



Predictability of Yen Angle, W Angle and Tau Angle and Their Correlation with ANB Angle, Beta Angle and Wit's Appraisal for Assessment of True Sagittal Skeletal Maxillomandibular Relationship - A Cephalometric Study

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KEYWORDS

ANB angle, Beta angle, Wit's appraisal, Tau angle, Yen angle, W angle and Cephalometric study.

ABSTRACT:

Aim: To access predictability of Yen angle, W angle and Tau angle by correlating them with ANB angle, Beta angle and WIT's appraisal as True Sagittal Skeletal Maxillomandibular relationship indicators.

Study Design: A cross-sectional cephalometric study was carried out by including total 90 lateral cephalograms based on the inclusion and exclusion criteria. These 90 cephalograms were equally divided into Skeletal Class I, II and III groups based on the ANB angle, Beta angle and Wit's appraisal. Further, the correlation of newer angles i.e. Tau angle, Yen angle and W angle with gold standard indicators i.e. ANB angle, Beta angle and Wit's appraisal was carried out to determine the best possible indicator for assessing True Sagittal Skeletal Maxillomandibular relationship.

Results: The newer angles i.e. Tau angle, Yen angle and W angle provided varying result for Class I, II and III sagittal relationships when compared to combined indicators (ANB angle, Beta angle and Wit's appraisal). Yen angle provided 10% predictability for Class I, 12.2% for Class II and 25.6% for Class III. Tau angle exhibited 13.3% predictability for Class I, 14.4% for Class II and 20.0% for Class III. Whereas, W angle showed 13.3% predictability for Class I, 8.9% for Class II and 21.1% for Class III. Furthermore, the kappa statistics of Tau angle and Yen angle was similar i.e. 0.217 similar. On contrary, the kappa statistics for W angle was 0.150.

Conclusion: True Sagittal Skeletal Maxillomandibular relationship was more accurately predicted by Tau angle and Yen angle amongst all newer angles.

1. Introduction

The field of orthodontics has expanded significantly over the period of time with incredible advances in region of diagnosis. After discovery of Cephalometric in 1931 by Holly Broadbent, it has been used as a Clinical tool for assessment of Jaw relationship in Sagittal, Transverse and Vertical planes.^{2,3} The Sagittal relationship usually needs critical evaluation for which

many researchers have integrated different Angular and Linear Measurements. ANB angle and WIT'S Appraisal are formerly established and most commonly used indicators for Sagittal relationship.³ These indicators have both advantage and inaccuracies associated as they include cranial reference line and landmarks like Frankfort Horizontal, Sella-Nasion plane and Point A, B and N.¹ To overcome the inaccuracies certain new



indicators; independent of Cranial reference plane and Landmarks; Tau angle, W angle, Yen angle were developed that claimed to reflect the True Sagittal relationship.^{1,3} Thus, assessing the predictability of these newer indicators to evaluate the True Sagittal Maxillomandibular relationship becomes the need of an hour.

ANB angle was introduced by Riedel in 1952, however was popularized by Cecil C Steiner in 1953. According to Steiner's article the mean value range for ideal sagittal relationship is between 2-4°. Certain Drawbacks of ANB angle have been encountered by various authors, suggesting that Displacement of Nasion due to Growth will directly affect the ANB angle. Also, with advancing age due to counter clockwise rotation of jaws the ANB angle decreases. Thus, ANB is affected by Rotation of jaws caused due to Growth or Orthodontic treatment.^{1,3}

WIT'S appraisal was introduced by Jacobson in 1975. WIT'S stands for University of Witswatersrand, Johannesburg, South Africa. This parameter identifies the Severity of Discrepancy, without cranial landmarks, by drawing perpendicular line from Point A and B on Functional Occlusal plane. This parameter reduces the Rotational effect of Jaw growth but uses Occlusal plane which is Dental parameter which could be easily affected by tooth eruption.^{1,3}

BETA angle was introduced by Baik and Ververidou. It utilizes three Skeletal Landmarks namely Point A, B and apparent axis of Condyle C to measure the angle. Authors claims the advantage of BETA angle over ANB and WIT'S Appraisal as it remains Stable even if the Jaws are Rotated reflecting the True changes of Sagittal Relationship.^{1,3}

All these Parameters Utilizes the Point A which has been reported to change the Position with Orthodontic Tooth Movement and Growth induced by Remodeling of Bone. Thus, Newer angles Rely on New Landmark points which are not affected by Growth and Orthodontic Tooth Movement.^{2,3}

YEN angle was introduced by Neela et al. This angle uses points like S, G and M to determine the sagittal relationship. This eliminates the difficulty of locating point A and B and the functional occlusal plane in WIT'S appraisal. Authors Claim it to be not

influenced by growth hence can be used in Mixed Dentition condition as well and can Depict the True Sagittal Relationship.^{2,3}

Similar to YEN angle is W angle with varying angle of measurement utilizing the same three measurement points.^{2,3}

Recently introduced angle by Gupta et al in 2020, Tau Angle utilizes the measurement points like T, G and M.^{1,2}

All Newly introduced indicators like Tau angle, W angle and YEN angle claims to overcome the drawbacks of evergreen used ANB angle, WIT'S Appraisal and BETA angle and provide the True Sagittal Relationship. Thus, there becomes Need to review the Correlation of newly introduced angles with previously proposed parameters for assessing the True Sagittal Relationship. Thus, the present research becomes the need of an hour.

2. Need of the Study

After appraising the literature till 30-01-2024 from PubMed, Google Scholar and Research Gate, there are multiple new angles introduced in cephalometric study with very few articles^{1,2,3} signifying their approachability to predict the sagittal maxillomandibular relationship. Thus, there becomes a need to evaluate these newer angles to predict the True Sagittal Maxillomandibular Relationship by comparing with ANB angle, Beta angle and WIT'S appraisal and come up with best possible indicator.

3. Aims And Objectives

Aim: To access predictability of Yen angle, W angle and Tau angle by correlating them with ANB angle, Beta angle and WIT's appraisal as True Sagittal Skeletal Maxillomandibular relationship indicators.

Objectives

1. To evaluate the predictability of Yen angle as indicator of True Sagittal Skeletal Maxillomandibular Relationship by comparing it with ANB angle, Beta angle and WIT'S appraisal.
2. To evaluate the predictability of W angle as indicator of True Sagittal Skeletal Maxillomandibular Relationship by comparing it with ANB angle, Beta angle and WIT'S appraisal.



- To evaluate the predictability of Tau angle as indicator of True Sagittal Skeletal Maxillomandibular Relationship by comparing it with ANB angle, Beta angle and WIT'S appraisal.
- To derive best possible True Sagittal Maxillomandibular Relationship indicator amongst Tau angle, Yen Angle and W angle.

5. Material and Methodology

Study Design

- Place of the study:** Department of Orthodontics and Dentofacial Orthopedics, K. M. Shah Dental College and Hospital, Sumandeep Vidyapeeth Deemed-to-be University.
- Source of the sample:** Lateral Cephalogram of various patients with varying Sagittal Maxillomandibular relationship
- Sample description:** Sample size is estimated based on the article titled "Tau Angle: A New approach for Assessment of True Sagittal Maxillomandibular Relationship" by Prateek Gupta¹ and basing our values on the parameters of Various Newer Angles for Predicting True Skeletal Sagittal Maxillomandibular Relationship as given in Table1, having 3 groups with Power of 99% and an Alpha error rate of 1%, the Z score are 2.326348 and 2.935199 respectively. Having a Standard deviation of 2.93 and to assess a clinically relevant difference (d) of 4, we need sample of **30** per group.

$$N = \frac{2(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2 \sigma^2}{d^2}$$

$$\begin{aligned} N &= 2[(2.935199 + 2.326348)^2 * (2.93)^2] / (4)^2 \\ &= [2 * (27.6838768) * (8.5849)] / (16) \\ &= [475.326628] / (16) \\ &= 29.7079143 \\ &= 30 \end{aligned}$$

We need Sample Size of **30 per group**, total **90 sample**.

- Time Scale of the Study:** Study will be started after obtaining SVIEC approval and will be completed within 6 Months from the date of Study Approval.

5. Selection Criteria

• Inclusion Criteria

- Age: 18 to 35 years
- High quality Pre-treatment cephalometric radiograph with 1:1 Magnification Ratio
- Patient having all permanent teeth erupted except for third molars

• Exclusion Criteria

- Patient with history of Orthodontic/Orthognathic treatment
- Patients having presence of any Craniofacial anomalies
- Patients having history of Maxillofacial Trauma
- Patients having history of Cleft Lip treatment

Materials And Equipment Used For The Study

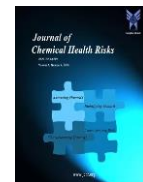
- Carestream 9600 X-Ray Machine having 73Kv, 8.0mA and Exposure Time of 12.3 sec.
- Standardized Lateral Cephalograms of Dimension's 8x 10 inches
- Acetate Matte Tracing Paper (8x10x0.003 inches)
- A shape 3H Drawing pencil.
- Tracing Table with X-ray View box
- 12 Inch Scale, big Protractors, Sharpener and Eraser

6. Methodology

After obtaining Ethical approval from Sumandeep Vidyapeeth Institutional Ethical Committee (SVIEC), the study will be conducted in the Department of Orthodontics and Dentofacial Orthopaedics, K.M. Shah Dental College & Hospital.

After sample size estimation, as per the inclusion / exclusion criteria, Lateral Cephalograms will be obtained from the patient's record from the Department of Orthodontics and Dentofacial Orthopaedics, K. M. Shah Dental College & Hospital. All the Lateral Cephalogram will be obtained from Carestream 9600 X-Ray Machine having 73Kv, 8.0mA and Exposure Time of 12.3 sec with 1:1 Magnification Ratio.

Once Lateral Cephalograms are obtained, using ANB angle, Beta angle and WIT'S appraisal, the



Sagittal Skeletal Maxillomandibular Relationship of Individual Lateral Cephalogram will be analyzed and categorized in Skeletal Class I (ANB angle = 0° to 2° , Beta angle = 27° to 35° & WIT'S appraisal AO-BO is 0mm (Males) and -1mm (Females) / Class II (ANB angle $> 2^{\circ}$, Beta angle $< 27^{\circ}$ & WIT'S appraisal AO-BO > 0 mm (Males) and > -1 mm (Females)) / Class III (ANB angle $< 0^{\circ}$, Beta angle $> 35^{\circ}$ & WIT'S appraisal AO-BO < 0 mm (Males) and < -1 mm (Females)). Based on Sample size estimation each group would consist of 12 Lateral Cephalogram each.

To determine the Predictability of certain new angles like YEN angle, W angle & Tau angle, the Sagittal Relationship of Individual Lateral Cephalograms, which are previously classified into Class I, II or III Sagittal relation based on ANB angle, Beta angle and WIT'S

Appraisal will be re- evaluated as Skeletal Class I (YEN angle : $120-125^{\circ}$, W angle: $53-57^{\circ}$, Tau angle : $30-$

33°) / Class II (YEN angle: $113-118^{\circ}$, W angle : $50-52^{\circ}$, Tau angle: $35-39^{\circ}$) / Class III (YEN angle : $137-146^{\circ}$, W angle : $64-69^{\circ}$, Tau angle : $21-26^{\circ}$) individually for all three angles and then the Sagittal Skeletal Maxillomandibular Relationship evaluated by new angles is compared to frequently used ANB angle, Beta angle & WIT'S appraisal.

Values of all the parameters will be obtained by manual cephalometric tracing by Principal Investigator. After 15 Days, to determine the measurement Reliability and to avoid intra-observer variation, the same investigator will repeat the manual cephalometric tracing with 10% of randomly chosen lateral cephalogram from the sample. All the collected data will be further subjected to suitable statistical analyses to conclude the results.

Following Tables shows Hard tissue Landmarks and Parameters to be evaluated.

Sr. No.	Landmark	Name of Landmark	Description
1	A	Point A (Subspinale)	The most Posterior Midline point in the Concavity between the ANS and the most inferior point on the alveolar bone overlying the maxillary incisors (Prosthion)
2	B	Point B (Supramentale)	The most Posterior Midline point in the Concavity of the mandible between the most Superior point on the Alveolar bone overlying the Mandibular Incisors (Infradentale) and Pog.
3	N	Nasion	The most Anterior point on the Frontonasal suture in the Midsagittal plane
4	Cd	Condylion	Most Superior point on the Head of the Condyle
5	S	Sella	Geometric center of the Pituitary fossa, located by Visual Inspection
6	M	Point M	Constructed point representing the center of the Biggest circle that is Tangent to the Frontal, Upper, and Palatal surfaces of the maxilla
7	G	Point G	Focal point of the Biggest circle that is Tangent to the Inner Frontal, Posterior, and Lower edge of the Mandibular symphysis.
8	T	Point T	Uppermost point at the junction of the Frontal wall of Pituitary fossa and Tuberculum sella
9	OP	Occlusal Plane (functional)	The line Bisecting the overlapping cusps of Premolars and First Molars.

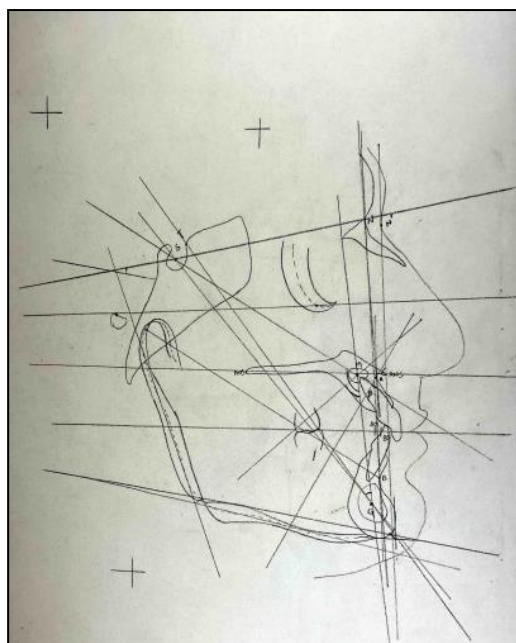


Figure 1. Cephalometric Landmarks and Parameters

Following is the Description for the Parameters to be measured.

Sr. No.	Name of Parameters	Description
1	ANB angle	Angle formed between NA and NB lines
2	WIT'S appraisal	Linear Distance between AO and BO (perpendicular drawn from point A and point B on to functional occlusal plane)
3	Beta angle	The angle formed between the A-B line and the perpendicular through point A from apparent axis of Condyle
4	W angle	The angle between the perpendicular line from point M to S-G line and M-G line. Angle formed at point M is considered
5	YEN angle	Angle formed by point S, G and M point. Angle formed at point M is considered
6	Tau angle	Angle formed by using point M, G and T angle. Angle at point G is considered

7. Results

The predictability of Yen angle, Tau angle and W angle as indicator of True Sagittal Skeletal Maxillomandibular Relationship by comparing with ANB angle, Beta angle and Wit's appraisal was carried out using Kappa Statistics

Table 1

Crosstab				
	Class (Based on ANB+Beta+Wits)			Total
	Class I	Class II	Class III	



Class As per Yen angle	Class I	Count	9	12	6	27
		% of Total	10.0%	13.3%	6.7%	30.0%
	Class II	Count	0	11	1	12
		% of Total	0.0%	12.2%	1.1%	13.3%
	Class III	Count	21	7	23	51
		% of Total	23.3%	7.8%	25.6%	56.7%
Total		Count	30	30	30	90
		% of Total	33.3%	33.3%	33.3%	100.0%

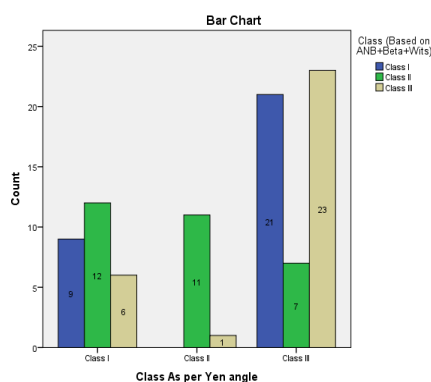


Figure 1

The assessment of Yen angle to the previous classified Sagittal Skeletal relationship based on combined classification of ANB angle, Beta angle and Wit's appraisal showed 10.0% cases were classified to be Class I, 12.2% as Class II and 25.6% as Class III. (Table 1)

Figure 1 suggests the Graphical representation of Yen angle for Class I, II and III Sagittal Skeletal Maxillomandibular relationship compared to combined Classification involving ANB angle, Beta angle and Wit's appraisal.

Table 2

Crosstab						
		Class (Based on ANB+Beta+Wits)			Total	
		Class I	Class II	Class III		
Class As per Yen angle	Class I	Count	12	13	11	36
		% of Total	13.3%	14.4%	12.2%	40.0%
	Class II	Count	3	13	1	17
		% of Total	3.3%	14.4%	1.1%	18.9%
	Class III	Count	15	4	18	37
		% of Total	16.7%	4.4%	20.0%	41.1%
Total		Count	30	30	30	90
		% of Total	33.3%	33.3%	33.3%	100.0%

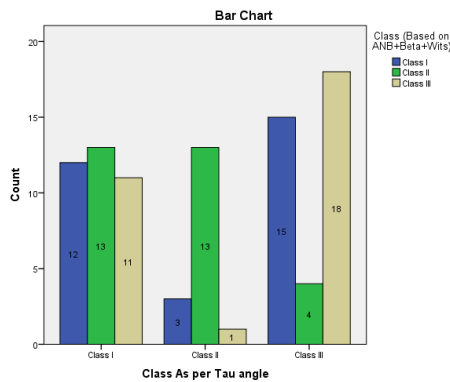


Figure 2

The assessment of Tau angle to the previous classified Sagittal Skeletal relationship based on combined classification of ANB angle, Beta angle and Wit's appraisal showed 13.3% cases were classified to be Class I, 14.4% as Class II and 20.0% as Class III. (Table 2)

Figure 2 suggests the Graphical representation of Tau angle for Class I, II and III Sagittal Skeletal Maxillomandibular relationship compared to combined Classification involving ANB angle, Beta angle and Wit's appraisal.

Table 3

Crosstab						
			Class (Based on ANB+Beta+Wits)			Total
			Class I	Class II	Class III	
Class As per Yen angle	Class I	Count	12	17	11	40
		% of Total	13.3%	18.9%	12.2%	44.4%
	Class II	Count	2	8	0	10
		% of Total	2.2%	8.9%	0.0%	11.1%
	Class III	Count	16	5	19	40
		% of Total	17.8%	5.6%	21.1%	44.4%
Total		Count	30	30	30	90
		% of Total	33.3%	33.3%	33.3%	100.0%

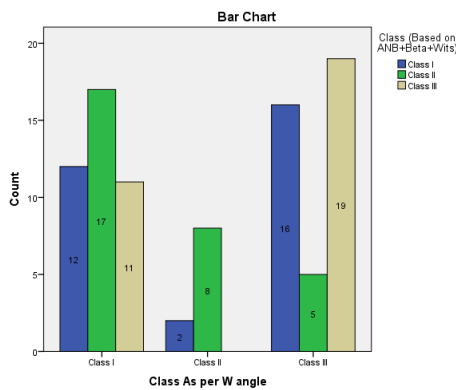


Figure 3

The assessment of W angle to the previous classified Sagittal Skeletal relationship based on combined classification of ANB angle, Beta angle and Wit's appraisal showed 13.3% cases were classified to be Class I, 8.9% as Class II and 21.1% as Class III. (Table 3)

Figure 3 suggests the Graphical representation of W angle for Class I, II and III Sagittal Skeletal Maxillomandibular relationship compared to combined Classification involving ANB angle, Beta angle and Wit's appraisal.



Table 4

Symmetric Measures						
		Value	Asymp. Std. Error ^a	Approx. T ^b	Approx. Sig.	P value
Measure of Agreement	Kappa	.217	.074	3.141	.002	.002
N of Valid Cases		90				
a. Not assuming the null hypothesis.						
b. Using the asymptotic standard error assuming the null hypothesis.						

Kappa Statistics for Yen angle

Table 5

Symmetric Measures						
		Value	Asymp. Std. Error ^a	Approx. T ^b	Approx. Sig.	P value
Measure of Agreement	Kappa	.217	.079	2.978	.003	.004
N of Valid Cases		90				
a. Not assuming the null hypothesis.						
b. Using the asymptotic standard error assuming the null hypothesis.						

Kappa Statistics for Tau angle

Table 6

Symmetric Measures						
		Value	Asymp. Std. Error ^a	Approx. T ^b	Approx. Sig.	P value
Measure of Agreement	Kappa	.150	.076	2.135	.033	.044
N of Valid Cases		90				
a. Not assuming the null hypothesis.						
b. Using the asymptotic standard error assuming the null hypothesis.						

Kappa Statistics for W angle

Furthermore, as per Kappa Statistics Tau angle and Yen angle provide slight agreement (0.217) whereas W angle has fair agreement (0.150) compared to ANB angle, Beta angle and Wit's appraisal.

Amongst the three angles Tau angle and Yen angle are more accurate indicators for assessing True Sagittal Skeletal Maxillomandibular relationship.



8. Discussion

Cephalometric analysis addresses the origin of discrepancies in sagittal and horizontal planes for interrelationship of both jaws to identify anterior-posterior and vertical malocclusions.²

According to a review of the indicators by **Vinay Kumar et al.**³ and **Jacek Kotula et al.**² ANB is the most widely used indicator for evaluating the True Sagittal Skeletal Maxillomandibular relationship because it is upfront and widely accepted, but it is also influenced by the growth and rotational effects of the jaws. The occlusal plane determines the linear parameter of Wit's evaluation. Also, Beta angle is said to represent the true anteroposterior relation. The author claims that the difficulties in identifying the A and B points, drawing the functional occlusal plane of Wits evaluation, and establishing the condyle axis for Beta angle have been resolved by more recent angles such as the Yen and W angles.

Bhad et al.⁵ and **Vinay Kumar et al.**³ made similar recommendations for W angle stability over ANB angle, Wit's evaluation, and Beta angle. **Neela P.K et al.**⁶ and **Vinay Kumar et al.**³ evaluated the reliability of Yen angle over ANB angle as it overcomes the challenge of locating A and B points. Additionally, **Vinay Kumar et al.**³ pointed out that jaw rotation had an effect on the Yen angle.

According to the study by **Gupta et al.**¹, Tau angle was more accurate and reliable than ANB angle, Wit's assessment, and beta angle in determining sagittal connection given that it had stable landmarks for measurement. Author also suggested that Tau angle was not affected by jaw rotation in vertical direction due to growth or orthodontic treatment.

The major primary limitation for the study by **Bhatt et al.**⁵, **Ali et al.**⁴ evaluating the W angle, and **Gupta et al.**¹ evaluating the Tau angle to ascertain the Sagittal Maxillomandibular relationship was the smaller number of participants.

Bhad et al.⁵ and **Vinay Kumar et al.**³, employing at least three analysis indicators in each case with a full understanding of each analysis indicator is the best way to achieve the greatest outcome and the most accurate assessment of the skeletal maxillomandibular connection.

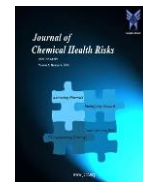
According to the author **Ali et al.**⁴, Yen angle was analogized with the W angle, ANB angle, and Wit's evaluation, there was no statistically significant difference between Class III patients implying that either the Class III group's data is insufficient or that the Yen angle analysis differs from the ANB angle, W angle, and Wit's appraisals. On the other hand, in Class I defects, the W angle is most similar to the ANB angle and Wit's appraisal, whereas in Class II and Class III patients, the W angle's efficacy was questioned. indicating that the W angle is ultimately less suitable than the ANB, Beta, and Wit's angles.

Similarly, this study when compared the newer angles i.e. Yen angle, Tau angle and W angle with commonly used indicators i.e. ANB angle, Beta angle and Wit's appraisal for assessment of True Sagittal Skeletal Maxillomandibular relationship resulted Moderate correlation for Tau angle and Yen angle with kappa statistics 0.217 whereas W angle showed mild correlation with kappa statistics 0.150. Thus, study recommended Tau angle and Yen angle to be most accurate indicators to predict the True Sagittal Skeletal Maxillomandibular relationship amongst the newer three angles

9. Conclusion

The study when compared the newer angles (Yen angle, W angle and Tau angle) with commonly used gold standard indicators (ANB angle, Beta angle and Wit's appraisal) to assess the True Sagittal Skeletal Maxillomandibular relationship concluded that

1. The Moderate correlation for predictability of Yen angle and Tau angle to accurately assess True Sagittal Skeletal Maxillomandibular relationship when compared to commonly used angles.
2. The mild correlation for predictability of W angle to accurately assess True Sagittal Skeletal Maxillomandibular relationship when compared to commonly used angles.
3. Amongst the three newer angles Tau angle and Yen angle provided similar predictability and most accurate results suggesting these angles to be best indicators for assessing True Sagittal Skeletal Maxillomandibular relationship.



10. References

1. Gupta P, Singh N, Tripathi T, Gopal R, Rai P. Tau angle: A New Approach for Assessment of True Sagittal Maxillomandibular Relationship. *Int J Clin Pediatr Dent.* 2020;13(5):497–500.
2. Kotuła J, Kuc AE, Lis J, Kawala B, Sarul M. New sagittal and vertical cephalometric analysis methods: A systematic review. *Diagnostics (Basel).* 2022;12(7):1723.
3. Kumar V, Sundareswaran S. Cephalometric assessment of sagittal dysplasia: A review of twenty-one methods. *J Indian Orthod Soc.* 2014;48(1):33–41.
4. Ali S, Manjunath G, Sheetal A. A comparison of 3 New Cephalometric Angles with ANB and Wits Appraisal for Assessing Sagittal Jaw Relationship. *Int J of Oral Care and Research.* 2018;6(2):28-32.
5. Bhad WA, Nayak S, Doshi UH. A new approach of assessing sagittal dysplasia: the W angle. *Eur J Orthod.* 2013;35(1):66–70.
6. Neela P, Mascarenhas R, Husain A. A New Sagittal Dysplasia Indicator: The Yen Angle. *World J of Orthod.* 2009;10(2):147-151.