

# Predictability of Yen Angle & Appraisal of Various Cephalometric Parameters in the Assessment of Sagittal Relationship between Maxilla and Mandible in Angle's Class II Malocclusion

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## Abstract:

The study was aimed to check the predictability and variability of Yen angle along with other sagittal discrepancy parameters and to discuss the correlation existing between them, so as to obtain a more reliable and least variable parameter for antero-posterior cephalometric analysis. The lateral cephalograms of 120 Class II malocclusion in Indian subjects were obtained and traced for seventeen different sagittal discrepancy parameters. The age of subjects ranged from 17-24 years. Study revealed that, Yen angle was highly reliable (CV= 1.81) and most homogeneously distributed angular parameter to assess antero-posterior sagittal discrepancy. Other parameters like FABA, APDI/ PABA, SGn-AB and Beta angle also exhibit homogenous distribution and less variability in comparison to other parameters. As all the parameters used in the study share statistically significant correlation amongst themselves, instead of relying on one single parameter, others also should be checked and should be correlated with clinical findings.

**Key Words:** A-P relationship, Class II malocclusion, Yen Angle.

## Introduction:

Up till now various methods of assessing the sagittal jaw base relationship have been formulated. Earlier the skeletal pattern was analyzed clinically by an overall profile view of the patient and palpation of the anterior surfaces of the basal part of the jaws with the teeth in occlusion. After the introduction of the cephalometry, various angular and linear parameters were studied and documented. Downs (1956) introduced the A-B plane angle, few years later; Riedel (1952) came up with the angle ANB. The reliability of ANB as an A-P discrepancy indicator has always been questioned (Beatly, 1975; Yank & Shur, 1995; Kim, 1979; Jacobson, 1975; Freeman, 1981; Hussels & Nenda, 1984; Bjork 1955; Cooke & Wei, 1988; Chang, 1987; Sarhan, 1990; Baik & Ververeidou, 2004).

After considering the fallacies of ANB angle, Jacobson (1975) considered using functional occlusal plane as a reference plane to assess points A and B, and thus eliminated the controversies surrounding the N point. Nevertheless, location of functional occlusal plane in itself was a difficult task. Having recognized the flaws with two of the commonly used measurements

to assess the sagittal jaw relationship, it was desirable that a measurement independent of the cranial reference planes or dental occlusion would be a better adjunct in determining the apical base relationship. Up till now number of different measurements have been developed like: A-B plane angle, ANB angle, AXB angle, AXD angle, FABA angle, PABA angle, SGn/AB angle, APDI angle, AB/TH angle, Beta angle & linear measurements like Wit's Appraisal, AB/PP distance, AB/SN distance, AD/SN distance, AB/FH distance and AB/TH distance. More recently in 2009 a new measurement named YEN Angle was projected (Fig. V).

So far very few studies have been done to check the validity of the Yen angle (Neela et al, 2009). Therefore, present study was aimed to assess the predictability and validity of YEN angle in comparison to other A-P dysplasia indicators. This study was also an attempt to check the correlation as well as variations existing in between these parameters, so that a more reliable and least variable parameter can be obtained.

## Materials and Methods:

The study was carried out using lateral Cephalograms of 120 Indian subjects with the age range of 17-24 years, obtained from out patient department of Orthodontics and Dentofacial Orthopedics, Darshan Dental College and Hospital, Udaipur. One hundred

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twenty subjects clinically diagnosed to have Class II malocclusion with convex profile and large overjet, were selected for the study. An informed consent was obtained from each of them. A lateral cephalogram was taken for each subject (Fig. I). Subjects full filling the following criteria were included in the study:

1. ANB angle of  $4^\circ$  or more
2. Wits appraisal was greater than or equal to 3mm
3. AB Plane angle more than  $-9^\circ$

Twenty individuals who did not meet the above set criteria were not included in the study.

The final sample consisted of 60 male and 40 female (n=100) of Class II malocclusion group. Lateral cephalometric radiographs for each patient were taken in natural head posture. The wire plumb line and suspended weight recorded the true vertical on each radiograph. Each subject was then asked to determine the self-balanced position of the head and lateral cephalogram was taken in the standard manner (Raju et al, 2001; Fig. I). Tracings were made by hand using a sharp 3H pencil on acetate tracing paper in a dark room using X-ray viewer. For the measurement of the linear distances, scale was used to the nearest of 0.5 mm and angles were measured to the nearest of 0.5 degree. The True vertical line was then established. The important hard and soft tissue structures were then marked on the cephalogram (Fig. II). Various reference points, planes and angles were drawn, and recorded for evaluation.



Fig I: Lateral cephalogram of Class II subject.

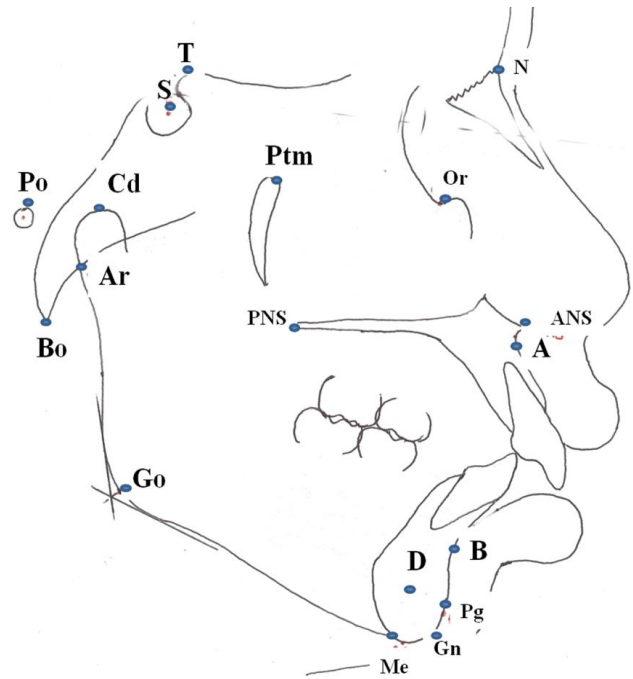


Fig II: Cephalometric tracing with reference points.

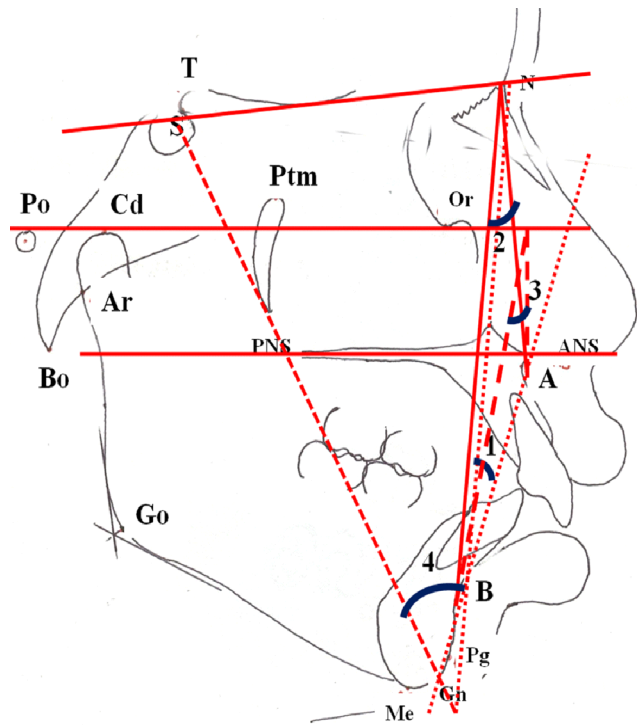


Fig III: Line Diagram with Angular parameters.

[1: (....)A-B plane, 2:(—) ANB, 3: (---)AFB, 4:(---/....) SGn-AB]

### 1. Angular measurements (Fig. III, IV, V & VI)

- A-B plane : A-B plane to N-Pog line
- ANB : Difference between SNA and SNB
- AXB : Angle formed from Point A to point AF (point of perpendicular contact on the F-H plane from point A) to point B

- AXD : Angle formed from point A to point AX (point of perpendicular contact on the S-N plane from point A) to point D
- FAB A : FH plane to AB plane
- PABA : Palatal plane to AB plane
- SGn/AB : S-Gn line to AB plane
- Beta : Angle formed between the Line from point A perpendicular to the C-B line and the A-B line
- APDI : Obtained from a combination of singular measurements, such as the facial angle, A-B plane angle, and palatal plane angle.
- AB/TH : True Horizontal plane to AB plane
- YEN : angle formed between SM line and MG line

## 2. Linear measurements (Fig. VII)

- Wit's A : Distance between A and B point on OP plane
- AB/PP : Distanced between A and B point on Palatal plane
- AB/SN : Distance between A and B point on SN Plane
- AD/SN : Distance between A and D point on SN Plane
- AB/FH : Distance between A and B point on FH plane
- AB/TH : Distance between A and B Point on True Horizontal Plane

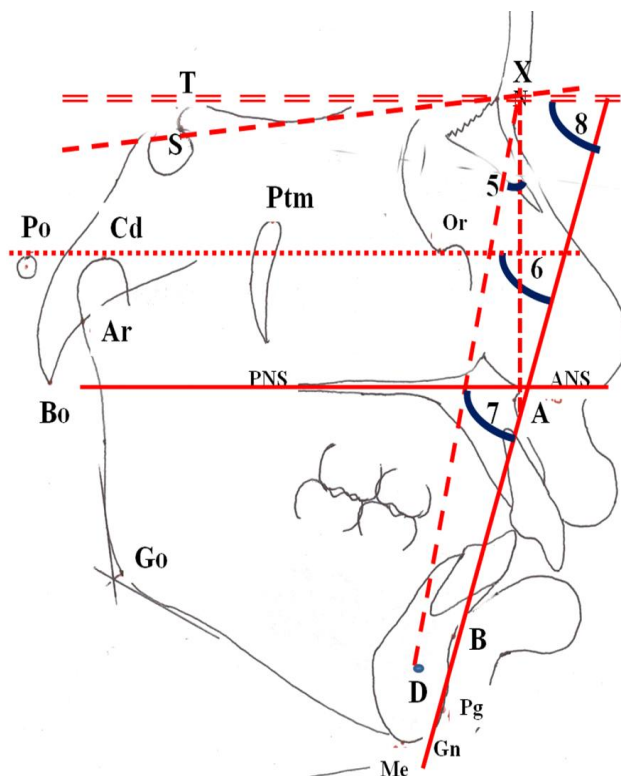


Fig IV: Line Diagram with Angular parameters.

[5:(---) AXD, 6:(.../ —) FAB A, 7: (—) PABA, 8: (—/==)AB/TH]

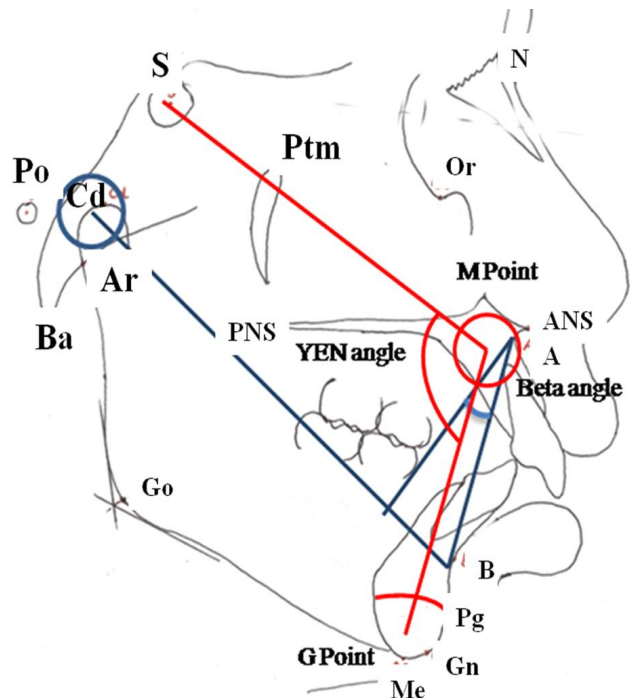


Fig V: YEN angle and Beta angle.

## Statistical Analysis

The data was collected, tabulated and statistically analyzed using the SPSS 10 software. Statistical methods employed in the present investigations were:

1. To determine the errors associated with radiographic measurements, 10 radiographs were selected at random from the observational group. Their tracing and measurements were repeated and compared with first measurements by using paired 't' test.
2. Minimum and maximum value, range, mean and standard deviation were calculated for each subject.
3. To find out the significant differences for the measurements between male and female sample, Independent 't' test was applied.
4. Coefficients of Variability of all parameters were calculated.
5. Correlation coefficients between the various parameters were calculated using Pearson's correlation to determine which combination would produce a higher value.

## Results:

The statistical analysis to check the error between repeated measurements, paired 't' test was used, and it suggested no significant difference between them ( $p > 0.05$ ). The results of the study suggested no

statistical significant differences between two sexes ( $p>0.05$ ). Therefore, all the measurements belonging to both sexes were pooled, and a correlation analysis was performed among them.

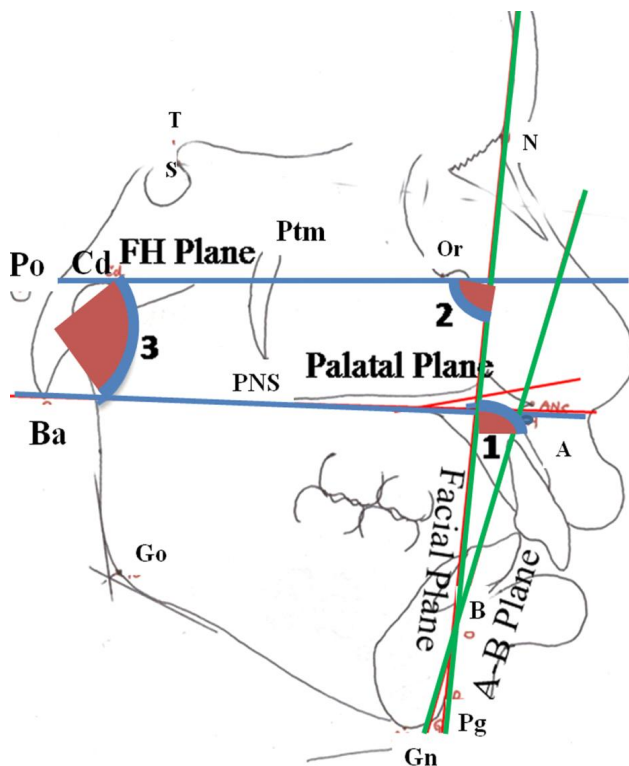


Fig VI6: Antero posterior Dysplasia Indicator (APDI), is a Sum of three angle.

[1: A-B Plane angle, 2: Facial plane angle, 3: Palatal plane angle]

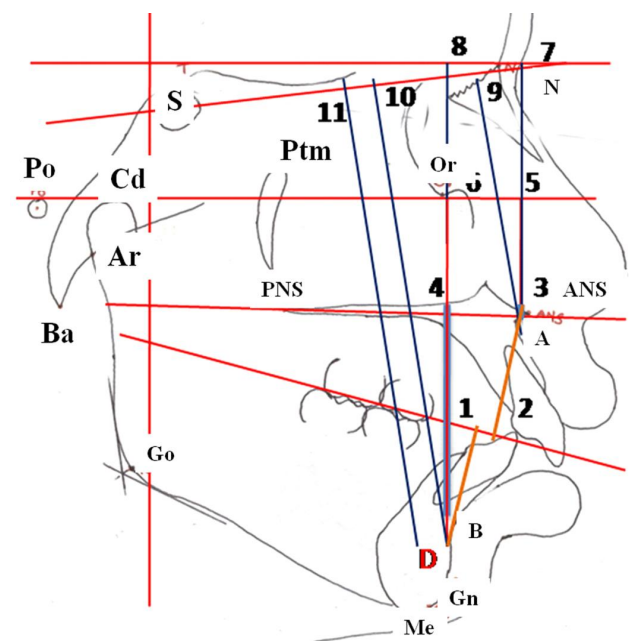


Fig VII: Line Diagram with Linear parameters.

[1-2: Wit's Appraisal, 3-4: AB/PP, 5-6: AB/FH, 7-8: AB/TH, 9-10: AB/SN, 9-11: AD/SN]

The coefficient of variability of all parameters is presented in Table II. According to it the measurements with most homogenous distribution in the group were YEN angle ( $CV=1.81$ ) followed by FABA, PABA, APDI, SGn-AB and Beta angle. In linear measurements, most homogenous distribution was AD-SN distance ( $CV=15.17$ ) and measurements with least homogenous distribution was the Wits Appraisal ( $CV=36.14$ ).

A statistically significant positive correlation between FMA and angles like AB Plane angle, Beta, and linear parameters like TH-Wits was observed. A significant negative correlation was found between FMA and SGn-AB angle and Wits appraisal. Rest all the parameters had no significant correlation with FMA angle (Table III, IV & V).

Among all the angular parameters, APDI and PABA angle exhibited highest statistically significant positive correlation with each other ( $r = 0.984$ ,  $p>0.05$ ). Highest negative correlation was found between AB-HP distance and FABA angle ( $r = -0.868$ ,  $p>0.05$ ) and between FABA and AXB angle ( $r = -0.867$ ,  $p>0.05$ ). Lowest significant positive correlation was present between FABA and AB-Plane. ( $r = 0.298$ ,  $p>0.05$ ) as shown in Table III.

When angular and linear parameters were compared, high significant positive correlation was found between AB-HP angle and TH- Wits distance ( $r = 0.780$ ,  $p>0.05$ ). High significant negative correlation was found between APDI angle and AB-PP distance ( $r = -0.848$ ,  $p>0.05$ ) as shown in Table V.

## Discussion:

In cephalometrics, both angular and linear variables have been proposed to analyze sagittal jaw relationship and jaw position. Angular measurements can be erroneous as a result of changes in facial height, jaw inclination, and total jaw prognathism; linear variables can be affected by the inclination of the reference line (Baik & Ververeidou, 2004). The literature reveals that, there are various ways to assess the maxilla mandibular jaw discrepancy, but none can be universally used with authenticity. Therefore, the present study was designed to analyze different statistical and geometrical variations in cephalometric measurements which were used to indicate the anteroposterior jaw relationship in Class II malocclusion and to assess the reliability and predictability of YEN angle and variability of all the sagittal parameter in

Table I: Measurements in Indian population with Class II Malocclusion (n = 100)

Measurements	Males (n=60)		Females (n=40)		t-value	p-value
	Mean	SD	Mean	SD		
FMA	22.733	3.734	23.913	3.66	1.559	0.122
AB_PLANE	-10.95	2.273	-10.91	2	0.085	0.933
ANB	6.067	1.233	5.975	1.358	0.35	0.727
AXB (AFB)	8.15	1.322	8.087	1.143	0.244	0.808
AXD	12.042	1.286	11.675	1.807	1.186	0.239
FABA	75.45	2.62	75.825	2.183	0.748	0.456
PABA	75.5	2.561	76.375	2.272	1.749	0.083
SGn-AB	45.825	2.757	45.35	2.565	0.868	0.388
BETA	23.167	2.805	23.95	2.698	1.389	0.168
AB-HP	14.183	3.105	14.15	2.392	0.057	0.954
APDI	75.433	2.664	76.225	2.337	1.528	0.13
YEN	114.42	2.04	114.1	2.14	0.77	0.44
WITS	5.65	1.992	5.075	1.88	1.446	0.151
TH-WITS	9.625	2.546	9.225	2.054	0.83	0.409
AF-BF distance	9.983	2.023	9.437	1.809	1.378	0.171
App-Bpp distance	9.7	1.862	9.163	1.579	1.501	0.137
AB-SN distance	15.233	2.346	14.962	2.188	0.581	0.563
AD-SN distance	22.592	3.46	21.738	3.219	1.243	0.217

Table II: Range of Measurements of Pooled Group (n=100) with coefficient of Variability

Measurements	Minimum	Maximum	Mean	SD	Coefficient of Variability
FMA	16	32	23.205	3.732	16.08
AB_PLANE	-16	-8	-10.94	2.158	19.73
ANB	4	8	6.03	1.279	21.21
AXB (AFB)	5	11	8.125	1.248	15.36
AXD	4.5	14	11.895	1.518	12.76
FABA	70	81	75.6	2.449	3.24
PABA	70	81	75.85	2.476	3.26
SGn-AB	41	53	45.635	2.679	5.87
BETA	17	28	23.48	2.776	11.82
AB-HP	9	20	14.17	2.829	19.96
APDI	70	81	75.75	2.556	3.37
YEN	110	120	114.3	2.07	1.81
WITS	2	11	5.42	1.959	36.14
TH-WITS	3	15.5	9.465	2.358	24.91
AF-BF distance	5	18	9.765	1.949	19.96
AB-PP distance	6	13	9.485	1.766	18.62
AB-SN distance	11	20	15.125	2.277	15.25
AD-SN distance	10	30	22.25	3.375	15.17

assessing the sagittal jaw discrepancy for the young adults of Indian population.

A new cephalometric measurement, named YEN angle was established by Neela et al (2009). This angle is formed between three reference points; S, midpoint of the sella turcica; M, midpoint of the premaxilla and G, center of the largest circle that is tangent to the internal inferior, anterior and posterior surfaces of the mandibular symphysis (Fig. V). Mean value for YEN angle in class II malocclusion subject was  $114.2 \pm 3.6$  (Neela et al, 2009). The mean value

recorded in the present study ( $114.3 \pm 2.07$ ) was at par with the above study. It had the lowest coefficient of variability (CV=1.81) in comparison to all measurements. This indicates that, YEN angle was homogenously distributed and reliable in comparison to other sagittal discrepancy parameters. Coefficient correlation suggested no significant correlation between YEN and FMA angle; which means, YEN angle remained stable even when the jaws are rotated. Among all the parameters, AXD angle and AD-SN distance had highest negative correlation with YEN angle and highest positive correlation with FABA.

Table III: Coefficient Correlation between angular measurements of Class II group

		FMA	AB PLANE	ANB	AXB	AXD	FABA	PABA	SGN-AB	BETA	ABHP	APDI	YEN
<b>FMA</b>	r	1											
	p	.											
<b>AB PLANE</b>	r	.281**	1										
	p	0.005	.										
<b>ANB</b>	r	-0.14	-0.766**	1									
	p	0.163	<0.0001	.									
<b>AXB</b>	r	0.151	-0.333**	.365**	1								
	p	0.133	0.001	<0.0001	.								
<b>AXD</b>	r	-0.003	-0.279**	.513**	.456**	1							
	p	0.974	0.005	<0.0001	<0.0001	.							
<b>FABA</b>	r	-0.065	0.298**	-.249**	-.867**	-.413**	1						
	p	0.521	0.003	0.012	<0.0001	<0.0001	.						
<b>PABA</b>	r	0.008	0.482**	-.437**	-.700**	-.485**	.735**	1					
	p	0.935	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	.					
<b>SGNAB</b>	r	-.513**	-0.710**	.502**	.478**	.357**	-.564**	-.608**	1				
	p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	.				
<b>BETA</b>	r	.446**	0.562**	-.313**	-.570**	-.368**	.672**	.598**	-.822**	1			
	p	<0.0001	<0.0001	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	.			
<b>ABHP</b>	r	0.187	-0.108	0.082	.819**	.311**	-.868**	-.622**	.402**	-.506**	1		
	p	0.063	0.286	0.415	<0.0001	0.002	<0.0001	<0.0001	<0.0001	<0.0001	.		
<b>APDI</b>	r	-0.017	0.481**	-.421**	-.703**	-.473**	.726**	.984**	-.566**	.585**	-.620**	1	
	p	0.868	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	.	
<b>YEN</b>	r	-.143	.172	-.306**	-.389**	-.502**	.328**	.223**	-.265**	.223**	-.251**	.195	1
	p	.156	.086	.002	.000	.000	.001	.026	.008	.026	.012	.052	

\*\* Correlation is significant at the 0.05 level, *r* value = Pearson's product-moment correlation coefficient,

To evaluate the antero-posterior relationship of jaw bases, Yang & Suhr (1995) introduced parameter on FH plane named FABA. According to them, this angle not only provides the anteroposterior relationship of the jaws but also gives a clue to the facial profile. Coefficient of variation analysis of all the sagittal parameters suggested that, except YEN angle, FABA had the second lowest coefficient of variability among the cephalometric parameters measured ( $CV = 3.24$ ), indicating that it was the second most homogeneously distributed parameter (Table III). No significant correlation between FABA and FMA angle was observed. This, however, was in contrast with the previous study. Highest negative correlation was found between AB-HP distance and FABA angle and between FABA and AXB angle, which means larger the FABA angle, smaller the AXB and AB-HP angle and vice versa. Other parameters showing less variability and more homogenous distribution within the population were PABA, APDI and SGn-AB angle.

Beta Angle was established by Baik & Ververeidou (2004). They observed mean value for Beta angle in white Class II patients to be  $24.5 \pm 3^\circ$ . This

is in contrast to the mean value of  $23.4^\circ \pm 2.7^\circ$ , recorded in the present study. This indicates more severe malocclusion in Indian population in comparison to whites. It had the lower coefficient of variability ( $CV = 11.8$ ) in comparison to all measurements except for YEN, FABA, PABA, APDI, and SGn-AB angle. This indicates that, Beta angle was homogeneously distributed and reliable in comparison to other sagittal discrepancy parameters.

In the present study, highly significant positive correlation between Beta and FMA angle was found. This is in contrast to the earlier study of Baik & Ververeidou (2004) who stated that Beta angle remained stable even when the jaws were rotated. Beta angle showed a significant positive correlation with measurements like AB Plane, FABA, PABA and APDI. Remaining parameters exhibited negative correlation with Beta angle. Among all the parameters, SGn-AB angle had highest negative correlation and FABA had highest positive correlation with Beta angle. Kim & Vietas (1978) for the first time measured PABA or APDI angle. This angle was obtained from a



Table IV: Coefficient Correlation between linear measurements of Class II group

	Value	Wits	TH Wits	AF-BF Distance	App-Bpp Distance	AB-SN Distance	AD-SN Distance
Wits	r	1					
	p	.					
TH-Wits	r	0.286**	1				
	p	0.004	.				
AF-BF Distance	r	0.362**	0.695**	1			
	p	<0.0001	<0.0001	.			
App-Bpp Distance	r	0.581**	0.592**	0.576**	1		
	p	<0.0001	<0.0001	<0.0001	.		
AB-SN Distance	r	0.537**	0.620**	0.611**	0.710**	1	
	p	<0.0001	<0.0001	<0.0001	<0.0001	.	
AD-SN Distance	r	0.290**	0.534**	0.599**	0.430**	0.751**	1
	p	0.003	<0.0001	<0.0001	<0.0001	<0.0001	.

\*\* Correlation is significant at the 0.05 level, r value = Pearson's product-moment correlation coefficient, p Value = probability of obtaining a test statistics

Table V: Coefficient Correlation between angular and linear measurements of Class II group

	Value	Wits	TH-Wits	AF-BF Distance	App-Bpp Distance	AB-SN Distance	AD-SN Distance
FMA	r	-.413**	.274**	0.171	0.128	0.064	0.149
	p	<0.0001	0.006	0.088	0.205	0.53	0.14
AB-PLANE	r	-.526**	-0.069	-0.173	-.399**	-.471**	-.248**
	p	<0.0001	0.495	0.085	<0.0001	<0.0001	0.013
ANB	r	.441**	0.193	.272**	.452**	.612**	.434**
	p	<0.0001	0.054	0.006	<0.0001	<0.0001	<0.0001
AXB	r	.530**	.714**	.741**	.655**	.737**	.613**
	p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
AXD	r	.229**	.357**	.388**	.377**	.623**	.731**
	p	0.022	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
FABA	r	-.548**	-.681**	-.677**	-.633**	-.652**	-.601**
	p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
PABA	r	-.616**	-.521**	-.540**	-.832**	-.632**	-.527**
	p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
SGn-AB	r	.674**	.204**	.290**	.367**	.470**	.336**

combination of measurements, such as the facial angle, A-B plane angle and palatal plane angle. They stated that PABA was equals to APDI. This geometric relationship holds true for all variable situations irrespective of the palatal plane inclination and/or the location of point A relative to Na-Pog. Thus, APDI may be considered to be the angle formed by the A-B plane in relation to the palatal plane. In the present study, to check the geometric relationship between PABA and APDI angle, both angles were separately measured. Mean value for class II malocclusion group was found to be 75.5° for both PABA and APDI angles. These findings were in agreement with the mean values of the earlier studies by Kim & Vietas (1978).

Highest negative correlation was found between PABA (APDI) and AB-PP distance. In addition, PABA and APDI had lower coefficient of

variability in relation to all the parameters except FABA (CV = 3.26, 3.37), indicating PABA/APDI was the most homogenously distributed parameter, which is further supported by Oktay (1991) and Yang & Suhr (1995). However, in contrast to their study, present study showed that, PABA and APDI angles exhibited no significant correlation with FMA angle.

Another parameter more homogenously distributed in this study was, SGn-AB angle introduced by Sarhan (1990). In the present study, SGn-AB angle represent the fourth homogenously distributed and less variable (CV=5.87) parameter, whereas Sarhan (1990) reported high variability of this parameter. It also showed high statistical significant correlation with FMA angle, which means, SGn-AB angle was affected by rotation of jaws.

Amongst the linear parameters studied, AD-SN

distance exhibited low coefficient of variability (CV = 15.17) indicating that it was the most reliable linear parameter. This result was in agreement with the study of Beatty (1975). Correlation between FMA and AD-SN distance was found to be statistically insignificant indicating AD-SN distance was not affected by the rotation of jaws. It showed highest negative correlation with YEN angle.

Wits appraisal was introduced by Jacobson in 1975. He employed the functional occlusal plane as a reference plane, because it was common to both maxillary and mandibular dental arches. However, in the present study, Wits appraisal showed the highest coefficient of variability (CV = 36.14), indicating that it was the least reliable parameter and is in agreement with the study by Kim (1979). The greatest coefficient of variability may be attributed, in part to difficulties or inaccuracies in identifying the functional occlusal plane and/or variation in it. The coefficient correlation between FMA and Wits appraisal was found to be highly significant, indicating that Wits appraisal was affected by rotation of jaws and is in agreement with Chang (1987), who opined that the Wits appraisal could be easily affected by changes in the inclination of occlusal plane and the variation in the vertical position of point A, point B or both. However, contrasting findings were reported by the studies of Jacobson (1975) and Richardson (1982).

## Conclusion:

YEN angle was highly reliable and more homogeneously distributed angular parameter used to assess antero-posterior sagittal discrepancy. Other parameters like FABA, PABA, APDI, SGN-AB and Beta angle also exhibit homogenous distribution and less variability as compared to all other parameters. Among all the parameters, higher interchangeability was statistically substantiated between PABA and APDI angle. However, as all the parameters used in the study share statistically significant correlation amongst themselves, instead of relying on one single parameter, others also should be checked and should be correlated with clinical findings.

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