RESEARCH PAPER

Comparative Assessment of Sagittal Discrepancy by Various Cephalometric Parameters in Skeletal Class I and Class II Malocclusion in the Bilaspur Population

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ABSTRACT

Background:
Accurate assessment of sagittal skeletal discrepancies is essential for orthodontic diagnosis and treatment planning. This study aimed to compare conventional and newer cephalometric parameters in skeletal Class I and Class II malocclusion among individuals from the Bilaspur population.

Materials and Methods:

This cross-sectional comparative study evaluated 120 pretreatment lateral cephalograms, equally divided into skeletal Class I (n=60) and Class II (n=60) groups. ANB angle, Wits appraisal, Yen angle, Pi angle, W angle, and Beta angle were measured. Statistical analysis included independent t-tests, Pearson's correlation, and receiver operating characteristic (ROC) curve analysis.

Results:
The mean ANB angle was 3.46 ± 1.36° in skeletal Class I and 6.85 ± 1.32° in skeletal Class II patients. Wits appraisal was higher in Class II (3.62 ± 1.73 mm) than Class I (0.85 ± 0.36 mm). Yen and W angles were higher in Class I patients. ROC analysis demonstrated an AUC of 0.973 for Yen angle, 0.826 for W angle, and 0.728 for Beta angle. Yen angle showed 90.2% sensitivity and 100% specificity in the reported analysis.

Conclusion:
Yen and W angles demonstrated promising discriminatory ability in assessing sagittal skeletal discrepancies and may serve as useful adjuncts to conventional cephalometric parameters. Combining multiple measurements may improve comprehensive orthodontic assessment.

Keywords: Sagittal skeletal discrepancy, Skeletal Class I malocclusion, Skeletal Class II malocclusion, ANB angle, Wits appraisal, Yen angle, Beta angle, Pi angle, W angle.

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INTRODUCTION

Accurate assessment of sagittal jaw discrepancies is essential for orthodontic diagnosis, treatment planning, and evaluation of skeletal relationships. Skeletal Class I and Class II malocclusions exhibit variations in the anteroposterior relationship between the maxilla and mandible, requiring reliable cephalometric parameters for accurate differentiation. The ANB angle, introduced by Riedel, remains one of the most commonly used measurements for evaluating sagittal skeletal relationships [1]. However, its reliability may be influenced by cranial base length, nasion position, and jaw rotation.

Jacobson introduced the Wits appraisal as an alternative linear measurement of sagittal jaw discrepancy, although its accuracy depends on the inclination and identification of the functional occlusal plane [2]. To overcome these limitations, Baik and Ververidou introduced the Beta angle, which utilizes skeletal landmarks independent of the cranial base and occlusal plane [3]. Subsequently, Neela et al. proposed the Yen angle using stable skeletal landmarks, including sella (S), midpoint of the premaxilla (M), and center of the mandibular symphysis (G), to assess sagittal dysplasia [4].

Bhad et al. introduced the W angle as another reliable parameter for evaluating anteroposterior skeletal discrepancies, particularly in patients with altered jaw relationships [5]. Similarly, Kumar et al. proposed the Pi analysis for assessing sagittal skeletal relationships using alternative skeletal reference points [6]. Bishara et al. demonstrated that ANB angle and Wits appraisal may change with craniofacial growth, highlighting the importance of considering multiple parameters during orthodontic assessment [7]. Oktay further emphasized variations among conventional cephalometric measurements and the need for comprehensive sagittal skeletal evaluation [8].

Although several cephalometric parameters are available, their diagnostic reliability may vary across populations because of differences in craniofacial morphology. Therefore, the present study aimed to compare ANB angle, Wits appraisal, Beta angle, Yen angle, Pi angle, and W angle in skeletal Class I and Class II malocclusion among individuals from the Bilaspur population and evaluate their usefulness in assessing sagittal jaw discrepancies.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional comparative study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Triveni Institute of Dental Sciences, Hospital and Research Centre, Bodri, Bilaspur, Chhattisgarh. The study involved the assessment of pretreatment lateral cephalograms of patients seeking fixed orthodontic treatment.

Sample Size and Study Population

A total of **120 pretreatment lateral cephalograms** of patients aged 16–35 years were selected according to the eligibility criteria. The participants were divided into two equal groups based on ANB angle and Wits appraisal:

- **Group I:** Skeletal Class I malocclusion (n=60).
- **Group II:** Skeletal Class II malocclusion (n=60).

Each group comprised 30 male and 30 female patients.

Inclusion Criteria

1. Patients aged 16–35 years.
2. Availability of good-quality pretreatment lateral cephalograms.
3. Skeletal Class I patients with ANB angle of 2°–4°, Wits appraisal approximately −1 mm in males and 0 mm in females, and Angle's Class I molar relationship.
4. Skeletal Class II patients with ANB angle >4°, increased Wits appraisal, and Angle's Class II molar relationship.

Exclusion Criteria

1. Poor-quality or distorted lateral cephalograms.
2. Previous orthodontic treatment.
3. History of temporomandibular joint trauma.
4. End-on molar relationship.
5. Missing permanent canines or molars.
6. Skeletal Class III malocclusion.

Materials Used

Good-quality pretreatment lateral cephalograms, 0.003-inch matte acetate tracing sheets, 0.3-mm tracing pencils, a geometric protractor, ruler, and illuminated view box were used for cephalometric tracing and measurements.

Cephalometric Assessment

All lateral cephalograms were manually traced under standardized conditions. The anatomical landmarks identified included nasion (N), sella (S), Point A, Point B, center of the mandibular condyle (C), midpoint of the premaxilla (M), and center of the mandibular symphysis (G).

The following six parameters were evaluated:

Cephalometric Parameter	Reference Landmarks	Measurement
ANB angle	Points A, N, and B	Angular difference between SNA and SNB
Wits appraisal	Points A and B projected onto the functional occlusal plane	Linear distance between AO and BO
Beta angle	Points A, B, and C	Angular assessment of sagittal jaw relationship
Yen angle	Points S, M, and G	Angle between SM and MG
Pi angle	Points G, G′, and M	Angle formed by GG′ and G′M
W angle	Points S, M, and G	Angle between MG and a perpendicular from M to SG

All six measurements were recorded for both skeletal groups. The values were compared to determine their ability to differentiate skeletal Class I and Class II malocclusion.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using **SPSS version 24.0**. Continuous variables were expressed as mean ± standard deviation. The independent Student's t-test was used to compare cephalometric measurements between skeletal Class I and Class II groups. Pearson's correlation coefficient was calculated to determine associations among different cephalometric parameters. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminatory ability, sensitivity, specificity, and optimal cutoff values of the newer cephalometric parameters. A **p-value <0.05** was considered statistically significant.

Ethical Considerations

The study was conducted following approval from the Institutional Ethics Committee. Patient confidentiality was maintained throughout the study, and all radiographs were used exclusively for research purposes.

RESULTS

A total of **120 pretreatment lateral cephalograms** were evaluated to compare sagittal skeletal discrepancies using six cephalometric parameters: ANB angle, Wits appraisal, Yen angle, Pi angle, W angle, and Beta angle. The participants were equally divided into skeletal Class I (n=60) and skeletal Class II (n=60) groups. The mean values of ANB angle, Wits appraisal, and Pi angle were higher in skeletal Class II patients, whereas Yen and W angles were higher in skeletal Class I patients. Statistically significant differences were reported for all six parameters. Correlation analysis demonstrated variable relationships among the cephalometric measurements, while ROC analysis indicated high discriminatory performance for the Yen and W angles.

Table 1. Comparative Evaluation of Cephalometric Parameters in Skeletal Class I and Class II Malocclusion

Cephalometric Parameters	Skeletal Class I (n=60), Mean ± SD	Skeletal Class II (n=60), Mean ± SD	t-value	p-value
ANB angle (°)	3.46 ± 1.36	6.85 ± 1.32	13.819	**0.001**
Wits appraisal (mm)	0.85 ± 0.36	3.62 ± 1.73	8.272	**0.001**
Yen angle (°)	119.49 ± 1.56	115.42 ± 0.77	18.559	**0.001**
Pi angle (°)	3.96 ± 0.85	5.79 ± 4.77	3.195	**0.002**
W angle (°)	52.33 ± 2.11	48.54 ± 1.41	11.292	**0.001**
Beta angle (°)	27.92 ± 0.92	27.65 ± 5.23	2.048	**0.039**

The mean ANB angle and Wits appraisal were higher in skeletal Class II patients (6.85 ± 1.32° and 3.62 ± 1.73 mm) than in skeletal Class I patients (3.46 ± 1.36° and 0.85 ± 0.36 mm). Yen and W angles were higher in Class I patients, whereas the Pi angle was higher in Class II patients. The Beta angle showed only a small difference between groups. The source reported statistically significant differences for all parameters.

Table 2. Correlation of ANB Angle and Wits Appraisal With Other Cephalometric Parameters in Skeletal Class I Malocclusion (n=60)

Cephalometric Parameters	ANB Angle (r)	p-value	Wits Appraisal (r)	p-value
ANB angle	—	—	0.274	**0.033**
Wits appraisal	0.274	**0.033**	—	—
Yen angle	-0.392	**0.002**	0.255	**0.048**
Pi angle	-0.032	0.806	-0.242	0.060
W angle	0.693	**0.001**	-0.001	0.991
Beta angle	0.634	**0.001**	0.305	**0.017**

Among skeletal Class I patients, ANB angle demonstrated significant positive correlations with W angle (r=0.693), Beta angle (r=0.634), and Wits appraisal (r=0.274). A significant negative correlation was observed between ANB and Yen angle (r=-0.392). Wits appraisal showed significant positive correlations with Yen and Beta angles, whereas its correlations with Pi and W angles were not statistically significant.

Table 3. Correlation of ANB Angle and Wits Appraisal With Other Cephalometric Parameters in Skeletal Class II Malocclusion (n=60)

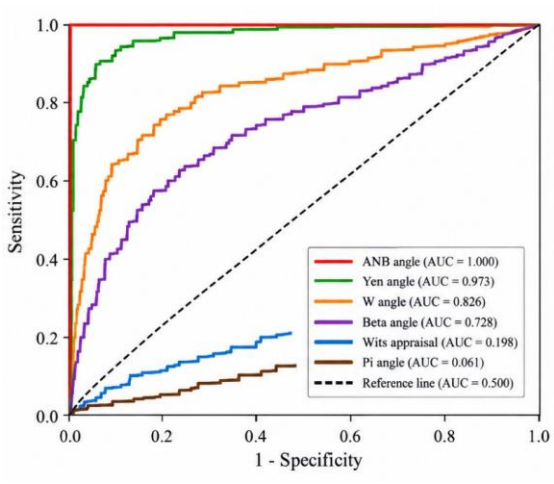
Cephalometric Parameters	ANB Angle (r)	p-value	Wits Appraisal (r)	p-value
ANB angle	—	—	0.791	**0.001**
Wits appraisal	0.791	**0.001**	—	—
Yen angle	-0.130	0.327	0.267	**0.041**
Pi angle	-0.020	0.880	0.098	0.462
W angle	-0.567	**0.001**	-0.273	**0.036**
Beta angle	-0.318	**0.014**	-0.411	**0.001**

In skeletal Class II patients, ANB angle showed a strong positive correlation with Wits appraisal (r=0.791, p=0.001). Significant negative correlations were observed between ANB and W angle (r=-0.567) and Beta angle (r=-0.318). Wits appraisal demonstrated a weak positive correlation with Yen angle (r=0.267) and negative correlations with W angle (r=-0.273) and Beta angle (r=-0.411). No significant correlations were observed between ANB and Yen or Pi angles.

Table 4. Diagnostic Performance of Cephalometric Parameters Using Receiver Operating Characteristic (ROC) Curve Analysis

Cephalometric Parameters	AUC	Sensitivity (%)	Specificity (%)	p-value
ANB angle	**1.000**	**100.0**	**100.0**	<0.0001
Wits appraisal	0.198	55.7	16.9	<0.0001
Yen angle	**0.973**	**90.2**	**100.0**	<0.0001
Pi angle	0.061	9.8	18.6	<0.0001
W angle	0.826	82.0	66.1	<0.0001
Beta angle	0.728	73.8	64.4	<0.0001

ROC analysis reported the highest AUC for ANB angle (1.000), followed by Yen angle (0.973), W angle (0.826), and Beta angle (0.728). Yen angle demonstrated high sensitivity (90.2%) and specificity (100.0%), suggesting strong discrimination between the predefined skeletal groups. W and Beta angles showed moderate discriminatory performance. Wits appraisal and Pi angle had low reported AUC values, which require consideration of the ROC direction and coding.



Graph. ANB angle showed the highest AUC (1.000), followed by Yen angle (0.973), W angle (0.826), and Beta angle (0.728). Yen angle demonstrated high sensitivity (90.2%) and specificity (100%), indicating strong discriminatory ability between skeletal Class I and Class II malocclusion. Wits appraisal and Pi angle showed low reported AUC values, requiring verification of ROC coding and direction.

DISCUSSION

The present study compared six cephalometric parameters—ANB angle, Wits appraisal, Yen angle, Pi angle, W angle, and Beta angle—for assessing sagittal skeletal discrepancies among 120 individuals with skeletal Class I and Class II malocclusion in the Bilaspur population. The findings demonstrated differences between the two skeletal groups, with the Yen and W angles showing promising discriminatory ability. These observations support the importance of using multiple cephalometric parameters for accurate orthodontic diagnosis and treatment planning.

The mean ANB angle was higher in skeletal Class II patients (6.85 ± 1.32°) than in skeletal Class I patients (3.46 ± 1.36°). Similarly, Wits appraisal increased from 0.85 ± 0.36 mm in Class I to 3.62 ± 1.73 mm in Class II. These findings are consistent with the observations of Nanda and Merrill [9], who emphasized the importance of assessing maxillomandibular sagittal relationships using appropriate skeletal reference planes. Hurmerinta et al. [10] also highlighted variations among cephalometric classification methods, suggesting that reliance on a single measurement may not adequately represent sagittal jaw relationships.

The present study demonstrated that the ANB angle was strongly correlated with Wits appraisal in skeletal Class II patients (r=0.791, p=0.001), whereas a weaker correlation was observed in skeletal Class I patients (r=0.274, p=0.033). These findings support the observations of Fida [11], who compared ANB angle and Wits appraisal for assessing anteroposterior jaw relationships. Al-Hammadi [12] also emphasized the importance of alternative cephalometric approaches for overcoming limitations associated with conventional sagittal measurements.

The Yen angle demonstrated higher mean values in skeletal Class I patients (119.49 ± 1.56°) than in skeletal Class II patients (115.42 ± 0.77°). ROC analysis showed an AUC of 0.973, with 90.2% sensitivity and 100% specificity. Bhardwaj et al. [13] highlighted the usefulness of alternative angular measurements for evaluating sagittal skeletal discrepancies. Similarly, Bohra et al. [14] compared Pi angle with ANB, W, Yen, and Beta angles and emphasized the diagnostic relevance of newer cephalometric parameters.

The W angle was also higher in skeletal Class I patients (52.33 ± 2.11°) than in skeletal Class II patients (48.54 ± 1.41°), with an AUC of 0.826. Kapadia et al. [15] reported that Yen and W angles could serve as useful adjuncts to conventional cephalometric measurements. Chandak et al. [16] similarly evaluated the reliability of Wits appraisal, Beta angle, and Yen angle in assessing sagittal jaw relationships, supporting the clinical applicability of newer cephalometric indicators.

The Beta angle showed relatively similar mean values in skeletal Class I (27.92 ± 0.92°) and Class II (27.65 ± 5.23°) patients, with an AUC of 0.728. Ahmed et al. [17] investigated the diagnostic validity of different cephalometric analyses and emphasized that individual measurements may demonstrate varying diagnostic performance. Dubey et al. [18] also compared sagittal discrepancy parameters among skeletal Class I and Class II patients, highlighting the importance of population-specific cephalometric assessment.

The present findings demonstrated significant correlations among several cephalometric measurements, particularly ANB, Wits appraisal, Yen angle, and W angle. Mehta et al. [19] evaluated Beta, Yen, and W angles in a North Indian population and supported their usefulness in assessing anteroposterior jaw relationships. Similarly, few studies emphasize the importance of comparing multiple sagittal skeletal indicators for comprehensive orthodontic evaluation. [20,21]

Overall, the findings suggest that the Yen and W angles may serve as useful supplementary parameters for differentiating skeletal Class I and Class II malocclusion. However, because ANB angle and Wits appraisal were used for initial group classification, the reported diagnostic performance should be interpreted cautiously. A combination of conventional and newer cephalometric measurements may provide a more comprehensive assessment of sagittal jaw relationships.

CONCLUSION

The present study demonstrated differences in cephalometric measurements between skeletal Class I and Class II malocclusion among individuals from the Bilaspur population. ANB angle and Wits appraisal showed higher values in skeletal Class II patients, whereas Yen and W angles were higher in skeletal Class I patients. Among the newer parameters, **Yen angle demonstrated the highest reported discriminatory ability (AUC=0.973)**, followed by W angle (AUC=0.826) and Beta angle (AUC=0.728). The findings suggest that Yen and W angles may be useful adjuncts to conventional cephalometric parameters for evaluating sagittal jaw discrepancies. However, no single parameter should be used independently for orthodontic diagnosis. A combined cephalometric approach is recommended for comprehensive assessment and treatment planning.

References

1. Riedel RA. The relation of maxillary structures to cranium in malocclusion and in normal occlusion. Angle Orthod. 1952;22(3):142-145.
2. Jacobson A. The "Wits" appraisal of jaw disharmony. Am J Orthod. 1975;67(2):125-138. doi: **10.1016/0002-9416(75)90065-2**.
3. Baik CY, Ververidou M. A new approach of assessing sagittal discrepancies: the Beta angle. Am J Orthod Dentofacial Orthop. 2004;126(1):100-105. doi: **10.1016/j.ajodo.2003.08.026**.
4. Neela PK, Mascarenhas R, Husain A. A new sagittal dysplasia indicator: the YEN angle. World J Orthod. 2009;10(2):147-151.
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. doi: **10.1093/ejo/cjr001**.
6. Kumar S, Valiathan A, Gautam P, Chakravarthy K, Jayaswal P. An evaluation of the Pi analysis in the assessment of anteroposterior jaw relationship. J Orthod. 2012;39(4):262-269. doi: **10.1179/1465312512Z.00000000040**.
7. Bishara SE, Fahl JA, Peterson LC. Longitudinal changes in the ANB angle and Wits appraisal: clinical implications. Am J Orthod. 1983;84(2):133-139. doi: **10.1016/0002-9416(83)90177-X**.
8. Oktay H. A comparison of ANB, WITS, AF-BF, and APDI measurements. Am J Orthod Dentofacial Orthop. 1991;99(2):122-128. doi: **10.1016/0889-5406(91)70114-C**.
9. Nanda RS, Merrill RM. Cephalometric assessment of sagittal relationship between maxilla and mandible. Am J Orthod Dentofacial Orthop. 1994;105(4):328-344. doi: **10.1016/S0889-5406(94)70127-9**.
10. Hurmerinta K, Rahkamo A, Haavikko K. Comparison between cephalometric classification methods for sagittal jaw relationships. Eur J Oral Sci. 1997;105(3):221-227. doi: **10.1111/j.1600-0722.1997.tb00204.x**.
11. Fida M. Assessment of anteroposterior jaw relationship: a comparison of ANB angle

and Wits appraisal. J Coll Physicians Surg Pak. 2008;18(11):679-683.
12. Al-Hammadi MS. A new method for measuring sagittal jaw relationship. J Orthod Sci. 2011;1(1):9-15. **DOI requires verification.**
13. Bhardwaj P, Kapoor DN, Rani MS. Assessment of sagittal skeletal discrepancy: a cephalometric study. J Indian Orthod Soc. 2013;47(4 Suppl 1):262-265.
14. Bohra S, Udeshi PS, Sinha SP, Saidath K, Shetty KP, Nayak US. Predictability of Pi angle and its comparison with ANB angle, W angle, Yen angle and Beta angle in South Indian population. J Indian Orthod Soc. 2018;52:22-28.
15. Kapadia RM, Diyora SD, Shah RB, Modi BN. Comparative evaluation of YEN angle and W angle with ANB angle, Wits appraisal, and Beta angle for predicting sagittal jaw dysplasia: a cephalometric study. Int J Clin Dent Res. 2017;1:26-31.
16. Chandak M, et al. Comparison of Wits appraisal, Beta angle and Yen angle in assessing anteroposterior jaw relationship. J Contemp Res J Med Sci. 2018;1(1):64-71.
17. Ahmed M, Shaikh A, Fida M. Diagnostic validity of different cephalometric analyses for assessment of the sagittal skeletal pattern. Dental Press J Orthod. 2018;23(5):75-81. doi: **10.1590/2177-6709.23.5.075-081.oar**.
18. Dubey J, Kallury A, Balani RK, Bharti C, Dubey C, Jholi D. Comparative assessment of sagittal jaw discrepancies by various cephalometric parameters in skeletal Class I and Class II malocclusion among Bhopal population: a cephalometric study. J Contemp Orthod. 2020;4(2):25-32.
19. Mehta PH, Bansal N, Singh G, et al. Evaluation of Beta, Yen, and W angle in assessment of anteroposterior jaw relationship in North Indian population: a cephalometric study. J Mahatma Gandhi Univ Med Sci Tech. 2021;6(2):60-63.
20. Jaiswal A, Gupta M, Kanungo H, Mishra K. Comparative analysis and correlation of anteroposterior jaw dysplasia indicators in Angle's Class I molar relation and normal overjet subjects of Central India: a pilot study. IP Indian J Orthod Dentofacial Res. 2023;9(1):46-52.
21. Kumari P, Jain AK, Sahu A, Prasad RR, Singh S, Roy S. Predictability of Wits appraisal, ANB, Beta, Yen, W, µ and Pi angle as indicators of anteroposterior dysplasia in Jharkhand population [Internet]. J Contemp Orthod. 2023 [cited 2026 Oct 14];7(2):79-89. Available from: https://doi.org/10.18231/j.jco.2023.015