that male soft tissue measurements at subnasale, upper lip, lower lip and nasolabial angle were statistically significantly greater than the females. The variables, means, SDs, and P values were presented in Table 5.

Table 5 Means and standard deviations for soft tissue measurements in males and females using TVL through alar

Variables	Female (n = 39)		Male (n = 31)		P value
	Mean	**S.D**	**Mean**	**S.D**	
A (mm)	10.22	1.61	11.84	1.93	.000*
B (mm)	14.13	2.12	15.56	2.16	.007*
C (mm)	11.91	2.07	13.30	2.33	.010*
D (mm)	5.81	2.24	6.78	2.20	.073
E (mm)	7.09	2.37	8.04	2.44	.106
1 (deg.)	72.08	4.79	74.53	3.75	.022*
2(deg.)	51.81	5.72	53.05	4.25	.301

*Statistically significant differences, $P < .05$

To define the intra-observer reliability, 20 of subjects' photograph were random and remeasured by the same investigator after 2 weeks. According to the Dahlberg's formula, method error of the linear and angular measurements ranged from 0.12 to 0.16 mm and 0.27 to 0.30 degree, respectively (Table 6). The differences were insignificant and within acceptable limits.

Table 6 Method error of the linear and angular measurements according to the Dahlberg's formula using TVL through alar

Variables	Method error
A	0.16 mm
B	0.16 mm
C	0.13 mm
D	0.12 mm
E	0.14 mm
1	0.27 degree
2	0.30 degree

Part 2: To test the effectiveness of the new diagnostic tool (compare with the currently used soft tissue analyses and the expert opinion which are regarded as gold standard)

Photograph of 36 subjects, 18 females and males, were measured and interpreted into the diagnosis using the 3 analyses consist of the new diagnostic tool (TVL through alar), TVL through Sn and E line.

As same as Part 1, to define the intra-observer reliability, 20 of subjects' photograph were random and remeasured by the same investigator after 2 weeks. According to the Dahlberg's formula, method error of the linear and angular measurements using TVL through alar ranged from 0.12 to 0.16 mm and 0.27 to 0.30 degree, respectively (Table 6). And method error of the linear measurements using TVL through Sn and E line were 0.08 to 0.09 mm and 0.09 to 0.1mm, respectively (Table 7, 8). The differences were insignificant and within acceptable limits.

Table 7 Method error of the linear and angular measurements according to the Dahlberg's formula using TVL through Sn

Variables	Method error
Upper lip	0.09 mm
Lower lip	0.08 mm
Chin	0.08 mm

Table 8 Method error of the linear and angular measurements according to the Dahlberg's formula using E line

Variables	Method error
Upper lip	0.10 mm
Lower lip	0.09 mm

The content validity of the questionnaire was determined by the index of item-objective congruence (IOC) and the reliability was measured by the Cronbach's alpha coefficient. In this study, the index of item-objective congruence (IOC) was 1 and the Cronbach's alpha coefficient was 0.838 and 0.815 for the questionnaire about male and female subjects respectively.

Out of 25 surveys, 22 were returned. The average age of experts was 37.14 years (range from 31- 45 years). They graduated from varieties of university in Thailand, aboard and had a qualification of diplomate of Thai board orthodontics or equal. They also had different work place (hospital, private practice and university) and average number of years in practice was 7.86 years (range from 5-16 years).

Agreements between the new diagnostic tool (TVL through alar) and the currently used soft tissue analyses (TVL through Sn and E line)

Agreements between the new diagnostic tool and TVL through Sn were shown in Table9. All variables (upper lip, lower lip and chin) were agreed substantially between the new

diagnostic tool and TVL through Sn in both sexes. The kappa values ranged from 0.71 to 0.76 in female subjects and 0.61 to 0.79 in male subjects.

Considering agreements between the new diagnostic tool and E line, the agreements for the upper lip in both sexes were moderate and higher than the lower lip which was fair in males and slight in females. The kappa values for these 2 analyses ranged from 0.18 to 0.44 in female subjects and 0.35 to 0.47 in male subjects as shown in Table 10.

Table 9 Agreements between the new diagnostic tool (TVL through alar) and TVL through Sn

Variables	Kappa	
	Female	**Male**
U lip	0.71	0.79
L lip	0.75	0.61
Chin	0.76	0.78

Table 10 Agreements between the new diagnostic tool (TVL through alar) and E line

Variables	Kappa	
	Female	**Male**
U lip	0.44	0.47
L lip	0.18	0.35

Agreements between the expert opinion and 3 analyses, the new diagnostic tool (TVL through alar), TVL through Sn and E line.

Agreements between the expert opinion and the new diagnostic tool were shown in Table 11. They were in moderate to substantial level except for Sn which were fair in both sexes. In females, the expert opinion agreed substantially with the new diagnostic tool for upper lip, supramentale, chin and nasolabial angle. While only chin was agreed substantially in males. For the lower lip and mentolabial angle in females and also the upper lip, lower lip, supramentale,

nasolabial angle and mentolabial angle in males were in moderate agreements. These indicated that the new diagnostic tool could diagnose the soft tissue in female consistently with the expert opinion more than in male. With the exception of Sn, The kappa values ranged from 0.47 to 0.67 in female subjects and 0.45 to 0.61 in male subjects.

Furthermore, agreements between the expert opinion and the TVL through Sn for all variables (upper lip, lower lip and chin) in both sexes were in moderate level, except chin in female subjects which was substantial agreement. The kappa values ranged from 0.54 to 0.62 in female subjects and 0.44 to 0.52 in male subjects as shown in Table 12.

Table 13 presented the kappa values of the agreements between the expert opinion and the E line. The agreements for the upper lip were higher than the lower lip in both sexes. The kappa values for upper lip was fair (0.40) and lower lip was slight (0.19) in females and the kappa values for upper lip was moderate (0.41) and lower lip was fair (0.34) in males.

Table 11 Agreements between the expert opinion and the new diagnostic tool (TVL through alar)

Variables	**Kappa**	
	Female	**Male**
A	0.38	0.32
B	0.64	0.52
C	0.52	0.51
D	0.67	0.59
E	0.62	0.61
1	0.67	0.48
2	0.47	0.45

Table 12 Agreements between the expert opinion and the TVL through Sn

Variables	Kappa	
	Female	Male
U lip	0.55	0.44
L lip	0.54	0.47
Chin	0.62	0.52

Table 13 Agreements between the expert opinion and the E line

Variables	Kappa	
	Female	Male
U lip	0.40	0.41
L lip	0.19	0.34

Sensitivity and specificity of the new diagnostic tool (TVL through alar)

Sensitivity and specificity of the new diagnostic tool in each variable were shown in Table 14 and Table 15 respectively. They were high in all variables except for sensitivity of this tool to evaluated Sn in both sexes.

Table 14 Sensitivity of the new diagnostic tool (TVL through alar)

Variables	Sensitivity	
	Female	**Male**
A	57%	50%
B	79%	100%
C	100%	100%
D	100%	82%
E	88%	82%
1	92%	86%
2	100%	100%

Table 15 Specificity of the new diagnostic tool (TVL through alar)

Variables	Specificity	
	Female	**Male**
A	91%	92%
B	100%	92%
C	100%	80%
D	88%	86%
E	88%	86%
1	100%	91%
2	89%	90%

CHAPTER 4

DISCUSSIONS

Part 1: Norms for soft tissue measurements in Thai males and females using the new diagnostic tool, TVL through alar.

The TVL through alar is the new diagnostic tool for soft tissue analysis that focus on lower facial area which are most esthetic matters that affected by orthodontic treatment. It was created in order to find the new reference line which place on the normal structure, stable and less variation even though the patient had class II or class III facial profile. Moreover, this line is related to natural head position to represents a realistic appearance of people in everyday life and could be seen clinically so we can use this line to evaluate the patient's soft tissue profiles for every visit during treatment.

The norms for this new soft tissue analysis in Thai adult males and females were developed as presented in Table 2. The upper lip was more protrusive than the lower lip around 2 mm in relation to TVL through alar in both sexes. Male soft tissue measurement average values were greater than the females in all variables. This finding of our study was similar to other studies. Fernandez-Riveiro *et al.*[23] found that males had greater heights and lengths as well as greater prominences of labial, nasal and chin area. Furthermore, Ioi *et al*.[50, 51] and Sodagar and Borujeni[52] also found that the most-favored female profile was slightly retruded than male profile.

Gender dimorphism was seen in four out of seven variables. Male soft tissue measurement at subnasale, upper lip, lower lip and nasolabial angle were statistically significantly greater than females. These findings of our study were unlike the study of Dechkunakon *et al*.[47] and Nuntasukkasame.[48] which found no statistically significant differences between sex for upper and lower lips. This is because the protocols to select the subject are difference. The subjects in our study not only had a class I facial profile but also were guarantee from 4 of 5 orthodontists that they had good facial profile which can represent the norms for adult Thai males and females. But the criteria for those studies used the facial contour angle (FCA) to select the subject for soft tissue

analysis. Another explanation is the difference reference lines were use. The TVL through alar was selected for our study. The TVL through Sn was selected for the study of Nuntasukkasame [48] and E line was chosen for Dechkunakon *et al*.'s study[47].

E-line is affected by the position of nose and chin. If these structure are protruded or retruded than normal, the evaluation of the lip with this line may bring misleading information. Moreover the tip of nose is the structure which has high variation, so it might be improper to use it as reference point to evaluate the lip position[14].

TVL through Sn like our new diagnostic tool, It related to natural head position that can represents a realistic appearance of people in everyday life. But the Sn point is affected by the position of maxilla. This may bring the error of evaluation in case of the abnormal position of the maxilla[24].

Part 2: To test the effectiveness of the new tool (compare with the currently used soft tissue analyses and the expert opinion which are regarded as gold standard)

Agreements between the new diagnostic tool (TVL through alar) and the expert opinion

Improvements in research methodology were made in this study. In contrast to the previous study the new diagnostic tool in our study was created not only base on the theory or someone's thought but also was proven by comparing with the currently used soft tissue analyses and the expert opinion which are regarded as gold standard.

The soft tissue analysis from the new diagnostic tool (TVL through alar) was compared with the expert opinion. The results showed that agreements between the expert opinion and the new diagnostic tool were in moderate to substantial level except Sn which was fair in both sexes.

On comparison with Huang and Li's study[53] which investigate the concordance between the objective measurements of cephalometry and subjective evaluation of profile by the orthodontist and the lay persons in bimaxillary protrusion patients. They found correlation between many variables (the upper, lower lip and Sm to E line, nasolabial angle and mentolabial angle) with the esthetic score ranged from 0.1-0.45 which were in low to moderate level. Furthermore,

Oh *et al*.[30] studied the correlation between many soft tissue analyses (E line, B line, TVL through Sn, H angle, Z angle, Nasolabial angle) with the facial attractiveness judge by the orthodontists. The results also showed that the correlation ranged from 0.04-0.53 which were in low to moderate level. When compare our results with the previous studied, these may imply that the TVL through alar can evaluate the soft tissue consistently with the expert opinion in the acceptable level.

The reason why the expert opinion was agreed with our tool in fair level for Sn point could be explained by the finding of Chan *et al*. [54]and Soh *et al.*[55] They reported that people were less sensitive to antero-posterior position of the maxilla compared with the mandible. When moving the maxilla forward or backward in antero-posterior position, It still were ranked as attractive. Position of Sn was influence by the position of the maxilla so it might be hard for the expert to evaluate this point. This was confirmed by the different answer of 22 experts in this study.

Another thing should be consider about this reference line was that it tended to evaluate soft tissue in females consistently with the expert opinion more than males. This result of our study was supported by the finding of Soh *et al*.[55, 56] that there was a difference in expert opinion about the most attractive male profiles. Moreover, they found the lack of significant correlation in the perception of male esthetics between dental students, laypersons and experts. These suggested a difference in how male profiles were perceived. But the perceptual trend of the female profiles by all groups was highly correlated. A possible contribution to this finding was society's exposure to media influences that often emphasize the female physical form and face.

Agreements between the new diagnostic tool (TVL through alar), the currently used soft tissue analyses (TVL through Sn) and the expert opinion

Agreements between the new diagnostic tool and TVL through Sn were in substantial level for all variables (upper lip, lower lip and chin) in both sexes. A possible contribution to high agreements between these lines is they are the same line (the true vertical line) but difference in the reference point where the lines pass. When considering the agreements between the expert opinion and the TVL through Sn, all variables (upper lip, lower lip and chin) in both sexes were moderate agreements, except chin in female subjects which was substantial agreement. Like our new diagnostic tool, expert opinion agree moderately to substantially with

TVL through Sn and it tended to evaluate soft tissue in females consistently with the expert opinion than males. However the expert opinion were agreed more with our tool for upper lip in both sexes and chin in males. These contrasting findings could point toward the fact that Sn point is affected by the position of maxilla and may bring the misleading diagnosis in case of the abnormal position of the maxilla as in our study which the subjects in part 2 had any profile type including prognathic and retrognathic maxilla. These can confirm by the results that in case of prognathic maxilla, TVL through Sn diagnosed the upper lip as normally or retruded position while our new diagnostic tool and expert diagnosed as protrude or normal, recpectively. On the other hand, in case of retrognathic maxilla, TVL through Sn diagnosed the upper lip as protruded or normally position while our new diagnostic tool and expert diagnose as normal or protrude, recpectively.

Agreements between the new diagnostic tool (TVL through alar), the currently used soft tissue analyses (E line) and the expert opinion

Agreements between the new diagnostic tool and E line were lower than agreements between the new diagnostic tool and TVL through Sn. The agreements for the upper lip in both sexes were moderate and higher than the lower lip which was fair in males and slight in females.

As mentioned above, E line is affected by the position of nose and chin which has high variation and may lead to the deceptive diagnosis in case of abnormal position of mandible. When compare the diagnosis from E line with the expert opinion, It is in the same way with comparing E line with our diagnostic tool which is the agreements for the upper lip were higher than the lower lip in both sexes. The agreement of upper lip was fair and lower lip was slight in females and the upper lip was moderate and lower lip was fair in males. Even though the difference occur in agreement of male and female upper lip, the kappa value almost the same. (0.40 in female,0.41 in male) These findings coincide with those of Oh *et al.*[30] that E line to lower lip is one of the poorer measures which did not correlate with the subjective evaluation of profile by the orthodontist. But in contrast to the findings by Erbay and Canikliogl[57] who found that among the soft tissue analyses used in their study (Steiner, Ricketts, Burstone, Sushner, Holdaway and Merrifield) Ricketts' norms for upper and lower lips were the closest to the values they found

for the attractive profiles. However Erbay and Canikliogluʼs study[57] determined the criteria for sample selection as Angle Class I occlusal relationship, normal antero-posterior and vertical skeletal relationships. So the case with abnormal position of mandible which could lead to the misdiagnosis of E line was not included in their study.

Another reason that could explain why expert agreed with E line in the lower level when compare to our diagnostic tool and TVL through Sn was that the norms for E line we use in this study were established in 1994 may not represent the norms which it should be in the present day. This fact was supported by many recent studies[50-52, 54, 56, 58]that the orthodontists, dental students and laypersons prefer a more retruded lip position and profile than norms for both men and women.[50-52, 54, 56, 58]

The results of this study suggest that E line could evaluate the upper lip consistently with the expert opinion more than the lower lip. This complement the findings of a previous investigation. Erbay and Canikliogluu[57]reported that when evaluating lip positions in relation to the nose and the chin, if the rotation of mandible occurred, the position of lower lip will be affected more than the upper lip. In this study the prognathic and retrognathic mandible were seen in our part 2 subjects so the abnormal chin position make an error on the lower lip diagnosis more than the upper lip.

Sensitivity and specificity of the new diagnostic tool (TVL through alar)

Sensitivity and specificity of the new diagnostic tool were high in all variables except for sensitivity of this tool to evaluated Sn in both sexes. These were consistent with the findings of the agreements between the expert opinion and the new diagnostic tool which were in moderate to substantial level in all variables except for Sn that was fair in both sexes. And could be explained by the same reason that people were less sensitive to antero-posterior position of the maxilla compared with the mandible. When moving the maxilla forward or backward in antero-posterior position, It still were ranked as attractive. Position of Sn was influence by the position of the maxilla so it might be hard for the expert to evaluate this point to be abnormal even though it was true. Therefore the sensitivity were not high as other variables whereas the specificity were still high. However, there was the limitation about how to test the sensitivity and specificity in this study. Because there was no tool that can exactly identified the soft tissue profile, so in this study

we use the majority of expert opinion as the gold standard to test the sensitivity and specificity of the new diagnostic tool.

Clinical application and suggestion

The results from part 2 in this study imply that the true vertical line through alar is an alternative diagnostic tool for clinical soft tissue evaluation in orthodontic treatment. The norms for soft tissue measurements in Thai males and females using this new diagnostic tool were established according to the data of part 1 in this study in term of 1 decimal place, point five or point zero as presented in Table 16.

However, the norms for soft tissue measurements in this study were established base on the Thai subjects with a pleasing and balanced profile. The difference among each ethnic group must be take into consideration when using this new diagnostic tool to evaluate soft tissue profile with these norms. Therefore, further study should be done to establish normal values for each ethnic group by using the TVL through alar as a reference line. And as the reference point in this diagnostic tool was the most posterior point of alar so this tool was use in the limitation with the patients who had normal development of nose.

For convenience of use, the norms for soft tissue measurements in males and females using TVL through alar may create into the template as shown in Fig.7. The blue line represents the lower limit of the norms and the red line represents the lower limit of the norms. This template can use for clinical evaluation of soft tissue profile. Although the size of the template was not fit to the size of face in some patients, this problem can be solve by sliding the template up and down to evaluate in each variable one by one. For examples, when using the template evaluate the upper lip, the rest of the variables may not fit to the template.

Table 16 The norms for soft tissue measurements in males and females using TVL through alar (for clinical application)

Variable	Female		Male	
	Mean	**S.D**	**Mean**	**S.D**
Sn (mm)	**10**	**1.5**	**12**	**2**
U lip (mm)	**14**	**2**	**15.5**	**2**
L lip (mm)	**12**	**2**	**13.5**	**2.5**
Sm (mm)	**6**	**2**	**7**	**2**
Pg' (mm)	**7**	**2.5**	**8**	**2.5**
NLA (deg.)	**72**	**5**	**74.5**	**4**
MLA (deg.)	**52**	**6**	**53**	**4**

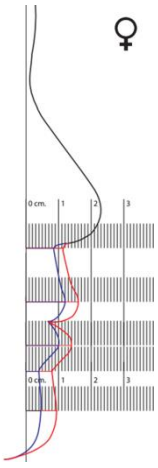

Fig. 7 Example of the template for female

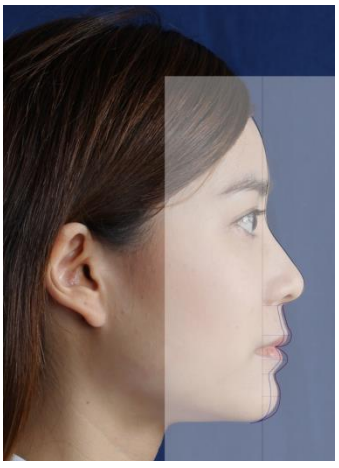

Fig. 8 Clinical application in using the template

CHAPTER 5

CONCLUSIONS

1. The true vertical line through alar is a new diagnostic tool for soft tissue profile analysis that was created from this study and the norms for Thai males and females were established from the measurement values of Thai adult males and females with good facial profiles. And the agreements between expert opinion with this new diagnostic tool were in moderate to substantial level except for the Sn point in both sexes.

2. When compare the new diagnostic tool (TVL through alar) with the currently used soft tissue analyses, the agreements of this tool with TVL through Sn were substantial for all variables in both sexes and higher than the agreements of this tool with E line which were moderate for the upper lip in both sexes and was fair in males and slight in females for the lower lip.

3. When compare the 3 analysyes with the expert opinion, the agreements of expert opinion with this tool was the highest, following by the agreements of expert opinion with TVL through Sn. And the last was the agreements of expert opinion with E line. The experts agreed with this tool more than the TVL through Sn for upper lip in both sexes and chin in males. They also agreed with this tool more than E line for upper and lower lips in both sexes. Moreover, this tool and TVL through Sn tended to evaluate the soft tissue profile in females consistently with the expert opinion more than males. And E line tended to evaluate the upper lip consistently with the expert opinion more than the lower lip.

From the results of this study, we can conclude that the true vertical line through alar is an alternative diagnostic tool for clinical soft tissue evaluation in orthodontic treatment.

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APPENDIX

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Documentary Proof of Ethical Clearance
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Faculty of Dentistry, Prince of Songkla University

The Project Entitled How to Identify Soft Tissue Profile for Orthodontic Diagnosis

REC Project No. : EC5904-18-P-LR

Principal Investigator : Assoc. Prof. Dr. Chairat Charoemratrote

Co- Principal Investigator : Miss Piyanart Songkongka

Approved by Research Ethics Committee (REC), Faculty of Dentistry, Prince of Songkla University.

This is to certify that REC is in full Compliance with International Guidelines for Human Research Protection such as the Declaration of Helsinki, the Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP).

Date of Approval : 23 MAY 2016 **No. of Approval** : MOE 0521.1.03/561

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