Evaluating the Effect of (W) Angle and ANB Angle in the Assessment of Anterioposterior Jaw Relationship and their correlation to gonial angle

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الخلاصة

الاهداف :يهدف البحث الى تقييم تاثير زاوية (w) , زاوية (ANB) وزاوية الركينة في تقييم خلل التنسج الفكي الامامي الخلفي وعلاقته بهذه الزوايا للمرضى من الاطباق الفكي للنوع الاول والثاني والثالث **المواد وطرائق العمل** : تكونت العينة من ١٢٠ مريضا تراوحت اعمارهم بين (١٨-٣٠ سنة) ذكورا واناثا من مركز مدينة الموصل تطابقوا مع متطلبات العينة للاطباق من النوع الاول والثاني والثالث قسموا الى ثلاثة مجاميع ، ٤٠% كانوا ذكورا(٤٨ حالة) و٦٠% اناثا (٧٢ حالة) ، ٤٠ حالة لكل مجموعة ،مع انجاز تحليلات قياسات الراس وقياسات الزوايا **النتائج:**معدل قيمة الزاوية الركينة للاطباق من النوع الاول ١٢٦.٢٤±٠.٧٧° للاطباق من النوع الثاني ١٢٣.٤٢±٠.٨٦° للاطباق من النوع الثالث ١٢٧.٥٣±٠.٨٦° ، قيمة زاوية (W) للاطباق من النوع الاول هو ٥٣.٩٥٣±٠.٣٠٩° للاطباق من النوع الثاني ٤٨.٧٨±١.٢٩° وللاطباق من النوع الثالث ٦٠.٩٦±٣.٠٠° اما قيمة زاوية (ANB) للاطباق من النوع الاول هو ٢.٧١±٠.١٥٥° للاطباق من النوع الثاني ٥.٨٢±٠.٤٣١° وللاطباق من النوع الثالث -٣.١٨٢±٠.٢٤١°، وجود اختلاف معنوي كبير عند المقارنة بين جميع المتغيرات لكل انواع الاطباق عند قيمة معنوية P<٠.٠٥ . معامل ارتباط برايسون بين المتغيرات في الاطباق من النوع الاول يوضح علاقة ضعيفة موجبة غير معنوية بين مقدار زاوية (W) مع زاوية (ANB)بينما علاقة ضعيفة سالبة غير معنوية بين زاوية الركينة وزاويتي (ANB) و (W). الاطباق من النوع الثاني عند مقارنة قيمة زاوية (W) مع زاويتي (ANB) والزاوية الركينة يوضح وجود علاقة ضعيفة موجبة غير معنوية على الطرف الاخر يوجد علاقة ضعيفة سالبة غير معنوية عند مقارنة قيمة زاوية (ANB)مع الزاوية الركينة .للاطباق من النوع الثالث عند مقارنة قيمة زاوية (W) مع قيم زوايا (ANB) والزاوية الركينة يوضح وجود ارتباط غيرمعنوي سالب ضعيف على الجهة الاخرى يوجد ارتباط ضعيف غير معنوي عند مقارنة قيمة (ANB) مع قيمة الزاوية الركينة **الاستنتاجات:** لا يمكن لاي من المتغيرات ان يعتمد الاكثر ملائمة والاكثر حقيقة لتحديد الخلل في التنسج الفكي الامامي الخلفي ويجب ان نعتمد على خطوط وزوايا اخرى في كل المستويات الثلاثية الابعاد لنصل الى التشخيص الصحيح وخطة العلاج.

ABSTRACT

Aims: to evaluate the accuracy of W angle, ANB angle and gonial angle in assessing anterio-posterior jaw dysplasia and the correlation between them in class I , II, III patients. **Materials and Methods:** one hundred twenty patients (18-30) years of male and female from the center of Mosul City that met the criteria of the sample with class I, II, and III, the sample was divided into 3 groups The: 40% was male (48 cases) and 60 % was female (72 cases). Three groups 40 cases were distributed for each one of class I, II, III. Cephalometric analysis and measurement of angles were done .**Results:** the mean value of gonial angle for class I was 126.24±0.77° , class II cases was 123.42±0.86° and the class III cases was 127.53±0.98°;the mean value of W angle for class I was 53.953±0.309° , for class II was 48.78±1.29° and for class III was 60.96±3.00; 3; the mean value of ANB angle for class I was 2.71±0.155° , class II was 5.82±0.431°and for the class III was -3.182±0.241.The comparison between all variables in all classes showed highly significant differences at p<0.05 Pearson correlation coefficient test between parameters in class I, revealed weak positive non-significant correlation between W angle value and ANB angle value while showed weak negative non-significant correlation between gonial angle value with ANB and W angles value in class II when comparing the values of, W angle with the values of gonial angle. ANB angles revealed a weak positive non- significant correlation. On the other side, there is a weak negative non-significant correlation when comparing ANB angle value with gonial angle value; in class III when comparing the values of, W angle with gonial and ANB angles rervealed a weak negative non- significant correlation on the other side, there is a weak positive non-significant correlation when comparing ANB angle value with gonial angle value. **Conclusions:** none of the parameters can be considered as the most appropriate and reliable one for determining the anteroposterior dysplasia and must be considered other lines and angles in all 3 plane of space to reach accurate diagnosis and treatment planning.
Key words: W angle, ANB angle, cephalometric

INTRODUTION

The strategy for successful orthodontic treatment is an accurate diagnosis and treatment planning, any inexactness in diagnosis result in unaccepted results which will aggravate both the orthodontist and most importantly the patients [1] (Pervez & Ahmed, 2014). Cephalometric analysis consumes both angular and linear measurements to analyze skeletal sagittal jaw relationship; various parameters are obtainable to calculate the sagittal relationship, but none can be universally applied with dependability, each one of them had its draw backs [2] (Mittal et al, 2016).

W angle is a valuable sagittal parameter in skeletal patterns with clockwise or counterclockwise rotation of the jaws as well as during transitional period when vertical facial growth is going on [3] (Sharma et al, 2015). W-angle has been established by [4] Bhad et al. (2013). It does not depend on any unstable landmarks or dental occlusion and would be especially precious to judge true sagittal changes because of the growth and orthodontic treatment; beside that W angle matches closely to ANB, Wits and beta angle, it is not subjective by the confounding factors that affect angle ANB in specific incisor angulations[4].

W angle is that it can be a precious implement for planning orthopedic or an orthognathic procedure as this angle is independent of cranial base length; As Cranial base length (position of point N) can sometimes camouflage true skeletal classes I, II, and III patterns [1].

Gonial angle (GA) on lateral cephalometric radiography (LCR) denotes mandibular morphology with respect to the mandibular ramus and mandibular body and is important in predicting growth [5]. The gonial angle can also be an accessible implement in age assessment in great situations like mass disaster, remains of human dead disclosed and murderous mutilations, missing individuals [6]. There is a downward and backward rotation (high mandibular angle), in the other word there is upward and forward direction of the growth (low mandibular angle) ,so that Gonial angle was considered as one of the most important angles for shaping orthodontic or surgical policies in a patient [7]. Gonial angle is a common factor used to describe orthodontic extractions [8]. Gonial angle was drawn by a line on the posterior border of the ramus and the lower border of the body of the mandible

[9]. There is a correlation of Ramus Height, Gonial Angle, and dental height with Different Facial Forms [10]. ANB, wits appraisal, Beta angle, Yen angle and W angle all show a significant correlation with each other [11].The aims of present study was to evaluate the accuracy of W angle, ANB angle and gonial angle in assessing anterio-posterior jaw dysplasia and the correlation between them in class I , II, III patients .

MATERIALS AND METHODS

Study was done on patients visiting the Department of P.O.P, College of Dentistry, Mosul University and after obtaining ethical committee approval of the sample, all patients have complete permanent dentition including 2nd molar with age group ranging from 18-30 years old were examined clinically (male and female) with Class I, Class II, and Class III malocclusion, all the sample selected was referred to liberty private dental clinics for taking cephalogram. (135) patient out of total (290) patient examined were selected for cephalogram taking who had never been submitted to any previous orthodontic treatment.

One hundred twenty patients were fit with the criteria of the study; cases were excluded due to the poor quality of cephalometric radiograph or failure to communicate with the patients. The selected cases were divided into 3 groups: 40% were male (48 cases) and 60 % were female (72 cases). Three groups 40 cases for each one of class I, II, III were classified.

Inclusion criteria

1 - Class I skeletal dysplasia:

(1) ANB angle of 2° to 4° (Riedel, 1952) [12]

(2) Beta angle between 27º to 35º and clinically a pleasant (almost

Straight) profile (Baik and Ververidou, 2004) [13]

B - Class II skeletal dysplasia:

(1) The ANB angle was above 4° (Riedel, 1952)

(2) Beta angle less than 27° (Baik and Ververidou, 2004).

C – Class III skeletal dysplasia:

(1) ANB less than 2° (Riedel, 1952)

(2) Beta angle more than 35° (Baik and Ververidou, 2004).

2.-Molar and canine relation:

A. bilateral Class I molar and canine relationship for Class I sample. [14]

B. bilateral Class II molar relationship for Class II sample ([14]

C. bilateral Class III molar relationshipfor Class III sample [14]

3- Incisal relation:

A. Normal overbite and overjet (2 – 4) mm for Class I sample. [15]

Overjet between 0 and 1 mm was excluded.

B. Class II incisal relationship with overjet more than 5 mm. [16]

Overjet between 4 and 5 mm was excluded.

C. Class III incisal relationship, edge to edge incisor relation [17,] and

Negative overjet cases were included in this study. [18]

*No congenital missing, cleft or any other congenital craniofacial problems.

*Good medical history, all subjects are Iraqi in origin and live in Mosul City.

Patients attended orthodontic department in P.O.P department seeking orthodontic treatment in the orthodontic clinic each patient was amine to exclude any craniofacial anomalies or asymmetry, check for handiness of full dentition also information was taken from the patient to except any history of orthodontic treatment or orthognathic surgery, then initial classification of the sagittal skeletal malocclusion was done based on Foster method (Two Finger method) (Foster ,1990)[18] , the patient was seated on dental chair in an upright position, the patient instructed to look forward with the Frankfort plane parallel with the floor then The fore finger of the examiner placed at a point corresponding to the point A & middle finger placed at a point corresponding to the point B. In skeletal bases

1-Class I case: The fore finger was slightly ahead (2-3 mm) of the middle finger or the hand at an even level

2-Class II case – The fore finger was considerably ahead of the middle finger, and the hand pointed upward.

3-Class III case – The middle finger was ahead of the fore finger, and the hand pointed downward.

The lateral cephalometric radiographs were taken for subject under standardized condition. [18] Each cephalogram was taken in centric occlusion for subject with lips in relaxed position [19]. After obtaining the radiographs, they were imported and analyzed using the software program [Easy Dent 4, software version: 4,14,1 (2012)] then the cephalometric points, planes were determined and the measurements were obtained by the researcher using the same software program. The following cephalometric points, planes and landmarks were first identified on the lateral cephalogram:

S: The midpoint of the pituitary fossa (sella turcica).

M: midpoint of the premaxilla, by drawing largest circle in the premaxilla that is tangent to the anterior and superior walls of the premaxilla and the midpoint of the circle was identified.

G: Centre of the largest circle that is tangent to the internal inferior, anterior and posterior surfaces of the mandibular symphysis

Point A: The deepest midline point on the premaxilla between the anterior nasal spine

and prosthion, near the apex of the central incisor root.

Point B: The deepest midline point of the bony curvature of the mandible.

(N) Nasion: The most anterior point in the frontonasal suture.

(Co) condylion: the midpoint of the condyle.

Ar: the midpoint of intersection of the external dorsal contours of the articular process of the mandible and the temporal bone

Go: the most posterior inferior point on the outline of the angle of the mandible.

(Me) Menton: the most inferior point of the mandibular symphysis in the midsagittal plane.

Line connecting **S** and **M** points.

Line connecting **M** and **G** points.

Line connecting **S** and **G** points.

Line from point M perpendicular to the **S – G** line.

Finally, measuring the **W angle**, this is the angle between the perpendicular line from point M to S – G line and the M – G line.

Line connecting **Ar** and **Go** points.

Line connecting **Go** and **Me** points.

Finally, measuring the **Gonial angle**, this is

the angle between the perpendicular lines from point Ar – Go, Go- Me line.

W angle:

After sample classification, W angle was constructed and measured. First, three points were located: Point S (midpoint of the sella turcica), Point M (midpoint of the premaxilla) was identified by drawing largest circle in the premaxilla and the midpoint of the circle was identified, Point G (centre of the largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphysis). After identifying these points, four lines were drawn: S-M line connecting S and M points, M- G line connecting M and G points, S-G line connecting S and G points. A perpendicular was drawn from point M on S – G line. W angle was measured which is the angle between the perpendicular line from point M to S – G line and the M – G line, according to Bhad et al [4] .(Figure 1)

Gonial angle:

Is done by draw a tangent on the posterior border of the ramus of the mandible and join it with another line passing through the point's gonion and gnathion [20]. (Figure 2)
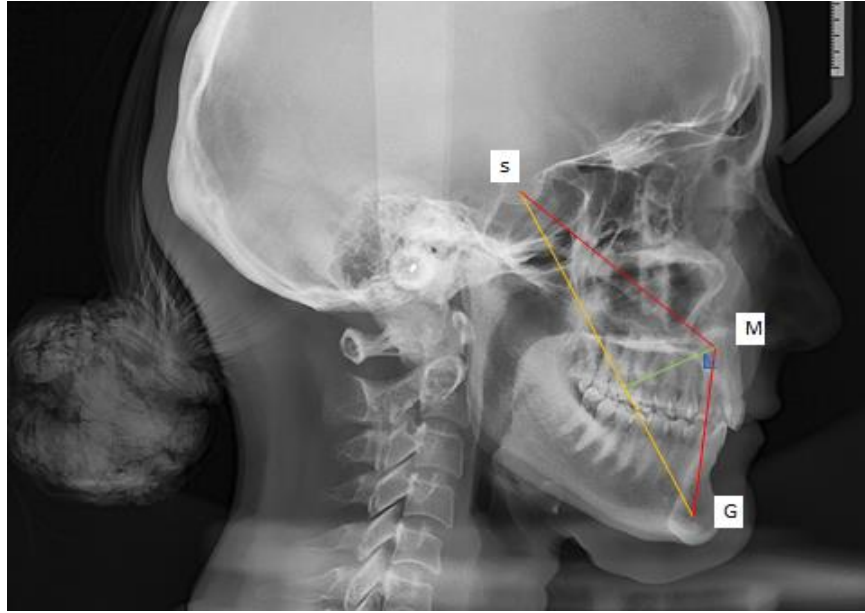
(Figure 1):W angle on cephalometric analysis (blue arrow)
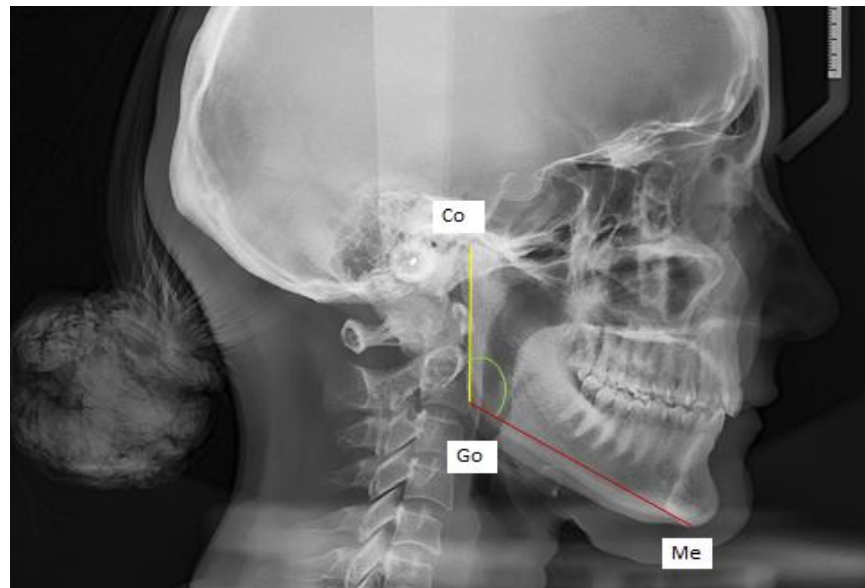
(Figure 2): gonial angle on cephalometric analysis

ANB angle:

This angle is identified by drawing two lines: N-A line, a line drawn from

N point (Nasion) to the point A, another line drawn from N (Nasion) to point B. The

angle between N-A and N-B lines is the ANB angle [12].

Then the angle was measured, if the angle was between 2-4 degree and indicating CL I

malocclusion, if the ANB angle was more than 4 degree the case considered CL II malocclusion, in case the ANB angle was less than 2 degrees this indicates a CL III malocclusion. (Figure 3).

(Figure3) : ANB angle on cephalometric analysis

RESULTS

Descriptive statistics: Table (1)

Table (1) Descriptive statistics of W angle, ANB angle, and GoniaL angle

Variable	Class type	Number	Mean	SD	Min	Maxi
W angle	Class I	40	53.953	0.309	52.9	54.29
	Class II	40	48.78	1.29	46.55	51.87
	Class III	40	60.96	3.00	57.0	70
Gonial angle	Class I	40	126.24	0.77	124.11	127.90
	Class II	40	123.42	0.86	122.02	126.70
	Class III	40	127.53	0.98	125.11	128.99
ANB angle	Class I	40	2.71	0.155	2.41	3.0
	Class II	40	5.82	0.431	4.89	6.91
	Class III	40	-3.182	0.241	-3.89	-2.57

1. Gonial angle: the mean value±SD of gonial angle for class I was 126.24±0.77° with minimum value 124.11°,maximum value was 127.90°,for the class II cases the mean value±SD of gonial angle was 123.42±0.86° with minimum value

122.02° and maximum value was 126.70°while for the class III cases the mean value±SD for the gonial angle was 127.53±0.98° with minimum value 125.11° and maximum value was 128.99°

2. W angle : the value±SD of W angle for class I was 53.953±0.309° with minimum value 52.9°,maximum value was 54.29°and for the class II the mean value±SD was 48.78±1.29° with minimum value 46.55° and maximum value was 51.87°while for the class III the mean value of W angle was 60.96±3.00 with minimum value of 57.0°and maximum value of 70°

3. ANB angle: the mean value± SD of ANB angle for class I was 2.71±0.155° with minimum value 2.41°, maximum value was 3.0°and for the class II the mean value±SD was 5.82±0.431° with minimum value 4.89° and maximum value was 6.91°, while for the class III the mean value±SD of ANB angle was -3.182±0.241° with minimum value of -3.89°and maximum value of -2.57°. Table (2) showed ANOVA and post-hoc (LSD) test when comparing gonial angle ,W angle and ANB angle in class I ,II, and III they were all highly significant differences (p ≤ 0.001)

Table (2) ANOVA and Post-hoc (LSD) test when comparing gonial angle, W angle and ANB angle

Variables	Classes	NO.	Mean±SD	P value	F value	Duncan's group
Gonial angle	class I	40	126.24±0.77			A
	class II	40	123.42±0.86	0.000	229.31	B
	class III	40	127.53±0.98			C
W angle	class I	40	53.95±0.309			A
	class II	40	48.783±1.29	0.000	414.89	B
	class III	40	60.96±3.00			C
ANB angle	class I	40	2.71±0.155			A
	class II	40	5.82±0.4317	0.000	9342.18	B
	class III	40	-3.18±0.241			C

Inferential Statistics that describe the Pearson correlation coefficient test between parameters in the study groups in class I when comparing the three variables, revealed weak positive non-significant correlation between ANB angle value and W angle value (r= 0.059&P= 0.719) while show weak negative non-significant correlation when comparing the ANB angle value with gonial angle value(r= -0.108&P=

0.508).When comparing the value of W angle with value of gonial angle there was a weak negative non-significant correlation between them(r = − 0.15&P 0.354). (Table 3).

Table (3) Correlation Between the Study Parameters in Class I Patients.

Variable	ANB angle		W angle		Gonial angle	
ANB angle	r(*)		r	0.059	r	-0.108
	P		P	0.719	P	0.508
	N		N	40	N	40
W angle	R	0.059	r		r	-0.150
	P	0.719	P		P	0.354
	N	40			N	40
Gonial angle	R	-0.108	r	-0.150	r	
	P	0.508	P	0.354	P	
	N	40	N	40	N	

(r)* Pearson Correlation Coefficient

In class II cases, the Pearson correlation coefficient comparison between the variables showed that when comparing the values of ANB angle and the W angle value a weak positive non- significant correlation between them(r=0.58&P=0.721). On the other side there is a weak negative non-significant correlation when comparing ANB angle value with gonial angle value(r=-0.169&P=0.298), while when comparing the gonial angle value with W angle value there is a weak positive non-significant correlation between them (r=0.295 & P=0.064) Table (4)

Table (4) :Correlation between the study Parameters in class II Patient

Variable	ANB angle		W angle		Gonial angle	
ANB angle	r(*)		r	0.058	r	-0.169
	P		P	0.721	P	0.298
	N		N	40	N	40
W angle	r	0.058	r		r	-0.295
	P	0.721	P		P	0.064
	N	40			N	40
Gonial angle	r	-0.169	r	-0.295	r	
	P	0.298	P	0.064	P	
	N	40	N	40	N	

(r)* Pearson Correlation Coefficient

In class III cases the Pearson correlation coefficient revealed a weak negative non- significant correlation between ANB angle, and W angle (r= -0.0169&P=0.27), beside that there was a weak positive non- significant correlation between the values of ANB angle and the gonial angle(r=0.025&P=0.0408) ,while when comparing the values of W angle and the gonial angle there was a weak negative non-significant correlation between them (r=-0.139 & P=0.394) Table(5).

Table (5): Correlation between the Study Parameters in Class III Patients

Variable	ANB angle		W angle		Gonial angle	
ANB angle	r(*)		r	-0.169	r	-0.025
	P		P	0.27	P	0.408
	N		N	40	N	40
W angle	r	-0.169	r		r	-0.139
	P	0.27	P		P	0.394
	N	40			N	40
Gonial angle	r	-0.025	r	-0.139	r	
	P	0.408	P	0.394	P	
	N	40	N	40	N	

(r)* Pearson Correlation Coefficient

DISCUSSION

The evaluation of anterio-posterior jaw relationship is an obligatory role in orthodontic diagnosis and treatment planning and this step is essentially to be done by cephalometric analysis [1].

Various linear and angular measurements can be used to assess sagittal jaw relationship and none of them can be applied with maximum reliability [21].Because these parameters can be affected by any changes in facial height, jaw inclination, total jaw prognathism and inclination in references lines [22].Thus the use of functional occlusal plane in analysis termed as Wits appraisal may solve the problem [23]

To overcome these difficulties the W angle was produced. Therefore, this study attempted to analyze ANB angle, gonial angle variation which was widely used as proposed cephalometric parameters to indicate the sagittal jaw relationship in Class I, Class II and Class III malocclusions and also to compare W angle with those parameters in assessment of sagittal jaw discrepancy.

The ANB angle was developed by Riedel in 1952[12]. Till now it is considered the most popular and widely used method; jaw rotation due to orthodontic treatment or growth have an effect on ANB reading in addition any displacement in point N have an influence on ANB value [12]. When using ANB angle many factors like patient age and the length of anterior cranial base should be deliberated which makes the explanation of this angle much more complex [23]. The value of ANB angle in the present study agree with the study results obtained by Mittal et al.[25]. Regarding the class I, III with minimal differences regarding class II may be due to the fact that the use of true horizontal plane passing through Nasion that during the growth period this point move upwards and forwards more in class II cases [24].

The values of W angle in this study is near to that of Bhad et al [4], and Mittal et al [25] with a minimal variations that might be due to differences in size of the sample and ethnic group. The present study showed that W angle values were statistically highly significant (p ≤0.001) among the groups. This agrees with Bhad et al [4] study who suggested that this angle is a pointer for sagittal skeletal dysplasia.

The geometry of the W angle provides the advantage to remain relatively stable even when the jaws are rotated or growing vertically as it uses three stable landmarks: point S, point M, and point G and the angle is measured between a perpendicular line from point M to the SG line and M-G line, thus the W angle remains relatively stable even when the jaws are rotated or growing vertically this is because of rotation of the S-G line along with jaw rotation, which transfers the perpendicular from point M with it Bhad et al [4]. Therefore, measurement of W angle is useful as a sagittal parameter in skeletal patterns with clockwise or counterclockwise rotation of the jaws in addition during transitional period when vertical facial growth is proceeding [3].

The gonial angle (Ar-Go-Me) values were significantly higher in class III which result from increase in the real length of the mandibule causing an increase in the angle the result of the current study agree with result obtained by Gasgoos et al. [26]. Beside that there is a significant difference in the means of gonial angle among class I, II, and III.

The correlation between the study parameters in class I cases showed weak positive non-significant correlation (r<0.4) between the W angle and ANB angle beside weak negative non- significant correlation between the gonial angle with W angle, and ANB angle. Also the gonial angle was found to be the least variable parameter this is due to the fact that gonial angle determination is so difficult accurately on cephalometric

radiograph in addition, it can be easily affected by the cant of occlusal plane and vertical dimension of the jaws [4] .The current study disagree with result obtain by Sharma et al. [3]. That shows that W angle value was the least variable parameter and disagreed with Pervez and Ahmed [1] study which shows strong negative correlation between W angle and ANB angle in CL I malocclusion.

The correlation coefficient of study parameters in class II cases showed that there is a positive weak non-significant correlation between the ANB and W angles and a negative weak non-significant correlation between the gonial angle with both W and ANB angles, this disagree with study conducted by Sharma et.al [3] and Pervez & Ahmed [1] that demonstrate a significant negative correlation between the ANB and W angles.

The correlation coefficient of study parameters demonstrates that weak negative non-significant correlation between the gonial angle and both ANB, W angles. And weak negative non-significant correlation between the W and ANB angles. The current study results disagree with the result obtained by Mittal et.al.[25] that shows negative correlation between ANB and W angles with no correlation coefficient with other variables also there is a disagreement with the result obtained by Pervez & Ahmed [1] that show significant negative correlation

coefficient between the W angle and ANB angles.

All the variation in the results might be related as mentioned previously due to ethic group differences, size of the samples, and accuracy in determining parameters. According to the results we conclude that none of the parameters can be considered as the most appropriate and reliable one for determining the anteroposterior dysplasia and must be considered other lines and angles in all 3 plane of space to reach accurate diagnosis and treatment planning.

REFERENCES

1. Pervez H & Ahmed I. A new cephalometric tool W angle in the evaluation of anteroposterior skeletal discrepancy in orthodonticpatient. *Int. J. D. H. S*. 2014; 1(3):299-304

2. Mittal A, Bohra S, Murali PS,Saidath K & Krishnanayak US.An evaluation of YEN and W angle in the assessment of anteroposterior jaw relationship. *J. of Indian Orthodontic Society*.2016; 50(1): 26.

3. Sharma R, Sharma K, Mathur A, Preethi N, Agarwal V, Singh S & Satija N. Comparison of W Angle with Different Angular and Linear Measurements in Assessment of Sagittal Skeletal Relationship inClass I and Class II Patients in Jaipur Population-A

Cephalometric Study. *OHDM*.2015; 14(3): 155-60.

4. Bhad WA, Nayak S, Doshi UH (2013). A new approach of assessing sagittal dysplasia: the W angle. *Eur. J. Orthodontics.2013; 35*(1): 66-70.

5. Akcam MO, Altiok T, Ozdiler E .panoramic radiographs: a tool for investigating skeletal pattern. *Am J Orthod Dentofacial thop*.2003; 123, 175-181.

6. Shahabi M, Ramazanzadeh BA, Mokhber N. Comparison between the external gonial angle in panoramic radiographs and lateral cephalograms of adult patients with class I malocclusion.*J Oral Sci*.2009;51: 4259.

7. Xiao D, Gao H, Ren Y. Craniofacial morphological characteristics of Chinese adults with normal occlusion and different skeletal divergence. *Eur J Orthod*.2011; 33:198-204.

8. Kitai N, Mukai Y, Murabayashi M, Kawabata A, Washino K, Mat-suoka M, Shimizu I, Katsumata A. Measurement accuracy with a new dental panoramic radiographic technique based on tomosynthesis. *Angle Orthod.* 2013 Jan; 83(1):117-26

9. Dahan J and H. J. Jesdinsky. Die bewertung des orthopantomogramms fur kephalometrische untersuchungen in der kieferorthopadie Stoma 1968; 21:126-38.

10. Ahila SC, Sasikala C, Kumar BM, Tah R, Abinaya K. Evaluation of the Correlation of Ramus Height, Gonial Angle, and Dental Height with Different Facial Forms in Individuals with Deep Bite Disorders. *Ann Med Health Sci Res*.2016; 6(4):232-238.

11. Sumit Bohra, Priyanka Subhash Udeshi, Suraj Prasad Sinha, K Saidath, K Prajwal Shetty, U S Krishna Nayak. Predictability of Pi Angle and Comparison with ANB Angle, W Angle,Yen Angle, and Beta Angle in South Indian Population, *J . In. orthodontic*.2018; : 52 (1) : 22-28

12. Riedel RA . The relation of maxillary structures to cranium in Malocclusion in normal occlusion. Angle Orthod.1952; 22(3):140-145.

13. Baik CY & Ververidou M. A new approach of assessing sagittal discrepancies: the Beta angle. *Am.J*.Orthod.2004; 126(1): 100 – 105.

14.Angle EH. Treatment of Malocclusion of Teeth. 7th ed. Philadelphia, S.S. White Manufacturing Co. 1907; Pp: 40 –52

15. Kinaan BK. Overjet and overbite distribution and correlation. A comparative epidemiological English Ira-qi Study. *Br J Orthod*.1986; 12: 79 – 86

16. Hayness S. (1972). The distribution of overjet and overbite in English children aged 11–12 years. *Dental Practitioner*.1972; 34: 380 – 383.

17. Houston WJB. Walthers Orthodontic Notes. 4th ed. Bristol, John Wiley and Sons Ltd. 1983; Pp: 1, 154.

18. Foster TD. A textbook of Orthodontics. 2nd ed. Blackwell Scientific Publications. 1982; Pp: 25 – 41, 313.

19. Major WP, Johnson DE, Hesse KL, Glover KE. Effect of head orientation on posterior anterior cephalometric landmark identification. *Angle Orthod*.1996; 66(1): 51 – 60.

20. Koeppe K. Prognose der mandibular entwicklung mit hilfe des orthopantomogramms. Fortscher der kieferorthopadie 1973;34:316-22.

21. Doshi J, Trivedi K, Shyagali T (2012). 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. *Peoples J Sci Res*.2012; 5(1):1-8.

22. Williams S, Leighton B C, Nielsen J H.Linear evaluation of the development of sagittal jaw relationship. *Am. J. Orthodontics*.1985; 88(3): 235 – 241.

23. Jacobson A. Application of the "Wits" appraisal. *Am. J. Orthodontics*. 1976; 70(2):179-89.

24. Kumar S, Valiathan A ,Gautam P ,Chakravarthy K, Jayaswal P. An evaluation of Pi analysis in the assessment of anteroposterior jaw relationship .*J Orthod*.2012;39:262-9.

25. Mittal A, Bohra S, Murali PS, Saidath K and Krishnanayak US. An evaluation of YEN and W angle in the assessment of anteroposterior jaw relationship. J.In. Orth. Society.2016; 50(1): 26.

26. Gasgoos SS, AL- Saleem NR, Awni KM. Cephalometric features of skeletal Class I,II,and III(A comparative study).*Al-Rafidain Dent J*.2007;7(2):122-130.