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Evaluating the Reliability of the 'Beta' Angle and 'W' Angle Compared To the ANB Angle for Sagittal Discrepancy

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ABSTRACT:

This study aimed to evaluate the reliability of the Beta angle and W angle in comparison with the ANB angle for assessing sagittal discrepancies in orthodontic patients. A total of 50 lateral cephalometric radiographs from patients with Class I and Class II division 1 malocclusion were analyzed. The mean values ± standard deviations for the Beta angle, W angle, and ANB angle were determined and compared between the two malocclusion groups. Statistical analyses including the Mann–Whitney U-test, Kruskal-Wallis test with Tukey HSD, and correlation analyses were conducted to assess the differences and associations among these angles within and between groups. The results showed significant differences in the mean values of the Beta angle and ANB angle between Class I and Class II division 1 malocclusions, with the Beta angle demonstrating a statistically significant difference. Correlation analyses revealed significant associations among the Beta angle, W angle, and ANB angle within both malocclusion groups. These findings highlight the utility of the Beta angle and W angle as potential alternatives or supplements to the ANB angle in cephalometric assessments of sagittal jaw relationships. Further research is warranted to validate these findings across diverse populations and clinical settings.

Keywords: Sagittal jaw relationship, Cephalometric analysis, Orthodontic malocclusion, Lateral cephalometric radiograph, Orthodontic diagnosis

1. Introduction

Sagittal discrepancy, a misalignment of the jaws in the anteroposterior direction, is a common orthodontic problem that affects facial aesthetics, function, and overall oral health [1]. Accurate assessment of sagittal discrepancies is crucial for diagnosing malocclusions and planning effective treatment [2]. Traditional methods of evaluating these discrepancies have relied heavily on angular measurements from cephalometric radioFigures. Among these, the ANB angle has been one of the most commonly used parameters [3,4]. However, recent advancements in cephalometric analysis have introduced alternative angular measurements, such as the 'Beta' angle and the 'W' angle, which are proposed to offer better reliability and clinical relevance [5,6].

The ANB angle, formed by the intersection of lines connecting point A (the deepest point on the anterior maxilla), point N (the nasion), and point B (the deepest point on the anterior mandible), has long been the gold standard for evaluating sagittal relationships [7-9]. This angle quantifies the anteroposterior position of the maxilla relative to the mandible, providing a straightforward measure of skeletal discrepancy [10,11]. An ANB angle of 2-4 degrees typically indicates a Class I relationship, values greater than 4 degrees suggest a Class II malocclusion, and angles less than 2 degrees are indicative of a Class III malocclusion [12]. While the ANB angle is widely used, it has notable limitations [13]. The ANB angle can be influenced by factors such as the position of the nasion, the inclination of the cranial base, and the overall vertical dimension of the face[14]. Variations in these factors can lead to inaccurate assessments of the sagittal relationship, potentially complicating diagnosis and treatment planning [15]. The 'Beta' angle, introduced as a more reliable measure for assessing sagittal discrepancies, aims to overcome some of the limitations of the ANB angle. This angle is defined by the intersection of lines drawn from the condylion (the most posterior point on the condyle) to point A and from point A to point B[16]. The Beta angle provides a direct assessment of the skeletal relationship between the maxilla and mandible without being influenced by the nasion's position or the cranial base inclination [17].

Another innovative measure, the 'W' angle, has been proposed to enhance the reliability of sagittal discrepancy assessment [18]. The W angle is formed by the intersection of lines from point S (sella) to point M (maxillary point) and from point M to point G (mandibular point). This angle aims to provide a straightforward and reproducible measurement that reflects the anteroposterior position of the jaws [19,20].

Proponents of the W angle argue that it offers advantages over the ANB angle by minimizing the influence of cranial base flexion and vertical growth patterns [21]. The simplicity of the W angle's geometric construction also contributes to its ease of use and reproducibility, which are essential for consistent clinical application [22,23]. To evaluate the effectiveness and reliability of these angular measurements, it is essential to compare them systematically [24]. The reliability of an angular measure in cephalometric analysis can be assessed based on its consistency across different observers (interobserver reliability) and its stability when measured by the same observer at different times (intraobserver reliability) [25]. Additionally, the clinical relevance of these measures can be evaluated by examining their correlation with other established diagnostic criteria and their impact on treatment outcomes [26].

The adoption of more reliable angular measures for sagittal discrepancy has significant clinical implications [27]. Accurate diagnosis of sagittal relationships is fundamental for developing effective orthodontic treatment plans. Misdiagnosis or inaccurate assessment can lead to suboptimal treatment outcomes, prolonged treatment duration, and patient dissatisfaction. By providing more reliable and reproducible measures, the Beta and W angles could enhance diagnostic accuracy and improve treatment planning [28].

The aim of the study is to evaluate the reliability of the Beta angle and W angle in comparison with the ANB angle for sagittal discrepancy. The objectives are to evaluate and compare sagittal discrepancy using the Beta angle, W angle, and ANB angle as cephalometric norms; to assess which angle—Beta angle or W angle—is more accurate and efficient compared to the ANB angle; and to determine which angle—Beta angle or W angle—is more reliable for assessing sagittal discrepancy[29]. Future research should focus on further validating the reliability and clinical relevance of the Beta and W angles through large-scale, multicenter studies. Longitudinal studies that track treatment outcomes based on these angular measures could provide valuable insights into their predictive value and practical utility. Additionally, advancements in imaging technology and digital cephalometry could refine these measurements and enhance their precision[30].

2. Material and method

Source of Data

The study was conducted in the Department of Orthodontics and Dentofacial Orthopedics at Rajasthan Dental College and Hospital, Jaipur, Rajasthan. This study included 50 lateral cephalometric radioFigures of the Rajasthani population.

Methods of Data Collection

The study included patients who reported for orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics at Rajasthan Dental College and Hospital, Jaipur. A total of 50 lateral cephaloFigures of patients aged 18 years and above were included, categorized based on skeletal patterns as Class I and Class II div 1 malocclusion. There were two groups: Group A and Group B, each consisting of 25 patients. Group A consisted of patients with Class I malocclusion, and Group B consisted of patients with Class II div 1 malocclusion.

Inclusion and Exclusion Criteria

The inclusion criteria for the study were orthodontic patients with Class I and Class II div 1 malocclusion, permanent dentition with no facial asymmetry, patients aged above 18 years, and patients with no previous history of orthodontic treatment. The exclusion criteria were previous orthodontic treatment, patients with missing teeth, Class III malocclusion, patients who had undergone orthognathic surgery, edentulous spaces, history of trauma, congenital deformity, marked asymmetry, and poor-quality radioFigures.

RadioFigureic Details

The lateral cephalometric radioFigure is a standardized, reproducible radioFigure obtained with the patient positioned in Natural Head Position, seated condyle, and with passive lips. It was taken using a Planmeca Promax radioFigureic machine from a distance of 1.5 mm with the head at a right angle to the X-ray beam at a distance of 30 cm, with a scale size of 100%, an exposure time of 6.7 seconds, an electric potential of 66 kV, and a current of 10 mA. The lateral cephaloFigures were hand traced for ANB, Beta, and W angles. To eliminate intraexaminer error, hand tracing was repeated for the same points after 4 weeks and formed the database for the study. The following materials were required for manual tracing: 50 left lateral cephaloFigures, tracing table, 0.003" lead acetate tracing paper, 0.5 mm HB lead pencil, geometry box (scale, protractor, rounder, set square), Scotch tape, and eraser.

Study Details

The study was conducted at the Department of Orthodontics and Dentofacial Orthopedics, Rajasthan Dental College and Hospital, Jaipur, Rajasthan. It involved 50 lateral cephalometric radioFigures from the Rajasthani population. Patients aged above 18 years were included and categorized based on skeletal patterns into Class I and Class II div 1 malocclusion groups, with each group (Group A and Group B) comprising 25 patients. Group A included patients with Class I malocclusion, while Group B included patients with Class II div 1 malocclusion. Inclusion criteria consisted of orthodontic patients with Class I and Class II div 1 malocclusion, permanent dentition without facial asymmetry, aged above 18 years, and no previous history of orthodontic treatment. Exclusion criteria included previous orthodontic treatment, missing teeth, Class III malocclusion, history of orthognathic surgery, edentulous spaces, history of trauma, congenital deformity, marked asymmetry, and poor-quality radioFigures.

3. Result and discussion

Statistical Analysis

The data were coded and entered into a Microsoft Excel spreadsheet for organization and initial preparation. Statistical analysis was performed using IBM SPSS Statistics Version 25 for Windows software program (SPSS Inc., IBM Corporation, NY, USA). Descriptive statistics, including percentages, means, and standard deviations, were computed to summarize the data. Normality of the data distribution was assessed using the Kolmogorov-Smirnov test prior to further statistical analyses. The Mann–Whitney U-test and Kruskal-Wallis test with Tukey's Honestly Significant Difference (HSD) post hoc analysis were applied to assess differences among groups where applicable. The level of significance was set at $P \leq 0.05$ to determine statistical significance.

Mean

The mean, also known as the average, is obtained by dividing the sum of observed values by the number of observations, n . The formula for the mean is given below:

$$\bar{X} = \frac{\sum_{i=1}^{i=n} X_i}{n}$$

Where, $\bar{X}$ = Mean
$\sum X$ = Sum of all individual observations
n = Total number of observations

Standard Deviation

The standard deviation provides a measure of how spread out the values in a dataset are from the average value. Data sets with a small standard deviation are tightly grouped around the mean, indicating precision and consistency. Conversely, data sets with a large standard deviation exhibit greater variability, with values spread out over a wider range. The formula for standard deviation is given below:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{i=n}(X_i - \bar{X})^2}$$

Where, σ = Standard deviation
$\bar{X}$ = Mean

Xi = Individual observation
∑ X = Sum of all individual observations
∑ (Xi - X) = Sum of differences of every observation from the mean value n = Total number of observations

Table 1. Description of different variables amongst patients with class I malocclusion

	Mean	Std. Deviation	Minimum	Maximum	P value
BETA angle (°)	30.500	2.3979	27.0	35.0	0.001 (S)
W angle (°)	53.280	1.6078	51.0	56.0	
ANB angle (°)	1.820	1.4992	-1.0	4.0	

Figure 1: Beta angle, W angle, ANB angle amongst patients with Class I malocclusion

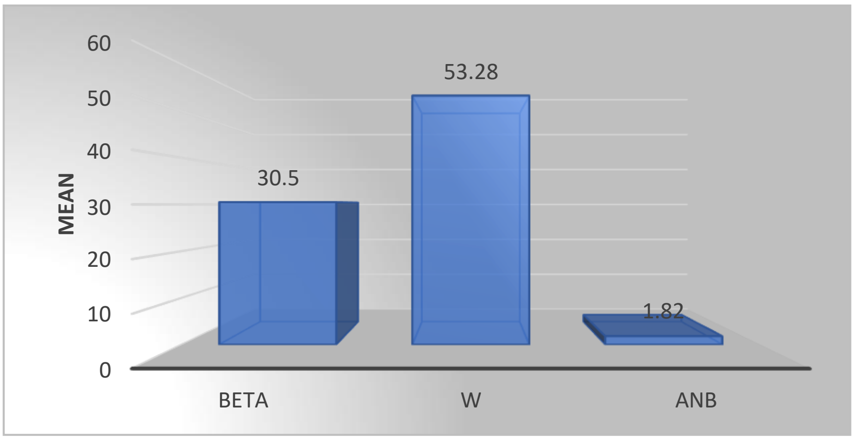

Table 2. Intra-group Comparisons for class 1 patients with Tukey HSD test

		Mean Difference	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Beta	W	-22.78Figure	.000	-24.051	-21.509
	ANB	28.68Figure	.000	27.409	29.951
W	Beta	22.78Figure	.000	21.509	24.051
	ANB	51.46Figure	.000	50.189	52.731
ANB	Beta	-28.68Figure	.000	-29.951	-27.409
	W	-51.46Figure	.000	-52.731	-50.189

Figure=significant

Table 3. Description of different variables amongst patients with class II division 1 malocclusion

Inter groups of Class 2 div 1

	Mean	Std. Deviation	Minimum	Maximum	P value
BETA angle (°)	22.760	2.2644	18.0	26.5	0.001 (S)
W angle (°)	47.400	1.3463	45.0	50.0	
ANB angle (°)	6.720	1.2423	4.5	9.0	

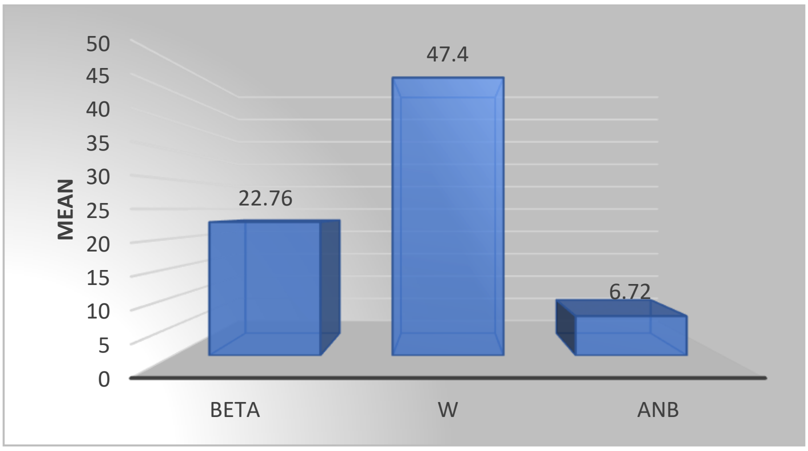

Figure 2: Beta angle, W angle, ANB angle amongst patients with Class II division 1 malocclusion

Table 4. Intra-group Comparisons for class II div 1 patient with Tukey HSD test

		Mean Difference	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Beta	W	-24.64^Figure	.000	-25.778	-23.502
	ANB	16.04^Figure	.000	14.902	17.178
W	Beta	24.64^Figure	.000	23.502	25.778
	ANB	40.68^Figure	.000	39.542	41.818
ANB	Beta	-16.04^Figure	.000	-17.178	-14.902
	W	-40.68^Figure	.000	-41.818	-39.542

^Figure=significant

Table 5. Comparison of beta angle amongst patients with class I and class II malocclusion Inter groups of Beta angle

	Group	Mean	Std. Deviation	P value
BETA angle (°)	Class I	30.500	2.3979	0.001 (S)
	Class 2 div 1	22.760	2.2644	

Figure 3: Beta angle amongst patients with Class I and Class II division 1 malocclusion

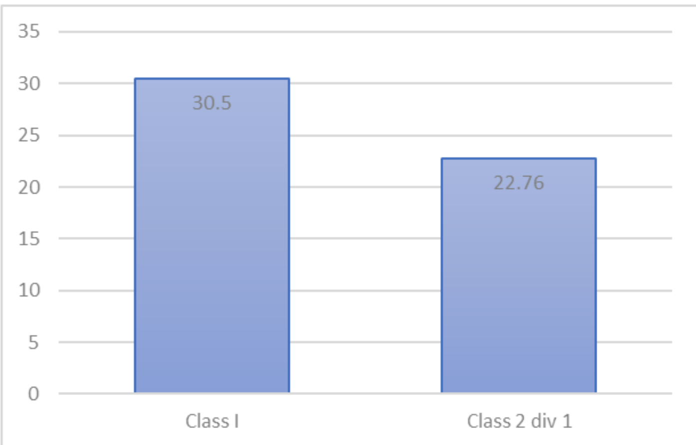

Table 6. Comparison of w angle amongst patients with class I and class II malocclusion
Inter groups of W angle

	Group	Mean	Std. Deviation	P value
W angle (°)	Class I	53.280	1.6078	0.001 (S)
	Class 2 div 1	47.400	1.3463	

Figure 4: W angle amongst patients with Class I and Class II division 1 malocclusion

Table 7. Comparison of ANB angle amongst patients with class I and class II malocclusion
Inter groups of ANB angle

	Group	Mean	Std. Deviation	P value
ANB Angle (°)	Class I	1.820	1.4992	0.001 (S)
	Class 2 div 1	6.720	1.2423	

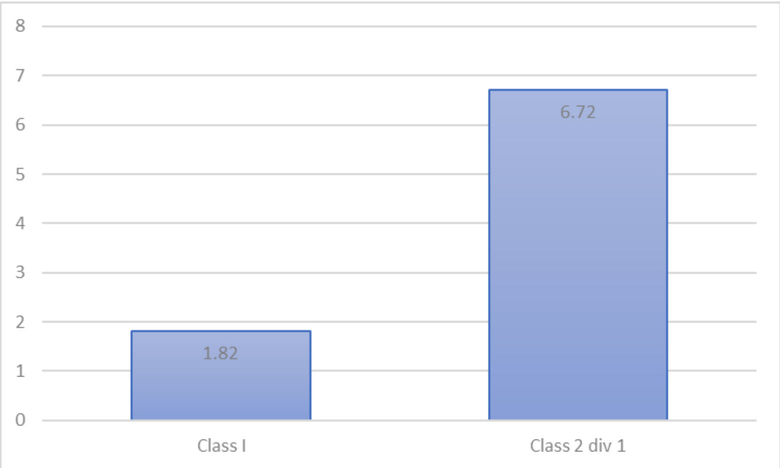

Figure 5: ANB angle amongst patients with Class I and Class II division 1 malocclusion

4. Discussion

In orthodontic research, the analysis of angular measurements such as the Beta angle, W angle, and ANB angle plays a crucial role in understanding and diagnosing malocclusions, particularly Class I and Class II division 1 malocclusions. These measurements provide insights into the skeletal relationships and deviations that characterize different types of malocclusions, influencing treatment planning and outcomes. This study examines the mean

± standard deviation values of these angles among patients with Class I and Class II division 1 malocclusions, highlighting their significance and correlations.

Table 1 presents the mean ± standard deviation values for patients with Class I malocclusion: the Beta angle was 30.5° ± 2.3979°, the W angle was 53.28° ± 1.6078°, and the ANB angle was 1.82° ± 1.4992°. In contrast, Table 3 displays the corresponding values for patients with Class II division 1 malocclusion: the Beta angle was 22.76° ± 2.2644°, the W angle was 47.4° ± 1.3463°, and the ANB angle was 6.720° ± 1.2423°. These values provide a quantitative overview of the angular measurements specific to each malocclusion type.

Statistical comparisons reveal significant differences between these angles across malocclusion types. The Beta angle among patients with Class I malocclusion was significantly greater than that among patients with Class II division 1 malocclusion ($p < 0.05$), as indicated in Table 5. Conversely, the W angle showed no significant difference between Class I and Class II division 1 malocclusions ($p > 0.05$), as noted in Table 6. Notably, the ANB angle was significantly larger in patients with Class II division 1 malocclusion compared to those with Class I malocclusion ($p < 0.05$), as shown in Table 7. These findings underscore the distinct skeletal characteristics and variations present in different types of malocclusions, influencing treatment planning strategies.

Further analysis within each malocclusion type reveals significant correlations between the Beta angle, W angle, and ANB angle. Among patients with Class I malocclusion (Table 2), significant correlations were observed between the Beta angle and W angle, Beta angle and ANB angle, as well as W angle and ANB angle. Similarly, among patients with Class II division 1 malocclusion (Table 4), these correlations remained significant. This suggests that these angular measurements are interrelated and collectively provide comprehensive information about the sagittal skeletal discrepancies present in orthodontic patients.

Utilizing Tukey's Honestly Significant Difference (HSD) test within each malocclusion group (Table 2 and Table 4), it was determined that there were statistically significant differences in the mean values of the Beta angle, W angle, and ANB angle. Each angle exhibited significant differences when compared across the different malocclusion groups, reinforcing the distinctiveness of these measurements in characterizing sagittal discrepancies.

5. Conclusion

The following conclusion was drawn from this study that, there can be numerous angular and linear parameters for assessing the antero posterior apical base discrepancies which have their own advantages and disadvantages. From the clinician’s perspective, two or more methods can be used for accurate anteroposterior measurement in orthodontic diagnosis and treatment planning. All the analysis has their own values for class I and class II division 1 skeletal pattern which was almost same for each in a given range. When correlation was assessed between all the analysis for class I and class II division 1 skeletal pattern, study show both positive and negative correlations between all the angles. Despite varying strengths of association, statistically significant correlations were found among all the three measures; ANB angle, Beta angle and W angle. Therefore, these all can be used to assess sagittal jaw discrepancy in addition to the established angles. This study shows W angle and ANB angle are more reliable in distinguishing between class I and class II division 1 malocclusion. The best accuracy among them for the assessment of correlation is given by W angle.

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