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Evaluation of Reliability of Various Cephalometric Angles for Assessing Sagittal Jaw Dysplasia in Different Skeletal Pattern: A Cephalometric Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Objective: The study aimed to compare the reliability of different cephalometric angles like the Beta, Yen, W and Pi angles to evaluate sagittal dysplasia in various skeletal patterns and assess the correlation between the variables.
Materials and Methods: 135 pre-treatment lateral cephalograms were taken and further divided into Class I, Class II and Class III groups. Each group had equal samples of 45 (n=45), based on ANB angle using Nemoceph software. Cephalometric landmarks Pi, Yen, Beta and W angle were identified and measured. Statistical analysis was done using the ANOVA test followed by Correlation coefficient analysis.
Results: Pi angle was highly predictable for differentiating class I cases, with 91.1% accuracy. Whereas in class II cases Pi and Beta angle were found to be most predictable with 73% and 66% accuracy respectively, while in class III cases Yen angle was found to be most predictable with 88% accuracy.
Conclusion: Overall Pi angle is considered the most reliable for assessing anteroposterior jaw relationship, followed by Beta and Yen angle.

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Keywords: Beta angle; Pi angle; Sagittal jaw discrepancy; W angle; Yen angle.

1. INTRODUCTION

Sagittal malocclusion is one of the most common skeletal malocclusions. A proper evaluation of the anteroposterior relationship helps in accurately identifying the sagittal discrepancy. Over the years, various linear and angular parameters such as ANB angle [1], Wits analysis [2], APDI (Anteroposterior Dysplasia Indicator) [3] and Beta angle [4] has been used effectively to evaluate sagittal discrepancy. However, according to various studies, the reliability of these parameters is still questionable [1,2].

Literature has shown that the position of point N during growth is considered to be unstable. One of the reasons could be due to the rotation of the jaw which occurs during growth that directly affects the ANB angle [1,5-8]. Wits Appraisal introduced as an alternative to the ANB angle, too had shortcomings due to the variability of the occlusal plane [2].

The validity of the two traditionally used intracranial reference planes namely the SN plane and the FH plane has also been questioned, because of their variability to the horizontal plane. In the case of Beta angle, the identification of derived landmark point C (condylion) can be subjected to error [9].

However, the points M and G represent the maxilla and mandible, respectively [10]. These landmarks in turn helped in the development of various analysis such as the Yen angle [11], W angle [12] and the Pi angle [13]. However, further studies are necessary to evaluate the effectiveness and reliability of these angles in comparison with the other sagittal indicators.

Therefore, this study aimed to evaluate and compare the reliability of different cephalometric angles like the Beta, Yen, W and Pi angle, and Pi angles to assess sagittal jaw dysplasia in different skeletal patterns.

2. MATERIALS AND METHODS

For the present study, 135 pre-treatment lateral cephalograms of different skeletal patterns were taken from the department of orthodontics. It was further divided into 3 groups based on the ANB angle.

Inclusion Criteria includes: the ANB angle between 1° and 4° were considered as Class I, values >4° and ≤0° as Class II and Class III respectively, permanent dentition with no missing teeth, patients with age group between 15 and 20 years. Whereas Exclusion Criteria includes: history of orthodontic treatment, patients with craniofacial deformities and history of craniofacial trauma, poor quality of lateral cephalograms.

The various cephalometric landmark included in this study are S Point, point A, point B, Condylion point, point M (the midpoint of the premaxilla), point G (the centre of the mandibular symphysis).

2.1 Statistical Analysis

Data were analyzed using the statistical package SPSS 22.0 (SPSS Inc., Chicago, IL) and the level of significance was set at $p<0.05$. ANOVA test was used to determine statistically significant differences between the Pi, W, Yen, and beta angles. Chi-square test was used for assessing the accuracy of prediction of jaw dysplasia by Pi, W Yen and Beta angle. Pearson's correlation analysis was done to assess the relation of various parameters among the groups.

3. RESULTS

The present study was conducted to assess the reliability of the Pi angle for assessment of skeletal jaw dysplasia and compare it with the W, Yen, and the Beta Angle. The mean value of the beta angle in class I group is 32.17° ± 4.37° whereas in class II group showed 25.17° ± 2.83°, while among the class III group shows 39.86° ± 5.64° [Table 1].

The mean value of the Pi angle in the class I group showed 3.40° ± 1.75°, whereas in class II group is 7.88° ± 3.65°, while among the class III group is -2.57° ± 3.06° [Table 2].

The mean value for W angle in class I group is 59.91° ± 6.7°, while among the class II group is 52.75° ± 3.81° whereas, in class III group showed 60.08° ± 5.79° [Table 3].

The mean value of the Yen angle in the class I group is 122.68 ° ± 5.04°, whereas in the class II group is 116.46° ± 4.56°, while among the class III group showed 129.77° ± 5.72° [Table 4].

The post hoc test was found to be significantly different for Pi, Yen, and Beta angles except for W angle, among the various malocclusion [Table 5].

The Chi-square test recorded Pi angle to be most certain for differentiating Class I cases, with 91.1% accuracy. In Class II cases Pi and Beta angle were found to be most predictable with 73% and 66% accuracy respectively and in Class III cases Yen angle was found to be more reliable with 88% accuracy [Tables 6-9].

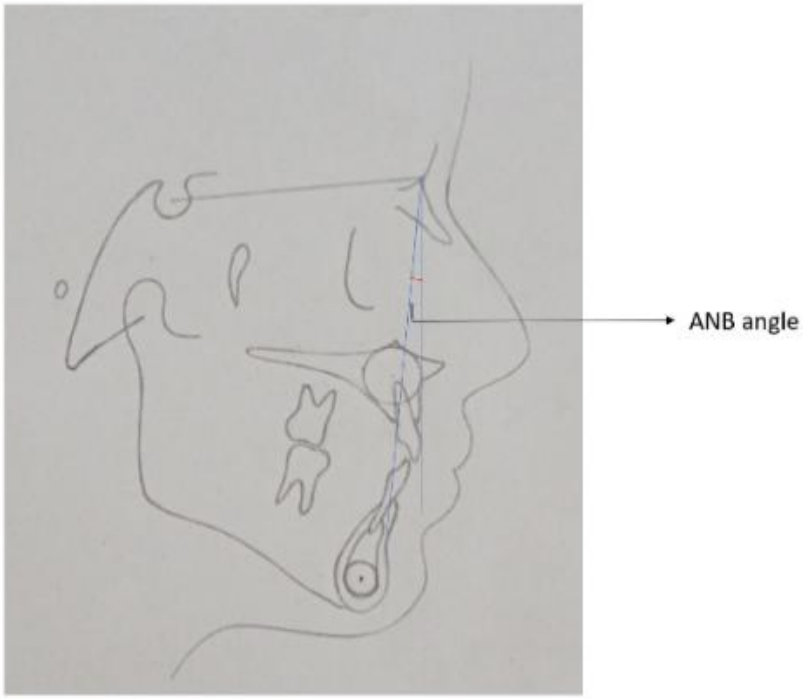

Fig. 1. Lateral cephalometric tracing showing ANB angle

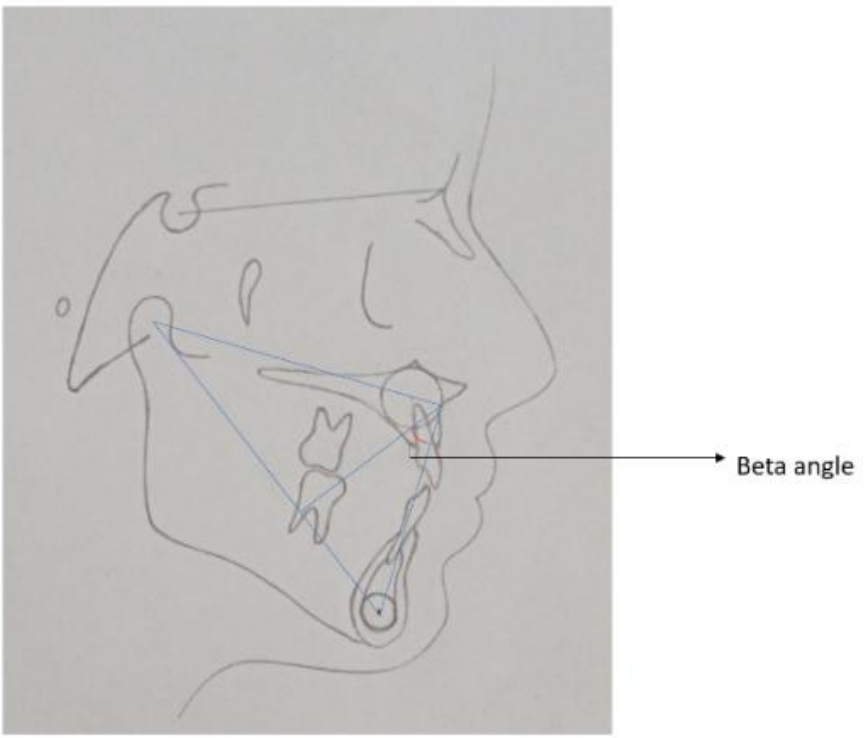

Fig. 2. Lateral cephalometric tracing showing Beta angle

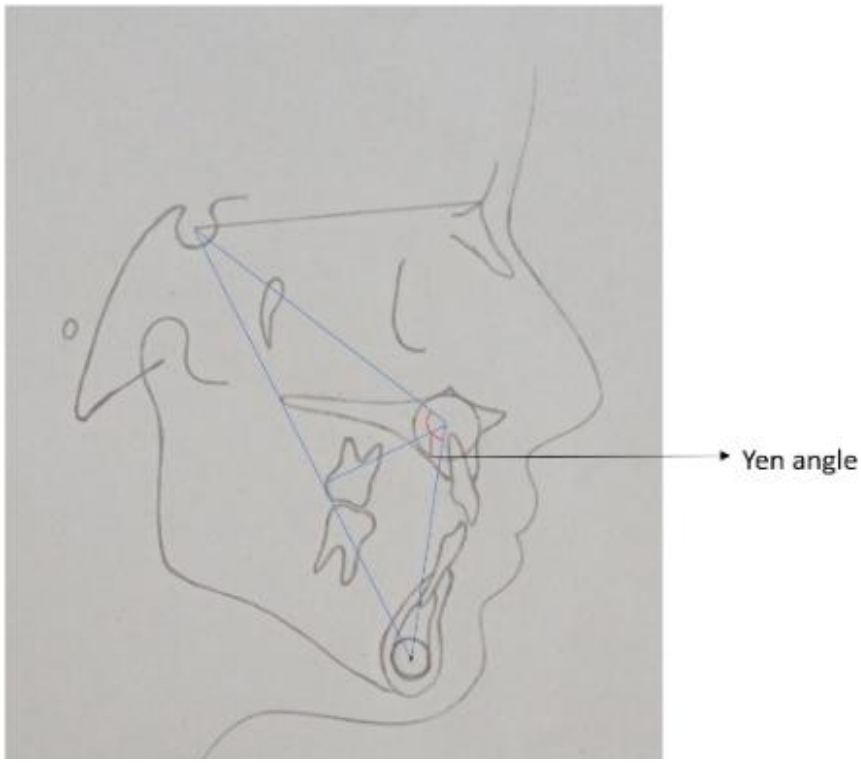

Fig. 3. Lateral cephalometric tracing showing Yen angle

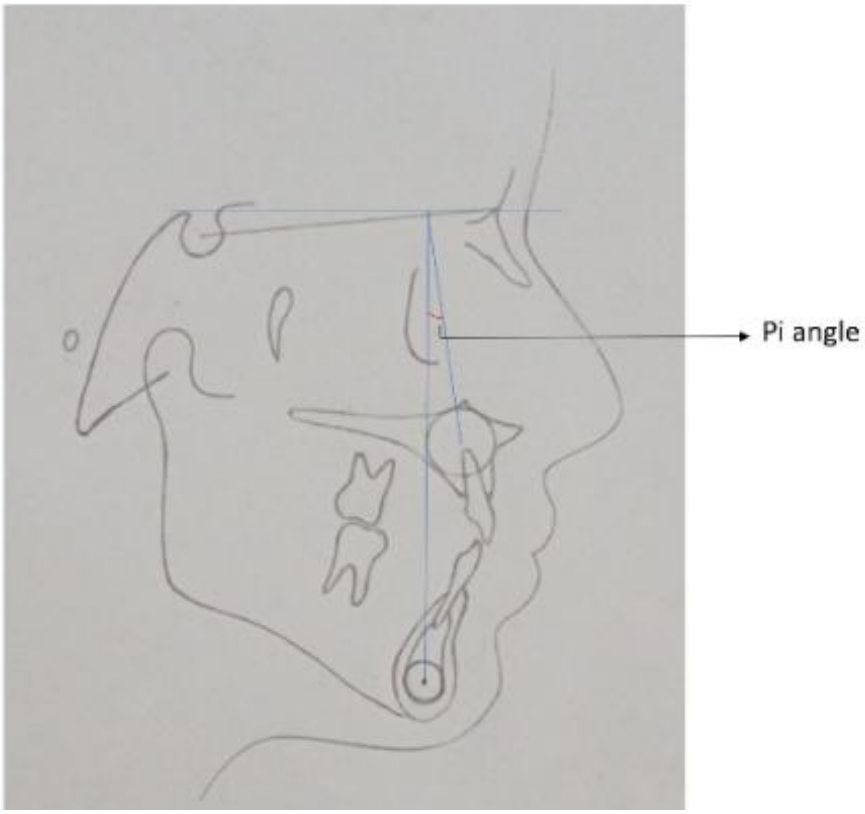

Fig. 4. Lateral cephalometric tracing showing Pi angle

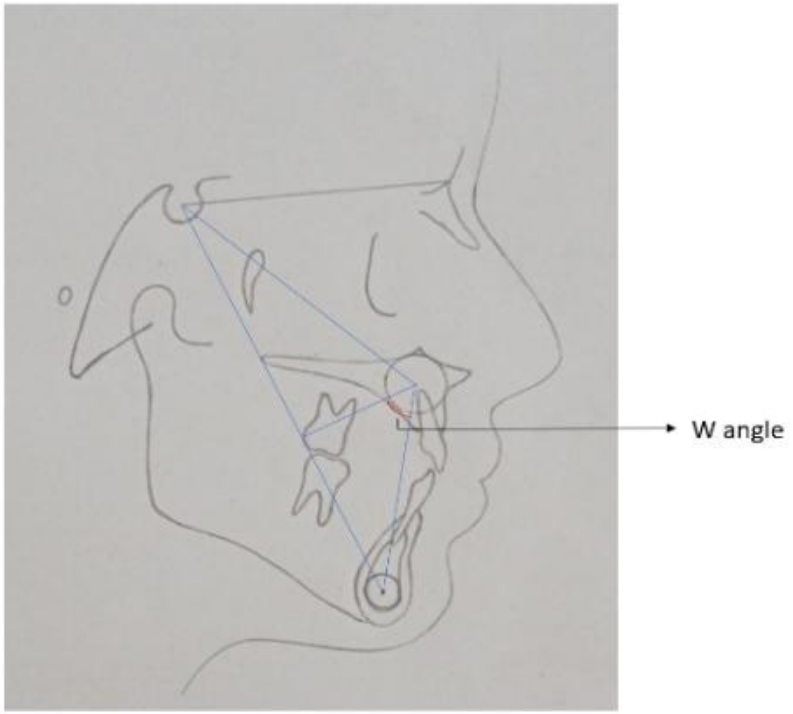

Fig. 5. Lateral cephalometric tracing showing W angle

Table 1. Difference in beta angle between class I, class II and class III patients using one way ANOVA test

Groups	Mean	Standard Deviation	95% Confidence Interval for Mean		F	P
			Lower Bound	Upper Bound		
Class I	32.1702	4.37045	30.8870	33.4534	123.658	.000 (HS)
Class II	25.1778	2.83075	24.3273	26.0282		
Class III	39.8667	5.64318	38.1713	41.5621		

HS = Highly significant (p<0.001).

Table 2. Difference in Pi angle between class I, class II and class III patients using one way ANOVA test

Groups	Mean	Standard Deviation	95% Confidence Interval for Mean		F	P
			Lower Bound	Upper Bound		
Class I	3.4043	1.75276	2.8896	3.9189	145.534	.000 (HS)
Class II	7.8889	3.65701	6.7902	8.9876		
Class III	-2.5778	3.06363	-3.4982	-1.6574		

Table 3. Difference in W angle between class I, class II and class III patients using one way ANOVA test

Groups	Mean	Standard Deviation	95% Confidence Interval for Mean		F	P
			Lower Bound	Upper Bound		
Class I	59.9149	6.70117	57.9474	61.8824	25.410	.000 (HS)
Class II	52.7556	3.81478	51.6095	53.9016		
Class III	60.0889	5.79507	58.3479	61.8299		

Table 4. Difference in Yen angle between class I, class II and class III patients using one way ANOVA test

Groups	Mean	Standard Deviation	95% Confidence Interval for Mean		F	P
			Lower Bound	Upper Bound		
Class I	122.6809	5.04806	121.1987	124.1630	75.714	.000 (HS)
Class II	116.4667	4.56568	115.0950	117.8383		
Class III	129.7778	5.72827	128.0568	131.4987		

Table 5. Post Hoc analysis

Groups	Class		Mean Difference	p	95% Confidence Interval for Mean difference	
					Lower	Upper
	I	II	6.99243*	.000	4.8015*	9.1833
		III	-7.69645*	.000	-9.8873*	-5.5056
Beta	II	I	-6.99243*	.000	-9.1833*	-4.8015
		III	-14.68889*	.000	-16.9035*	-12.4743
	III	I	7.69645*	.000	5.5056*	9.8873
		II	14.68889*	.000	12.4743*	16.9035
	I	II	-4.48463*	.000	-5.9281*	-3.0411
		III	5.98203*	.000	4.5385*	7.4255
Pi	II	I	4.48463*	.000	3.0411*	5.9281
		III	10.46667*	.000	9.0076*	11.9258
	III	I	-5.98203*	.000	-7.4255*	-4.5385
		II	-10.46667*	.000	-11.9258*	-9.0076
	I	II	7.15934*	.000	4.3974*	9.9213
		III	-.17400	.988	-2.9360	2.5880
W	II	I	-7.15934*	.000	-9.9213*	-4.3974
		III	-7.33333*	.000	-10.1252*	-4.5415
	III	I	.17400	.988	-2.5880	2.9360
		II	7.33333*	.000	4.5415*	10.1252
	I	II	6.21418*	.000	3.6760*	8.7524
		III	-7.09693*	.000	-9.6351*	-4.5587
Yen	II	I	-6.21418*	.000	-8.7524*	-3.6760
		III	-13.31111*	.000	-15.8768*	-10.7455
	III	I	7.09693*	.000	4.5587*	9.6351
		II	13.31111*	.000	10.7455*	15.8768
		II	-7.95556*	.000	-8.6378*	-7.2733

Table 6. Chi-square analysis for beta angle

Count	Class (%)			Total	X^2	P
	I	II	III			
I	33 (73.3)	15 (33.33)	9 (20)	57 (42.22)		
II	5 (11.11)	30 (66.67)	0 (0)	35 (25.92)		
III	7 (15.55)	0 (0)	36 (80)	43 (31.85)	111.544	.000
Total	45	45	45	135		

Table 7. Chi-square analysis for Pi angle

Count	Class			Total	X^2	P
	I	II	III			
I	41 (91.11)	12 (26.67)	7 (15.55)	60 (44.44)		
II	0 (0)	33 (73.33)	0 (0)	33 (24.44)		
III	4 (8.88)	0 (0)	38 (84.44)	42 (31.11)	161.986	.000
Total	45	45	45	135		

Table 8. Chi-square analysis for W angle

Count	Class			Total	X^2	P
	I	II	III			
I	12 (26.66)	25 (55.55)	3 (6.66)	40 (29.62)		
II	2 (4.44)	12 (26.66)	6 (13.33)	20 (14.81)		
III	31 (68.88)	8 (17.77)	36 (80)	75 (55.55)	43.790	.000
Total	45	45	45	135		

Table 9. Chi-square analysis for Yen angle

Count	Class			Total	X^2	P
	I	II	III			
I	17 (37.77)	20 (44.44)	5 (11.11)	42 (31.11)		
II	4 (8.88)	23 (51.11)	0 (0)	27 (20)		
III	24 (53.33)	2 (4.44)	40 (88.88)	66 (48.88	75.646	.000
Total	45	45	45	135		

Table 10. Correlation test between beta, Pi, W, Yen and ANB in Class I

Groups	Values	Groups				
		beta	Pi	W	Yen	ANB
Beta	r	1	-.179	.251	.092	-.213
	p		.227	.088	.538	.150
Pi	r	-.179	1	.284	-.125	.079
	p	.227		.053	.402	.599
W	r	.251	.284	1	.424**	-.355*
	p	.088	.053		.003	.014
Yen	r	.092	-.125	.424**	1	-.040
	p	.538	.402	.003		.789
ANB	r	-.213	.079	-.355*	-.040	1
	p	.150	.599	.014	.789	

r = Correlation value; p = probability value

Table 11. Correlation test between beta, Pi, W, Yen and ANB in Class II

Groups	Values	Groups				
		beta	Pi	W	Yen	ANB
Beta	r	1	-.020	.330*	.291	-.283
	p		.896	.027	.053	.059
Pi	r	-.020	1	-.207	-.485**	.183
	p	.896		.172	.001	.230
W	r	.330*	-.207	1	.597**	-.109
	P	.027	.172		.000	.477
Yen	r	.291	-.485**	.597**	1	-.261
	P	.053	.001	.000		.083
ANB	r	-.283	.183	-.109	-.261	1
	p	.059	.230	.477	.083	

r = Correlation value; p = probability value

Table 12. Correlation test between beta, Pi, W, Yen and ANB in Class III

Groups	Values	Groups				
		beta	Pi	W	Yen	ANB
Beta	r	1	.036	.091	.094	-.511**
	p		.813	.553	.539	.000
Pi	r	.036	1	.137	-.067	.272
	p	.813		.368	.662	.071
W	r	.091	.137	1	.663**	-.132
	p	.553	.368		.000	.389
Yen	r	.094	-.067	.663**	1	-.272
	p	.539	.662	.000		.071
ANB	r	-.511**	.272	-.132	-.272	1
	p	.000	.071	.389	.071	

r = Correlation value;
p = probability value

Pearson's correlation analysis shows significant correlations among the anteroposterior parameters. [Tables 10-12] Among the class I groups significant correlation was observed between the Yen and W angle (r = 0.42). Whereas in the class II skeletal group, a statistically significant negative correlation between Yen and Pi angle (r = 0.485) and a positive correlation between Yen and W angle (r = 0.597) was observed. While among the class III skeletal group, a statistically significant positive correlation was found between the Yen and W angle (r = 0.663).

4. DISCUSSION

In the present study, 135 lateral cephalograms were traced and were grouped into different skeletal malocclusions. The sagittal relationship is critically evaluated among Orthodontists for proper diagnosis and treatment planning. Wylie [14] in 1947 first evaluated the anteroposterior relationship by measuring the linear distance between the perpendiculars dropped from the various landmarks to the FH plane. The major disadvantage was the linear measurement, which is more likely to be subjected to error than the angular measurement.

SN plane is commonly used and a relatively stable reference plane. But according to Bjork, he stated that the points Sella and Nasion may weaken the SN reference plane for estimation of facial changes. Similarly, the displacement in the point N may occur with growth thereby directly affecting the ANB angle [15]. To overcome the shortcomings of these reference planes, Baik et al. [4] introduced the Beta angle. This analysis did not make use of any cranial landmarks but was still subjected to error due to difficulty in locating the condylar axis.

To overcome the demerits of previous variables, analyses such as the Yen, W and the Pi angles have been introduced by Neela et al. [11] in 2009, Bhad et al. [12] in 2011 and Kumar et al. [13] in 2012 respectively. The M and G points were used to represent the maxilla and mandible respectively. These points are found to be least affected by the surrounding remodelling secondary to the dental movements.

In the present study, the Pi angle showed a significant difference in all malocclusion groups. These results were found to be following the previous study as reported by Kumar et al. [13]. Whereas according to the present study, W angle showed significant differences in all skeletal groups. The mean value of W angle recorded in the present study was at par with the values recorded in the previous study as reported by Bhad et al. [12].

In this study, Yen Angle showed a significant difference in all skeletal groups. This result was following the study conducted by Neela et al. [11]. While, the Beta angle showed a significant difference in all skeletal groups. The result recorded in the present study were found to be similar to the values recorded in the previous study as reported by Baik and Ververidou [4].

The post hoc reported significant differences for Pi, Yen, and Beta angle among the skeletal groups; except for W angle, which could not

significantly difference the class I and class III groups.

According to the present study, it indicated that the Pi angle is most predictable for differentiating class I and class II cases, while the Yen angle is more predictable for differentiating the class III cases. However, the Beta angle was reported to be least predictable in differentiating class III cases, whereas the W angle was reported to be least predictable in differentiating class I and class II cases.

5. CONCLUSION

In conclusion,

- Previously established analysis for accurately assessing the anteroposterior jaw discrepancy can often be considered to be misleading in orthodontic diagnosis.
- Pi angle was considered to be more reliable in differentiating the Class I and Class II case from the other cephalometric parameters. While in the case of class III skeletal pattern, the Yen angle was the most reliable. Overall the present study showed Pi angle had a significant correlation with Yen angle in Class III subjects.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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