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RESEARCH ARTICLE

CORRELATION OF VARIOUS CEPHALOMETRIC PARAMETERS FOR THE ASSESSMENT OF SAGITTAL RELATIONSHIP BETWEEN MAXILLA AND MANDIBLE IN NORTH INDIAN POPULATION: A CEPHALOMETRIC STUDY

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ABSTRACT

Aims: The study was aimed to check the correlation of Yen angle with other sagittal discrepancy parameters and to obtain a more reliable and least variable parameter for antero-posterior cephalometric analysis**.** ***Methods and Material****:* The lateral cephalograms of 450 North Indian subjects were obtained and traced for five different sagittal discrepancy parameters. The age of subjects ranged from 18-30 years. ***Statistical analysis****:* ANOVA analysis, t-test and correlation coefficient analysis were done. ***Results:*** Mean values of YEN angle, W angle, BETA angle, ANB angle and WITS appraisal were found to be 120.63±5.55, 53.13±4.21, 27.83±4.97 and 3.07±2.79 respectively. The ANOVA analysis revealed highly significant differences among the means of all the three groups (Group I, II & III). Pearson's correlation coefficient test revealed that YEN angle was correlated with W and BETA angles. ***Conclusions:*** Study revealed that, YEN angle was highly reliable (CV= 4.6) and most homogenously distributed parameter to assess antero-posterior sagittal discrepancy among North Indian population. In addition it could significantly differentiate among the three groups and was highly correlated to W and BETA angle.

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INTRODUCTION

The evaluation of antero-posterior (AP) jaw relationship is an important step in diagnosis and treatment planning of skeletal malocclusions. The earlier method of differentiating various skeletal patterns in patients was to analyze the profile and also by palpating the anterior surface of basal part of the jaws. (Doshi *et al.,* 2012). After the development of lateral cephalograms by Broadbent in 1931, a more precise method of measurement evolved and a more scientific solution for orthodontic problems was formulated. The first cephalometric measurement to evaluate the anteroposterior relationship was introduced by Downs[3] in 1948. He measured the angle formed by AB and NPog and indicated the protrusion of mandible by positive sign and the retrusion of mandible by negative sign.

In 1952 Riedel measured the SNA and SNB angles using nasion as a reference point and used their difference i.e. ANB angle to describe the apical base relationship. In 1975 another parameter for evaluating sagittal discrepancy was introduced by Jacobson[5] called as WITS appraisal and it's an essential part of cephalometric analysis now. In 2004 Baik and Ververidou introduced the BETA angle which indicates the severity and the type of skeletal dysplasia in sagittal dimension. In 2009, Neela *et al.* (2009) introduced the sagittal dysplasia indicator YEN angle based on the landmarks point M (midpoint of anterior maxilla), point G (centre at the bottom of the symphysis), and point S (midpoint of sella turcica) as reference points which forms the YEN angle measured at point M. The other measurement named as W angle was developed by Bhad *et al.* in 2013. All these methods have their own merits and demerits. The present study was aimed to assess the correlation of the various available sagittal discrepancy indicators including YEN angle, W angle, BETA angle, WITS appraisal and ANB angle.

MATERIALS AND METHODS

Pre-treatment standardized digital lateral cephalograms of 450 patients between age groups 18-30 years who had never undergone previous orthodontic treatment were taken in the Department of Oral medicine and Radiology, Saraswati Dental College, Lucknow. The radiographs were taken with the teeth in occlusion and natural head position. Samples for this study consisted of North Indian population who were willing to

undergo orthodontic treatment in the Department of Orthodontic and Dentofacial Orthopedics, Saraswati Dental college, Lucknow. An informed consent was obtained from each of them. All the patients included in the study were born and residents of Uttar Pradesh with age between 18 to 30 years, there was no previous history of Orthodontic treatment, no history of facial trauma, no congenital facial anomaly and no history of facial cosmetic surgery or orthognathic surgery. Those patients having previous history of Orthodontic treatment, or with any cranial or facial malformation, history of craniofacial trauma and with congenital anomaly were excluded from the study. While recording the lateral cephalograms, the patients were placed in Natural head position (Solow and Tallgren, 1971). The Frankfort Horizontal plane was parallel to the floor and the teeth in centric occlusion. All of the cephalograms were recorded with the same exposure parameters (KVP - 80, mA-10 exposure time 0.5 sec) with 100% magnification and the same machine (Kodak 8000C Digital and Panoramic System Cephalometer Rochester). The x-rays were printed using Fujifilm Medical Dry Imaging film (8x10 inches in size) and the Fujifilm Dry pix plus printer. In order to eliminate the magnification errors of lateral cephalographs, a fixed metallic cross of length 2 inch were incorporated in the radiographs. Those cephalographs showing magnification in the measurement of the metallic cross were discarded from the study. These cephalograms were hand traced using a sharp 4H pencil on acetate tracing paper using X- ray viewer. All the relevant structures and landmarks were marked. 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. Various reference points, planes and angles were drawn, and recorded for evaluation. The parameters ANB angle, WITS appraisal, YEN angle, W angle and BETA angle were measured for all the patients to find out the anteroposterior dysplasia. The data were verified and analyzed statistically for the correlation of various sagittal dysplasia indicators were used in this study.

Measured parameters in the study

- Yen angle (Neela *et al.* 2009)
- W angle (Bhad *et al.* 2013)
- BETA angle (Baik & Ververidou 2004)
- ANB angle (Downs, 1948)
- WITS appraisal (Jacobson, 1975)

The pre-treatment lateral cephalograms of the samples selected (n =450) for the study were divided into three groups: Group I – Class I skeletal pattern group, Group II – Class II skeletal pattern group, Group III – Class III skeletal pattern group. To be included in a particular skeletal pattern group, a patient had to have a minimum of three of the five parameters (ANB angle, WITS appraisal, YEN angle, W angle, BETA angle) in favor of a particular group. The following inclusion criteria were taken for class I skeletal pattern group:

- ANB angle of 1° to 3°
- Wits appraisal between 0 and -3mm
- Beta angle between 27° - 35° degrees
- Yen angle between 117° - 123°
- W angle between 51° - 56°
- Pleasant profile.

Inclusion criteria for class II skeletal pattern group:

- ANB of greater than 4 degrees
- Wits appraisal with AO ahead of BO in females or AO coinciding with or ahead of BO in males.
- Beta angle less than 27 degrees
- Yen angle less than 117°
- W-angle less 51°
- Profile had a Class II appearance.

Inclusion criteria for class III skeletal pattern group

- ANB less than 1 degrees
- Wits BO ahead of AO in females or BO ahead of AO by more than 1 mm in males
- Beta angle greater than 35 degrees
- Yen angle more than 123°
- W angle more than 56°
- Profile had a Class III appearance.

Statistical Analysis: After collection and tabulation, the data were analyzed by using software SPSS 16.0 version (Chicago, Inc., USA). The statistical methods employed in the present study were:

- For reliability analysis, 50 randomly selected cephalograms were compared using Dahlberg's error analysis.
- Mean, standard deviation, maximum and minimum values were calculated.
- Independent't' test was applied to find out the significant differences for measurements between male and female sample.
- Coefficient of variability was calculated.
- Correlation coefficients between various parameters were calculated using Pearson's correlation coefficient.

RESULTS

The statistical analysis to check the error between repeated measurements, Dahlberg's[10] error analysis was done and it suggested that for all the parameters the error was well below the acceptable criteria of 0.5mm.

Figure 1.

Table 1 shows that YEN angle, W angle and WITS was significantly ($p<0.05$) higher among males compared to females. The coefficient of variability of all parameters is presented in table 2. According to it the measurement with most homogeneous distribution in the group were YEN angle (CV=4.6) followed by W angle, BETA angle, WITS and ANB angle.

Table 1. Comparison of various study parameters with gender

Parameters	Male	Female	p-value[1]
YEN angle	122.74±4.84	119.71±5.59	0.001*
W angle	54.04±4.57	52.73±3.99	0.002*
BETA angle	27.45±5.27	28.00±4.84	0.28
WITS	3.54±2.74	2.86±2.79	0.01*
ANB	4.01±2.26	4.51±2.57	0.06

[1]Unpaired t-test, *Significant

Table 2. Distribution of various study parameters

Parameters	Mean ± SD	Minimum	Maximum	CV %
YEN angle	120.63±5.5	107	134	4.6
W angle	53.13±4.21	27	63	7.9
BETA angle	27.83±4.97	12	42	17.9
WITS	3.07±2.79	-3	11	90.9
ANB	4.36±2.49	-3	12	57.1

Table 3. Mean, Standard Deviation and p- Value for the three groups

Study parameters	Groups	Mean	SD	p-value[1]
YEN angle	I	120.26	1.94	0.0001*
	II	113.16	2.62	
	III	127.06	2.76	
W angle	I	53.57	1.56	0.0001*
	II	47.76	3.28	
	III	58.40	1.36	
BETA angle	I	30.12	2.19	0.0001*
	II	22.53	3.31	
	III	37.57	1.70	
WITS	I	0.84	1.06	0.0001*
	II	5.20	1.83	
	III	-2.12	0.34	
ANB	I	2.28	0.68	0.0001*
	II	5.83	1.69	
	III	-0.57	0.99	

ANOVA test, *Significant

Table 4. Correlation of YEN angle with various study parameters

Parameters	Correlation coefficient	p-value
	YEN angle	
W angle	0.71	0.0001*
BETA angle	0.57	0.0001*
WITS	-0.56	0.0001*
ANB	-0.75	0.0001*

*Significant

The mean values of the different parameters in this study i.e. YEN angle, W angle, BETA angle, WITS and ANB were 120.63±5.55, 53.13±4.21, 27.83±4.97, 3.07±2.79 and 4.36±2.49 respectively. Table 3 shows the mean, standard deviation and p value for each parameter. ANOVA analysis was performed and highly significant differences were found in Beta angle, Yen angle, W-angle, Wits and ANB in all the three groups (Group I, Group II, and Group III). A statistically significant positive correlation between YEN angle and angles like W angle, BETA angle was observed. A significant negative correlation was found between YEN angle with WITS and ANB angle.

DISCUSSION

Many angular and linear measurements have been devised till date for sagittal dysplasia. This study correlates an important measurement, the YEN angle used for evaluating the sagittal jaws relationship with other anteroposterior dysplasia indicators like ANB angle, WITS appraisal, BETA angle and W-angle in North Indian Population. The YEN angle was introduced by Neela *et al.* (2009) in the Department of Orthodontics, Yenepoya dental college Mangalore. The mean age of patients in this study was 20.69+/- 2.62 years ranging from 18 to 30 years. In our study the unpaired t-test for comparing various parameters with gender showed that the YEN angle, W angle and WITS were significantly ($p<0.05$) higher among males compared to females. However there were no statistically significant difference between the mean BETA and ANB angle values of males and females in the present study. So the present study concluded that sex differentiation affects YEN angle, W angle and WITS appraisal in North Indian population. The mean and SD values of YEN angle (120.63° ± 5.55) and W angle (53.13° ± 4.21) in this study were found to be similar to the original values given by Neela *et al.* (2009)[7] i.e., 119.79° ± 3.575 and that of Bhad *et al.* (2013)[8] i.e., 54.5° ± 4.09. These findings correlate with that of Mittal *et al.* (2016)[11] and Kapadia *et al.* (2017)[12]but not correlating with that of the values derived by Polina *et al.* (2013)[13] in Andhra population and Wani *et al.* (2017)[14] among the Maratha ethnic population. The mean value of Beta angle was found to be 27.83+/-4.97 which was lesser than the original values of 30.1+/- 3.0 by Baik & Ververidou (2004). The variability might be due to racial variation. This was similar to Prasad *et al.* (2013) but dislikes with that of Agarwal *et al.* (1980).

The mean value of WITS was recorded was (3.07±2.79) higher than the values measured by Jarvinen (1988) (−0.6 mm ± 2.9), Jacobson (1975)[5] (1.07 ± 1.77), Robertson and Pearson (1980) [18] (0.30± 1.9), Richardson (1982) (−0.32 ± 2.81). However higher values of WITS were derived by Hurmerinta *et al.* (1997), Sherman SL (1988), Oktay HA (1991), Polina *et al.* (2013), Mittal *et al.* (2015), Ishikawa *et al.* (2000)[23] in their studies. The mean value for ANB angle was 4.36± 2.49 in this study and it was found to be correlating with findings of Hussels and Nanda (1984) who showed mean ANB values of 4.5°. The study conducted by Walker and Kowalski (1971)[25] also mentioned mean ANB value of 4.5. The measurement of ANB angle was not correlating with the studies conducted by Doshi *et al.* (2012), Mittal *et al.* (2015), Aparna *et al.* (2015), Atul *et al.* (2018). The greatest coefficient of variability (CV) was observed for WITS appraisal (90.9%). YEN angle exhibited the lowest CV (CV = 4.6) in comparison to all other measurements indicating it to be more reliable compared to other parameters. This was correlated with Doshi *et al.* (2012). W angle had the second lowest CV (7.9) indicating that it was the second most homogeneously distributed parameter. This finding was correlated to that obtained by Bhad *et al.* (2013).

The correlation among all the five parameters were calculated and it's shown that there were significant correlation ($p<0.001$) with each other, suggesting that all the five parameters can be successfully used in assessing the sagittal jaw discrepancy. The YEN angle showed a good positive correlation with W angle ($r = 0.71$ and $r^2 = 0.51$.) and with BETA angle ($r = 0.57$, and $r^2 = 0.33$). This finding also correlates with that of Mittal *et al.* (2015)[11] ($r = 0.735$), Trivedi *et al.* (2015)[28] ($r = 0.894$) and

Kapadia *et al.* (2017). However the present study derived a weak negative correlation of YEN angle with ANB angle and WITS appraisal with 'r' values of – 0.75 and – 0.56 respectively. This was contradicting the findings of Mittal *et al.* (2015)[11] but correlates with that of Trivedi *et al.* (2015). All the parameters analyzed in this study ie YEN angle, W angle, BETA angle, WITS and ANB angle were statistically significant ($p < 0.001$) among three skeletal groups. So these parameters can clearly differentiate the different skeletal pattern of the patients. The YEN angle showed better performance among the different sagittal dysplasia indicators analyzed in this study. This is because YEN angle depend on stable points S midpoint of sella turcica, M- midpoint of pre-maxilla and G- center of largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphysis and so it was not influenced by growth changes and can easily be used in mixed dentition. The geometry of the W angle also had the advantage to remain relatively stable even when the jaws were rotated or growing vertically. The configuration of the Beta angle gives it the advantage to remain relatively stable even when the jaws are rotated.

The values of WITS appraisal do not remain stable throughout the growth period. The readings were not entirely dependent upon the relative sagittal movements of points A and B. They also showed that any change in the angulation of the functional occlusal plane may profoundly influence the positions of points A and B relative to that plane, and therefore to the value of the WITS appraisal. ANB might be giving erroneous results due to rotation of jaws or the spatial position of point N, upward or downward rotation of the Sella- Nasion plane, the age of the patient, the relation of Sella- Nasion plane to the occlusal plane. Additional studies should be undertaken amongst various populations groups for checking these findings. A single cephalometric analysis might not be providing an accurate diagnosis due to the large variability in human population. The cephalometrics has its own limitations also. So relying on any one cephalometric parameter may mislead to inappropriate diagnosis. So multiple analyses should be considered before arriving to a definitive diagnosis. This study was done on North Indian population; further studies can be done for different ethnicities and also with more than one operator to avoid bias.

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and B. They also showed that any change in the angulation of the functional occlusal plane may profoundly influence the positions of points A and B relative to that plane, and therefore to the value of the WITS appraisal. ANB might be giving erroneous results due to rotation of jaws or the spatial position of point N, upward or downward rotation of the Sella- Nasion plane, the age of the patient, the relation of Sella- Nasion plane to the occlusal plane. Additional studies should be undertaken amongst various populations groups for checking these findings. A single cephalometric analysis might not be providing an accurate diagnosis due to the large variability in human population. The cephalometrics has its own limitations also. So relying on any one cephalometric parameter may mislead to inappropriate diagnosis. So multiple analyses should be considered before arriving to a definitive diagnosis. This study was done on North Indian population; further studies can be done for different ethnicities and also with more than one operator to avoid bias.

Conclusion

The following conclusions can be drawn from our study:

- YEN angle showed positive correlation W angle and BETA angle but negatively correlated with ANB angle and WITS appraisal.
- The YEN angle was found to be the most homogenously distributed parameter to assess the antero-posterior dysplasia.
- This study revealed that all the five parameters can be used as valuable tool for assessing the different skeletal patterns and can be implemented for orthodontic diagnosis and treatment planning in subjects residing in North India

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