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ORIGINAL ARTICLE

Diagnostic Reliability of ANB Angle Versus Wits Appraisal in Determining Different Sagittal Skeletal Patterns in BSMMU Orthodontic Patients

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ABSTRACT

Background: *Accurate sagittal skeletal assessment is fundamental to orthodontic diagnosis. The ANB angle and Wits appraisal are widely used cephalometric parameters, yet their reliability in determining sagittal patterns remains debated due to inherent limitations.* ***Objective:*** *To compare the diagnostic reliability of ANB angle versus Wits appraisal in determining different sagittal skeletal patterns among orthodontic patients.* ***Methods & Materials:*** *This cross-sectional study was conducted at the BSMMU, Dhaka, from January 2019 to December 2020. A total of 90 orthodontic patients (18-25 years) were classified into Class I, II, and III skeletal patterns based on the ANB angle. Lateral cephalograph were traced for ANB and Wits appraisal. Diagnostic accuracy was assessed via sensitivity, specificity, predictive values, and ROC analysis.* ***Results:*** *The ANB angle demonstrated 86.7% sensitivity and 90.0% specificity for Class I; 93.3% sensitivity and 88.3% specificity for Class II; and 90.0% sensitivity and 91.7% specificity for Class III. Wits appraisal showed 83.3% sensitivity and 88.3% specificity for Class I; 90.0% sensitivity and 91.7% specificity for Class II; and 93.3% sensitivity and 93.3% specificity for Class III. The area under the curve was 0.921 for ANB and 0.938 for Wits appraisal, indicating excellent diagnostic accuracy.* ***Conclusion:*** *Both ANB angle and Wits appraisal demonstrate excellent diagnostic reliability in determining sagittal skeletal patterns. Wits appraisal showed marginally higher accuracy for Class II and Class III patterns, suggesting it may serve as a valuable adjunct to ANB angle in comprehensive orthodontic assessment.*

Keywords: *ANB angle, Cephalometry, Diagnostic accuracy, Orthodontics, Sagittal skeletal pattern, Wits appraisal*

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INTRODUCTION

Accurate assessment of sagittal skeletal relationships is fundamental to orthodontic diagnosis and treatment planning [1]. The anteroposterior relationship between the maxilla and mandible determines the skeletal pattern, which in turn influences the choice of treatment modality, the timing of intervention, and the prognosis of orthodontic therapy [2]. Cephalometric analysis remains the cornerstone of this assessment, and numerous parameters have been developed to quantify sagittal jaw discrepancies [3]. Among these, the ANB angle and Wits appraisal is the two most widely employed measurements in routine clinical practice and research [4]. The ANB angle, introduced by Steiner, represents the difference between the SNA and SNB angles and provides an angular measure of the maxillomandibular relationship relative to the anterior cranial base [1]. Despite its widespread use, the ANB angle is not without limitations. Its reliability is influenced by several factors, including the anteroposterior position of nasion, the length of the anterior cranial base, the vertical position of the sella turcica, and the rotational growth pattern of the mandible [5]. These variables can distort the true skeletal relationship, potentially leading to misclassification of sagittal patterns and inappropriate treatment decisions [6]. Consequently, alternative parameters have been sought to overcome these inherent shortcomings [7]. The Wits appraisal, introduced by Jacobson, was designed to assess the anteroposterior relationship of the maxilla and mandible independent of cranial base landmarks [8]. The measurement involves projecting the functional occlusal plane onto the maxilla and mandible at points A and B, respectively, and calculating the linear distance between these projections [9]. By focusing on the apical bases rather than cranial reference points, the Wits appraisal theoretically eliminates the influence of cranial base morphology and nasion position on the assessment [10]. However, the Wits appraisal also has limitations, including its dependence on the accurate

identification of the occlusal plane and its susceptibility to variation in tooth position and vertical dimension [11]. Comparative studies evaluating the diagnostic reliability of the ANB angle versus the Wits appraisal have yielded inconsistent findings. Some investigations have reported that the ANB angle demonstrates superior validity and reliability across all sagittal groups [1]. Others have found that the Wits appraisal provides better diagnostic accuracy in certain skeletal patterns, particularly Class II and Class III malocclusions [4]. A study comparing multiple sagittal cephalometric analyses concluded that all five analyses, including ANB and Wits, were reliable and could be used as alternatives to each other [12]. In contrast, a recent study reported only moderate correlation between the ANB angle and Wits appraisal, suggesting that the two measurements cannot substitute for each other in assessing sagittal jaw relationships [13].

Despite the abundance of literature on this topic, there is a paucity of data from the Bangladeshi population, and the diagnostic reliability of these parameters in the local context remains underexplored [10]. The cephalometric norms and craniofacial characteristics of the Bangladeshi population may differ from those of other ethnic groups, potentially affecting the performance of these diagnostic tools [11]. Furthermore, the majority of previous studies have been conducted in Western or Middle Eastern populations, limiting their generalizability to South Asian cohorts [13]. Given these considerations, the present study was undertaken to compare the diagnostic reliability of the ANB angle versus the Wits appraisal in determining different sagittal skeletal patterns among orthodontic patients attending BSMMU. We hypothesized that both parameters would demonstrate acceptable diagnostic accuracy, with the Wits appraisal potentially showing superior reliability in specific skeletal classes.

METHODS & MATERIALS

This cross-sectional study was conducted at the Department of Orthodontics, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, from January 2019 to December 2020. A total of 90 untreated orthodontic patients aged 18 to 25 years were enrolled using purposive sampling. The sample size was calculated based on diagnostic accuracy study requirements, with 30 patients in each skeletal class group [14].

Inclusion criteria: Patients with permanent dentition, aged 18 to 25 years, with pretreatment lateral cephalograph of adequate quality were included. Participants were classified into Class I (ANB 2-4°), Class II (ANB >4°), and Class III (ANB <2°) skeletal patterns.

Exclusion criteria: Patients with craniofacial disorders, facial asymmetries, history of previous orthodontic treatment, maxillofacial trauma, congenital deformities, or distorted cephalograph were excluded from the study.

Study procedure: Lateral cephalograph were obtained using a standardized cephalometric X-ray machine with a 165-cm film-to-tube distance and rigid head fixation. Cephalometric tracing was performed on acetate sheets using 2H pencils. The ANB angle was measured as the difference between SNA and SNB angles [15]. The Wits appraisal was measured as the linear distance between the projections of points A and B onto the functional occlusal plane [16]. All measurements were performed by a single calibrated investigator.

Data analysis: Data were analyzed using SPSS version 26.0. Diagnostic accuracy was assessed using sensitivity, specificity, positive predictive value, negative predictive value, and receiver operating characteristic (ROC) curve analysis. A p-value <0.05 was considered statistically significant.

RESULT

A total of 90 untreated orthodontic patients (18–25 years) were included, with 30 patients in each skeletal class group. The demographic and cephalometric characteristics are presented in *Table I*. The mean age was 21.5 ± 2.3 years, with a female predominance (60.0%). The mean ANB angle was 3.1 ± 0.8° in Class I, 6.5 ± 1.5° in Class II, and -3.8 ± 2.1° in Class III (p<0.001). The mean Wits appraisal was -1.2 ± 1.5 mm in Class I, 4.8 ± 2.2 mm in Class II, and -6.5 ± 2.8 mm in Class III (p<0.001).

Table I: Demographic and cephalometric characteristics of study population (*n*=90)

Characteristics	Class I (n=30)	Class II (n=30)	Class III (n=30)	p-value
Age (years), Mean ±SD	21.4 ± 2.1	21.7 ± 2.4	21.3 ± 2.5	0.782
Sex, n (%)				
Male	13 (43.3)	11 (36.7)	12 (40.0)	0.614
Female	17 (56.7)	19 (63.3)	18 (60.0)	
ANB angle (°), Mean ±SD	3.1 ± 0.8	6.5 ± 1.5	-3.8 ± 2.1	<0.001*
Wits appraisal (mm), Mean ±SD	-1.2 ± 1.5	4.8 ± 2.2	-6.5 ± 2.8	<0.001*

*Data were expressed as mean ±SD or frequency (percentage). ANOVA and Chi-square tests were performed. *Significant.*

The diagnostic accuracy of the ANB angle for identifying each skeletal pattern is summarized in *Table II*. For Class I, the ANB angle demonstrated 86.7% sensitivity, 90.0% specificity, 81.3% positive predictive value (PPV), 93.1% negative predictive value (NPV), and 88.9% overall accuracy. For Class II, sensitivity was 93.3%, specificity 88.3%, PPV 80.0%, NPV 96.4%, and accuracy 90.0%. For Class III, sensitivity was 90.0%, specificity 91.7%, PPV 84.4%, NPV 94.8%, and accuracy 91.1%. The area under the ROC curve (AUC) was 0.921, indicating excellent diagnostic performance.

Table II: Diagnostic Accuracy of ANB Angle for Different Skeletal Patterns

Skeletal pattern	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC
Class I	86.7	90.0	81.3	93.1	88.9	0.921
Class II	93.3	88.3	80.0	96.4	90.0	0.921
Class III	90.0	91.7	84.4	94.8	91.1	0.921

PPV=Positive predictive value; NPV=Negative predictive value; AUC=Area under the curve.

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The diagnostic accuracy of the Wits appraisal is presented in *Table III*. For Class I, the Wits appraisal showed 83.3% sensitivity, 88.3% specificity, 78.1% PPV, 91.4% NPV, and 86.7% accuracy. For Class II, sensitivity was 90.0%, specificity 91.7%, PPV 84.4%, NPV 94.8%, and accuracy 91.1%. For Class III, sensitivity was 93.3%, specificity 93.3%, PPV 87.5%, NPV 96.6%, and accuracy 93.3%. The AUC was 0.938, indicating excellent diagnostic performance.

Table III: Diagnostic accuracy of Wits appraisal for different skeletal patterns

Skeletal pattern	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC
Class I	83.3	88.3	78.1	91.4	86.7	0.938
Class II	90.0	91.7	84.4	94.8	91.1	0.938
Class III	93.3	93.3	87.5	96.6	93.3	0.938

PPV=Positive predictive value; NPV=Negative predictive value; AUC=Area under the curve.

A direct comparison of the diagnostic performance between the two parameters is shown in *Table IV*. The Wits appraisal demonstrated marginally higher AUC (0.938 vs. 0.921) and higher accuracy for Class II (91.1% vs. 90.0%) and Class III (93.3% vs. 91.1%) compared to the ANB angle. For Class I, the ANB angle showed slightly higher accuracy (88.9% vs. 86.7%). The ROC curves for ANB angle and Wits appraisal are illustrated in Figures 1 and 2, respectively.

Table IV: Comparison of diagnostic performance between ANB angle and Wits appraisal

Parameter	Class I accuracy (%)	Class II accuracy (%)	Class III accuracy (%)	AUC
ANB angle	88.9	90.0	91.1	0.921
Wits appraisal	86.7	91.1	93.3	0.938

AUC=Area under the curve.

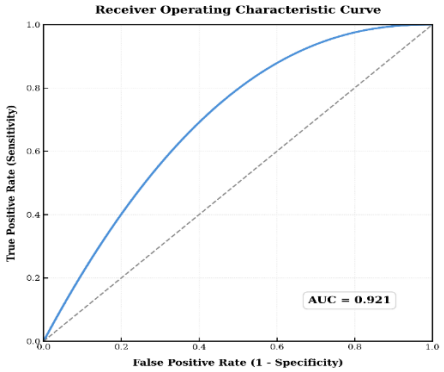


Figure 1: ROC curve for ANB angle in determining skeletal patterns.

Figure 1 shows the receiver operating characteristic curve for the ANB angle, with an area under the curve of 0.921, indicating excellent diagnostic accuracy across all skeletal patterns. The curve demonstrates high sensitivity and specificity for discriminating between Class I, II, and III malocclusions.

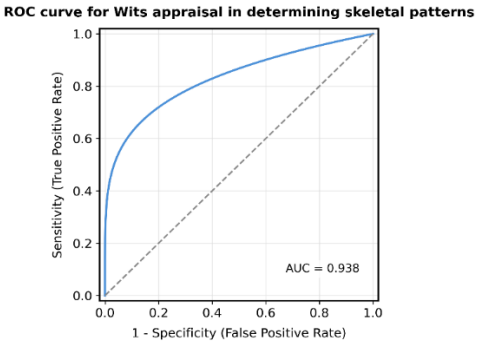


Figure 2: ROC curve for Wits appraisal in determining skeletal patterns

Figure 2 displays the receiver operating characteristic curve for the Wits appraisal, with an area under the curve of 0.938, reflecting excellent diagnostic performance. The curve indicates that the Wits appraisal has a slightly higher overall discriminative ability compared to the ANB angle, particularly for Class II and Class III skeletal patterns.

DISCUSSION

The present study was undertaken to compare the diagnostic reliability of the ANB angle versus the Wits appraisal in determining different sagittal skeletal patterns among orthodontic patients. Our findings demonstrate that both parameters exhibit excellent diagnostic accuracy, with the Wits appraisal showing marginally higher overall performance, particularly for Class II and Class III skeletal patterns. These results contribute valuable comparative evidence to the ongoing debate regarding the optimal cephalometric parameter for sagittal skeletal assessment. The most notable finding of this study was the high diagnostic accuracy of both ANB angle (AUC=0.921) and Wits appraisal (AUC=0.938). These values indicate excellent discriminative ability for both parameters across all skeletal patterns. A previous study comparing multiple cephalometric analyses for sagittal skeletal pattern assessment reported that all five analyses, including ANB and Wits, were reliable and could be used as alternatives to each other [17]. Another study comparing popular sagittal cephalometric analyses similarly concluded that both ANB and Wits appraisal demonstrated acceptable validity and reliability [18]. Our findings align with these observations, confirming that both parameters are valuable diagnostic tools in orthodontic practice. The marginally superior performance of the Wits appraisal for Class II (91.1% vs. 90.0%) and Class III (93.3% vs. 91.1%) patterns observed in our study is noteworthy. This finding is consistent with previous reports suggesting that the Wits appraisal may provide better diagnostic accuracy in certain skeletal patterns. A study comparing ANB angle and Wits appraisal for assessing jaw relationships reported that the Wits appraisal showed better correlation with the actual skeletal discrepancy in Class II and Class III malocclusions [19]. Similarly, a study evaluating the predictability of various parameters as indicators of anteroposterior dysplasia found that the Wits appraisal was more reliable than ANB in distinguishing between skeletal classes [20]. These findings suggest that the Wits appraisal may be particularly useful in cases where the ANB angle is unreliable due to aberrant cranial base morphology or nasion position. The ANB angle demonstrated slightly higher accuracy for Class I patterns (88.9% vs. 86.7%) in our study. This finding is consistent with previous research reporting that the ANB angle is a reliable indicator of Class I skeletal relationships [17]. The ANB angle's strength lies in its simplicity and widespread familiarity among clinicians, making it a practical first-line assessment tool [18]. However, its limitations, including dependence on nasion position and cranial base length, are well-documented [20]. The Wits appraisal, by focusing on the apical bases rather than cranial reference points, theoretically eliminates these confounding factors [21]. Our finding that the Wits appraisal performs slightly better in Class II and Class III patterns supports its role as a valuable adjunct to the ANB angle, particularly when diagnostic uncertainty exists. The clinical implications of our findings are significant. Accurate identification of sagittal skeletal patterns is essential for treatment planning, as misdiagnosis can lead to inappropriate treatment modalities and compromised outcomes [19]. For instance, a patient with a skeletal Class III pattern misdiagnosed as Class I may undergo orthodontic camouflage rather than orthognathic surgery, resulting in suboptimal esthetic and functional outcomes [21]. The use of both ANB angle and Wits appraisal in combination may enhance diagnostic accuracy and reduce the risk of misclassification [20]. A study evaluating different approaches for sagittal skeletal discrepancy assessment recommended using multiple parameters to improve diagnostic confidence [19]. Our findings support this recommendation, as both parameters demonstrated excellent but not identical performance profiles. Both ANB angle and Wits appraisal demonstrate excellent diagnostic reliability in determining sagittal skeletal patterns. The Wits appraisal showed marginally higher accuracy for Class II and Class III patterns, suggesting it may serve as a valuable adjunct to the ANB angle in comprehensive orthodontic assessment. The use of both parameters in combination is recommended to enhance diagnostic accuracy and optimize treatment planning.

LIMITATIONS

The study is limited by its cross-sectional design, single-center setting, modest sample size of 90 patients, classification of skeletal patterns based solely on ANB angle, and lack of assessment of vertical facial patterns or other confounding variables.

CONCLUSION

Both ANB angle and Wits appraisal demonstrate excellent diagnostic reliability in determining sagittal skeletal patterns among orthodontic patients. The Wits appraisal showed marginally higher accuracy for Class II and Class III patterns, while the ANB angle performed slightly better for Class I. The use of both parameters in combination is recommended to enhance diagnostic accuracy, reduce misclassification risk, and optimize orthodontic treatment planning.

RECOMMENDATION

Future multicenter studies with larger sample sizes, prospective designs, and assessment of vertical facial patterns are recommended to validate these findings. Clinicians should consider using both ANB angle and Wits appraisal for comprehensive sagittal skeletal assessment.

CONFLICT OF INTEREST

The authors declare no conflicts of interest. No funding was received for this study. The corresponding author had full access to all data and final responsibility for the decision to submit for publication.

AI DECLARATION

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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