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Original Research Article

Cephalometric analysis of upper lip thickness as a critical aid in formulating a treatment plan in skeletal Class I malocclusion in adults

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A B S T R A C T

Introduction: It is very crucial to understand that both soft tissue drape and the underlying skeletal malocclusion, are sometimes overlooked and this could be misleading for diagnosis and treatment planning .Therefore a sound knowledge of underlying malocclusion and CTP (cephalometric treatment planning) along with accurate clinical examination can aid in better diagnosis and treatment planning.

Objective: The objective of this study is to understand that soft tissue drape and underlying skeletal malocclusion in Angle's class I malocclusion could be misleading in treatment planning and therefore to perform necessary cephalometric hard and soft tissue analysis.

Material and Methods: Lateral cephalograms were obtained in NHP (Natural head position) position of size (20×25cm) FUJIFILM and lateral cephalograms were obtained on radiographic films. Evaluation of lateral cephalograms and the above mentioned parameters were traced and assessed by manual tracing of 150 lateral cephalogram was done using tracing papers with the help of tracing backlight box .Tracing was done with lead pencil point (0.3 mm HB). 150 patient of central Indian population with Angle's class I malocclusion full permanent dentition between ages 18-45 years were included. Out of these 150 patients 75 males and 75 females patients are included in the study.

Result: Upper lip anterior and lip angle shows moderate positive correlation with W angle. The key ridge shows a strong positive correlation with W angle. The upper lip thickness can be used as a treatment plan predictor in Angle's class I malocclusion as it is strong correlated with W angle.

Conclusion: Soft tissue drape especially the upper lip thickness is an essential parameter along with identification of underlying skeletal malocclusion with cephalometric treatment planning measurement like W angle, for treatment planning of even a simple Angle's class I malocclusion case.

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1. Introduction

Soft tissue, skeletal relationship and dental relationship after tracing the cephalogram have been used and considered as an essential tool for diagnosis during case discussion and for evaluation of a proper treatment plan for orthodontic treatment. It is very crucial to understand that soft tissue drape may be misleading in diagnosis and treatment plan of malocclusion. Also Angle's classification masks the underlying skeletal maIocclusion.[1–4] So it is very important to analyse these two aspects of treatment planning that is Soft Tissue analysis especially LIP THICKNES and to diagnose the underlying Skeletal Malocclusion present in Angle's class I malocclusion .So the most important parameter would be correlating the lip thickness with Angle's class I malocclusion and its underlying skeletal malocclusion. Many studies have investigated the effect of orthodontic treatment on the facial profile have focused on predicting lip response relative to incisor movement. For the diagnosis and treatment planning of malocclusions,

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the skeletal malocclusion is evaluated by the antero - posterior (AP) jaw relationship which is an important step, and this relationship is generally determined by cephalometric analysis. The 'Wits' analysis, was first described by Jacobson (1975, 1976) at the University of the Witwatersrand, South Africa, hence the name 'WITS'.[5] But still sagittal jaw relationships are difficult to evaluate because of rotations of the jaws during growth, vertical relationships between the jaws and the reference planes, and a lack of validity of the various methods proposed for their evaluation (Jacobson, 1975 ; Moyers et al. , 1979 ; Baik and Ververidou, 2004 ; Nanda, 2005). Wits appraisal was used to overcome the existing limitations of angle ANB (Jacobson, 1975). In Wits appraisal we don't use nasion so it reduces the rotational effects of jaw growth, but it uses the occlusal plane, which is a dental parameter, to describe the skeletal discrepancies. The occlusal plane can be easily affected by tooth eruption and dental development as well as by orthodontic treatment (Richardson, 1982; Frank, 1983; Sherman et al., 1988). This can profoundly influence the Wits appraisal. Furthermore , accurate identification of the occlusal plane is not always easy or accurately reproducible (Rushton et al. , 1991 ; Haynes and Chau, 1995), especially in mixed dentition patients or patients with open bite, canted occlusal plane, multiple impactions, missing teeth, skeletal asymmetries, or steep curve of Spee. Therefore, a new Cephalometric measurement named the W angle was introduced to assess the sagittal relationship between maxilla and mandible with accuracy and reproducibility.This angle uses three skeletal landmarks — point S, point M, and point G — to measure an angle that indicates the severity and the type of skeletal dysplasia in the sagittal dimension.

2. Objectives

To understand that soft tissue drape could be misleading in diagnosis and treatment plan of malocclusion, so to perform the necessary cephalometric diagnostic hard and soft tissue analysis.[6]

To understand the significance of certain cephalometric parameters that determine the malocclusion as skeletal class I like W angle[7] along with WITS[5] appraisal ANB angle.[8]

To understand the correlation of SNA, SNB, ANB, W ANGLE, with class I class II and class III patients. To study soft tissue facial profile specifically upper lip thickness using soft tissue analysis and understanding the importance of three valuable measurements used in the study.

To analyse the role of KEY RIDGE[9] in determining Angle's class I and the underlying skeletal malocclusion.

3. Material and Methods

Several reference Angle's are prescribed in the literature and have been used in previous studies for evaluating skeletal relationship and lip thickness and soft tissue profile. These include SNA angle, SNB angle, ANB angle, WITS appraisal[5], W angle and KEY RIDGE[9]

All of these Angle's are related to facial growth; therefore, they could be used as reference to measure skeletal relationship between maxilla and mandible,[10] Lateral cephalograms were obtained in NHP (Natural head position) position of size (20×25cm) FUJIFILM and lateral cephalograms were obtained on films and some were obtained and retained as soft copies. Manual tracing of 100 lateral cephalogram was done manually using tracing papers with the help of tracing backlight box .Tracing was done with lead pencil point of 0..3mm After tracing manually various cephalometric landmark were marked, measurement were done using the help of geometric box protractor ,divider ,pointer, set square, lead pencil (0.3 mm HB) & geometry box. Lacquered polyester single matte tracing papers from CITIZEN of 50 micron thickness, tracing backlight box.

All cephalograms that were taken in natural head position (NHP).[11] The natural head position was used to establish a reliable and reproducible reference line from which the linear measurements could be calculated. Patients radiographs were taken and traced with pencil on a tracing paper .The landmarks were marked and the parameters were measured manually with the help of tools of the geometry box and the values were noted measured and written on the individual proforma chart. This manual tracing on x ray films was done for 100 cephalograms

Using tracing backlight box with uniform lighting and same pencil for all 100 tracings.

3.1. A) Skeletal relationship

The following values were measured and entered in a tabular form in the proforma

The following parameters for the evaluation of SKELETAL RELATIONSHIP were traced and the measurements were recorded and the inferences were obtained on the proforma chart.

3.1.1. SNA angle, SNB angle and ANB angle[8]
3.1.2. W angle[7]

It's a new angle formed by using three skeletal landmarks point S – midpoint of sella turcica ,point M – midpoint of premaxilla ,point G centre of largest circle that is tangent to internal inferior, anterior and posterior surfaces of mandibular symphysis, the line segment SN ,MG and SG are connected and a line from point M perpendicular to SG line is drawn and the angle between the perpendicular line from M to SG and line MG is W angle .This angle is used
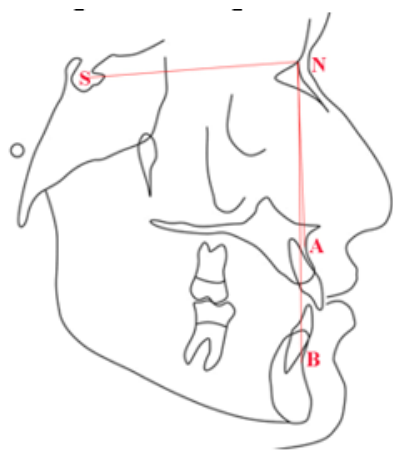
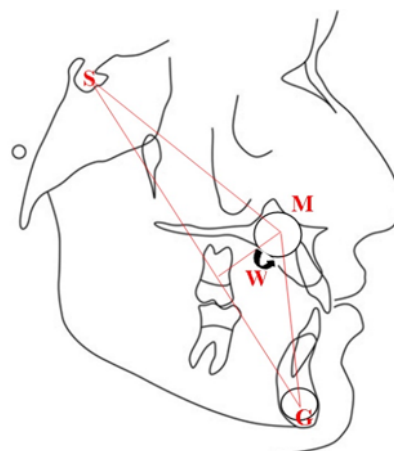**Figure 1:** Schematic representation of angle SNA, SNB and ANB

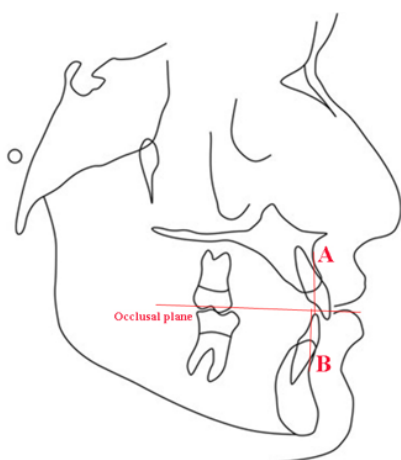**Figure 2:** Schematic representation of measurement of wits appraisal

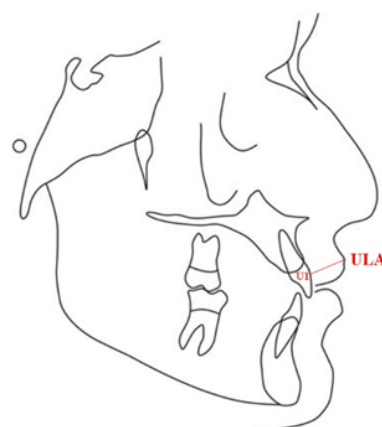**Figure 3:** Schematic representation of measurement of w angle

Figure 4: Schematic representation of measurement of upper lip thickness

for assessing the intermaxillary skeletal discrepancy in the sagittal plane.

B) Soft tissue analysis of following parameters for evaluating upper lip thickness were done and measurements and inference were recorded on proforma sheets comparing them to the STCA values given by Arnett for white population

1) *Upper lip thickness* (the horizontal distance between Labrale superius (Ls)and vermillion border of lip)

2) Projection of upper lip to TVL (True Vertical Line) or upper lip anterior (ULA)[11] drawing of true vertical line: This is a line drawn through subnasale parallel to the chain representing the true vertical and perpendicular to the NHP.The horizontal distance from TVL to the most anterior portion of lip is measured.

Distance from TVL to anterior part of lip is measured.

3) *Upper Lip Angle* (angle formed by segment labial superioris to pogonion and labial superioris to vermillion border of lip)[12]
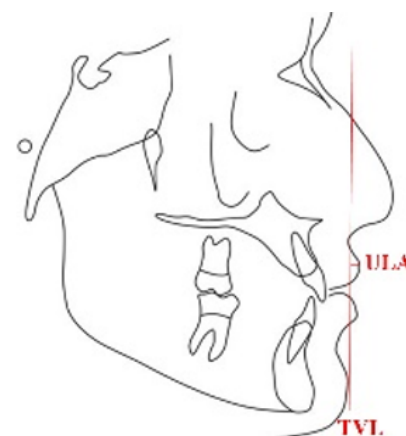

Figure 5: Schematic representation of measurement of projection of upper lip to true vertical line or upper lip anterior (ULA)
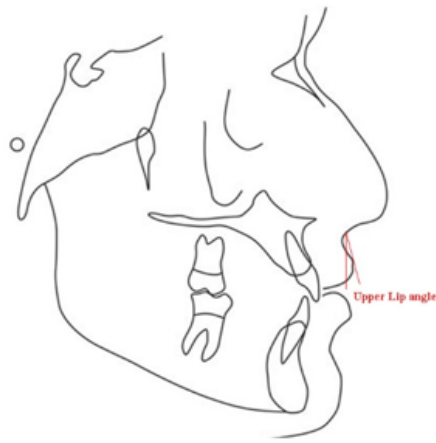
Figure 6: Schematic representation of measurement of upper lip angle

Figure 7: Schematic measurement of distance of key ridgeto mesiobuccal root of permanent maxillary first molar

The obtained values were also compared with the values depicted by studies on Indian population out of which the parameter of upper lip thickness (ULT)

3.2. C) Tracing of key ridge[9]

Following landmarks are selected

1. Long axis of molar (mesiobuccal cusp to mesiobuccal root tip)
2. Occlusal plane (a line passing through the intercuspation of molars ,premolars and bisecting the overbite)
3. Point KR (representing key ridge of infrazygomatic crest)
4. Point KO
5. Line KO
6. Nasion
7. Point A
8. Point B

Horizontal distance of key ridge from the mesiobuccal cusp tip (MBCT) and mesiobuccal root tip (MBRT) of maxillary first molar was measured and according to values obtained, it was confirmed that the malocclusion was Angle's class I malocclusion[5]

4. Result

The study parameter measurement and standard deviation by manual method was given in Table 1. The measurement of parmaters included in the study were as follows:

SNA = 83.45°±4.23°, SNB = 79.34°±4.48°, ANB = 4.05°±2.40°, Wits Analysis = 2.26±2.25

W angle = 54.15±3.09, Upper Lip Thickness = 10.39±2.02, Projection form = 4.39±1.85, Upper Lip Angle = 11.89±7.63 and Key ridge = 6.65±2.63.
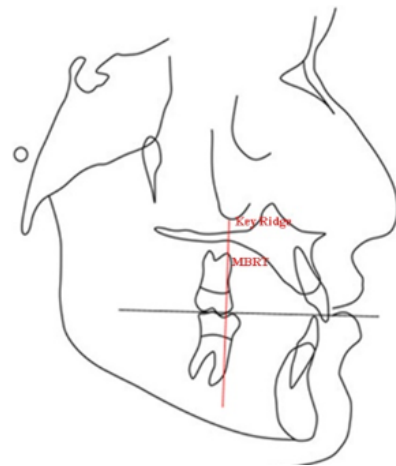
Table 1: Study parameter measured byclinical methods

| Parameters	N	Mean	Std. Deviation
SNA	150	83.45	4.23
SNB	150	79.34	4.48
ANB	150	4.05	2.40
WITS	150	2.26	2.25
Wangle	150	54.15	3.09
UL thickness	150	10.39	2.02
Projection of upper lip to TVL	150	4.39	1.85
ULA	150	11.89	7.63
KEY RIDGE	150	6.65	2.63

The parameters were compared between males and females and it was documented in Table 2. The measurement SNA among male was 82.35°±4.35° and female was 84.55°±4.11°. There were significant difference between the values of SNA between males and females.

Table 2: Comparison between males and females

| Parameters	Males		Females		P value
	Mean	SD	Mean	SD	
SNA	82.35	4.35	84.55	4.11	0.001*
SNB	78.24	4.29	80.64	4.09	0.001*
ANB	3.95	2.37	4.10	2.46	0.001*
WITS	2.70	2.72	1.73	2.09	0.001*
Wangle	54.25	3.09	54.05	2.98	0.67
UL thickness	11.23	2.01	9.85	2.021	0.001*
Projection of upper lip to TVL	4.38	1.81	4.44	1.852	0.89
ULA	9.9	7.37	12.40	7.65	0.001*
KEY RIDGE	6.55	2.54	6.70	2.73	0.74

The measurement Wits analysis among male was 2.70±2.72 and female was 1.73±2.09.There were significant

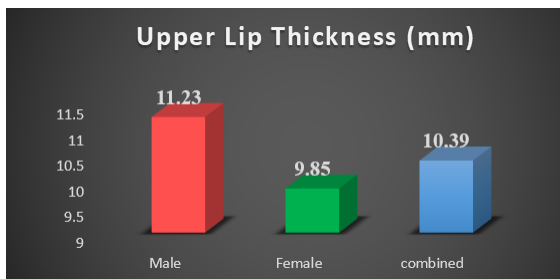difference between the values of SNA between males and females. (Graph 1)
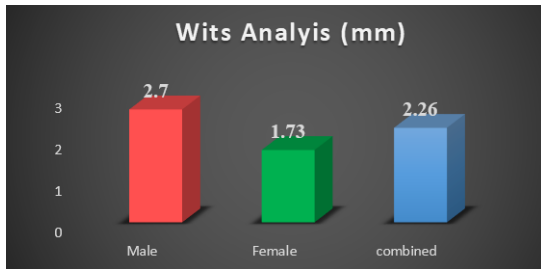
Graph 1: Comparison of wits analysis between males and females

There were significant difference between the values of W angle between males and females. (Graph 2)
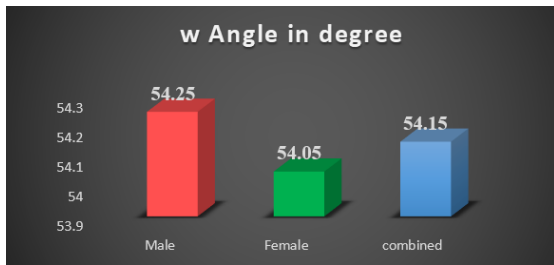
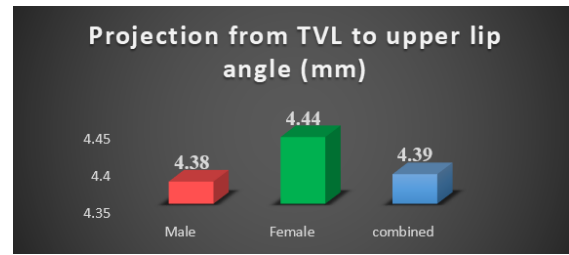Graph 2: Comparison of W angle between males and females

The measurement Upper Lip Thickness among male was 11.23±2.01mm and female was 9.85±2.01mm.There were significant difference between the values of W angle between males and females. (Graph 3)

Graph 3: Comparison of upper lip thickness between males and females

The measurement projection from TVL to upper lip angle also known as upper lip anterior among male was 4.39±1.81 mm and female was 4.44±1.85mm.There were significant difference between the values of W angle between males and females. (Graph 4)

The measurement of Lip angle among male was 9.9°±7.37° and female was 12.40°±7.65 °.There were


Graph 4: Comparison of projection from TVL to upper lip angle between males and females

significant difference between the values of W angle between males and females. (Graph 5)
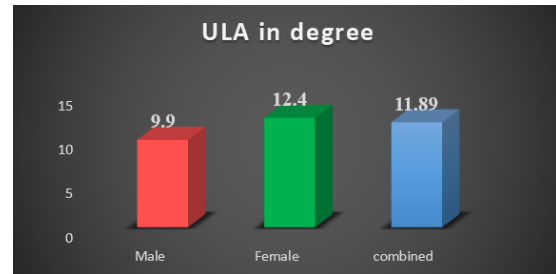
Graph 5: Comparison of upper lip angle between males and females

The measurement Key ridge among male was 6.55±2.54 and female was 6.70±2.73.There were non-significant difference between the values of W angle between males and females. (Graph 6)
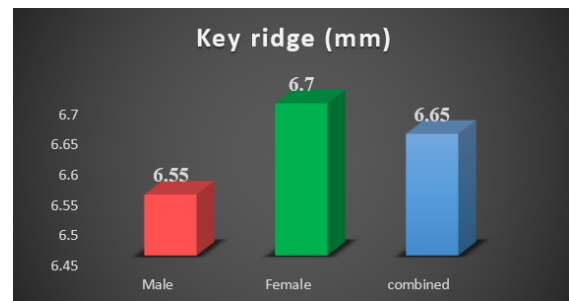
Graph 6: Comparison of key ridge between males and females

The correlation between Wits analysis and ANB was done. The test result shows that there were moderate Positive correlation between the two variables with correlation coefficient 0.50. (Table 3).

The upper lip thickness shows strong negative correlation with W angle while the Key ridge shows strong positive correlation with W angle but the correlation are not significant. While the Upper lip Anterior ad Lip angle shows moderate positive correlation with W angle. The upper lip

Table 3: Pearson correlation between anb and wits analysis

Variable 1	Variable 2	Correlation Coefficient	P value
ANB angle	Wits Analysis	0.50	0.001*

thickness can be used as predictor in class I relationship as it is strongly correlated with W angle (Table 4)

Table 4: Correlation of upper lip thickness, projection from tvl to ulanterior, upper lip angle, w angle and key ridge

Variable 1	Variable 2	Correlation Coefficient	P value
W angle	Upper lip thickness	-0.80	0.001*
W angle	Projection from TVL to upper lip angle	0.37	0.001*
W angle	Lip angle	0.45	0.001*
W angle	Key ridge	0.84	0.001*

5. Discussion

For a treatment resolution of a given malocclusion, it might be easy for any orthodontist to believe that adhering to certain arbitrary standards will automatically lead to desirable treatment result. But a wise approach is to treat the real objectives as suggested by Jackson's triad – esthetic stability and function.[13] Lip thickness and lip posture are very closely associated with all these objectives .Normally the dentoskeletal and soft tissue standards serve as guides in treating orthodontic patients,[14] however the facts that variation in the lip thickness and lip posture of every individual and variation in the dentoskeletal pattern of each individual,[15] This approach seems to be incomplete and its validity needs to be questioned. Therefore this study is trying to formulate the need of a better approach where accurate anterioposterior skeletal relationships and diagnosis is generated through cephalometric treatment planning where STCA is used as a guide and correlated with the accurate skeletal discrepancy.

As per Arnett et al.[12] the CTP states that the incisor and the maxilla should be moved forward when the upper lip is thick and upper lip angle is upright .in the present study. As per Arnett thick upper lip coincides with midface retrusion .According to author thick upper lip correlates with retruded maxilla and vice versa. The upper lip angle reflects the position of the upper incisor teeth and the thickness of the soft tissue overlying this teeth. This angle is very important for an orthodontist to make an extraction decision. If upper lip angle is increased it may suggest an extraction approach.My present study shows that the measurement of Upper Lip Thickness among male was 11.23±2.01mm and female was 9.85±2.01mm. But what is important is that cephalogram should be taken

in natural head position, seated condyles, and relaxed lip position for an accurate evaluation.seperate values should be followed for male and females and for different races and different regions. The present study focuses on age specific and gender specific values for central Indian population as less study for the same has been done in central India ethnic values and article to be added. Here it is important to state that CTP with the help of STCA is not sufficient to fulfill the aim of orthodontic treatment .The underlying jaw relation which many a time goes unnoticed and only the dental problems are addressed leaving the sagittal skeletal discrepancy untreated. The cephalometric measurement of SNA SNB ANB and wits appraisal have their limitation to be accurate all the time because of their dependence on several factors .this study also uses a new cephalometric measurement that is W angle as suggested by W A Bhad et al.[7] (Bhad W, Nayak S, Doshi U. A new approach of assessing sagittal dysplasia: The W angle. Eur J Orthod. 2011;1-5)'. to diagnose the sagittal discrepancy between maxilla and mandible with great accuracy and the measurements are made and compared with the norms as suggested in this article. Hence with the sound knowledge of underlying skeletal malocclusion and CTP we should be able to make better diagnosis and treatment planning for patients. However this is meant to be used along with accurate clinical examination, model analysis or various other suitable diagnostic aids. Serial radiographic measurements obtained from the manual tracing and digital tracing of the values of the landmarks like SNA angle, SNB angle , ANB angle, WITS APPRAISAL,W angle, upper lip anterior, protrusion of lip to TVL, upper lip angle determines that there is a correlation between the soft tissue and hard tissue measurements.

Many system have been developed to classify malocclusion. Kingsley, Angle, Case, Dewey Anderson, Hellman, Bennet, Simon, Ackerman and profitt etc.[1–3] The classification given by E. H Angle is universally most accepted and was given in 1889, based on the position of maxillary first molar in the craniofacial anatomy.[1] Angle gave his classification of malocclusion assuming that the position of maxillary first molar is unchangeable and it lies on the key ridge. So anatomically maxillary first molar rest on the broad buttress of bone of the cranial base. Key ridge was given by Atkinson on 1923.[16] The key ridge was first shown by Sicher and Drubrul as a pillar of trajectories in the craniofacial anatomy. The strong key ridge of bone projects downward from the anterior end of the zygomatic process and normally extends over the mesiobuccal roots of the upper permanent molar.[17,18] The position of key ridge never changes and its position is same irrespective to age, race and what happens to tooth or alveolar bone.[19] This study points out that key ridge plays an important role in determining Angle's class I and underlying skeletal malocclusion.

6. Conclusion

It has been found by this study that tissue drape is an important parameter in diagnosis and treatment planning.

1. Upper lip thickness is a major decipherer of orthodontic treatment plan .Soft tissue facial profile and upper lip thickness should be decoded and soft tissue analysis using STCA are mandatory for good diagnosis and treatment planning

2. Cephalometric parameters that determine the malocclusion as skeletal class I, class II and class III i.e. W angle WITS appraisal, and ANB angle were pertinent and W angle was found adequately reliable.

3. This study specifies that variation in lip thickness and lip posture of every individual and the variations in the dentoskeletal pattern of each individual, make it essential to generate the diagnosis through cephalometric treatment planning (CTP) where STCA is used as a guide and correlated with accurate underlying skeletal discrepancy .More studies on this subject can be conducted in future in different parts of the world, and that will further validate the study.

7. Source of Funding

None.

8. Conflict of Interest

None.

References

1. Angle EH. Classification of malocclusion. *Dent Cosmos.* 1899;41(1):350–7.
2. Katz MI. Angle classification revisited. 1: is current use reliable? *A J Orthod Dentofac Orthop.* 1992;102(2):173–9.
3. Katz MI. Angle classification revisited. 2: a modified Angle classification. *Am J Orthod Dentofac Orthop.* 1992;102(2):277–84.
4. Rinchuse DJ, Rinchuse D. Ambiguities of Angle's classification. *Angle Orthodontist.* 1989;59(4):295–7.
5. Robertson NRE, J C. Pearson The 'Wits' Appraisal of a Sample of the South Wales Population. *British Journal of Orthodontics;*7(4):183–184.
6. Jacobson A. Radiographic Cephalometry: From Basics to Videoimaging; 2019. p. 322.
7. Bhad W, Nayak S, Doshi U. A new approach of assessing sagittal dysplasia: The W angle. *Eur J Orthod.* 2011;p. 1–5.
8. Steiner CC. Cephalometrics for you and me. *Am J Orthod.* 1953;39(10):729–55.
9. Kamble R, Hazarey A, Hazarey P, Singh J. Assessment of positional variation of maxillary permanent first molar with respect to the infrazygomatic crest(key ridge) in skeletal class I, II and III cases. *World J Dent.* 2013;4(4):228–62.
10. Andria LM, Leite LP, Prevatte TM, King LB. Correlation of the cranial base angle and its components with other dental/skeletal variables and treatment time. *Angle Orthod.* 2004;74(3):361–7.
11. Moorrees CF, Kean MR. Natural head position: A basic consideration in the interpretation of cephalometric radiographs. *Am J Phys Anthropol.* 1958;16(2):213–34.
12. Arnett GW. Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. *Am J Orthod Dentofac Orthop.* 1999;116(3):239–53.
13. Mary AV, Mahendra J, John J, Moses J, Ebenezar AVR, Kesavan R. Assessing quality of life using the oral health impact profile (OHIP-14) in subjects with and without orthodontic treatment need in Chennai. *J Clin Diagn Res.* 2017;11(8):78–81.
14. Uysal T, Yagci A, Basciftci YFA. Standards of soft tissue Arnett analysis for surgical planning in Turkish adults. *Eur J Orthod.* 2009;31(4):449–56.
15. Lalitha C, Gopalkumar KG. Assessment of Arnett soft tissue cephalometric norms in Indian (Andhra) population. *Orthod Cyber J.* 2010;9(1):45–51.
16. Kim JE, Sinha PK, Nanda RS. Transition of molar relationships in different skeletal growth patterns. *Am J Orthod Dentofaci Orthop.* 2002;121(3):280–90.
17. Atkinson SR. Strategy of orthodontic treatment. *J Am Dent Assoc.* 1937;24(4):560–74.
18. Bien SM. A method of recording the key ridge. *Am J Orthod Dentofac Orthop.* 1963;32(11):619–26.
19. Weingart M. The key ridge as diagnostic aid in orthodontics. *J Am Dent Assoc.* 1942;29(13):1583–9.

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