

Correlation of Beta Angle with Antero-Posterior Dysplasia Indicators and FMA: An Institution Based Cephalometric Study

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ABSTRACT

Introduction: Beta angle utilizes three skeletal landmarks – point A, point B, and point C (the apparent axis of the condyle). It is formed between A-B line and point A perpendicular to C-B line. Further this angle indicates the severity and the type of skeletal dysplasia in the sagittal dimension and it changes with the growth pattern of the patient. Hence, it is important to study the dependence of beta angle on the growth pattern.

Aim: The present study was designed to evaluate the correlation of Beta angle with point A–Nasion–point B (ANB) angle, points A and B to palatal plane (App-Bpp), Wit's appraisal and Maxillary-Mandibular plane angle Bisector (MMB) and Frankfort-Mandibular plane Angle (FMA) in Skeletal Class I, Class II and Class III malocclusion groups.

Materials and Methods: Pre-treatment lateral head cephalograms of 120 subjects in age group of 15-25 years were obtained.

Three skeletal Class I, Class II and Class III malocclusion groups (40 each) were assorted on the basis of ANB, MMB, App-Bpp, Wit's appraisal and FMA. Analysis of variance (ANOVA) and mean differences were calculated to compare the study groups. Bivariate correlations among different parameters of these groups were obtained.

Results: Normal values of beta angle in skeletal Class I group, skeletal Class II group and skeletal Class III group was 31.33 ± 3.25 , 25.28 ± 4.28 and 40.93 ± 4.55 respectively. Overall beta angle showed a strong correlation with all parameters of antero-posterior dysplasia indicators except FMA.

Conclusion: Beta angle shows weak correlation with FMA and is not affected by growth pattern/jaw rotation. The normal values are in same range irrespective of the differences in craniofacial morphology.

Keywords: Bivariate correlations, Malocclusion, Skeletal dysplasia

INTRODUCTION

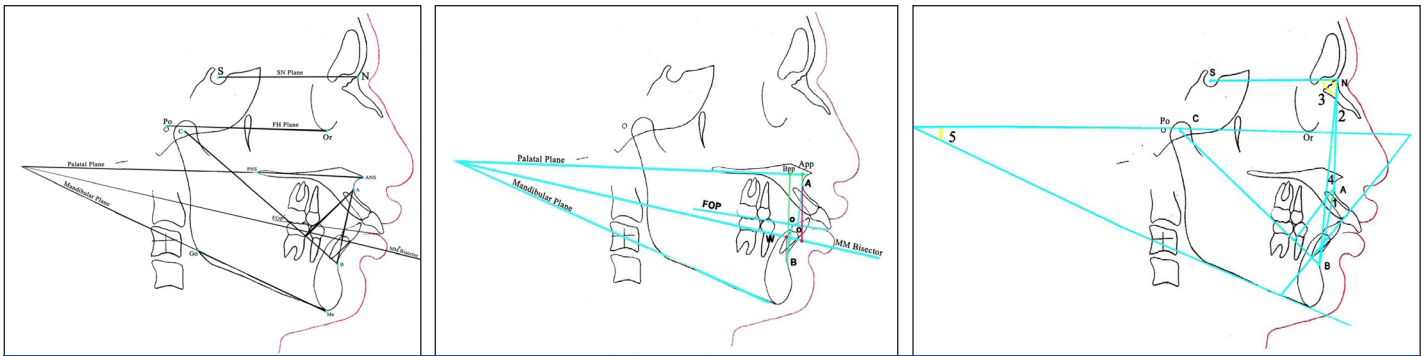
Cephalometric analyses comprises of various angular and linear measurements which assist the clinician in recognizing antero-posterior discrepancies. Down introduced the A-B plane angle to determine the sagittal denture base relationship whereas, Riedel recommended the use of SNA, SNB, and ANB angles [1,2]. The ANB angle is most commonly manipulated and well recognized indicator for skeletal sagittal discrepancy [3,4]. Several authors elucidated the shortcomings of ANB due to number of distorting factors [4-9] and recommended linear measurements to be made on occlusal plane [5,6] while others endorsed linear or angular measurements on palatal plane, Maxillary-Mandibular Bisector (MMB) and Frankfort Horizontal (FH) plane [10-12]. Some authors suggested other measurements to analyze antero-posterior discrepancies but all these used cranial or dental reference plane [13,14]. Each one of these planes had its own limitations.

In determining the apical base relationship and for comparison of pre- and post-treatment sagittal correlation of the jaws, an assessment independent of cranial reference planes or dental occlusion would be a preferable supplement. In this context, beta angle was originated by Baik CY which does not depend on any cranial landmark or dental occlusion to evaluate the sagittal jaw relationship [15]. It would be especially valuable where the previously established cephalometric measurements, such as ANB angle and the Wit's appraisal (point A and B projects in two perpendicular lines, along the functional occlusal plane called as AO and BO. The plane in between AO and BO is referred to as the Wit's appraisal), cannot be accurately used because of its dependence on varying factors (length of SN plane, jaw rotation, occlusal plane etc.). Beta angle indicates the severity and the type of skeletal dysplasia in the sagittal dimension and it can be useful in evaluating the growth pattern of the patient. Any alteration in Frankfort-Mandibular Plane Angle (FMA) values may also modify the beta angle [16]. Sundaeswaran S et al., in their analytical work

determined that the vertical growth patterns significantly increased Beta angle values; thus, influencing its authenticity as a sagittal discrepancy appraisal tool [16]. Consequently, Beta angle may not be a substantial tool for assessment of sagittal jaw discrepancy in patients manifesting vertical growth patterns with skeletal Class I and Class II malocclusions. Therefore, it is a fundamental need to study the impact of Beta angle on the growth pattern. The parameters used for evaluation of skeletal malocclusion also show ethnic variation [17-21]. Hence, the present study was undertaken to evaluate correlation of Beta angle with antero-posterior dysplasia indicators and FMA in skeletal Class I, Class II and Class III group and to establish norms of Beta angle. The objectives that were taken into consideration were to evaluate the normal values of beta angle for skeletal Class I, II and III malocclusions; the correlation of Beta angle with ANB, App-Bpp, Wit's appraisal and MMB in skeletal Class I, Class II and Class III malocclusion groups and the correlation of beta angle with FMA.

MATERIALS AND METHODS

After obtaining the institutional ethical clearance from the institute and informed consent from all the participants, the present cross-sectional institution based study was conducted in Department of Orthodontics and Dentofacial Orthopaedics of Swami Devi Dyal Dental College and Hospital, Barwala, Haryana, India, for a period of 9 months. Pre-treatment lateral head cephalograms of 120 subjects in age group of 15-25 years belonging to Haryana/Punjab population were obtained. Determination of sample size was done using a power calculation that is based upon mean Beta angle value of Class I occlusion i.e., $31.1\pm 2^\circ$ [15]. To identify a change of 2° from this mean value with 95% confidence and 80% power, a minimum sample size of 16 in each group was required. Out of 120 cephalograms, 40 each for skeletal Class I, skeletal Class II and skeletal Class III group were assorted. The distribution of cases into these three categories was achieved using existing antero-posterior



[Table/Fig-1]: Cephalometric plane considered in the study. **[Table/Fig-2]:** Linear measurements considered in the study. **[Table/Fig-3]:** Angular measurements (1-Beta angle, 2-SNA, 3-SNB, 4-ANB and 5-FMA angle) considered in the study.

indicators of skeletal malocclusion (ANB, MMB, App-Bpp, Wit's, FMA).

Subjects in the permanent dentition stage and those with completed pre-treatment records taken within a period of 6 months were included in the study. The exclusion criteria for the study were patients having craniofacial anomalies, previous history of trauma, orthodontic treatment or orthognathic surgery and functional mandibular shifts or congenital defects.

Cephalometric Radiograph and Analyses: The 120 selected pre-treatment lateral head cephalogram were traced manually on an acetate paper with a 3H drawing pencil. Landmarks, planes, angular and linear measurements used in the study were:

Cephalometric Planes [Table/Fig-1]:

1. Sella-Nasion (SN) plane: The line connecting S and N.
2. Frankfort Horizontal (FH) plane: The line connecting Po and Or.
3. Functional Occlusal Plane (FOP): Drawn through the cuspal overlap of maxillary first molar and bicuspid.
4. C-B line: Line connecting the centre of the Condyle (C) with point B.
5. A-B line: Line connecting A and B points.
6. Line from point A perpendicular to C-B line.
7. Line bisecting mandibular and palatal plane.
8. Line connecting ANS and PNS.

Linear Measurements [Table/Fig-2]:

1. AO-BO (mm): The distance between perpendiculars drawn from point A and point B on to the occlusal plane [5,6].
Values for skeletal Class I: -1mm to 2 mm
2. MMB (mm): The distance between perpendiculars drawn from point A and B on to bisector plane of mandibular and palatal plane [11].
Value for skeletal Class I: -4mm
3. App-Bpp (mm): The distance between perpendiculars drawn from point A and B on to palatal plane [12].
Value for skeletal Class I: 4.8±3.6mm

Angular Measurements [Table/Fig-3]:

1. Beta angle: Angle formed between A-B line and the perpendicular line dropped from point A and C-B line [15].
2. SNA-The angle from sella to nasion to point A.
3. SNB-The angle from sella to nasion to point B.
4. ANB-The angle from point A to nasion to point B, SNA-SNB difference.
Value for skeletal Class I: 2°±2°.
5. FMA-The angle formed between Frankfort horizontal plane and mandibular plane (Tweed's).

STATISTICAL ANALYSIS

All measurements were entered into SPSS software package (version 15.0) and mean standard deviation was obtained. Analysis of variance (ANOVA) and unpaired t-test was used to determine the difference between mean Beta angle values in all three skeletal classes. Bivariate correlations among different parameters of these groups were also obtained.

RESULTS

Out of total 120 subjects enrolled in the present study, each of skeletal Class I, II and III malocclusion groups had 40 subjects (33.3%). The cephalometric analysis was conducted and measurement of Beta angle and other antero-posterior indicators of malocclusion were done.

Establishment of Normative Data for Beta Angle: The beta angle measurement was done on the lateral cephalogram for all the 120 subjects enrolled in the study. [Table/Fig-4] shows the range (minimum and maximum) of beta angle measurements in different skeletal Class groups with calculated mean and standard deviation values.

Comparison of Measurements of Beta Angle in Skeletal Class I, II and III Malocclusion Groups: Analysis of variance and mean differences were calculated to compare the skeletal Class I, the skeletal Class II and skeletal Class III groups which showed a statistically significant intergroup difference ($p < 0.001$) [Table/Fig-5]. Comparison of beta angle, showed a mean difference of 6.05° between Class I and Class II, -9.60° between Class I and Class III and -15.65° between Class II and Class III groups. This comparison between the groups revealed that skeletal Class I had significantly higher mean beta angle as compared to skeletal Class II but had a significantly lower mean value as compared to Class III ($p < 0.001$) [Table/Fig-6].

On the basis of above evaluation, the increasing order of beta angle values were observed in different malocclusion groups as follows: Class III > Class I > Class II.

Correlation of Beta Angle with Wit's Appraisal, ANB, App-Bpp, MMB and FMA in Skeletal Class I, Class II and Class III Groups: Overall beta angle showed a strong negative correlation with all the other variables except FMA [Table/Fig-7]. Only MMB showed significant correlation for skeletal Class I, followed by ANB and Wit's with the existence of weak correlation, whereas for App-

S. No.	Skeletal Class	N	Mean	SD	Median	Min	Max	95% CI	
								Lower Bound	Upper Bound
1.	I	40	31.33	3.25	32	26	42	30.28	32.37
2.	II	40	25.28	4.28	25	17	35	23.90	26.65
3.	III	40	40.93	4.55	40	28	50	39.47	42.38

[Table/Fig-4]: Beta angle measurements in different skeletal class groups.
N: Number of subjects, SD: Standard Deviation

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4982.47	2	2491.23	150.592	<0.001
Within Groups	1935.53	117	16.54		
Total	6917.99	119			

[Table/Fig-5]: Analysis of variance (ANOVA) of beta angle in skeletal Class I, II and III.

S.No.	Comparison	Mean difference	SE of Mean difference	"t"	p
1.	Class I vs Class II	6.05	0.85	7.112	<0.001
2.	Class I vs Class III	-9.60	0.88	-10.858	<0.001
3.	Class II vs Class III	-15.65	0.99	-15.840	<0.001

[Table/Fig-6]: Comparison of mean differences using unpaired t-test in beta angle measurements in Skeletal Class I, II and III., p<0.001: Statistically highly significant

	ANB		Wit's		MMB		App-Bpp		FMA		Beta Angle	
	r	p	r	p	r	p	r	p	r	p	r	p
ANB	1.000	<0.001	0.840	<0.001	0.865	<0.001	0.878	<0.001	0.247	0.007	-0.865	<0.001
Wit's			1.000	<0.001	0.879	<0.001	0.833	<0.001	0.113	0.220	-0.856	<0.001
MMB					1.000	<0.001	0.899	<0.001	-0.012	0.893	-0.904	<0.001
App-Bpp							1.000	<0.001	0.283	0.002	-0.830	<0.001
FMA									1.000	<0.001	-0.020	0.827
Beta Angle											1.000	<0.001

[Table/Fig-7]: Overall correlation matrix showing bivariate correlation among different parameters under evaluation. r: Correlation coefficient, p<0.001: Statistically highly significant

	ANB		Wit's		MMB		App-Bpp		FMA		Beta Angle	
	r	p	r	p	r	p	r	p	r	p	r	p
ANB	1.000	<0.001	0.399	0.011	0.395	0.012	0.612	<0.001	0.356	0.024	-0.300	0.060
Wit's			1.000	<0.001	0.207	0.201	0.043	0.794	-0.020	0.903	-0.331	0.037
MMB					1.000	<0.001	0.370	0.019	-0.151	0.351	-0.656	<0.001
App-Bpp							1.000	<0.001	0.587	<0.001	-0.108	0.508
FMA									1.000	<0.001	0.197	0.222
Beta Angle											1.000	<0.001

[Table/Fig-8]: Correlation matrix showing bivariate correlation among different parameters under evaluation for skeletal Class I. r: Correlation coefficient, p<0.001: Statistically highly significant

	ANB		Wit's		MMB		App-Bpp		FMA		Beta Angle	
	r	p	r	p	r	p	r	p	r	p	r	p
ANB	1.000	<0.001	0.076	0.641	-0.083	0.612	0.190	0.240	0.407	0.009	-0.241	0.134
Wit's			1.000	<0.001	0.202	0.212	0.267	0.096	0.233	0.147	-0.140	0.390
MMB					1.000	<0.001	0.344	0.030	-0.170	0.295	-0.350	0.027
App-Bpp							1.000	<0.001	0.443	0.004	0.050	0.760
FMA									1.000	<0.001	0.247	0.125
Beta Angle											1.000	<0.001

[Table/Fig-9]: Correlation matrix showing bivariate correlation among different parameters under evaluation for skeletal Class II. r: Correlation coefficient, p<0.001: Statistically highly significant

	ANB		Wit's		MMB		App-Bpp		FMA		Beta Angle	
	r	p	r	p	r	p	r	p	r	p	r	p
ANB	1.000	<0.001	0.636	<0.001	0.717	<0.001	0.650	<0.001	-0.115	0.481	-0.782	<0.001
Wit's			1.000	<0.001	0.786	<0.001	0.649	<0.001	-0.300	0.060	-0.829	<0.001
MMB					1.000	<0.001	0.790	<0.001	-0.510	0.001	-0.840	<0.001
App-Bpp							1.000	<0.001	-0.032	0.845	-0.783	<0.001
FMA									1.000	<0.001	0.280	0.080
Beta Angle											1.000	<0.001

[Table/Fig-10]: Correlation matrix showing bivariate correlation among different parameters under evaluation for skeletal Class III. r: Correlation coefficient, p<0.001: Statistically highly significant

Bpp and FMA the correlation was not significant [Table/Fig-8]. For skeletal Class II, the correlation of beta angle with all parameters (ANB, Wit's App-Bpp, FMA and MMB) was non-significant and among them MMB shows strongest correlation [Table/Fig-9]. For skeletal Class III, beta angle showed a strong significant correlation

with all the indicators (ANB, Wit's, MMB, App-Bpp) except FMA. The result of correlation matrix confers very weak co-relation of FMA with beta angle [Table/Fig-10]. The findings of the present study revealed that beta angle show weak correlation with FMA in all types of malocclusion groups.

DISCUSSION

The present study showed that the beta angle had a value of $31.33 \pm 3.25^\circ$ for skeletal Class I group, $25.28 \pm 4.28^\circ$ for skeletal Class II group, $40.93 \pm 4.55^\circ$ for skeletal Class III group. For the beta angle, any value $< 28^\circ$ indicates Class II skeletal pattern and any value $> 35^\circ$ indicates Class III skeletal pattern. These results are in accordance with the norms for Caucasian population given by Baik CY et al., who introduced beta angle as a powerful tool to assess

	ANB		Wit's		MMB		App-Bpp		FMA		Beta Angle	
	r	p	r	p	r	p	r	p	r	p	r	p
ANB	1.000	<0.001	0.399	0.011	0.395	0.012	0.612	<0.001	0.356	0.024	-0.300	0.060
Wit's			1.000	<0.001	0.207	0.201	0.043	0.794	-0.020	0.903	-0.331	0.037
MMB					1.000	<0.001	0.370	0.019	-0.151	0.351	-0.656	<0.001
App-Bpp							1.000	<0.001	0.587	<0.001	-0.108	0.508
FMA									1.000	<0.001	0.197	0.222
Beta Angle											1.000	<0.001

sagittal discrepancies [15]. Similarly, Prasad M et al., designed a study to validate the norms of beta angle to assess the sagittal discrepancy for Nellore district population. There was statistically significant difference for beta angle within the three skeletal patterns and no difference among Nellore district population and Caucasian

norms [22]. Zeng ZS et al., reported ethnic differences among Asian and Caucasian population using various cephalometric variables [23]. On contrary, beta angle may not be a definitive tool for evaluating the sagittal jaw discrepancy in patients exhibiting vertical growth patterns in skeletal Class I and Class II malocclusions according to Sundareswaran S et al. However, it is a reliable indicator of sagittal dysplasia in normal and horizontal growth patterns. Additionally, skeletal Class III malocclusions showed complete adherence to beta angle values irrespective of the growth pattern [16].

A study also compared cephalometric mean values of Saudi population with the norms suggested for a white Caucasian population by Down's and Steiner's and significant differences were noticed [19]. Another research work encountered significant differences between white and black subjects using various hard tissues, dental and soft tissue variables [20]. Singh SP et al., established cephalometric norms for North Indians and compared those measurements with Caucasians. In this study North Indians had more retruded maxilla and mandible, more facial convexity as compared to the Caucasians. Upper incisor inclination and wit's value were also more among North Indians; whereas, Caucasians had more values of maxillary and mandibular lengths, chin depth, vertical skeletal and dental heights [21]. There are several other studies in literature presenting distinct cephalometric norms for different populations [17,18].

Analysis of variance and mean differences were calculated to compare the Skeletal Class I, the Skeletal Class II and Skeletal Class III groups. Analysis of variance showed a statistically significant intergroup difference ($p < 0.001$). Beta angle showed strong correlation with all antero-posterior dysplasia parameters. Thus, beta angle gives equally good assessment of skeletal malocclusion. Moreover, in the present study, the beta angle showed strongest correlation with MMB which indicates both can be used interchangeably with less chance of error.

The correlation of beta angle with FMA in the present study was very weak or non-significant. Thus, the assumption that the increase or decrease in FMA may affect the values of beta angle has been proved false. We conclude that the beta angle can be used efficiently without any effect of FMA and it is not dependent on growth pattern.

LIMITATION

The limitation of the present study was that we have assumed point A to be constant in the present study, but in real it changes, which further modify the value of beta angle. This part has not been considered in the study. As the present study was conducted on Haryana/ Punjab population, the collected data can be used in future for further research on the particular population group. Certainly, prospective studies are mandatory to assess the vertical change in the position of point A with its effect on beta angle.

CONCLUSION

The normal values of beta angle in the three skeletal malocclusion groups are in the same range as mentioned in previous studies. Thus, the study interprets the stability of beta angle irrespective of the difference in craniofacial morphology. The overall beta angle showed a strong correlation with ANB, MMB, App-Bpp and Wit's; thus, can be used interchangeably in diagnosis of skeletal malocclusion. Beta angle can be used efficiently without any effect of FMA. The growth pattern does not affect the interpretation of malocclusion using beta angle.

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