Section: Dentistry

Original Research Article

COMPARATIVE EVALUATION AND CORRELATION OF YEN ANGLE AND W ANGLE WITH ANB ANGLE AND WITS APPRAISAL IN ASSESSING SAGITTAL SKELETAL DISCREPANCIES AMONG THE BODO TRIBAL POPULATION OF ASSAM

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ABSTRACT

Background: Cephalometric analysis is crucial in orthodontic diagnosis because it evaluates anteroposterior skeletal discrepancies. Common measures like ANB angle and Wits appraisal are often used; however, their reliability can be affected by growth changes or variations in the cranial base. New measures like the Yen angle and W angle may offer benefits due to their reduced reliance on cranial base landmarks. Still, their use in certain ethnic groups, such as the Bodo tribal population of Assam, has not been thoroughly studied. The objective is to evaluate the correlation and applicability of Yen angle and W angle with traditional cephalometric parameters (ANB angle and Wits appraisal) for assessing sagittal skeletal relationships among the Bodo tribal population of Assam. **Materials and Methods:** A cross-sectional study was conducted on 60 subjects (15–35 years), equally divided into three skeletal pattern groups: Class I, II, and III (n=20 each). Pretreatment lateral cephalograms were analyzed using standardized tracing methods. ANB angle, Wits appraisal, Yen angle, and W angle were measured. Group-wise comparisons were conducted using one-way ANOVA followed by Tukey's post hoc test. Pearson's correlation coefficients were calculated to determine relationships between variables. Statistical significance was set at $p < 0.05$. **Result:** All four cephalometric parameters showed statistically significant differences among Class I, II, and III skeletal patterns ($p < 0.05$). The Yen angle and W angle had the lowest coefficient of variation, indicating more consistency across groups. Pearson's correlation revealed strong negative correlations between traditional parameters (ANB and Wits) and the newer parameters (Yen and W angles) across all classes ($p < 0.001$). **Conclusion:** The Yen angle and W angle are reliable and appropriate measures for evaluating sagittal skeletal discrepancies. They show strong correlations with the ANB angle and Wits appraisal. Their consistent performance in the Bodo population suggests they could be useful diagnostic tools, especially when traditional landmarks are unclear.

INTRODUCTION

The anteroposterior relationship between the maxillary and mandibular dental bases is defined as the dental base relationship. It is sometimes called the skeletal pattern, the jaw relationship, or the sagittal apical base relationship. Not only does the skeletal pattern play a major role in occlusal development, but it also imposes limits to the amount of anteroposterior movement of the incisor teeth during treatment. Variations in the size of the jaws and their position relative to the cranial base, may alter the skeletal relationship.[1]

Diagnosis and treatment planning in orthodontics have progressed with the advent of Cephalometry. Plaster casts, dental roentgenograms, photographs and the patient are no less important as diagnostic criteria; cephalometrics actually makes each of these criteria more valuable by extracting more information from each and correlating them.[2]

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Many angular and linear measurements have been used in different cephalometric analyses in order to enable the clinician in diagnosing sagittal jaw discrepancies. Different analyses may at times give different values for the same jaw relationship due to change in the reference planes. Since Wylie's,[3] initial attempt in 1947 to describe the anteroposterior (AP) jaw relationship, numerous cephalometric parameters have been proposed. Downs (1956),[4] introduced the A-B plane angle, and a few years earlier, Riedel (1952),[5] had proposed the ANB angle.

The ANB Angle, which is the angle formed between the nasion, A-point, and B-point, is a traditional and widely used measurement in orthodontics. The ANB angle has been a mainstay in orthodontic diagnosis, measuring the anteroposterior relationship between the maxilla and mandible. However, its reliability can be compromised by factors like jaw rotation as a consequence of orthodontic treatment or growth, Any shift in point N can cause potential inaccuracies.[5,6]

Jacobson introduced the Wits Appraisal in 1975,[7,8] measures the horizontal jaw relationship using perpendicular distances from A- and B-points to the occlusal plane, and is less influenced by cranial base variations. It serves as an alternative to the ANB angle but has limitations in cases with mixed dentition, missing teeth,or open bite.[9] Its accuracy can be affected by changes in the inclination of the functional occlusal plane due to orthodontic treatment or normal dental development.[10]

Recognizing the limitations of widely used cephalometric measurements such as the ANB angle and Wits appraisal—due to their dependence on cranial base landmarks and occlusal plane orientation—there has been a shift toward developing parameters that offer greater reliability in assessing sagittal jaw relationships.

The W angle, introduced by Bhad et al. (2011),[11] is formed using three landmarks: S (midpoint of the sella turcica), M (midpoint of the premaxilla), and G (center of the largest circle tangent to the internal borders of the mandibular symphysis). The angle is defined between the line from point M to point G and a perpendicular line drawn from point M to the S–G line, providing an assessment of the severity and type of sagittal skeletal dysplasia.

Similarly, the Yen angle, proposed by Neela et al. (2009),[12] also employs the S, M, and G points. It is measured at point M, formed by joining points S, M, and G. Both the Yen and W angles offer cephalometric alternatives that are less affected by cranial base variability or dental occlusion, enhancing their utility in accurately diagnosing sagittal skeletal relationships.

Despite the growing application of these parameters in various populations, the specific applicability of the Yen Angle and W Angle in ethnic groups such as the Bodo tribe of Assam remains largely unexplored. Most researchers agree that there are clear differences in facial and skeletal features among different ethnic and racial groups. That's why many cephalometric standards have been created specifically for various populations, to better reflect their unique characteristics.[13] The Bodo people, with their distinct genetic heritage and cultural practices,[14] may present unique craniofacial characteristics that differ from those of other populations, necessitating a tailored approach in cephalometric analysis. The need to understand how these newer angular measurements perform in this context is crucial, as it could lead to more accurate diagnoses and culturally relevant orthodontic interventions.

There is no study reported till date that have used both Yen angle and W angle as a measure to study the sagittal skeletal discrepancies in Class I, Class II, Class III Skeletal Pattern in the Bodo tribal population of Assam. Considering the above facts it is of utmost importance to study correlation among these angles and applicability of established norms of Yen angle and W angle.

MATERIALS AND METHODS

Source of Data: Data for the present study were obtained from pretreatment records and from patients who attended the outpatient department or were referred from other clinics and hospitals to the Department of Orthodontics and Dentofacial Orthopedics, Regional Dental College, Guwahati, Assam. All the subjects were belonging to Bodo tribe of Assam. Thorough medical history was taken regarding any previous major illness in childhood that might have affected the growth. All the subjects of this study were informed about the exact nature of the study and informed and written consent was obtained. Ethical clearance was obtained from the Institutional Ethical Committee of Regional Dental College, Guwahati as the present study would cause x ray exposure of the samples.

Exclusion criteria:

1. Subjects with Craniofacial anomalies.
2. Missing permanent teeth.
3. Subjects with history of orthodontic treatment.
4. Marked Asymmetry.

Study Design and Radiographic Procedure: This study involved 60 participants including both 26 males and 34 females of Bodo tribe of Assam state with the age group ranging from 15-35 years old. The pretreatment lateral cephalograms were collected from each patient with teeth in centric occlusion, lips in relaxed posture and the head in the natural head position, with their spines erect and FH plane parallel to the floor and the eyes straight ahead, with the maximum intercuspation and the lips in rest position. The object source distance was 5 feet. A voltage of 80 Kvp and a current of 10mA was used to obtain the lateral head film (8x 10 inches) with the exposure time of 1 Second. The radiation exposure caused by each lateral cephalogram is 2-3uSv which is within the normal

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exposure limit of general people. i.e 1mSv per year (According to guidelines of International Commission on Radiological Protection). All the exposed film were developed and fixed manually by a single technician using standard procedure. Each lateral cephalograms were traced with the help of X-ray viewer on a transparent cellulose acetate sheet of 0.003'' thickness with sharp 3H pencil and landmarks were identified. A standardized lateral cephalogram of a bodo subject from assam is shown in [Figure 1].

Figure 1: Standardised Lateral Cephalogram of a Bodo Subject from Assam

Identification and tracing of these following Cephalometric landmarks and planes were done:

1. **Point N:** The most anterior point of the frontonasal suture in median plane.
2. **Point S:** The midpoint of the Sella turcica.
3. **Point A:** The deepest midline point in the curved bony outline from the base to the alveolar process of the maxilla.
4. **Point B:** The most posterior point in the outer contour of the mandibular alveolar process, in the median plane.
5. **Point M:** Midpoint of the premaxilla
6. **Point G:** Center of the largest circle, i.e., at a tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphysis.
7. **Sella Nasion plane (SN plane):** Line extending from sella to nasion.
8. **Functional occlusal plane:** Line extending through the first molars and premolars.

All the corresponding reference points, planes and angles were drawn, and recorded for evaluation as shown in [Figure 2].

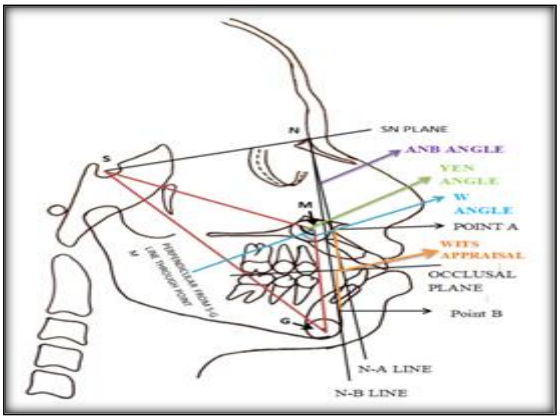

Figure 2: Drawn corresponding reference points, planes and angles for evaluation

Four cephalometric parameters were measured

ANB angle: Measuring the angle between the NA and NB lines at point N. [Figure 3]

This angle helps classify the skeletal pattern:

- Class I: ANB 1° to 4°.
- Class II: ANB > 4°.
- Class III: ANB < 1°.

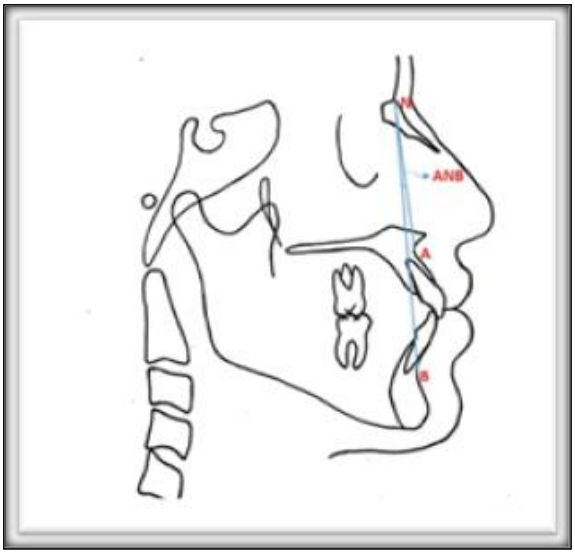

Figure 3: illustrates the ANB angle

Wits Appraisal: The AO-BO distance, sometimes referred to as the Wits assessment, Points A and B are projected at right angle to the occlusal plane. The normal value in women is 0 mm, whereas in men it is-1 mm. Point AO was placed ahead point BO in skeletal class II, while in class III, point AO is far behind of point BO. [Figure 4]

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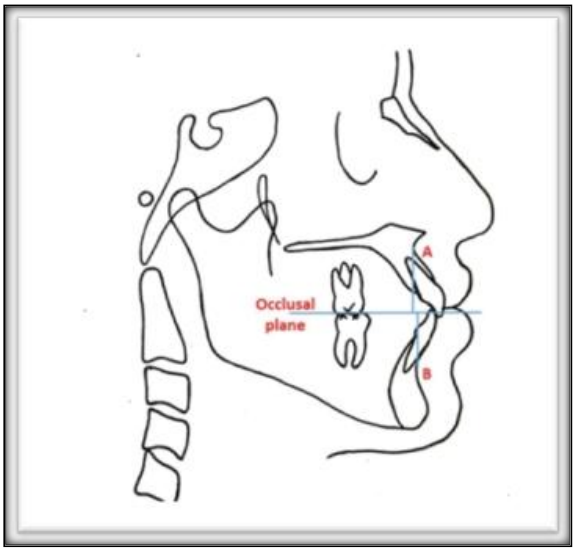

Figure 4: illustrates the measurement of the Wits Appraisal

W Angle: To measure the W angle, three key skeletal landmarks were identified: Point S (sella), the midpoint of the sella turcica; Point M, the midpoint of the premaxilla; and Point G, the center of the largest circle tangent to the inner anterior, posterior, and inferior borders of the mandibular symphysis. Lines were then drawn connecting S to M (S–M line), M to G (M–G line), and S to G (S–G line). A perpendicular is dropped from Point M to the S–G line. The W angle is defined as the angle formed between this perpendicular line and the M–G line. [Figure 5].

Figure 5: illustrates the measurement of the Wangle

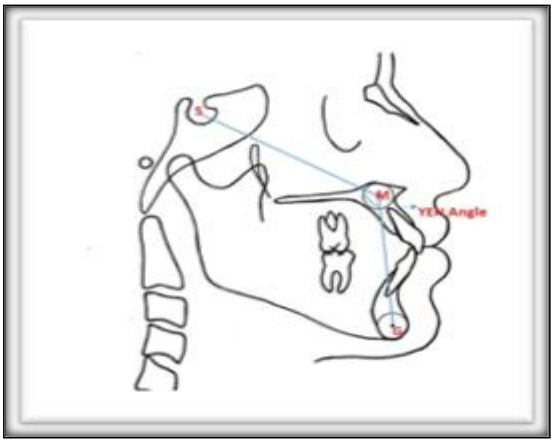

Figure 6: illustrates the measurement of the Yen angle

Yen Angle: To measure the Yen angle, three skeletal landmarks were identified: Point S (the midpoint of the sella turcica), Point M (the midpoint of the anterior maxilla), and Point G (the center of the mandibular symphysis, often determined as the center of the largest circle tangent to the inner surfaces of the symphysis). Two lines were drawn—one from Point S to Point M (S–M line) and another from Point M to Point G (M–G line). The Yen angle is defined as the angle formed between the S–M and M–G lines.

Grouping of samples:

The total sample were divided into three skeletal groups—

1. Group 1 (Class I Skeletal Pattern): 12 females, 8 males
2. Group 2 (Class II Skeletal Pattern): 10 females, 10 males
3. Group 3 (Class III Skeletal Pattern): 12 females, 8 males

Sample selection were made by measuring the parameters ANB angle, WITS appraisal after identifying and tracing all the important landmarks. All the lateral cephalograms were later retraced by single investigator in a standard manner and YEN angle and W angle were measured for tabulation.

Statistical Analysis: The two group mean comparisons were done using Independent samples t test and three or more group mean comparisons were done using Analysis Of Variance with Tukey's post hoc test for pairwise comparisons. All tests were conducted at 0.05 significance level. A p value of less than 0.05 is considered as statistically significant. All statistics were computed using IBM SPSS version 20 and Microsoft Excel.

RESULTS

[Table 1] shows the minimum, maximum, mean, standard deviation (SD), and coefficient of variation (CV) of ANB angle, Wits appraisal, Yen angle and W angle for different Skeletal Classes (Class I, II, and III) in the Bodo Tribal Population of Assam. Each skeletal class consisted of 20 individuals (N=20).

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Table 1: Descriptive Statistics (Minimum, Maximum, Mean, Standard deviation (SD), and Coefficient of variation (CV)) of ANB angle, Wits appraisal, Yen angle and W angle for different Skeletal Classes (Class I, II, and III) in the Bodo Tribal Population of Assam.

CLASS		N	Minimum	Maximum	Mean	Std. Deviation	CV
Class I	ANB Angle (Degrees)	20	2	4	3.0	0.7	0.24
	Wits Appraisal (mm)	20	1	5	2.7	1.4	0.51
	Yen Angle (Degrees)	20	118	133	123.5	4.5	0.04
	W Angle (Degrees)	20	51	62	55.1	3.3	0.06
Class II	ANB Angle (Degrees)	20	5	10	6.4	1.4	0.22
	Wits Appraisal (mm)	20	1	8	5.0	1.6	0.33
	Yen Angle (Degrees)	20	95	122	114.7	6.0	0.05
	W Angle (Degrees)	20	42	55	50.1	3.4	0.07
Class III	ANB Angle (Degrees)	20	-11	-1	-3.4	2.9	-0.84
	Wits Appraisal (mm)	20	-17	-1	-6.8	3.7	0.55
	Yen Angle (Degrees)	20	125	146	132.7	5.7	0.04
	W Angle (Degrees)	20	57	70	62.3	3.5	0.06

YEN angle and W angle showed lowest coefficient of variation that means least variability among all skeletal classes which suggests that they are more predictable and homogenously distributed. In contrast, ANB angle and Wits appraisal showed higher variability, especially in Class III cases, suggesting these parameters may be less reliable in subjects with severe skeletal discrepancies. The findings support the stability and diagnostic reliability of Yen and W angles for assessing sagittal skeletal relationships, particularly in ethnically distinct populations such as the Bodo tribe.

Table 2: Mean and Standard deviation (SD) and Pairwise Significance of ANB angle, Wits appraisal, Yen angle, W angle among Class I, II, and III skeletal patterns in the Bodo tribal population of Assam.

	CLASS	Mean	Std. Deviation	P value	Pairwise comparisons	P values
ANB Angle (Degrees)	Class I	3.00	0.73	p < 0.001, S	Class I vs Class II	p < 0.001, S
	Class II	6.40	1.39		Class II vs Class III	p < 0.001, S
	Class III	-3.43	2.87		Class III vs Class I	p < 0.001, S
Wits Appraisal (mm)	Class I	2.70	1.39	p < 0.001, S	Class I vs Class II	0.016, S
	Class II	4.95	1.64		Class II vs Class III	p < 0.001, S
	Class III	-6.80	3.74		Class III vs Class I	p < 0.001, S
Yen Angle (Degrees)	Class I	123.50	4.48	p < 0.001, S	Class I vs Class II	p < 0.001, S
	Class II	114.70	6.00		Class II vs Class III	p < 0.001, S
	Class III	132.65	5.73		Class III vs Class I	p < 0.001, S
W Angle (Degrees)	Class I	55.10	3.32	p < 0.001, S	Class I vs Class II	p < 0.001, S
	Class II	50.05	3.38		Class II vs Class III	p < 0.001, S
	Class III	62.30	3.53		Class III vs Class I	p < 0.001, S

[Table 2] shows Mean and Standard deviation (SD) values for ANB angle, Wits appraisal, Yen angle, W angle among Class I, II, and III skeletal patterns in the Bodo tribal population of Assam. All parameters showed statistically significant differences ($p < 0.05$) among all the skeletal classes. A one-way ANOVA was used to assess overall differences among the skeletal classes, followed by Tukey's HSD test for post-hoc pairwise comparisons. These results showed that all four measurements can clearly distinguish between different skeletal classes. Among them, the Yen angle and W angle proved to be the most consistent and reliable in identifying differences in jaw relationships across the various skeletal pattern.

Table 3: Pearson correlation between ANB angle and Wits appraisal with Yen angle and W angle among Class I, II, and III skeletal patterns with significance levels.

			Yen Angle	W Angle
Class I	ANB Angle (Degrees)	Pearson Correlation	-0.405	-0.415
		P value	0.076	0.069
	Wits Appraisal (mm)	Pearson Correlation	0.190	0.360
		P value	0.422	0.119
Class II	ANB Angle (Degrees)	Pearson Correlation	-0.502	-0.351
		P value	0.024, S	0.129
	Wits Appraisal (mm)	Pearson Correlation	-0.272	-0.223
		P value	0.246	0.345
Class III	ANB Angle (Degrees)	Pearson Correlation	-0.774	-0.800
		P value	P < 0.001, S	P < 0.001, S
	Wits Appraisal (mm)	Pearson Correlation	-0.788	-.835
		P value	P < 0.001, S	P < 0.001, S

[Table 3] shows Pearson correlation coefficients (r) between ANB angle and Wits appraisal with Yen angle and W angle among Class I, II, and III skeletal patterns in Bodo tribe of assam. A p-value less than 0.05 was considered statistically significant. Pearson's correlation test was used to assess the

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strength and direction of these associations. Yen angle and W angle showed strong negative correlations with ANB angle and Wits appraisal in Class III cases, highlighting their effectiveness in assessing pronounced skeletal discrepancies. In Class I and II groups, the correlations were weaker, suggesting these angles are more diagnostic in cases of significant jaw disharmony.

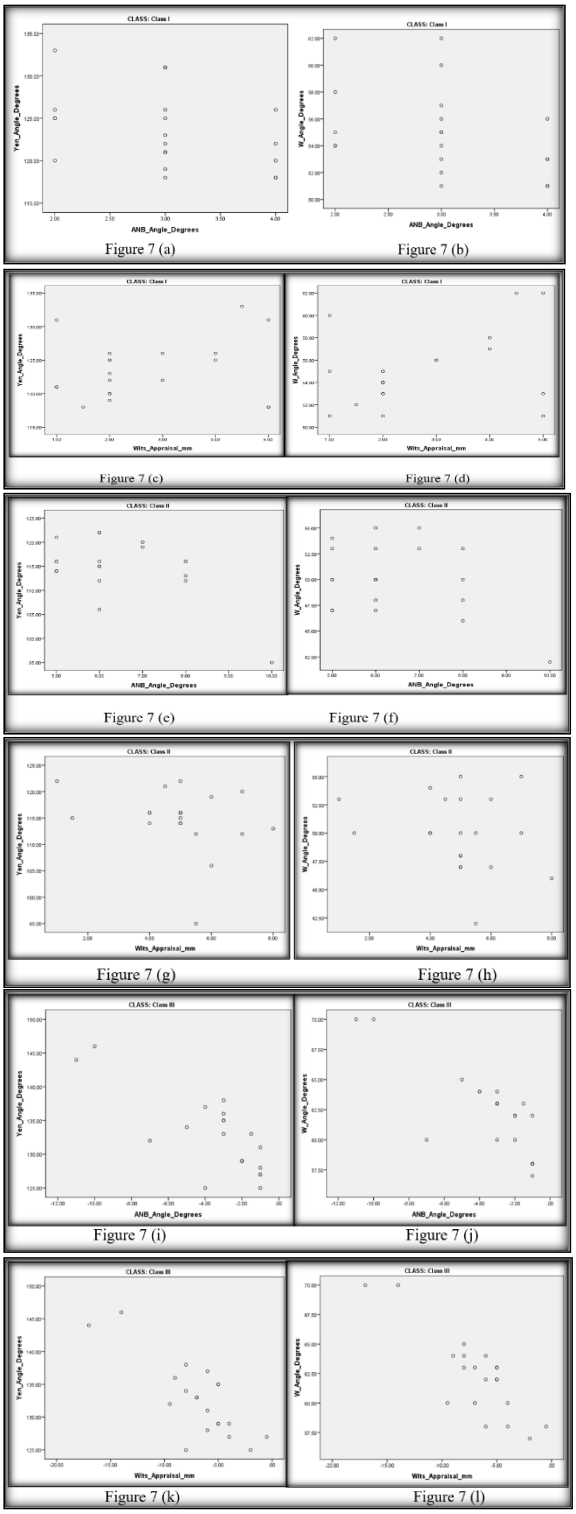

Figure 7(a) to 7(l): Scatter diagrams showing Pearson correlation between ANB/Wits Appraisal and Yen Angle/ W Angle among Class I, II and III skeletal patterns in the Bodo tribal population of Assam.

DISCUSSION

Diagnosis and treatment planning in orthodontics evolved with the introduction of Cephalometry. It helps in estimating the sagittal interrelationship of craniofacial structures like maxilla to mandible. It is an important diagnostic criterion in orthodontic treatment. Although clinical observation helps determine the sagittal relationship to some extent, accurate evaluation is possible only with the help of cephalometrics. Many angular and linear measurements have been incorporated into various cephalometric analyses to help the clinician diagnose sagittal jaw discrepancies.

When using the ANB angle, factors such as the patient's age, growth rotation of the jaws, vertical growth, and the length of the anterior cranial base (AP position of N) should be considered and that the position of nasion is not fixed during growth, any displacement of nasion will directly affect the ANB angle. Furthermore, rotation of the jaws by either growth or orthodontic treatment can also change the ANB reading.[5,15]

Although the WITS appraisal avoids nasion point and reduces the rotational effects of jaw growth, it uses the occlusal plane, a dental parameter to describe a skeletal maxillo-mandibular relation. Any change in angulation of occlusal plane which occurs during tooth eruption and dental development profoundly influences the positions of point A, B and thereby Wits appraisal.[16]

Another A-P measuring parameter is YEN angle which was introduced by Neela et al,[12] in 2009 in the Department of Orthodontics and Dentofacial Orthopedics, Yenepoya Dental College, Mangalore, Karnataka, India and hence its name. The main advantage of YEN angle is that it eliminates the difficulty in locating points A and points B or the functional occlusal plane used in Wits appraisal. Since it is not influenced by greater changes, it can be used in mixed dentition as well, but the angle measured between the lines SM and MG, growth rotation of jaw or orthodontic treatment can mask the true basal dysplasia, similar to ANB angle.

To overcome the limitations of the above mentioned parameters W angle was developed by Wasundhara Bhad et al in 2011.[11] This measurement does not depend on unstable landmarks or the functional occlusal plane. The geometry of the W angle gives it the advantage to remain relatively stable even when the jaws are rotated or growing vertically. This is a result of rotation of the S - G line along with jaw rotation, which carries the perpendicular from point M with it. Because the M - G line is also rotating in the same direction, the W angle remains relatively stable.

Recent studies have shown that no single factor can fully evaluate sagittal skeletal relationships. Therefore, it is advisable to use several cephalometric indicators for a more reliable diagnosis.[20] Understanding how different jaw

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relationship parameters agree with each other and what affects them is crucial for assessing skeletal conditions accurately. This study was designed as a cross-sectional analysis to evaluate and compare both traditional and newer cephalometric parameters used for assessing sagittal jaw discrepancies. It was conducted to determine whether the Yen angle and W angle—less influenced by cranial base variability—could serve as reliable alternatives to the conventional ANB angle and Wits appraisal. By analyzing their correlation and consistency across different skeletal classes in the Bodo tribal population, the study aimed to assess the applicability and diagnostic value of these newer angles in an underrepresented ethnic group.

The mean value and standard deviation for ANB angle in Bodo tribal population of assam for all the skeletal patterns were calculated which was found to be (3.0°± 0.7°) for Class I, (6.4°±1.4°) for Class II, and (-3.4°±2.9°) for Class III. The mean Wits Appraisal and the standard deviation were found to be (2.7mm± 1.4mm) for Class I, (5mm±1.6mm) for Class II, and (-6.8mm±3.7mm) for Class III.

In our study, the mean Yen angle values in the Bodo population were 123.5° ± 4.5° for Class I, 114.7° ± 6° for Class II, and 132.65° ± 5.73° for Class III skeletal patterns. The mean value of W angle in this study was 55.1° ± 3.3° for Class I, 50.1° ± 3.4° for Class II, and 62.3° ± 3.5° for Class III skeletal patterns in the Bodo population.

The result of this study shows the difference in the coefficients of variability. The YEN angle and W angle shows the smallest variation among all groups, as shown by its lowest coefficient of variation. This suggests that they are most consistent among all the angles measured. This findings are similar with Mittal et al,[17] Katti et al,[18] Doshi et al,[19] they found that the yen angle had lowest coefficient of variation which means that it was most homogenously distributed and reliable indicator in anteroposterior dysplasia. Because of this, Yen angle and W angle can be a reliable indicator to assess skeletal patterns, irrespective of what kind of malocclusion is present in bodo tribal population of assam state.

All four cephalometric variables—ANB angle, Wits appraisal, Yen angle, and W angle—in this study showed statistically significant differences among skeletal Classes I, II, and III. Pairwise comparisons consistently showed significant differences between each skeletal category ($p < 0.001$), supporting their diagnostic utility. The ANB angle and Wits appraisal findings align with established norms, whereby higher and positive values signify Class II, and negative values define Class III skeletal relationships. Similarly, variations in the Yen and W angles, which had been shown previously by Neela et al,[12] and Bhad et al,[11] to have smaller values for Class II and larger values for Class III. These findings support the accuracy of these parameters in identifying sagittal discrepancies and agree with previous studies by Kapadia et al,[20] Mittal et al,[17] Doshi et al,[19] and Mehta et al,[21] strengthen their use in cephalometric evaluation in all skeletal classes.

The Pearson correlation analysis in this study highlights variability in the relationship between traditional (ANB angle, Wits appraisal) and newer cephalometric parameters (Yen and W angles) among skeletal classes. In the Class I group, there were weak and statistically non-significant correlations were observed, suggesting minimal concordance between these parameters in individuals with normal skeletal patterns. In the Class II group, a moderate, statistically significant negative correlation between the ANB angle and Yen angle ($r = -0.502$, $p = 0.024$) was observed, suggesting a potential inverse relationship. However, some correlations in this group were weaker and not statistically significant. In contrast, the Class III group displayed strong, statistically significant negative correlations between both ANB and Wits values with Yen and W angles. This highlights their reliability in assessing severe anteroposterior discrepancies. These findings align with earlier studies by Mittal et al,[17] and Amit Kumar et al,[22] which noted that the Yen and W angles are more stable and reliable indicators, especially when conventional landmarks are affected by growth or orthodontic treatment.

CONCLUSION

The following conclusion can be drawn from this study:

1. All four cephalometric parameters—ANB angle, Wits appraisal, Yen angle, and W angle showed statistically significant differences among skeletal Classes I, II, and III in the Bodo tribal population of Assam State.
2. The Yen angle and W angle had the lowest coefficients of variation, which indicates higher consistency and reliability among different skeletal patterns in Bodo tribe of Assam.
3. Strong negative correlations were found between the newer (Yen angle and W angle) and conventional (ANB angle and Wits appraisal) parameters, especially in Class III malocclusion. This supports their diagnostic accuracy in severe discrepancies.
4. These findings agree with previous studies and strengthen the use of multiple cephalometric indicators for a better sagittal diagnosis.
5. Further studies on larger and more diverse populations are recommended to create strong normative data and improve diagnostic reliability.

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