Original Article

pISSN, eISSN 0125-5614
M Dent J 2020; 40 (3) : 257-266

Correlation between H angles and visual perception in skeletal type I females

Kitpat Lersinghanart, **Supatchai Boonpratham**, Suwannee Luppanapornlarp

Department of Orthodontics, Faculty of Dentistry, Mahidol University.

Objective: To study the agreement among the hard tissue H angle, soft tissue H angle, and visual perception of facial profile in Thai patients with skeletal Type I patterns.

Material and methods: Sixty-one lateral cephalograms of female patients of skeletal Type I patterns (ANB 1.97-5.69°) were hand traced and analysed. The outlines of the soft tissue profile of all cephalograms were separately traced and distributed to ten orthodontic residents to be rated for the convexity of the soft tissue profile using a visual analogue scale (VAS). Spearman's rank-order correlation tests were used to analyse the relationship among the H angles and visual perception score.

Results: The mean values of the soft tissue and hard tissue H angles were 15.25±2.73° and 11.13±2.82°, respectively, while the mean visual perception score pointed towards a very slightly convex profile. The soft tissue and hard tissue H angles were moderately correlated with one another (r=0.713; p<0.01). There were equal significant correlations between the soft and hard tissue H angles with the visual perception score (r=0.441; p<0.01).

Conclusion: Both the soft and hard tissue H angles had the same degree of agreement with visual perception of the facial profile; hence, clinicians can choose either measurement to define the soft tissue profile in skeletal Type I adult patients.

Keywords: Cephalometric analysis, Correlation, Facial profile, Hard tissue H angle, Skeletal Type I, Soft tissue H angle, Visual perception

How to cite: Lersinghanart K, Boonpratham S, Luppanapornlarp S. Correlation between H angles and visual perception in skeletal type I females. M Dent J 2020; 40: 257-266.

Introduction

The concept of facial aesthetics and harmony has constantly evolved over the centuries. Facial aesthetics can be defined as the balance and concordance among facial proportions, which are established by the skeletal structures, teeth, and soft tissues. Growth, aging, and orthodontic treatment can affect these dental or skeletal structures, which will subsequently contribute to the changes in patient's soft tissue profile [1].

In the process of diagnosis and treatment planning as well as evaluation of treatment outcome, orthodontists are concerned with many possible variations in the hard and soft tissues. Such skeletodental measures of morphological variations are generally derived from cephalometric analysis [2]. Orthodontists have long been on the quest for a hard tissue measurement that meets all the requirements of the objectives in orthodontic treatment, which are: balance and harmony of facial lines, stability of the dentition after treatment, health of oral tissues, and an efficient chewing mechanism.

Correspondence author: Supatchai Boonpratham
Department of Orthodontics, Faculty of Dentistry Mahidol University, Bangkok, Thailand.
6 Yothi Road, Ratchathewi, Bangkok 10400, Thailand.
Email: supatchai.boo@mahidol.ac.th
Received : 14 July 2020 Accepted : 30 October 2020

During the 20th century, Edward Angle [3], who was one of the pioneers of modern orthodontics, stated that if patients have their teeth in ideal relations, the face will be in perfect harmony and balance, as well as having a well-functioning stomatognathic system. When Broadbent [4] introduced the application of cephalometric methods to analyse dental and skeletal structures, it marked the beginning of a new area in orthodontic diagnosis. Initially, these clinicians believed that if the dental occlusion and dentoskeletal relationships were ideal, the soft tissues would also follow.

However, besides the dentoskeletal framework, there is even more information to be gathered from the soft tissue structures covering the hard tissues, which has led to a shift towards the importance of soft tissue contours – and not just hard tissue configurations – that strongly influence facial relationships as it affects both aesthetic outcome and long-term stability of treatment. This has been termed the ‘soft tissue paradigm’. Hence, it is now believed that all this information put together can contribute to a more meaningful approach in treatment planning. [5]

Soft tissue cephalometric assessments have since been developed, [6,7] such as facial convexity angle [8], S-line [9], E-line[10], and Z angle[6], to analyse the facial profile but there has been no definitive judgement as yet of which measurement provides the best diagnosis.

For instance, Ricketts introduced a line he termed the ‘aesthetic plane’, where he advocates that ideally, the lips should lie on a line extending from the chin to the tip of the nose when the mouth is closed without strain, and that the lower lip should be slightly ahead of the upper lip. Steiner instead suggested that the lips should fall upon a plane extending from the chin to the middle of the S-shaped curve formed by the lower border of the nose and the upper lip. This analysis, in which the lip position is more emphasized, would take into consideration the size of the nose and chin to harmonize them with the lips as well. The majority of these assessments share one main disadvantage, which is that they are unable to provide information regarding the relationship between the hard and soft tissues.

Later in 1983, Holdaway proposed the hard and soft tissue H angles to evaluate patient’s profile. The soft tissue H angle is formed by a straight line extending from the point of the soft tissue chin tangent to the upper lip with the NB line. Holdaway believed that the soft tissue facial convexity should coincide with the underlying skeletal convexity. Because of this, as his analysis was based on Steiner’s earlier research, Holdaway decided to modify the measurement of facial convexity expressed by the ANB angle and instead to use the NB line as the vertical profile line.

Nevertheless, relying purely on these objective cephalometric measurements is insufficient to come to a proper diagnosis for individual profiles. Atchison et al [11] stated that clinical examination from orthodontists is more important than the radiographs in everyday use. As a result, the use of visual perception by orthodontists themselves to increase the accuracy of clinical diagnosis is becoming more important [12]. Therefore, our study aimed to assess the agreement between the hard tissue H angle, soft tissue H angle, and visual perception from the orthodontists' point of view to contribute towards a better standard in the evaluation of the patient’s soft tissue profile by cephalometric analysis.

Materials and methods

This research was granted the certificate of approval by the institutional review board of Faculty of Dentistry/ Faculty of Pharmacy, Mahidol University, COA No. MU-DT/PY-IRB 2017/DT058. Five-hundred lateral cephalometric films of Mahidol University students from years 2016 - 2018 were traced and examined by a single investigator.

As per the ANB values of the Thai norm, the films were categorized into skeletal Type I (ANB 1.97-5.69°)[13], skeletal Type II (ANB >5.69°), and skeletal Type III (ANB <1.97°). A final total of 61 lateral cephalometric films of Thai adult females with age ranging between 19 to 22 years old who presented with skeletal Type I pattern were chosen. The inclusion and exclusion criteria were as follows:

Inclusion criteria

1. All subjects with complete records including chart records and pre-treatment lateral cephalogram were used.

2. All subjects were non-growing Thai adults, 19-22 years of age, with skeletal Type I pattern (defined by ANB within the range of 1.97 – 5.69 [13]).

3. All subjects did not have any previous orthodontic treatment.

4. All radiographs had adequate resolution and quality to allow identification of all necessary hard and soft tissue landmarks.

5. All radiographs were taken from the same orthopantomograph machine (Orthopantomograph OP 100, Instrumentarium, Munich, Germany).

6. All subjects had no reported congenital anomalies or severe systemic disease.

Exclusion criteria

1. Subjects whose radiographs were distorted or not sufficiently clear for landmark identification.

2. Subjects with cleft lip and palate or other congenital craniofacial deformity.

3. Subjects with any systemic medical conditions that might affect their physical or emotional growth, including psychiatric conditions.

4. Subjects with any facial plastic surgery.

5. Subjects with skeletal Type II and III patterns.

Any data or labels presented on the films were blinded and replaced with identification numbers. All films were hand-traced on a clean sheet of acetate paper and analysed. Measurements of soft and hard tissue H angles from 10 randomly chosen cephalometric films were repeated two weeks after the initial measurements to evaluate for intra-examiner reliability with intraclass correlation coefficient. All films were handed-traced on a clean sheet of acetate paper and analysed according to the definition of the landmarks and parameters[13] as outlined in Table 1 and Figure 1.

Facial profile evaluation by visual perception

The outline of the soft tissue profile of all cephalograms was separately traced on a clean white background. Ten sets of copies were distributed to 10 randomly selected postgraduate orthodontic students from the Faculty of Dentistry, Mahidol University to perform the visual perception tests of the soft tissue profiles.

A Visual Analog Scale (VAS) with a score of 0 to 10, as follows, was used to rate the convexity of each soft tissue profile.

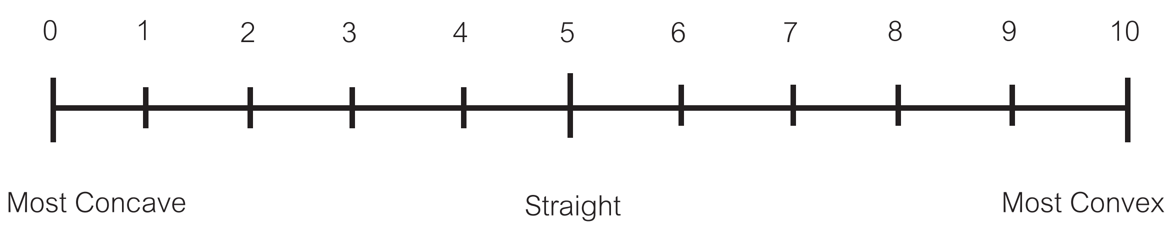
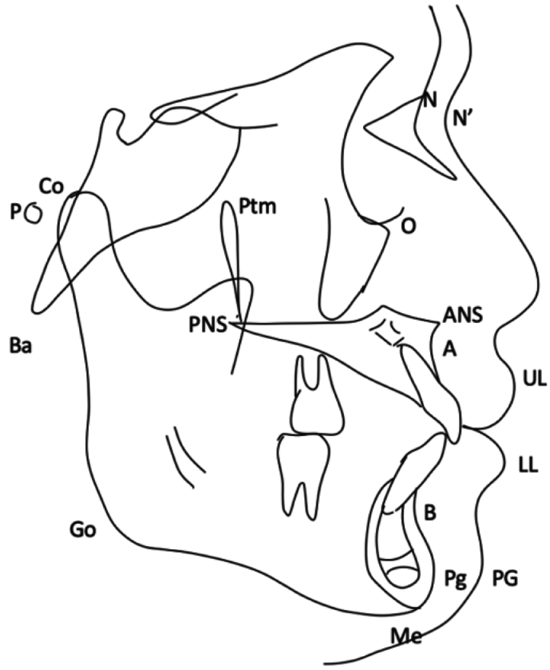
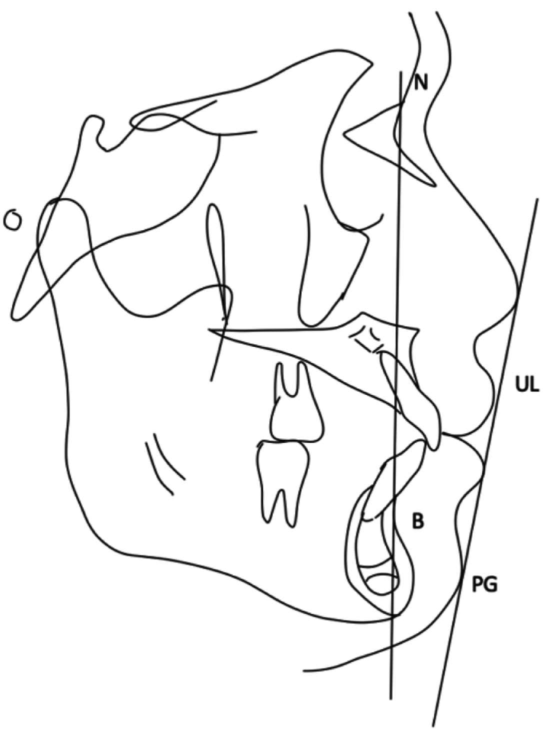


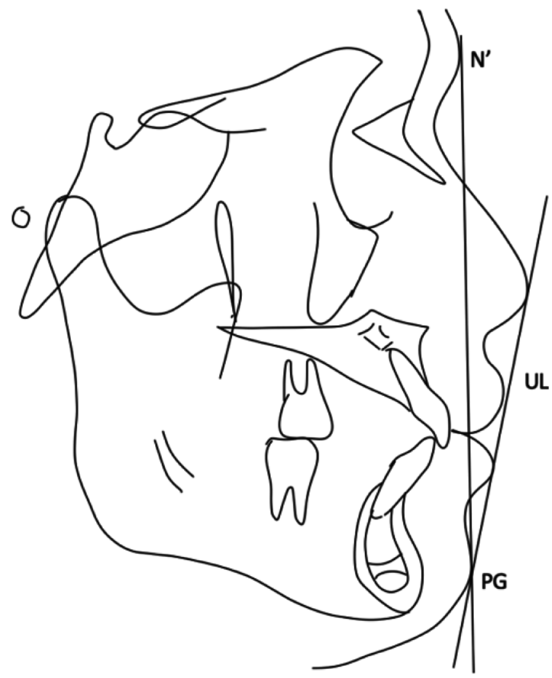
Table 1 Descriptive statistics of cephalometric measurements

Cephalometric measurement	Thai Norm		This Study	
	Mean	SD	Mean	SD
Soft tissue H angle (°)	-	-	15.27	2.73
Hard tissue H angle (°)	-	-	11.13	2.82
Visual perception score	-	-	5.80	0.63
SNA (°)	85.22	3.94	82.34	3.03
SNB (°)	81.26	3.68	78.98	2.98
ANB (°)	3.96	1.70	3.39	0.98
A to N Perpend. (mm.)	4.82	3.10	1.75	2.86
B to N Perpend. (mm.)	-	-	-3.21	4.10
AF-BF (mm.)	-	-	4.64	2.39
AO-BO (mm.)	-	-	-1.16	2.71
SN-Pg (°)	81.22	3.70	79.84	3.07
Pg-NB (mm.)	-0.09	1.41	1.44	1.58
Co-A (mm.)	90.13	2.84	78.74	9.31
Co-Gn (mm.)	116.93	4.57	108.42	4.87
Max-mand difference (mm.)	26.8	4.07	28.80	3.68
NS-MP (°)	31.19	5.25	33.05	5.50
NS-PP (°)	-	-	8.87	3.07
MP-PP (°)	-	-	24.33	4.89
FH-FO (°)	8.00	3.66	9.26	3.97
NS-Gn (°)	-	-	69.58	3.66
Mandibular Angle (°)	119.74	6.44	119.28	6.01
PFH/AFH (%)	65.05	4.74	64.33	6.29
Facial index (%)	-	-	80.69	7.42
U1 – NA (°)	21.56	4.69	25.07	6.92
U1 – NA (mm.)	3.51	1.93	4.98	2.40
U1 – SN (°)	106.78	5.68	107.22	8.04
L1 – NB (°)	31.19	4.91	29.75	7.03
L1 – NB (mm.)	6.42	2.13	6.34	2.54
L1 – MP (°)	97.01	5.82	97.26	7.83
Inter-incisal angle (°)	123.3	6.76	121.42	12.00
Overjet (mm.)	2.62	0.65	2.75	1.08
Overbite (mm.)	1.63	0.81	2.26	1.10
Anterior maxillary alveolar height	-	-	27.51	2.49
Posterior maxillary alveolar height	-	-	23.03	2.60
Naso-labial angle (°)	-	-	95.72	14.54
Lower lip to E-plane (mm.)	1.77	2.02	0.87	2.36
Facial convexity angle (°)	9.42	4.76	8.15	3.74



(a) Hard and soft tissue landmarks





(b) Hard tissue H angle

(c) Soft tissue H angle

Figure 1 Cephalometric landmarks

The same sets of tracings were distributed again to the same 10 examiners to repeat the facial profile assessments two weeks after their first evaluation for assessment of both intra- and inter-examiner reliability.

Data analysis

Statistical Package for Social Sciences (SPSS version 18.0, SPSS Inc, Chicago, IL, USA) was used for the statistical analysis. The means and standard deviations of all the parameters were calculated, and the normality of data distribution was determined by the Kolmogorov Smirnov test.

Spearman's rank-order correlation tests were carried out to evaluate the correlations between the soft tissue H angles, hard tissue H angles, and visual perception score. Intra- and inter-observer reliability tests were assessed by Cronbach's alpha coefficient which ranges from 0 to 1, where the closer the value to 1, the better the reliability [14].

Koo and Li in 2016 classified the coefficient as follows: values less than 0.50 are considered poor reliability, 0.50 to 0.75 are considered moderate reliability, 0.75 to 0.90 is considered good reliability, and greater than 0.90 is considered excellent reliability [15].

Results

The Kolmogorov Smirnov test revealed certain data sets of had non-normal distribution; hence, non-parametric statistical analyses were carried out. Table 1 shows the means and standard deviations of all cephalometric measurements. Soft tissue and hard tissue H angles had means of 15.27°±2.73° and 11.13°±2.82°, respectively. Both values fall within the norms of the Thai population.

From the Spearman's rank-order tests, statistically significant correlations were found between all three main variables: between the soft tissue and hard tissue H angles (r_s=0.713; p<0.01), between soft tissue H angle and visual perception (r_s=0.441; p<0.01), and between hard tissue H angle and visual perception (r_s=0.441; p<0.01). (Table 2)

The Cronbach's alpha for the visual perception score among 10 examiners was 0.787 (inter-examiner reliability) and within individual examiners was 0.839 (intra-examiner reliability).

Discussion

In the cephalometric analysis protocol used at Mahidol University, the hard tissue H angle, lower lip to E-plane, and nasolabial angle are key parameters used to assess the soft tissue profile in Thai patients. It has been found that the relationship between the hard tissue and soft tissue H angles may not be coincident [16], for example, a hard tissue H angle value may indicate a concave profile but the soft tissue H angle value may indicate a straight profile when compared to the population norm. This suggests that relying on only one of the H angle

Table 2 Spearman's rank-order correlation coefficients between soft tissue H angle, hard tissue H angle, and visual perception score

	Soft Tissue H Angle	Hard Tissue H Angle	Visual Perception
Soft Tissue H Angle	-	0.713**	0.441**
Hard Tissue H Angle	0.713**	-	0.441**
Visual Perception	0.441**	0.441**	-

**Statistically significant at p < 0.01

measurements may produce an inaccurate diagnosis. Hence, our study aimed to determine which H angle would be a better diagnostic tool for the soft tissue profile, and if there were any correlations between visual perception of the facial profile with other cephalometric measures.

Achieving an aesthetically pleasing profile is an important goal of orthodontic therapy, and is also one widely recognized motivation for patients to seek orthodontic treatment. Evaluation of the facial profile by the orthodontic practitioner is, thus, highly crucial before commencing treatment, especially if irreversible changes such as extractions are part of the decision-making process. [17]

Many methods have been tested and developed to define and standardize the evaluation of facial aesthetics. Cephalometric analysis is one of them, where it aims to aid the clinician in communicating certain aspects of treatment with the patients, colleagues, and perhaps more importantly, with themselves, through the identification of various structural relationships that are essential to the diagnosis and treatment planning process.

Over the past few decades, many authors have attempted to create different planes for facial profile analysis such as the H line, E line, Z line, and S line[18]. Each of these planes used different landmarks on the soft tissue facial profile and attempted to define the ideal position or relation of the soft tissue structures to each other to achieve a well-balanced face. It should be kept in mind that the ideal values proposed by their respective authors were limited to the population that were available for their research at that time, and may not be fully applicable to populations of different racial ancestry across the globe.

The profile analysis of interest in our study was introduced by Holdaway in 1983, which was the hard tissue H angle [19]. It is an angle formed by the NB line with another line extending from the point of the soft tissue tangent to the upper lip. Holdaway observed that skeletal convexity should correlate with the soft tissue facial convexity (N'PG plane) if the entire facial complex is to be one of balance and harmony with its type. An H angle of 10 degrees is ideal when the measurement of facial convexity is 0, while a range of 7 to 15 degrees would lie within an optimal range as dictated by the degree of acceptable facial convexity. (Table 3)

Table 3 Comparison of H angle measurements with facial convexity

Facial Convexity of Steiner (A to NaPg)	Hard Tissue H Angle of Holdaway	
-5	5	
-4	6	
-3	7	Ideal range (7–15)
-2	8	
-1	9	
0	10	
1	11	
2	12	
3	13	
4	14	
5	15	
6	16	
7	17	
8	18	
9	19	
10	20	

Table 4 Level of reliability

Reliability	Score
Excellent	0.90-1.00
Good	0.75-0.90
Moderate	0.50-0.75
Low/Poor	<0.50

Despite what one might assume, the soft tissue profile does not always correlate directly with changes in the underlying skeletal structures. Only certain regions of the soft tissue profile such as Stomion and Li show strong correlations with changes in the hard tissue profile. The study by Kasai [20] suggests that while the spatial position of hard tissue structures can be used to predict soft tissue changes with reasonable accuracy, orthodontists should still be cautious in interpreting the cephalometric measures because of the variations in the thickness of and tension within the soft tissues.

As a result, this led to the revision of the H angle, where rather than using the NB line based upon the hard tissues, the soft tissue H angle is constructed instead using the soft tissue N'PG plane, which should give a more realistic appreciation of the overall soft tissue facial profile. Since then, researchers have picked up on this change to use the soft tissue H angle in evaluating the patient's profile. [19-22]

Moreover, our subjects were adult female patients with an age range of 19 to 22 years old, in part due to the inadequate sample size of male subjects available. As changes in the soft tissue profile in females occur much earlier than in males (10-15 years old in females as compared to 15-20 years old in males) [23], we can assume that our sample would have a mature and relatively stable soft tissue profile and not be influenced by growth or aging.

The majority of previous studies used profile photographs in the assessment of the soft tissue profile, but we chose to trace only the outline of the soft tissue profile on a clear white background. This is because Kandel et al in 2000 stated that many aspects of the face that are visible in photographs such as shape, color, and distance between facial features could have an influence on the evaluation solely of the soft tissue profile. [24]

Shamlan et al [25] analyzed the relationship between the facial hard and soft tissues by studying the corresponding hard and soft tissue landmarks in 60 adults (30 males and 30 females with mean age 22 years), concluding that 84% of the variations in the soft tissue can be explained by the variations in hard tissue. As we found a moderate level of correlation between the soft tissue and hard tissue H angles (r_s=0.713) in our samples, our findings also found a positive relationship between the soft and hard tissues of the facial profile as the aforementioned study. This would also indicate that there is about a 30% chance that the soft tissue and hard tissue H angles may not translate into the same facial profile category when each of the measurements are compared with their respective norms. However, we could not directly compare our result to this study due to the difference of patient's gender and method of selecting hard and soft tissue landmarks.

Regarding the association between the visual perception of the facial profile with cephalometric measurements, our results revealed a significant but moderate relationship between the visual perception score and the soft tissue and hard tissue H angles. Interestingly, the correlation coefficient between the visual perception score with both soft tissue and hard tissue H angles were of a similar value (r_s=0.441). We can infer from this finding that both the hard tissue or soft tissue H angles have an equal chance of accurately predicting the visual perception of the soft tissue profile. From the moderate correlation, clinically, it points to a tendency that the actual soft tissue facial profile may not totally agree with the H angle measurements.

Moreover, the Cronbach's alpha for the visual perception had an inter-examiner reliability score of 0.787 and intra-examiner of 0.839. Both of these values were within good agreement range (Table 1).

However, this present study only evaluated a sample of skeletal Type I females. It would be another question to be researched that whether our interpretations of the H angles would also apply for facial profiles on the other ends of the spectrum, such as in skeletal Type II and III patients.

Perhaps another future area of interest would be whether the laypersons' perspective of the facial profile would produce different results in regards to the relationship with the H angle or other cephalometric measurements. Some patients have high expectations of changing or even keeping their facial profile from orthodontic treatment, so an expert orthodontic opinion is not the only standpoint involved in proper diagnosis and treatment planning.

Evidently, clinicians should be wary of relying too heavily on only one soft tissue cephalometric analysis for a consistent and reliable diagnosis. This emphasizes the importance of careful treatment planning and evaluation of the patient profile. Acknowledging these patient demands, combined with a thorough examination of both intra- and extraoral structures and adequate knowledge regarding the limits of orthodontic therapy should be a crucial guide for orthodontists to fulfil ideal treatment goals.

Conclusions

1. The correlation between the soft tissue and hard tissue H angles was approximately 70% in female adult patients with a skeletal Type I pattern.

2. The accuracy of using either the soft tissue or hard tissue H angles to portray the soft tissue profile was about 45%.

Disclosure

There are no conflict of interest regarding this study as per the authors are concerned.

References

1. Siqueira DF, Sousa MV, Carvalho PE, do Valle-Corotti KM. The importance of the facial profile in orthodontic diagnosis and treatment planning: a patient report. *World J Orthod*. 2009; 10: 361-70.
2. Kim JC, Mascarenhas AK, Joo BH, Vig KW, Beck FM, Vig PS. Cephalometric variables as predictors of Class II treatment outcome. *Am J Orthod Dentofacial Orthop*. 2000; 118: 636-40.
3. Angle EH. Treatment of malocclusion of the teeth. Angle's system. 7th ed., greatly enl. and entirely rewritten, with six hundred and forty-one illustrations. *Philadelphia: S.S. White dental manufacturing Co.*; 1907
4. Broadbent BH. A NEW X-RAY TECHNIQUE and ITS APPLICATION TO ORTHODONTIA. *Angle Orthod*. 1981; 51: 93-114.
5. Proffit WR. The soft tissue paradigm in orthodontic diagnosis and treatment planning: a new view for a new century. *J Esthet Dent*. 2000; 12: 46-9.
6. Merrifield LL. The profile line as an aid in critically evaluating facial esthetics. *Am J Orthod*. 1966; 52: 804-22.
7. Ricketts RM. Esthetics, environment, and the law of lip relation. *Am J Orthod*. 1968; 54: 272-89.
8. Burstone CJ, James RB, Legan H, Murphy GA, Norton LA. Cephalometrics for orthognathic surgery. *J Oral Surg*. 1978; 36: 269-77.
9. Steiner CC. The use of cephalometrics as an aid to planning and assessing orthodontic treatment: Report of a case. *Am J Orthod*. 1960; 46: 721-35.
10. Ricketts RM. Planning Treatment on the Basis of the Facial Pattern and an Estimate of Its Growth. *The Angle Orthodontist*. 1957; 27: 14-37.
11. Atchison KA, Luke LS, White SC. Contribution of pretreatment radiographs to orthodontists' decision making. *Oral Surgery, Oral Medicine, Oral Pathology*. 1991; 71: 238-45.
12. Reis SAB, Abrão J, Claro CAA, Fornazari RF, Capelozza Filho L. Concordância dos ortodontistas no diagnóstico do padrão facial. *Dental Press J Orthod*. 2011; 16: 60-72.
13. Dechkunakorn S. Lateral cephalometric norms for Thai adults. *J Dent Assoc Thai* 1994; 44: 202-14.
14. Helms JE, Henze KT, Sass TL, Mifsud VA. Treating Cronbach's alpha reliability coefficients as data in counseling research. *The counseling psychologist*. 2006; 34: 630-60.

15. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J. Chiropr. Med*. 2016 Jun 1; 15: 155-63.
16. Suchato W CJ. Cephalometric evaluation of the dentofacial complex of Thai adults. *J Dent Assoc Thai*. 1984; 34: 233.
17. Ackerman JL, Proffit WR. Soft tissue limitations in orthodontics: treatment planning guidelines. *Angle Orthod*. 1997; 67: 327-36.
18. Hambleton RS. The soft-tissue covering of the skeletal face as related to orthodontic problems. *Am J Orthod*. 50: 405-20.
19. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. *Am J Orthod*. 1983; 84: 1-28.
20. Kasai K. Soft tissue adaptability to hard tissues in facial profiles. *Am J Orthod*. 1998; 113: 674-684
21. Albarakati SF, Bindayel NA. Holdaway soft tissue cephalometric standards for Saudi adults. *Saudi J Dent Res*. 2012; 3: 27-32.
22. Hwang H-S, Kim W-S, Jr JAM. Ethnic Differences in the Soft Tissue Profile of Korean and European-American Adults with Normal Occlusions and Well-Balanced Faces. *Angle Orthod*. 2002; 72: 72-80.
23. Bishara SE, Jakobsen JR, Hession TJ, Treder JE. Soft tissue profile changes from 5 to 45 years of age. *Am. J. Orthod. Dentofac. Orthop*. 1998; 114: 698-706.
24. Kandel ER, Schwartz JH, Jessell TM, Biochemistry Do, Jessell MBT, Siegelbaum S, et al. Principles of neural science: McGraw-hill New York; 2000.
25. Shamlan MA, Aldrees AM. Hard and soft tissue correlations in facial profiles: a canonical correlation study. *Clin Cosmet Investig Dent*. 2015; 7: 9-15.