Research Article

Correlation of Beta Angle and Wits Appraisal with ANB Angle in the Evaluation of Sagittal Skeletal Discrepancy

Dr. Aaditya Mallik[1], Dr. Manish Bajracharya[2], Dr. Abhilasha Khanal Parajuli[3], Dr. Shreeya Baral[4]

[1]Consultant Orthodontist, [2]Professor, [3]Associate Professor,
Orthodontic Unit, Department of Dental Surgery, National Academy of Medical Sciences, Bir Hospital, Kathmandu

[4]Dental Surgeon, Man Mohan Institute of Health Sciences, Kathmandu

Corresponding author: Aaditya Mallik; Email: aadityamallikwork@gmail.com

ABSTRACT

Introduction: Different cephalometric parameters are used to assess sagittal skeletal discrepancy including ANB angle, Wits appraisal and Beta angle. This study aimed to determine the Beta angle measurement in the study population and correlate it with the ANB angle, along with a comparison of Wits appraisal and ANB angle for the validity and reliability of the Beta angle.

Materials and Methods: A comparative observational study was carried out on 114 participants (45 males and 69 females) aged 10 to 35 years. ANB angle, Wits Appraisal and Beta angle from the lateral cephalogram were used for the assessment of sagittal skeletal discrepancy. Ten percent of the cephalograms were randomly selected, retraced and re-analyzed by the investigator, and two readings were compared for reliability. The mean and standard deviation of the Beta angle were obtained for different skeletal patterns. Pearson's correlation test and multiple regression analysis (stepwise) were used to measure the significance level. Finally, an independent t-test was used to determine differences between the study population and Caucasian norms.

Results: The mean values of the Beta angle for class I was 34.99°, for class II was 28.84°, and for class III was 49.66°. There were significant differences between obtained values for different skeletal patterns (p<0.001). A statistically significant negative correlation is observed for Beta angle to ANB (p<0.001). The Wits appraisal was positively correlated with the ANB angle. No significant difference was observed in the Beta angle between the Caucasian norms and the studied population. No significant differences were observed in the mean values for the Beta angle between males and females.

Conclusion: Irrespective of the ethnicity and race of the population group, the Beta angle provides an important tool in the assessment of sagittal skeletal dysplasia.

KEYWORDS: ANB angle, Beta angle, Sagittal Skeletal Discrepancy,Wits appraisal

INTRODUCTION

Malocclusion occurs due to variations in normal craniofacial growth and development in sagittal, vertical, or transverse planes. In the orthodontic problem list, a sagittal plane discrepancy has a major impact on structural, functional, and aesthetic aspects. In this regard, both angular and linear measurements have been used in various cephalometric analyses to diagnose the skeletal pattern and establish a needful treatment plan.[1]

Analysis of the jaws in the sagittal plane is a key step that Wylie first introduced in 1947.[2] Afterwards, many methods of assessing the jaw in the anteroposterior (AP) plane have been formulated. Down used the Frankfort plane (Porion-Orbitale) to other planes for assessing the facial type.[3] Riedel measured the Sella-Nasion-Point A (SNA), Sella-Nasion-Point B (SNB) angle and used their difference or point A–Nasion–point B (ANB) angle as an expression of the dental apical base relationship.[4] Cecil C. Steiner proposed the appraisal of various parts of the skull separately, namely the skeletal, dental, and soft tissues. Emphasis is placed on the inaccuracy of the Frankfort plane as a reference plane, proposing the use of Sella and Nasion, which can be located more easily and accurately.[5] The Wits appraisal of jaw disharmony as proposed by Jacobson, relates points A and B to the occlusal plane. According to the appraisal, the measurement of the cranial base did not necessarily provide a reliable framework for analyzing the sagittal relationship.[6]

The difference in the ANB angle is not always a true indication of the apical base relationship, and certain changes in the relative position of nasion to points A and B influence the ANB angle.7 Further, the questionable accuracy in determining the reproducibility and reliability of Wits appraisal has been questioned due to the variations in inclination and difficulties in the identification of the functional occlusal plane. Small errors in the location of the functional occlusal plane have an impact on the Wits value.[8]

Beta angle was introduced by Baik and Ververidou and does not depend on any cranial landmarks or dental occlusion and uses 3 skeletal landmarks - point A, point B, and the apparent axis of the condyle (C).[9] According to Baik et al, the Beta angle would be especially beneficial whenever previously established cephalometric measurements, such as the ANB angle and the Wits appraisal, could not be accurately used because of their dependence on varying factors. Some studies revealed that Beta angle can be a valuable tool in assessing skeletal patterns.[10,11]The present study intends to compare the correlation between the Beta angle to ANB angle and similarly, Wits appraisal to ANB angle, to determine which cephalometric parameter stands out in providing a concrete background for diagnosis and treatment plan.

MATERIALS AND METHODS

Lateral cephalograms with readily identifiable landmarks were taken from patients visiting the Orthodontic Unit, Department of Dental Surgery at National Academy of Medical Sciences (NAMS), Bir Hospital, Nepal. Ethical clearance was obtained from the Institutional Review Board (approval No. 1425/2078/79) of NAMS. The sample was collected from June 2021 to July 2022.

A convenience sampling technique was used and the sample size was calculated using the OpenEpi software (version 3.0). The alpha was taken as 0.05 and the power of the study was set at 80% to calculate the sample size. Determination of the sample size was done using a power calculation based on the mean Beta angle value of Class I occlusion i.e., 31.1±2°.[12] The results suggested a sample size of a minimum of 38 subjects in each group. As the subjects were divided into three groups based on the sagittal facial pattern, a minimum of 114 subjects were required.

The sample consisted of 114 individuals (45 males and 69 females) visiting the Orthodontic Unit for treatment. Lateral cephalograms of patients aged 10 to 35 years were taken as part of the inclusion criteria, with sagittal discrepancies classified as follows: Class I (ANB angle -1° to 3°,Class I appearance), Class II (ANB angle >3°, Class II appearance), and Class III (ANB angle < -1°, Class III appearance). The exclusion criteria included patients with a history of any previous or on-going orthodontic treatment, a history of craniofacial disorders or craniofacial trauma.

Lateral cephalograms were taken using Sideaxis 4 (Build version 4.2.0.6310) software of the Sirona Dental X-Ray Imaging System 4. Cephalometric tracings were done by a single investigator using acetate tracing paper and a 0.5mm pencil. Three parameters were used in this study namely, the ANB angle, Wits Appraisal and Beta angle for the assessment of sagittal skeletal discrepancy.

Cephalometric landmarks included:

Sella(S): The midpoint or center of sella turcica (in horizontal diameter).

Nasion (N): The most anterior point of the frontonasal suture in the mid-sagittal plane.

Point A (A): The deepest point on the curved bony outline between the anterior nasal spine (ANS) and prosthion (Pr).

Point B (B): The deepest midline point on the mandible between the infradentale and pogonion.

Apparent center of condyle (C): The center of the condyle, found by tracing the head of the condyle and approximating its center.

Cephalometric planes included:

Sella-Nasion (SN) plane: The line connecting S and N

A-B line: The line connecting A and B points.

C-B line: The line connecting the center of the Condyle (C) with point B.

A-X line: The line from point A perpendicular to C-B line (X).

Functional Occlusal Plane (FOP): A line drawn through the cuspal overlap of the maxillary first molar and bicuspids. A perpendicular line was drawn from A to FOP (AO), and another perpendicular line was drawn from B to the FOP (BO).

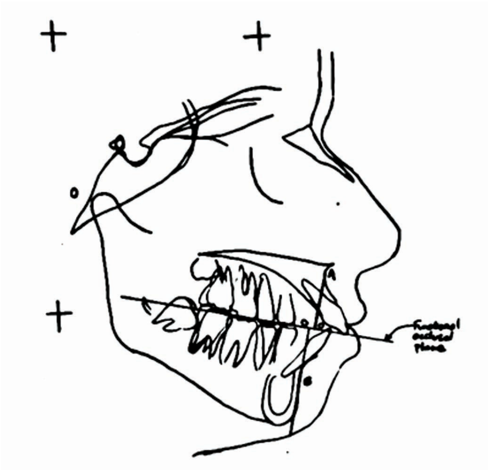

Figure 1. Lateral cephalometric tracing showing Wits appraisal where point A (A), point B (B) and perpendicular line drawn from points mentioned above to functional occlusal plane (AO, BO) respectively.

Linear measurement included AO-BO (mm) which is the distance between AO and BO on to the FOP (Fig. 1).
Similarly, angular measurements included (Fig. 2,3):
SNA: The angle from Sella to Nasion to point A.
SNB: The angle from Sella to Nasion to point B.
ANB: The angle from point A to Nasion to point B (SNA-SNB difference).
Beta angle: Angle formed between A-B line and the perpendicular line dropped from point A and C-B line (X).

Figure 2. Lateral cephalometric tracing showing measurement of ANB angle where Sella (S), Nasion (N), point A, point B are used.

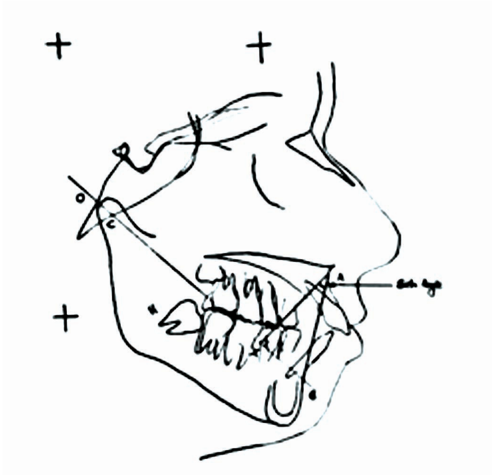

Figure 3. Lateral cephalometric tracing showing Beta angle (β) and its landmarks where A is point A, B is point B, and the apparent axis of the condyle (C) and X is point on CB where perpendicular is drawn to A.

According to Baik et al, a Beta angle between 27° and 35° indicates a Class I skeletal pattern; a Beta angle less than 27° indicates a Class II skeletal pattern, and a Beta angle greater than 34° indicates a Class III skeletal pattern.[9]

Each group was evaluated for statistical significance using the Statistical Package for Social Sciences 23 (SPSS 23, IBM). The Kolmogorov Smirnov (KS) test was used for the evaluation of the normal distribution of the skeletal patterns. The mean and standard deviation were calculated for three different skeletal patterns based on the ANB angle, Beta angle and Wits Appraisal. An analysis of variance (ANOVA) and Tukey post hoc test were used to determine whether there was statistically significant difference between mean values of three different skeletal patterns. Pearson's correlation test was used to evaluate the sagittal skeletal relationship using different analyses. A multiple regression analysis (stepwise) was used to measure the significance level between the Beta angle and Wits appraisal in relation to the ANB angle.

An independent t–test was conducted to study the means and standard deviations between the study population and Caucasian norms for different skeletal patterns. Ten percent of the cephalograms were randomly selected, retraced and re-analyzed by the investigator and the two readings were compared for reliability; the second reading was taken one month after the first reading. The errors were calculated according to the intra-class coefficient correlation (ICC) for intra-rater reliability analysis.

RESULTS

In this study, out of 114 subjects, 45 were males and 69 were females (Class I: 10 males, 28 females; Class II: 17 males, 11 females; Class III: 18 males, 20 females). Kolmogorov-Smirnov test was performed for normal distribution of different skeletal pattern based upon ANB angle which showed normal distribution.

Mean values (±S.D.) were obtained for ANB angle for different sagittal skeletal pattern in the studied population as shown in Table 1.

Table 1: Mean (± S.D.) for ANB angle in different skeletal patterns

	Skeletal pattern	Minimum	Maximum	Mean	Std. Deviation
ANB Valid N (listwise)	I	-1.0	3.0	1.882	1.3478
	II	3.5	14.0	6.329	2.2339
	III	-12.0	-2.0	-4.987	2.8056

Mean (± S.D.) were obtained for Wits appraisal and Beta angle for 3 different skeletal patterns as shown in Table 2.

Table 2: Mean (± S.D.) for Wits appraisal and Beta angle in different skeletal patterns

Skeletal pattern	Parameters	N	Minimum	Maximum	Mean	Std. Deviation
I	Wits appraisal	38	-12.0	5.0	-1.961	4.2369
	Beta angle	38	18.5	46.0	34.987	5.8500
II	Wits appraisal	38	-5.0	22.0	3.276	4.6436
	Beta angle	38	12.0	42.0	28.842	6.2278
III	Wits appraisal	38	-29.0	0.0	-12.434	6.2246
	Beta angle	38	36.0	63.0	49.658	6.4233

The ANOVA test showed statistically significant intergroup differences (p<0.001) in beta angle in all different skeletal classes (Table 3).

Table 3: Analysis of variance (ANOVA) of Beta angle in skeletal Class I, II and III

	Sum of squares	Df	Mean square	F	Sig.
Between groups	8693.066	2	4346.533	114.116	<.001
Within groups	4227.849	111	38.089		
Total	12920.914	113			

Post-hoc Tukey test showed a mean difference of 6.1447° between Class I and Class II, -14.6711° between Class I and Class III and -20.8158° between Class II and Class III groups. (Table 4). The mean difference for all skeletal patterns were statistically significant. (p<0.001)

Table 4: Tukey post-hoc test for different skeletal patterns

Pattern (I)	Pattern (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Skeletal class I	Skeletal class II	6.1447*	1.4159	<.0001	2.781	9.508
	Skeletal class III	-14.6711*	1.4159	<.0001	-18.035	-11.308
Skeletal class II	Skeletal class I	-6.1447*	1.4159	<.001	-9.508	-2.781
	Skeletal class III	-20.8158*	1.4159	<.0001	-24.179	-17.452
Skeletal class III	Skeletal class I	14.6711*	1.4159	<.0001	11.308	18.035
	Skeletal class II	20.8158*	1.4159	<.0001	17.452	24.179

*. The mean difference is significant at the 0.001 level.

Pearson's correlation test was used to evaluate the sagittal skeletal relation using different analyses (p value < 0.05 considered to be statistically significant). Statistically significant correlation was observed for Beta angle and ANB angle compared to Wits appraisal and ANB angle for all three sagittal skeletal patterns (Table 5). Beta angle was negatively correlated to ANB whereas Wits appraisal was positively correlated.

Table 5: Correlations for class I, II, and III for different variables

Correlations for class I		ANB	Wits appraisal	Beta angle
ANB	Pearson Correlation	1	.452**	-.516**
	Sig. (2-tailed)		.004	<.001
	N	38	38	38
Wits appraisal	Pearson Correlation	.452**	1	-.667**
	Sig. (2-tailed)	.004		<.001
	N	38	38	38
Correlations for class II				
ANB	Pearson Correlation	1	.191	-.341*
	Sig. (2-tailed)		.251	.036
	N	38	38	38
Wits appraisal	Pearson Correlation	.191	1	-.475**
	Sig. (2-tailed)	.251		.003
	N	38	38	38
Correlations for class III				
ANB	Pearson Correlation	1	.704	-.723
	Sig. (2-tailed)		<.001	<.001
	N	38	38	38

Wits appraisal	Pearson Correlation	.704	1	-.824
	Sig. (2-tailed)	<.001		<.001
	N	38	38	38
Pearson's correlation analysis between 3 parameters				
		ANB	Wit's appraisal	Beta angle
Wits appraisal	Pearson Correlation	.844**	1	-.882**
	Sig. (2-tailed)	.000		.000
	N	114	114	114
Beta angle	Pearson Correlation	-.868**	-.882**	1
	Sig. (2-tailed)	.000	.000	
	N	114	114	114

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Correlation in class I for Beta angle to ANB was -0.516 compared to 0.452 for Wits to ANB, similarly, for class II was -0.341 vs 0.191 and class III was -0.723 vs 0.704.

Multiple regression analysis (stepwise) was used for measuring the significance level between Beta angle and Wits appraisal to ANB angle for different skeletal patterns as shown in Table 6.

Table 6: Step-wise multiple regression analysis for Beta angle in Class I, II, and III

Pattern	R	R Square	Adjusted R square	Std error of estimate
Class I	-.516	.266	.246	1.1704
Class II	-.341	.116	.092	2.1290
Class III	-.723	.523	.510	1.9639

Regression analysis for all subjects is shown in Table 7.

Table 7: Multiple regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.868[a]	.753	.751	2.5776
2	.884[b]	.781	.777	2.4392

a. Predictors: (Constant), Beta_angle
b. Predictors: (Constant), Beta_angle, Wits_appraisal
Dependent Variable: ANB

Independent t–test was conducted to study means and standard deviation between the study population and Caucasians norms for different skeletal patterns. (Table 8)

Table 8: Independent t-test showing no significant differences between study population and Caucasian norms

Skeletal pattern	Mean In Caucasians	Mean in study population	Sig. (two-tailed)
I	31.02	34.99	0.507
II	24.19	28.84	0.467
III	40.2	49.66	0.155

DISCUSSION

An evaluation of the antero-posterior or sagittal relationship of skeletal bases using various angular and linear measurements is important in orthodontic diagnosis and treatment planning.[9] One of the most popular parameters to assess this is the ANB angle. Besides this, Wits appraisal is also a commonly used indicator. Although not affected by rotation of jaws or cranial landmarks, Wits appraisal is dependent upon the functional occlusal plane which can be difficult to assess, especially in cases of mixed dentition. The Beta angle, devised by Baik and Ververidou is an angular measurement tool for determining sagittal skeletal discrepancy.

Intra-rater reliability is >0.9 for average measures (ANB: 0.972, Wits appraisal: 0.970 and Beta angle: 0.961) which shows excellent reliability. Ahmed et al reported ICC for ANB, Wits appraisal, and Beta angle to be 0.987, 0.943, and 0.989 respectively.[13] Whereas Alhammadi et al[1] reported intra-examiner reliability of 0.889 and 0.999 for ANB and Beta angle respectively. Bhardwaj et al reported only insignificant differences for repeated lateral cephalograms.[14] According to Sundareswaran et al the ICC showed a reliability of 0.894.[15] This indicates the use of high-quality lateral cephalograms for precise tracing.

The intra-Class Coefficient (ICC) test was comparatively lower for the Beta angle (0.961) than for Wits appraisal (0.970). This could be attributed to the inaccuracy in locating and tracing the center of the condyle (point C). However, the apparent axis of condyle described by Baik and Ververidou has the advantage that the precise tracing is not actually necessary, as the point C if located within 2 mm of radius affects Beta angle by less than 1˚, making it still acceptable. Wits appraisal, on the other hand, is affected by the occlusal plane angulation and growth pattern.[14] Other studies also showed insignificant differences between the first and second measurements for reliability.[14,16]

The results of the mean values for Beta angle in class I skeletal pattern were 34.99 ± 5.85˚, class II was 28.84 ± 6.23˚ and class III was 49.66 ± 6.42˚ which were statistically significant. High standard deviation means the values for certain skeletal pattern are spread out rather than being clustered around the mean. This could be due to a smaller sample size and variation in growth type in each skeletal pattern. The mean values with standard deviation presented in this study showed no significant differences compared to the norms of Caucasians, as shown by Baik and Ververidou[9]. This is in accordance with studies by Alhammadi et al[1], Ahmed et al[13] and Prasad et al.[17] Alhammadi et al reported Beta angle measurements as 31.14 ± 2.91˚ for class I, 25.48 ± 2.99 ˚ for class II and 38.09 ± 3.00˚ for class III.[1] Ahmed et al reported mean values for skeletal patterns as 32.49 ± 5.43˚ in class I, 26.31 ± 4.03˚ in class II and 43.54 ± 4.75˚ in class III.[13] Prasad et al reported measurements as 31.33 ± 3.25˚, 25.28 ± 4.28˚, 40.93 ± 4.55 ˚ for class I, II, III respectively.[17] The measurements for class III skeletal pattern in our study were higher as most of the study population in this group was intended for orthognathic surgery in future. The absence of differences in between the ethnic origins can be explained by measurement of apical base differences independent of cranial base morphology, rotation of jaws and dental occlusion.

There were no statistically significant differences between males and females in this study. The mean Beta angle for males and females in class I skeletal pattern were 35.2˚ and 34.9˚ with a S.D. of 5.26˚ and 6.13˚ respectively. The lack of gender-based significant findings is in accordance with previous studies by Baik et al, Bhardwaj et al and Prasad et al.[9]

Analysis of variance (ANOVA) and Tukey post-hoc tests were calculated to compare skeletal pattern I, II, and III and they showed a statistically significant intergroup difference (p<.001). A number of studies have established norms of Beta angle in different skeletal patterns in various population which have shown significant differences in mean and standard deviation values.[1]

Beta angle is statistically more correlated to ANB angle than Wits appraisal to ANB angle for different skeletal patterns. Overall, Beta angle showed strong a negative strong linear correlation with ANB angle (r= -0.868); thus, indicating an increase in Beta angle with decrease in ANB angle and vice versa. The correlation of Wits appraisal to ANB is 0.844 in the present study. Ahmed et al. reported a moderate correlation between ANB and Beta angle of -0.775 whereas a strong correlation of 0.831 between ANB and Wits appraisal.13 Similarly, Alhammadi et al. reported weak to moderate correlation of -0.49, -0.44 and -0.75 for class I, II and III cases.1 Bhardwaj et al reported moderate correlation of -0.648 of Beta angle with ANB angle.[14] Alassiry found ANB and Beta angle showed the highest sensitivity (0.933) followed by Wits appraisal (0.900) in evaluating class III skeletal discrepancy for the Saudi population.[18] In the different skeletal patterns, Wits appraisal was weakly correlated to ANB. It can be justified as variation in occlusal plane angle in any skeletal pattern if the growth pattern is hypodivergent or hyperdivergent. This would result in greater variation in Wits appraisal.

Jajoo et al compared Beta and ANB angles and concluded that both angles indicated significant differences with different skeletal patterns.[10] They found that both ANB and Beta angle were similar in providing supportive diagnostic measurements to establish sagittal jaw relationship. Singh et al. presented with results showing correlation of -0.3, -0.241 and -0.782 for class I, II and III for Beta angle to ANB angle, whereas correlations of was 0.399, 0.076 and 0.636 were reported for Wits appraisal to ANB angle.[19] Compared to previous studies, higher correlation of Beta angle for ANB was observed in this study rather than Wits appraisal and ANB angle which shows Beta angle as a reliable parameter to assess the sagittal skeletal discrepancy. Among the various factors that could affect the regression analysis presented in this study, skeletal pattern can be affected by growth rotation and trends; horizontal, normal or vertical growth.

Further studies are needed to compare Beta angle and Wits appraisal, and correlate to ANB angle with larger sample size. The skeletal growth patterns in sagittal skeletal classes i.e., normodivergent, hypodivergent and hyperdivergent need to be analyzed. This study emphasizes the need for future research on the incorporation of reliable and valid parameters in the assessment of sagittal skeletal discrepancy in the population. It is important as facial norms and standards have been linked to racial predispositions. Sagittal skeletal discrepancies can be evaluated with fewer analyses with higher accuracy and time-saving diagnosis to formulate an efficient treatment plan. Thus, irrespective of the ethnicity and race of the population group, the Beta angle serves as an important tool in the assessment of sagittal skeletal dysplasia of varying degrees.

CONCLUSION

1. Statistically significant differences in mean for different skeletal sagittal dysplasia were present based on the Beta angle.
2. Statistically significant negative correlation was observed for Beta angle to ANB which validates the use as a routine parameter for assessment of sagittal skeletal dysplasia. Wits appraisal is positively correlated to ANB angle.
3. No significant difference was observed in terms of Beta angle for norms in Caucasians and the studied population.
4. No significant differences in mean values for Beta angle were observed for males and females.

CONFLICT OF INTEREST:

There are no conflicts of interest.

OJN

REFERENCES

1. Alhammadi MS, Almaqrami BS, Cao BC. Reliability of Beta-angle in different anteroposterior and vertical combinations of malocclusions. Orthodontic Waves. 2019;78(3):111–7.
2. 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.
3. Downs WB. Variations in facial relationships: Their significance in treatment and prognosis. Am J Orthod. 1948;34(10):812–40.
4. Riedel A. Richard. The relation of maxillary structures to cranium in malocclusion and in normal occlusion. Vol. 22, The Angle Orthodontist. 1952. p. 142–5.
5. Steiner CC. Cephalometrics for you and me. Am J Orthod. 1953;39(10):729–55.
6. Jacobson A. The "Wits" appraisal of jaw disharmony. Am J Orthod. 1975;67(2):125–38.
7. Taylor CM. Changes in the relationship of nasion, point A, and point B and the effect upon ANB. Am J Orthod. 1969;56(2):143–63.
8. Rushton R, Cohen AM, Linney AD. The relationship and reproducibility of angle ANB and the Wits appraisal. Br J Orthod. 1991;18(3):225–31.
9. Baik CY, Ververidou M. A new approach of assessing sagittal discrepancies: The Beta angle. American Journal of Orthodontics and Dentofacial Orthopedics. 2004;126(1):100–5.
10. Jajoo A, Agarkar SS, Sharma S, Gadhiya N, Sonawane S, Narkhede S. Comparison of Beta and ANB angles for evaluation of sagittal skeletal discrepancy: A cephalometric study. Journal of Contemporary Dental Practice. 2018;19(6):739–42.
11. Maruthi V, Kandasamy S. Establishment of norms of the Beta angle to assess the sagittal discrepancy for Chennai population: A prospective study. International Journal of Pedodontic Rehabilitation. 2016;1(2):52.
12. Baik CY, Ververidou M. A new approach of assessing sagittal discrepancies: The Beta angle. American Journal of Orthodontics and Dentofacial Orthopedics. 2004;126(1):100–5.
13. 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.
14. Bhardwaj P, Kapoor D. Assessment of Sagittal Skeletal Discrepancy: A Cephalometric Study. J Indian Orthod Soc. 2013;262–5.
15. Sundareswaran S, Kumar V. Reliability of Beta angle in assessing true anteroposterior apical base discrepancy in different growth patterns. J Nat Sci Biol Med. 2015;6(1):125–30.
16. Haynes S, Chau MNY. The reproducibility and repeatability of the Wits analysis. Am J Orthod Dentofacial Orthop. 1995;107(6):640–7.
17. Prasad M, Reddy KPK, Talapaneni AK, Chaitanya N, Reddy MVB, Patil R. Establishment of norms of the Beta angle to assess the sagittal discrepancy for Nellore district population. J Nat Sci Biol Med. 2013;4(2):409–13.
18. Alassiry AM. Accuracy of different cephalometric analyses in the diagnosis of class III malocclusion in Saudi and Yemeni population. J Orthod Sci. 2020;9(1):14–20.
19. Singh G, Verma S, Singh DP, Yadav SK, Yadav AB. Correlation of Beta angle with antero-posterior dysplasia indicators and FMA: An institution based cephalometric study. Journal of Clinical and Diagnostic Research. 2016;10(11):ZC75–8.