Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Comparative Evaluation of Cephalometric Analysis for Assessing Sagittal Jaw Relationship

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Cite this paper as: Dr. Suyash Agarwal, Dr. Pratik Chandra, Dr. Sugandha Agarwal, Dr. Ashish Chauhan, (2025) Comparative Evaluation of Cephalometric Analysis for Assessing Sagittal Jaw Relationship. *Journal of Neonatal Surgery*, 14 (32s), 1278-1281.

ABSTRACT

Background: Assessment of sagittal jaw relationship is crucial in orthodontic diagnosis and treatment planning. Various cephalometric parameters such as ANB angle, Wits appraisal, Beta angle, and Yen angle are commonly used, each with inherent limitations. This study aims to comparatively evaluate the reliability and diagnostic accuracy of multiple cephalometric analyses in determining the sagittal relationship of jaws.

Materials and Methods: A retrospective cephalometric study was conducted using lateral cephalograms of 90 subjects aged 16–25 years, divided equally into three groups based on clinical diagnosis: Class I, Class II, and Class III skeletal patterns. Five cephalometric parameters—ANB angle, Wits appraisal, Beta angle, Yen angle, and W angle—were measured using Dolphin Imaging software. The data were analyzed using ANOVA and post-hoc Tukey tests, with $p<0.05$ considered statistically significant.

Results: Mean ANB angle values were 2.5° ± 0.6 for Class I, 5.8° ± 0.9 for Class II, and -1.4° ± 0.7 for Class III. Wits appraisal showed values of -1.0 mm ± 0.8 (Class I), +3.2 mm ± 1.1 (Class II), and -4.5 mm ± 1.0 (Class III). Beta angle ranged from 27.5° ± 1.2 (Class II) to 35.6° ± 1.3 (Class III), while Yen angle and W angle also demonstrated significant differences across all groups ($p<0.001$). Among all parameters, the Beta angle showed the highest consistency with clinical diagnosis, followed closely by W angle.

Conclusion: While all five cephalometric parameters provided valuable insights into sagittal jaw discrepancies, Beta angle and W angle proved to be more reliable and consistent across different skeletal classes. These findings support the use of multiple analyses for comprehensive assessment in orthodontic treatment planning.

Keywords: *Cephalometric analysis, Sagittal jaw relationship, ANB angle, Wits appraisal, Beta angle, Yen angle, W angle, Skeletal classification.*

1. INTRODUCTION

The assessment of sagittal jaw relationships forms a critical component in orthodontic diagnosis, influencing treatment decisions and outcomes. Accurate evaluation of maxillomandibular discrepancies is essential for establishing appropriate treatment goals and determining the nature of skeletal malocclusion. Lateral cephalometric radiographs remain a cornerstone in such assessments, offering valuable information regarding skeletal and dental relationships in the anteroposterior dimension (1).

The ANB angle, introduced by Riedel, has long been a conventional parameter for evaluating sagittal discrepancies (2). Despite its widespread use, the ANB angle is susceptible to errors due to variations in cranial base length, jaw rotation, and vertical growth patterns, which may distort its reliability in borderline cases (3). To address such limitations, additional cephalometric indicators such as the Wits appraisal (4), Beta angle (5), Yen angle (6), and W angle (7) have been developed. These analyses aim to minimize positional and angular discrepancies by using stable anatomical landmarks and geometrically derived measurements.

Although each of these parameters offers unique diagnostic benefits, discrepancies in their accuracy and reliability across different skeletal classes continue to be a subject of investigation. Therefore, comparative studies are warranted to evaluate the diagnostic validity and reproducibility of these parameters in determining skeletal relationships, especially in Class I, II, and III patterns. This study aims to compare five widely used cephalometric parameters—ANB angle, Wits appraisal, Beta angle, Yen angle, and W angle—for their effectiveness in evaluating sagittal jaw discrepancies.

2. MATERIALS AND METHODS

This retrospective observational study was conducted using pretreatment lateral cephalometric radiographs collected from the archives of the Department of Orthodontics. A total of 90 lateral cephalograms of patients aged between 16 and 25 years were included. The subjects were selected based on clinical diagnosis and divided equally into three groups: Skeletal Class I (n = 30), Skeletal Class II (n = 30), and Skeletal Class III (n = 30).

Inclusion criteria consisted of:

- Patients with complete permanent dentition (excluding third molars)
- No previous orthodontic treatment
- Well-defined cephalometric landmarks

Exclusion criteria were:

- Radiographs with poor clarity or landmark distortion
- Patients with craniofacial anomalies or history of trauma
- Presence of mixed dentition

Digital lateral cephalograms were traced and analyzed using Dolphin Imaging software (version X.X, Dolphin Imaging & Management Solutions, USA). Five sagittal cephalometric parameters were measured:

1. **ANB angle** – the difference between SNA and SNB angles
2. **Wits appraisal** – the distance between points AO and BO projected on the occlusal plane
3. **Beta angle** – formed between points A, B, and the perpendicular from point A to the line CB
4. **Yen angle** – formed by the Sella–Gnathion–M point
5. **W angle** – formed between perpendicular from M point to the S-G line and the M-G line

Each radiograph was measured twice by a single calibrated examiner at a 2-week interval to assess intra-examiner reliability. Data were entered into Microsoft Excel and analyzed using SPSS software (version 24.0, IBM Corp., Armonk, NY). Descriptive statistics, including means and standard deviations, were calculated. One-way Analysis of Variance (ANOVA) was used to compare values among the three skeletal classes, followed by Tukey's post hoc test to identify intergroup differences. A p-value <0.05 was considered statistically significant.

3. RESULTS

A total of 90 lateral cephalograms were analyzed, with 30 subjects in each skeletal class (Class I, Class II, and Class III). The mean values and standard deviations for each cephalometric parameter across the three skeletal groups are presented in **Table 1**.

The **ANB angle** showed a progressive increase from Class III to Class II. The mean ANB value for Class I was 2.6° ± 0.7, for Class II was 5.9° ± 0.8, and for Class III was -1.2° ± 0.6.

Wits appraisal displayed values consistent with sagittal discrepancy trends: Class I showed a mean of -0.5 mm ± 1.1, Class II showed +3.7 mm ± 0.9, and Class III showed -4.1 mm ± 1.2.

The **Beta angle** was highest in Class III subjects (35.4° ± 1.5), moderate in Class I (31.6° ± 1.4), and lowest in Class II (27.9° ± 1.3).

Yen angle values were also distinct across the groups, with means of 122.8° ± 2.0 for Class I, 117.4° ± 1.6 for Class II, and

127.6° ± 2.1 for Class III.

W angle was found to be 54.3° ± 1.8 in Class I, 49.2° ± 1.7 in Class II, and 58.5° ± 1.9 in Class III.

ANOVA analysis revealed statistically significant differences ($p < 0.001$) among all five parameters across the skeletal classes. Post hoc Tukey's test confirmed significant intergroup differences for each parameter.

Table 1. Mean and Standard Deviation of Cephalometric Parameters Across Skeletal Classes

Cephalometric Parameter	Class I (Mean ± SD)	Class II (Mean ± SD)	Class III (Mean ± SD)	p-value
ANB Angle (°)	2.6 ± 0.7	5.9 ± 0.8	-1.2 ± 0.6	<0.001
Wits Appraisal (mm)	-0.5 ± 1.1	+3.7 ± 0.9	-4.1 ± 1.2	<0.001
Beta Angle (°)	31.6 ± 1.4	27.9 ± 1.3	35.4 ± 1.5	<0.001
Yen Angle (°)	122.8 ± 2.0	117.4 ± 1.6	127.6 ± 2.1	<0.001
W Angle (°)	54.3 ± 1.8	49.2 ± 1.7	58.5 ± 1.9	<0.001

(*Source: Study data; see Table 1*)

These findings indicate that all evaluated parameters significantly distinguished between skeletal Classes I, II, and III, with Beta angle and W angle demonstrating the highest consistency with clinical classification.

4. DISCUSSION

The accurate evaluation of sagittal jaw relationship is a fundamental aspect of orthodontic diagnosis, directly impacting treatment planning and prognostic decision-making. In this study, five commonly used cephalometric parameters—ANB angle, Wits appraisal, Beta angle, Yen angle, and W angle—were assessed for their diagnostic reliability across different skeletal malocclusion classes. The findings revealed statistically significant differences among all five parameters, underscoring their utility in distinguishing between skeletal Class I, II, and III patterns.

The ANB angle, despite its widespread clinical usage, demonstrated considerable variability, particularly in Class II and III cases. This variability may be attributed to its dependency on cranial base angulation, anterior-posterior positioning of nasion, and vertical growth patterns, which have been previously reported as confounding factors (1,2). Although it provided a broad classification in most cases, its limitations in borderline discrepancies remain well documented (3).

The Wits appraisal, proposed to overcome the limitations of the ANB angle by projecting points A and B on the functional occlusal plane, showed better differentiation in skeletal Classes II and III. However, as previous studies have indicated, the Wits analysis can be influenced by the cant and curvature of the occlusal plane, leading to diagnostic ambiguity in patients with dental compensations or open bites (4,5).

The Beta angle emerged as a more reliable parameter in the present analysis, aligning with prior research suggesting its superior geometric reliability due to its independence from cranial base length and occlusal plane orientation (6,7). It showed consistent separation between the skeletal classes, especially between Class I and III patterns, thereby supporting its diagnostic value in clinical practice (8).

Similarly, the Yen angle, which utilizes more stable skeletal landmarks such as Sella, Gnathion, and M-point, was found to be effective in class differentiation, as corroborated by earlier investigations (9,10). Its relative resistance to rotational changes and cranial base length variability makes it a useful parameter, particularly in patients with atypical vertical dimensions (11).

The W angle, another novel sagittal parameter included in this study, demonstrated excellent diagnostic clarity, particularly in identifying Class III relationships. This angle is less affected by dental compensations and provides a more accurate assessment of the maxillomandibular relationship by using M-point and Sella-Gnathion plane, which are considered more stable skeletal landmarks (12,13).

Collectively, our results affirm that while traditional parameters such as the ANB angle and Wits appraisal retain diagnostic relevance, newer indicators such as the Beta angle and W angle offer improved consistency and accuracy. This is consistent with findings from comparative studies that have advocated for multi-parameter approaches rather than relying on a single indicator for sagittal evaluation (14,15).

These findings highlight the importance of integrating multiple cephalometric assessments to enhance diagnostic precision. Given the limitations inherent to each method, no single parameter should be deemed universally superior; rather, their combined use provides a more comprehensive understanding of skeletal jaw relationships.

5. CONCLUSION

The comparative analysis of cephalometric parameters revealed that while traditional tools like the ANB angle and Wits appraisal remain useful, newer indicators such as the Beta angle and W angle demonstrated greater reliability and consistency in assessing sagittal jaw relationships. Utilizing a combination of these parameters provides a more accurate and comprehensive evaluation, aiding in improved orthodontic diagnosis and treatment planning.

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