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A COMPARISON OF W ANGLE, PI ANGLE AND YEN ANGLE AS AN INDICATOR FOR ASSESSING ANTEROPOSTERIOR SKELETAL DYSPLASIA IN VARIOUS MALOCCLUSION AMONG REGIONAL POPULATION: A CEPHALOMETRIC STUDY

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ABSTRACT

Background and Objectives

The purpose of this study was to compare newly introduced sagittal dysplasia indicators, YEN angle, W angle and Pi angle in class I, II & III malocclusion and assess the reliability and validity of the YEN angle, W angle and Pi angle along with ANB and Beta angle.

Methods

45 Pre-treatment lateral cephalograms of Angles Class I, II & III malocclusion taken from the archives of department of Orthodontics, were traced manually. For each subject the following cephalometric parameter were measured: ANB angle, Beta angle, YEN angle, W angle and Pi analysis. The data was analysed .

Results

There is no statistical significant differences between males and females for all the measured variables except ANB angle, and the measurements with most homogenous distribution in the group is YEN angle followed by W angle & Beta angle. Measurements with least homogenous distribution was the ANB angle followed by Pi angular & Pi linear.

Conclusion

All the performed cephalometric analyses are valid and can be used to evaluate sagittal discrepancies & there is no statistical significant differences between males & females for all the measured variables except for ANB Angle. The YEN angle is highly reliable and more homogenously distributed parameter followed by W angle & Beta angle.

KEYWORDS: Sagittal Dysplasia, ANB Angle, Beta Angle, YEN Angle, W Angle & Pi Analysis

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Original Article

INTRODUCTION

Cephalometrics is the most commonly used clinical tool for evaluating jaw relationships in all the three planes-sagittal, transverse and vertical. Sagittal relationship is of utmost concern to the patient and an accurate measurement of sagittal discrepancy of the jaws is critical in orthodontic diagnosis and treatment planning.[1]

In the past, the skeletal pattern was examined 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 Cephalometry, various linear and angular parameters were formulated, used effectively, studied and documented. These analyses have both merits and demerits. An accurate anteroposterior (AP) measurement of the jaw relationship is critically important in orthodontic diagnosis and treatment planning.[2]

A number of geometrical parameters, such as the ANB angle, WITS analysis, AF-BF[3],APDI[4],and Beta angle[5]have been defined and used effectively for the evaluation of AP discrepancies affecting the apical bases of the jaws. However, none of the parameters currently defined give a definitive picture of the AP relationship. In particular, various cranial reference planes, such as the Frankfort horizontal and Sella-Nasion line have been used in the determination of jaw dysplasia; however, measurements related to the cranium do not provide a wholly reliable estimation of the AP jaw relationship within the dentofacial complex.[6]

Nanda and Merrill introduced the G and M points and later used by Braun and co-workers, to represent the mandible and maxilla respectively. G and M points are constructed at the centre of the largest circle placed tangent to the anterior, superior (represented by nasal floor) and palatal surfaces of the premaxilla and the internal anterior, inferior and posterior surfaces at the mandibular symphysis respectively. These points are least affected by local remodeling secondary to dental movements, unlike points A and B.[7] These landmarks lead to the development of newer cephalometric analysis like the YEN angle, W angle and Pi analysis. They do not depend on the cranial reference planes or dental occlusion.

The sagittal dysplasia indicators should be an accurate measurer of apical base differences. So far, very few studies have been carried out to evaluate the reliability and validity of these newly introduced parameters.

Therefore, the present study was aimed to measure the newly introduced sagittal dysplasia indicators W angle, Yen angle and Pi angle as an indicator for assessing anteroposterior skeletal dysplasia in various malocclusion and to assess the reliability and validity of the W angle, Yen angle and Pi angle in compaison with ANB angle and Beta angle.

MATERIALS AND METHODS

The study was conducted in ‘JSS Dental College and Hospital,Mysuru’. It included 45 orthodontic patients of 10 to 30 years old individual, who were willing to undergo orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics. The patients were divided into three groups,Group 1: Class I Skeletal pattern(n=15);Group 2: Class II Skeletal pattern(n=15); and Group 3: Class III Skeletal pattern(n=15) . The inclusion criteria were: (1) Orthodontic patient with Class I skeletal pattern and ANB angle of 2-4 degree and pleasant class I profile; Class II skeletal pattern group and ANB angle of greater than 4 degree class II profile appearance; Class III skeletal pattern group with ANB angle of less than 2 degree class III profile appearance.(2) permanent dentition with no missing teeth (3)Patient with no previous history of orthodontic treatment. The exclusion criteria were: (1)Patient with mutilated occlusion.(2)Patient with severe skeletal discrepancies(3)Poor quality radiographs (4)Previous history of orthodontic intervention.

45 Pre-treatment lateral cephalograms of patients with Angles Class I, Class II and Class III malocclusionaged between 10-30 years who had never undergone orthodontic treatment were taken. The reference points, planes and angles were drawn and recorded for evaluation. For each subject the following cephalometric parameter were measured:

ANB Angle (Figure.1)

It was measured between the angle formed between the lines joining nasion to point A and nasion to point B.

Beta Angle (Figure.2)

It is measured by locating 3 points:

(1) Point A- the deepest midline point on the premaxillae between the ANS and prosthion.(2)Point B -the most posterior point in the concavity between infradentale and pogonion.(3). The center of the condyle, found by tracing the head of the condyle and approximating its center (C). Next will be defining 3 lines:(1). Line connecting the center of the condyle C with B point (C-B line).(2). Line connecting A and B points.(3). Line from point A perpendicular to the C-B line.

Finally the Beta angle was measured by measuring the angle between the last perpendicular line and the A-B line.

W Angle (Figure 3)

It was be measured by locating three points:

(1)Point S- midpoint of the sellaturcica; (2)Point M- midpoint of the premaxilla;

(3)Point G- centre of the largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphysis. Next,will be defining four lines: (1)Line connecting S and M points.(2)Line connecting M and G points(3)Line connecting S and G points.(4)Line from point M perpendicular to the S–G line. Finally the angle between the perpendicular line from point M to S–G line and the M–G line was measured.

YEN Angle (Figure.4):

Reference point used:(1)S: midpoint of sellaturcica(2)M: midpoint of premaxilla(3)G: center of the largest circle that is tangent to the internal inferior, anterior and posterior surfaces of the mandibularsymphysis.

The angle between lines SM and MG measured the YEN angle.

Pi angle (Figure.5):

It was constructed in the following manner:

A perpendicular line was drawn from G point to intersect with the true horizontal line at G’, with a further line constructed from G’ to M point. Connecting the points G’G and G’M forms the angle GG’M, or Pi angle. A virtual line was also drawn from M point to intersect perpendicular to the true horizontal line at M’. The distance between points G’ and M’ was estimated to be the Pi linear.

Statistical Analysis

Descriptive Analysis using One way Anova is used to calculate the means of different variables recorded in this study and the measurements were compared using paired ‘t’ test to evaluate intra-observer’s efficiency. Minimum and maximum value, range, mean and standard deviation were calculated for each subject. Significant differences for the measurements between male and female samples, was calculated using independent ‘t’ test. Coefficients of Variability of all parameters were calculated. Correlation coefficients between the various parameters were calculated using Pearson’s correlation to determine which combination would produce a higher value.

RESULTS

Descriptive Analysis using One way Anova is used to calculate the means of different variables recorded in this study. (Table I)

No statistically significant differences between males and females (p>0.05) was observed for all the measured sagittal dysplasia indicators, except for ANB (p=0.01) (Table II & III).

The measurements with most homogenous distribution in the group were YEN angle (CoV=7.7) followed by W angle, Beta angle and Pi linear. Measurements with least homogenous distribution was the ANB angle (CoV=46.24), followed by Pi angle (Table IV).

ANB angle showed statistically significant positive correlation with Pi angle and significant negative correlation with Beta, YEN and W angle. Beta angle showed statistically significant positive correlation with YEN and W angle. Highly significant positive correlation was found between YEN and W angle. Whereas it was observed that Pi angle had significant negative correlation with YEN and W angle. (Table V).

Gender wise comparison of mean values of different study variables is shown in Graph I.

Mean & Coefficient of Variation of different study variables is shown in Graph II.

DISCUSSIONS

Cephalometric radiography in orthodontics is the analysis and interpretation of standardized radiographs of facial bones to assess facial, dental and skeletal relationships as well as airway analysis. Spawned by the classic work of Broadbent in United States and Hofrath in Germany, cephalometrics has enjoyed wide acceptance. Cephalometric radiography is commonly used as a diagnostic tool to assess skeletal discrepancies in the anteroposterior direction. In orthodontic diagnosis and treatment planning, the evaluation of the sagittal jaw relationship is an indispensable step and this relationship is generally determined by cephalometric analysis. To evaluate this relationship, various angular and linear measurements have been suggested.

Experience in analyzing cephalometric x-ray pictures of patients being treated and educating the patient and parents, has developed some opinions regarding methods of analysis for the use of clinical orthodontists.

Angular and linear measurements can be erroneous as angular measurements are affected by changes in face height, jaw inclination and total jaw prognathism, linear variables can be affected by the inclination of the reference line. The stability of anatomic landmarks has long been a subject of interest to those in orthodontic research, very little has been done to assess the direction and degree of change which occurs at nasion during the average period of orthodontic treatment. Nasion is one of the three points which establish the angular relation of the maxilla to the mandible when ANB is used. Therefore, if this is an important link in the diagnostic chain of cephalometric analysis and if nasion does change regularly and to a significant extent, the introduction of this third variable could make ANB a poor reflection of apical base relationship.

The ANB angle remains the most popular parameter for assessing the sagittal jaw relationship due to its simplicity and global acceptability, but it is affected by various factors and can often be misleading.

Variation in the spatial positions of nasion horizontally and/or vertically, and point A or B vertically is a normal anatomic occurrence, which affects the ANB angle. Binder observed that for every 5 mm of anterior displacement of Nasion horizontally, the ANB angle reduces by 2.5 degrees. A 5 mm upward displacement of Nasion decreases the ANB angle by 0.5 degrees and 5 mm downward displacement increases ANB angle by 1 degree. According to Hussels and Nanda[8] four geometric factors that affect angle ANB are, 1) the anteroposterior position of point N in relation to points A and B, 2) inclination of the occlusal plane,3) dental height and 4) distance between points N and B. However, in the present study, ANB Angle showed the highest coefficient of variability (CV = 47.76) after Pi analysis, indicating that it was the least reliable parameter and is in agreement with studies by Kim.

Therefore while using the ANB angle, factors such as the patient's age, growth rotation of the jaws, vertical growth, and the length of the anterior cranial base should be considered, which makes the interpretation of this angle much more complex.

Beta angle proposed by Baik and Ververidou[9], uses three landmarks-point A, point B, and the apparent axis of the condyle. It evaluates the sagittal discrepancy well but locating the landmarks sometimes becomes difficult and also dental movements influence point A and B.

Beta angle avoids use of functional plane and is not affected by jaw rotations. It remains relatively stable even if the jaws are rotated clockwise or counter clockwise and it reflects true changes of the sagittal relationship of the jaws, which might be due to growth, orthodontic or orthognathic intervention[9].

In the present study, Beta angle showed the lower coefficient of variability (CV=26.90) in comparison to all measurements except for YEN and W angle. This indicates that, Beta angle is homogenously distributed and reliable in comparison to other sagittal discrepancy parameters. Also Beta angle showed significant positive correlation with YEN and W angles. A significant negative correlation with ANB angle was observed. This is in agreement with study by Aparnaet al[11] wherein Beta angle can be more reliably used to assess sagittal jaw discrepancies than ANB angle and Wits appraisal.

Prasad[11]studied a sample of Nellore district population, Andhra Pradesh, India and concluded that the Caucasian norms of Beta angle could be well utilized in assessing the sagittal jaw base discrepancy in Indian ethnic groups. Qamaruddin et al[12] studied and concluded that the Beta angle is a reliable method to diagnose skeletal sagittal malocclusion and can be used as an alternative to angle ANB as it correlated significantly with ANB angle.

The norms for various jaw anteroposterior discrepancy indicators like ANB angle and Wits appraisal in the three skeletal pattern groups (Class I, II and III) can have an ethnic difference because of the dependency of these indicators on the cranial base morphology, the inclination of jaw bases and the total vertical height of the craniofacial skeleton.

However, the Beta angle uses point A and point B which can be re modelled by orthodontic treatment and growth according to a study by Richardson[13]and Rushton et al[14]. Moore et al[15] showed that, the reproducibility and the location of condylion on mouth-closed lateral head films is limited. Furthermore Beta angle does not diagnose which jaw is involved in skeletal discrepancy (whether maxilla or mandible) therefore other cephalometric analyses need to be used to assess the position of the jaws.

The newer parameters like W angle, YEN angle and Pi angle, do not utilize A and B points as skeletal landmarks, which are affected by local remodelling due to orthodontic treatment. Instead they utilize points M and G which are not affected by local remodelling and they approximate to being centroid points similar to Sella. The concept of centroid was given by Johnson[16]. A centroid is the center of an area of an image representing the mean point within the shape, about which it varies and is subjected to least variation relative to non-mean anatomic points and therefore provides more stable reference points.

The purpose of this study was to assess the reliability and validity of the newly introduced sagittal dysplasia indicators, the W angle, YEN angle and Pi angle along with ANB and Beta angle.

The W angle was developed by Bhadet al[17] measured between the points S, G and M. The W angle had the second lowest coefficient of variability among the cephalometric parameters measured (CV = 11.18), indicating that it was the second most homogenously distributed, among the measured parameters. W angle showed significant positive correlation with Beta and YEN angle.

A study done by by Sara et al[18] on a sample of Iraqi adults showed that there is no statistically significant difference between mean W angle values of males and females. Also the W angle had a negative significant relation with ANB in all three classes and with WITS appraisal in class III group, while it had a positive significant relation with BETA and YEN angles in all the three skeletal relations. The W angle is a viable diagnostic tool to evaluate the AP jaw relationship more consistently in comparison with ANB angle and witts appraisal.

A study done by Agarwal et al[19]compared different angular measurements to assess sagittal jaw discrepancy in Jaipur population and concluded that Beta angle and W angle are statistically significant angles to assess the sagittal jaw relationship between maxilla and mandible and can be used as adjuncts to ANB angle and Wits appraisal.

A study done byAhmad SH, Jahjah YT et al[20]on ANB angle, Beta angle, W angle and YEN angle in Syrian populations for Class I, Class II and Class III cases showed no significant difference as compared to original values of these measurements. Therefore, these measurements are valid and can also be used on an Arabian or a Syrian population to evaluate sagittal discrepancy. This observation can be attributed to the fact that, Syrian populations do not differ very much in craniofacial morphology from Caucasian or Indian.

A new cephalometric measurement, the YEN angle was established by Neela et al, using three reference points S, M, and G. The angle between lines SM and MG measures the YEN angle. Though morphological landmarks seem to be more reliable, constructed points may in some instances better represent the true nature of the underlying skeletal pattern.

In the present study, it had the lowest coefficient of variability (CV= 7.73) in comparison to all other measurements. This indicates that, YEN angle was homogenously distributed and reliable in comparison to other sagittal discrepancy parameters. This is in agreement with a studies conducted by Doshi JR et al[2]and Mittal A et al[21]. Also YEN angle may reliably predict the post-functional change with the use of twin block appliance as observed by Trivedi et al.[22]

In the present study, Coefficient correlation suggested highly significant positive correlation between YEN and W angle, which may be attributed to the fact that similar landmarks were used to measure both the angles. A significant positive correlation between YEN and Beta angle was observed. YEN angle showed significant negative correlation with ANB and Pi analysis.

Recently introduced Pi analysis by Kumar S et al[6], uses the skeletal landmarks G and M points and the true horizontal plane. The reference plane utilized in measuring the Pi analysis is the true horizontal, a line perpendicular to the true vertical obtained in natural head position.

It showed highest coefficient of variability, indicating that it is least homogenously distributed and least reliable among the parameter evaluated in the study after ANB. This observation might be due to the limitation of the Pi angle, as it includes the use of the true horizontal plane passing through Nasion as it is evident from the literature that during growth nasion moves upward and forward and geometrically, the construction and interpretation of the Pi angle is similar to the ANB angle.

Pi analysis showed statistically significant positive correlation with ANB angle. It also showed significant negative correlation with W and YEN angle. However, highest level of correlation was obtained for the Pi angle and Pi linear.

A study done by Kumar S[3] et al showed that the highest level of correlation was found between Pi angle and Pi linear (0.96).

A study done by Divi Mittal□ et al[23] compared the credibility of four recently introduced cephalometric measurements in assessing the antero-posterior jaw relationship and assessed the correlation between various measurements used for assessment of antero-posterior discrepancy and concluded that Pi angle has 100% sensitivity and specificity to discriminate a Class II and a Class III case from a Class I to a Class III case from a Class II. Yen angle and W angle showed very low specificity to differentiate a Class II from a Class I.

In the present study, among the recently introduced parameters to evaluate sagittal discrepancy, the most reliable parameter was the YEN angle followed by W angle. Among ANB and Beta angle, Beta angle was the most reliable one. Hence these can be considered as significant angles to assess the sagittal jaw relationship in agreement with Sachdeva K et al.[24]

There are various ways to evaluate sagittal discrepancy, but none of the parameters can be universally used with authenticity. The probable solution would be to apply at least three analyses in each individual case. A thorough knowledge of the various analyses at hand will help the astute clinician in choosing the most appropriate ones for each case.

CONCLUSIONS

It was concluded from the study that,

- the mean value of W angle in class I, II & III malocclusion is 55.33±3.41 mm, 50.20±2.00 mm & 66.13±4.03 mm respectively.
- The mean value of Yen angle in class I, II& III malocclusion is 124.33 ±5.87 mm, 116.20± 4.99 mm & 136.13±5.094 mm respectively.
- The mean value of Pi angle in class I, II& III malocclusion is 2.73 ± 3.75 mm, 9.20± 5.28 mm & -6.20 ± 4.25 mm respectively.
- There was no statistical significant differences between males and females for all the measured sagittal dysplasia indicators, except for ANB Angle.
- The YEN angle was highly reliable and more homogenously distributed cephalometric analysis to assess sagittal discrepancy, followed by W angle and Beta angle.
- Most of the parameters used in the study shared statistically significant correlation amongst themselves. Hence, instead of relying on one single parameter, others parameters should also be checked and should be correlated with clinical findings.

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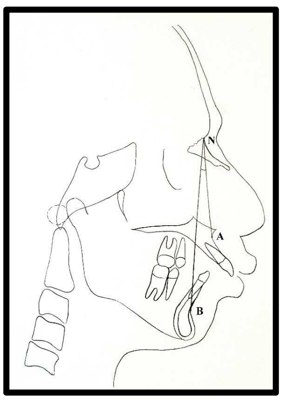


Figure 1: ANB Angle

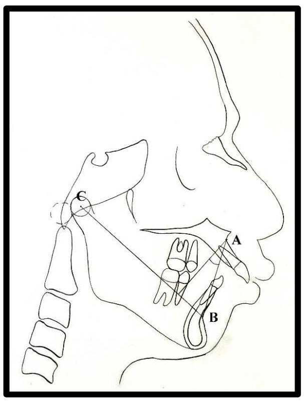


Figure 2: Beta Angle

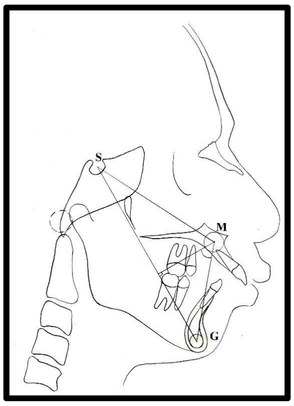


Figure 3: W Angle

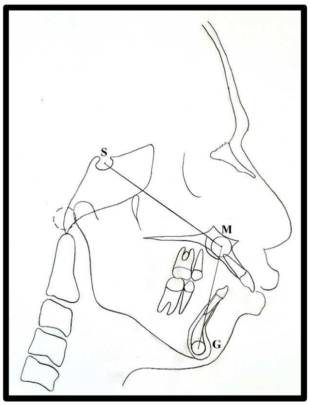


Figure 4: YEN Angle

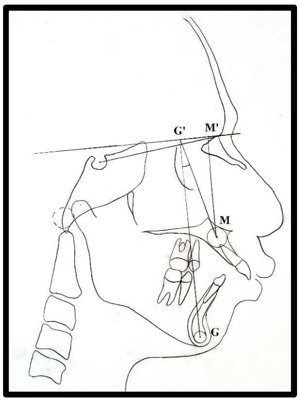


Figure 5: Pi Angle

Table 1: Showing One Way Anova

Variable	Class	N	Mean	Std. Deviation	Minimum	Maximum
w_angle	I	15	55.3333	3.41565	49.00	62.00
	II	15	50.2000	2.00713	48.00	55.00
	III	15	63.1333	4.03320	58.00	73.00
	Total	45	56.2222	6.25187	48.00	73.00
yen_angle	I	15	124.9000	5.87428	119.00	135.00
	II	15	116.9333	4.99238	110.00	128.00
	III	15	136.2667	5.94579	127.00	148.00
	Total	45	126.0333	9.72251	110.00	148.00
pi_angle	I	15	2.7333	3.75531	-1.00	13.00
	II	15	9.2000	5.28407	2.50	25.00
	III	15	-6.2000	4.25021	-13.00	3.00
	Total	45	1.9111	7.73884	-13.00	25.00
ANB_angle	I	15	2.8667	.99043	2.00	4.00
	II	15	6.2000	1.61245	5.00	10.00
	III	15	-3.7333	2.96327	-9.00	1.00
	Total	45	1.7778	4.62154	-9.00	10.00
Beta_angle	I	15	31.9333	3.15021	27.00	35.00
	II	15	24.2667	1.98086	19.00	26.00
	III	15	44.0000	5.39841	38.00	58.00
	Total	45	33.4000	9.00858	19.00	58.00

Table 2: Gender wise Comparison of Mean Values of Different Study Variables Using Student Unpaired T Test

Variables	Gender	N	Mean	SD	S.E.M	Mean Diff	t	P-value

W_angle	Males	19	57.4211	6.57703	1.50887	0.71	1.555	0.92
	Females	26	55.3462	5.97958	1.17269			
Yen_angle	Males	19	126.2368	10.36871	2.37875	0.06	0.068	0.95
	Females	26	125.8846	9.42901	1.84918			
Pi_angle	Males	19	3.9737	8.81362	2.02198	-0.56	-0.458	0.65
	Females	26	1.4038	6.62423	1.29912			
Pi_linear	Males	19	3.9737	8.81362	2.02198	-0.77	0.791	0.43
	Females	26	1.4038	6.48077	1.27098			
ANB_angle	Males	19	2.5789	4.51314	1.03539	-0.15	-0.131	0.01
	Females	26	1.1923	4.69910	.92157			
BETA_angle	Males	19	33.2105	9.13223	2.09508	0.30	0.265	0.79
	Females	26	33.5385	9.09607	1.78389			

- Statistically Significant (P value ≤ 0.05 – statistically significant)

Table 3: Gender wise Comparison of Mean Values of Different Study Variables

Gender	ANB	Beta	YEN	W	Pi angle	Pi linear
Males	2.5789	33.2105	126.2368	57.4211	3.9737	3.9737
Females	1.1923	33.5385	125.8846	55.3462	1.4038	1.4038

Table 4: Range of Measurements of Pooled Group [n=45] with Coefficient of Variability

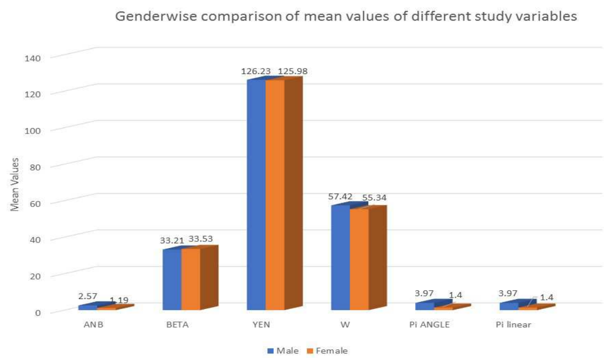
Variables	Mean	SD	Minimum	Maximum	CoV
ANB	1.7778	4.62154	-9.00	10.00	46.60
Beta	33.4000	9.00858	19.00	58.00	26.90
YEN	126.0333	9.72251	110.00	148.00	**7.73**
W	56.2222	6.25187	48.00	73.00	11.18
Pi angle	1.9111	7.73884	-13.00	25.00	30.92
Pi linear	2.4889	7.56899	-12.00	25.00	30.24

Table 5: Correlation Coefficients Between Different Variables using Pearson's Correlation Test

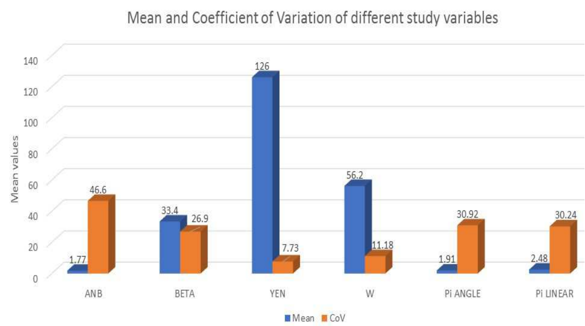
		W_Angle	Yen_Angle	Pi_Angle	Pi_ Linear	ANB_ Angle	Beta_ Angle
w_angle	Pearson Correlation	1	.909**	-.706**	-.612**	-.856**	.922**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	45	45	45	45	45	45
yen_angle	Pearson Correlation	.909**	1	-.757**	-.678**	-.899**	.884**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	45	45	45	45	45	45
pi_angle	Pearson Correlation	-.706**	-.757**	1	.872**	.858**	-.791**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	45	45	45	45	45	45
pi_linear	Pearson Correlation	-.612**	-.678**	.872**	1	.780**	-.717**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	45	45	45	45	45	45
ANB_angle	Pearson Correlation	-.856**	-.899**	.858**	.780**	1	-.902**

	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	45	45	45	45	45	45
Beta_angle	Pearson Correlation	.922**	.884**	-.791**	-.717**	-.902**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	45	45	45	45	45	45

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



Graph 1: Gender Wise Comparison of Mean Values of Different Study Variables



Graph 2: Mean & Coefficient of Variation of Different Study Variables