Comparison of W Angle with Different Angular and Linear Measurements in Assessment of Sagittal Skeletal Relationship in Class I and Class II Patients in Jaipur Population - A Cephalometric Study

Ruchi Sharma[1], Kuldeep Sharma[2], Ayush Mathur[1], Naveena Preethi[3], Vijay Agarwal[1], Swapnil Singh[4], Nupur Satija[5]

[1]Department of Orthodontics & Dentofacial Orthopedics, NIMS Dental College & Hospital, NIMS University, Rajasthan, India. [2]Department of Orthodontics & Dentofacial Orthopedics, Rajsthan Dental College & Hospital, Rajasthan, India. [3]Rajarajeshwari Dental College & Hospital, Bangalore, India. [4]Department of Oral & Maxillofacial Surgery, Daswani Dental College, Rajasthan, India. [5]Oral Medicine, Diagnosis and Radiology, Rajasthan, India

Abstract

Background: An evaluation of skeletal sagittal jaw relationship has an important place in orthodontic diagnosis and treatment planning. A new measurement named W angle has been introduced for assessing the skeletal relationship between the maxilla and the mandible in the sagittal plane which uses three skeletal landmarks; point S, point M, and point G.

Aim: to compare the W angle along with other sagittal relationship parameters such as ANB angle, Wits appraisal, Beta angle, so as to obtain more reliable parameter for antero-posterior cephalometric analysis.

Materials and Methods: Sample comprised of 50 pre-treatment lateral cephalograms of Jaipur subjects which were divided into 2 groups: Group I-Class I skeletal pattern (n=25), Group II- Class II skeletal pattern (n=25) and traced for different sagittal relationship parameters. The age of subjects were ranged from 15-30 years.

Results: t-test analysis was performed and highly significant differences were found in ANB angle, Beta angle and W-angle in all the 50 patients. Coefficient of variability was calculated for intra-group comparisons. Wits appraisal was found to be highly variable parameter and W angle was found to be the least variable parameter. In both study groups, ANB angle correlated significantly positively with Wits appraisal while beta angle showed significant negative correlation with ANB angle and Wits. In class II subjects, a significant negative correlation was also seen between ANB angle and W angle.

Conclusion: it is concluded from the study that ANB angle, Beta angle and W-angle are significant angles to assess the sagittal jaw relationship between maxilla and mandible. W angle showed highly significant results. However, instead of relying on one single parameter, others also should be checked and should be correlated with clinical findings.

Key Words: Skeletal sagittal jaw relationship, ANB, Beta Angle, Wits appraisal and W-Angle

Introduction

The accurate evaluation of skeletal sagittal jaw relationship between the maxilla and the mandible has an important place in diagnosis and treatment planning in the field of orthodontics. Various angular and linear measurements have been proposed to assess this in various cephalometric analyses which could help the orthodontist to establish the most suitable and appropriate treatment plan for the particular patient. Downs [1] in 1948 introduced the A-B plane angle. Four years later Riedel [2] in 1952 introduced ANB angle and it gained the popularity of most commonly used parameter for sagittal relationship. However, both Down's and Riedel's methods are subject to error due to variations in the position of nasion which is not fixed during growth and its displacement can directly affect the A-B plane angle and ANB angle. A second widely used measurement, the Wits appraisal was introduced by Jacobson [3] in 1975 to overcome the problems related to the ANB angle which considered functional occlusal plane as a reference plane to assess points A and B, and thus eliminated the controversies related to the position of N point [4]. Though Wits appraisal does not advocate use of point N, accurate identification of functional occlusal plane is not always easy or accurately reproducible [5,6], particularly in mixed dentition patients. Secondly, any change in the angulation of functional occlusal plane, caused by either tooth eruption and development or orthodontic intervention, can markedly influence Wits appraisal [7].

Baik and Ververidou [8] introduced the beta angle in 2004, which reflects true antero-posterior changes as a result of growth and orthodontic intervention, without being influenced by changes in occlusion. Though, it assesses sagittal discrepancies, it depends on point C in condyle, the precise tracing of which is not always easy or its center is not clearly visible. On the other side, it uses point A as a reference point for the antero-posterior position of the maxilla. The position of point A is believed to be affected by alveolar bone remodelling associated with orthodontic tooth movement of the upper incisors [9,10]. Till now the description of different measurements is available in literature, such as: AXB angle, AXD angle, FABA angle, PABA angle, SGn/ AB angle, APDI angle, AB/TH angle and linear measurements like AB/PP distance, AB/SN distance, AD/SN distance, AB/FH distance and AB/TH distance. Recently introduced sagittal dysplasia indicator is YEN angle introduced by Neela et al. [11] in 2009. It measures an angle between line SM and MG, but rotation of jaw because of growth or orthodontic treatment can mask true basal dysplasia, similar to ANB angle [12].

To overcome these problems, more recently W-angle has been developed by Bhad et al. [12] in 2011. It does not depend on any unstable landmarks or dental occlusion and would be especially valuable to assess true sagittal changes because of growth and orthodontic treatment. It uses three skeletal landmarks—point S, point M, and point G—to measure an angle that indicates the severity and the type of

Corresponding author: Ruchi Sharma, MDS, Orthodontics & Dentofacial Orthopedics, Senior Lecturer, Department of Orthodontics & Dentofacial Orthopedics, NIMS Dental College & Hospital, NIMS University, Shobha Nagar, Jaipur-Delhi Highway (Nh-11c) Jaipur, Rajasthan- 303121, India, Tel: 9461752741; e-mail: dr.sharmaruchi@rediffmail.com

skeletal dysplasia in the sagittal dimension. The W angle is actually the angle between the perpendicular line from point M to S–G line and the M–G line.

Aims and Objectives

So the aim of this study was to assess the W-angle in comparison to other skeletal sagittal dysplasia indicators such as ANB angle, Wits appraisal, and Beta angle in Class I and Class II patients and to find out which is more reliable amongst them.

Materials and Methods

The present study was conducted in patients who attended out patients department of Orthodontics & Dentofacial Orthopedics, NIMS Dental College Jaipur. Ethical committee approval was taken before starting the study.

Criteria for selecting the cases

- Total 50 cases were selected within the age group of 15 to 30 years who had never undergone orthodontic treatment.
- Complete case history & clinical examination was conducted to assess occlusion & facial symmetry and to exclude those with history of TMJ disorders & pain.
- Occlusal state was evaluated on study models to exclude dentition with cross-bite, rotations, & absence of teeth.
- Cephalometric analysis was conducted to categorize the malocclusion.

Informed consent was taken for exposure to lateral cephalogram. Selected cases were divided into 2 groups **Group I** - Class I skeletal pattern group (n=25) **Group II** - Class II skeletal pattern group (n=25).

Inclusion criteria for categorization of study groups

The following inclusion criteria was taken for the Class I skeletal pattern group: (1) ANB angle of 1° to 3°, (2) Wits appraisal between 0 and -3 mm, (3) Beta angle between 27º to 35º degrees, and (4) W angle between 51º to 56º and clinically a pleasant (almost straight) profile.

The following inclusion criteria was taken for the Class II skeletal pattern group: (1) The ANB angle was above 4°, (2) Wits appraisal greater than 0 mm, (3) Beta angle less than 27°, (4) W angle less than 51° and, the profile having a Class II appearance.

Then the lateral cephalograms were taken with teeth in centric occlusion, lips in relaxed posture and the head in the natural head position. These cephalograms were traced and ANB, Wits appraisal, and Beta angle, and W-angle were measured to find out the skeletal relationship and the most reliable parameter amongst them. All the corresponding reference points, planes and angles were drawn, and recorded for evaluation as shown in *Figure 1 and 2*.

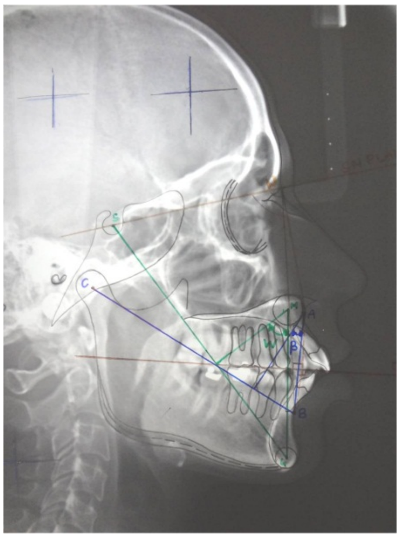

Figure 1: Tracing of corresponding reference points, planes and angles from radiograph.

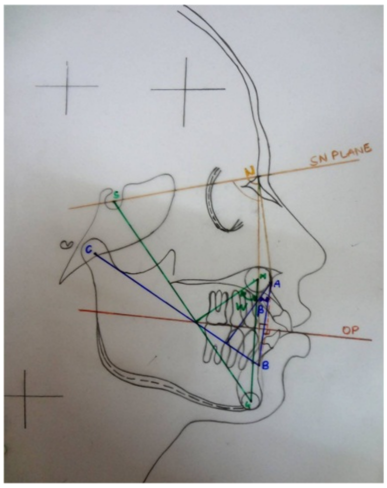

Figure 2: Drawn corresponding reference points, planes and angles and recorded for evaluation.

The W angle can be found by, first, locating three points: Point S—midpoint of the sella turcica; Point M—midpoint of the premaxilla; Point G—centre of the largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphysis. Next, defining four lines: Line connecting S and M points, Line connecting M and G points, Line connecting S and G points and Line from point M perpendicular to the S–G line. Finally W angle is measured, which is the angle between the perpendicular line from point M to S–G line and the M–G line.

Thus the data obtained in this manner was recorded and tabulated as shown in *Table 1 and 2*.

Table 1. Recorded cephalometric parameters of male and female (Class I subjects).

Skeletal parameter	Male subjects (n=17)		Female subjects (n=8)	
	Mean	SD	Mean	SD
ANB	3.17	1.62	4.00	1.069
Witt's Appraisal	1.52	1.90	1.50	1.069
ß Angle	27.5	4.86	26.00	4.720
W Angle	53.88	1.70	54.87	0.640

Table 2. Recorded cephalometric parameters of male and female (Class II subjects).

Skeletal parameter	Male subjects (n=9)		Female subjects (n=16)	
	Mean	SD	Mean	SD
ANB	3.77	1.986	5.68	1.85
Witt's Appraisal	2.77	1.715	2.37	2.41
ß Angle	23.11	4.166	23.81	3.29
W Angle	51.11	2.472	48.50	1.31

Statistical Analysis

The mean and standard deviation *(Table 1 and 2)* were calculated for each parameter. Sample size was estimated at 80% of study power to detect differences at 5% level. The sample thus obtained, was 25 patients in each of the 2 groups. The Power for ANB angle was 85.56%, for Wits appraisal was 45.47% and for Beta Angle was 83.24%. We expect minimum 80% power to be there, so with respect to Wits appraisal study was considered under powered while for other parameters it was found to be acceptable. t-test analysis *(Table 3)* was performed and highly significant differences were found in ANB angle, Wits appraisal, Beta angle, and W-angle in both the Groups (Group I, Group II). To determine the variability of all the skeletal parameters, coefficient of variability for each parameter in both groups (group I and group II) was calculated as shown in table 4 and 5. Correlation coefficients between the various parameters were calculated using Pearson's correlation coefficient. *(Table 6)* Cephalometric recordings were performed by single trained examiner.

*Table 3. t-test analysis (pooled group n=50); *significant at 0.05 level; **significant at 0.001 level, thus highly significant.*

Skeletal parameters	Class I group	SD	Class II group	SD	P value
ANB	3.44º	1.52	5.0º	2.08	0.004∗
Witt's Appraisal	1.52mm	1.68	2.52mm	2.18	0.076
ß Angle	27.04º	4.77	23.56º	3.55	0.005∗
W Angle	54.2º	1.47	49.44º	2.18	0.000∗∗

*Table 4. Coefficient of variability in class I group; *Most homogenous distribution; **Least homogenous distribution.*

Skeletal parameters	Min.	Max.	Mean	SD	CV
ANB	2	6	3.44º	1.52	1.10
Witt's Appraisal	0	5	1.52	1.68	1.67**
ß Angle	19	35	27.04	4.77	0.17
W Angle	52	56	54.2	1.47	0.02*

*Table 5: Coefficient of variability in class II group; * Most homogenous distribution; ** Least homogenous distribution.*

Skeletal parameters	Min.	Max.	Mean	SD	CV
ANB	2	9	5.0	2.08	0.41
Witt's Appraisal	0	7	2.52	2.18	0.86**
ß Angle	18	31	23.56	3.55	0.15
W Angle	46	55	49.44	2.18	0.04*

*Table 6: Correlation coefficient among all four skeletal parameters; *. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).*

			ANB	WITS APPRAISAL	BETA ANGLE	W ANGLE
Class I	ANB	R value	1	0.414*	-0.761**	-0.207
		p-value		0.039	<0.001	0.320
	WITS APPRAISAL	R value		1	-0.523**	0.041
		p-value			0.007	0.846
	BETA ANGLE	R value			1	.100
		p-value				0.636
	W ANGLE	R value				1
		p-value				
Class II	ANB	R value	1	0.505**	-0.523**	-0.661**
		p-value		0.010	0.007	<0.001
	WITS APPRAISAL	R value		1	-0.511**	-0.087
		p-value			0.009	0.68
	BETA ANGLE	R value			1	0.251
		p-value				0.225
	W ANGLE	R value				1
		p-value				

Results

Results from this study show that ANB angle, Beta angle and W angle are reliable in evaluation of skeletal pattern as Table 3 shows. (p value <0.05 for ANB angle and ß angle and p value <0.001 for W angle). The results were found to be highly significant for W angle and least for Wits appraisal.

Table 4 and 5 show that coefficient of variability is highest for Wits appraisal and least for W angle in both Class I and Class II groups. This shows that Wits appraisal is highly variable parameter and W angle is least variable parameter on intra-group comparisons.

Table 6 shows that in Class I subjects, ANB angle correlated positively with Wits appraisal (r = 0.414; p=0.039, while Beta angle showed negative correlation with ANB angle (r = -0.761 p<0.001) and Wits appraisal (r = -0.523; p=0.007).

Similarly in Class II subjects, ANB angle correlated positively with Wits appraisal (r=0.505; p=0.01, while Beta angle showed negative correlation with ANB angle (r = -0.523 p=0.007) and Wits appraisal (r = -0.511; p=0.009). Also, a negative correlation was seen between ANB angle and W angle (r = -0.661; p<0.001).

Discussion

In the field of orthodontics, cephalometrics utilizes both angular and linear variables to analyze skeletal sagittal jaw relationship. If we review the literature, various parameters are available to assess the sagittal relationship but none can be universally applied with reliability. Therefore, this study attempted to analyze different statistical and geometrical variations in widely used and recently proposed cephalometric parameters which were used to indicate the sagittal jaw relationship in Class I and class II malocclusions and also to compare W angle with those other parameters in assessment of sagittal jaw discrepancy for the Jaipur population.

The most popular parameter for assessing the sagittal jaw relationship remains the ANB angle but it is affected by various factors and can often lead to errors. When 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 (AP position of N) should be considered, which makes the interpretation of this angle much more complex [3]. Several authors have shown that the position of nasion is not fixed during growth, and any displacement of nasion will directly affect the ANB angle [3]. Furthermore, rotation of the jaws by either growth or orthodontic treatment can also change the ANB reading [4].

The result of this study shows that the ANB angle values are significant among the groups *(Table 3)*. However, the studies conducted by Brown [13], Chang [14] and Jacobson [3-4], claimed that any change in the SN plane would affect the ANB angle. Rotberg et al. [15] also stated that nasion usually moves in anterior and slightly superior direction because of the growth increments on the cranial base plane passing through sella and nasion.

After considering such drawbacks 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. However, the location of functional occlusal plane in itself was a difficult task [5-6]. Our study shows that Wits values were also non-significant among both groups *(Table 3)*. This is also supported by Moore et al. [16] and Ishikawa et al. [17] who also stated that Wits appraisal although not affected by landmarks or jaw rotations; it still has the problem of correctly identifying the functional occlusal plane, which can sometimes be impossible, especially in mixed dentition or patients with open bite, severe cant of the occlusal plane, multiple impactions, missing teeth, skeletal asymmetries, or steep curve of Spee. Second, any change in the angulation of the functional occlusal plane, caused by either normal development of the dentition or orthodontic intervention, can markedly influence the Wits appraisal [7].

Our study shows that Beta angle values were statistically significant ($p < 0.05$) among both groups *(Table 3)*. This is also supported by Biak and Ververidou [8] who stated that Beta angle does not depend on cranial landmarks or the functional occlusal plane and remain relatively stable even when the jaws are rotated. Therefore, the Beta angle can assess the sagittal jaw relationship more accurately in skeletal patterns, when clockwise or counterclockwise rotation of the jaws would tend to camouflage it. But it still uses point A & point B which are considered to be affected by alveolar bone remodelling associated with orthodontic tooth movement of the incisors.

Most recently introduced sagittal dysplasia indicator is YEN angle (Neela et al. [11] in 2009). But since it measures an angle between line SM and MG, rotation of jaw because of growth or orthodontic treatment can mask true basal dysplasia, similar to ANB angle.

To overcome these existing problems, a measurement was developed and named W angle. This angle does not depend on any unstable landmarks or dental occlusion and would be especially valuable to assess true sagittal changes because of growth and orthodontic treatment. Our study shows that W-angle values were statistically highly significant ($p < 0.001$) among two groups *(Table 3)*. This is also supported by Bhad et al. [12] who proposed this angle as a sagittal skeletal dysplasia indicator. 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. The geometry of the W angle also has the advantage to remain 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 carries the perpendicular from point M with it. Therefore, measurement of W angle is useful sagittal parameter in skeletal patterns with clockwise or counterclockwise rotation of the jaws as well as during transitional period when vertical facial growth is taking place.

Cranial base length (position of point N) can sometimes camouflage true skeletal classes I, II, and III patterns. In this regard, W angle can be a valuable tool for planning orthopaedic or an orthognathic procedure as this angle is independent of cranial base length. Also, in favour of W angle, our study results showed that coefficient of variability was found to be highest for Wits appraisal and least for W angle in both Class I and Class II groups. This shows that Wits appraisal is highly variable parameter and W angle is least variable parameter on intra-group comparisons *(Table 4 and 5)*. Another advantage of W angle is that it can be used for evaluation of treatment progress because it reflects true changes of the sagittal relationship of the jaws, which might be due to growth or orthodontic or orthognathic intervention. However, precisely tracing the premaxilla and locating its centre is not always easy. To accurately use this angle, the cephalogram must be of high quality. It is then much easier for the clinician to follow the contour of premaxilla and locate its centre.

In our study, among both Class I and class II subjects, ANB angle correlated significantly positively with Wits appraisal while beta angle showed significant negative correlation with ANB angle and Wits appraisal *(Table 6)*. However a positive correlation was found between beta and W angles among both the groups but that was not statistically significant. In class II subjects, a significant negative correlation was seen between ANB angle and W angle. Thus it is clear that cephalometric analyses based on angular and linear measurements have obvious limitations and hence dependency on any one parameter for skeletal assessment is discouraged. Also the analyses should be correlated with clinical findings.

As far as the limitations of the present study are considered, it included only two malocclusion groups i.e. Class I & Class II but not Class III, so in future studies can be done with all malocclusion groups to get more reliable results.

Conclusion

It was concluded from the present study that ANB angle, Beta angle, and W-angle are significant angles to assess the sagittal jaw relationship between maxilla and mandible. The use of W angle can provide more accurate assessment of sagittal skeletal jaw relationship (than ANB angle and beta angle) and other measurements such as Wits appraisal can be misleading for the assessment of antero-posterior discrepancy. W angle adds a valuable tool for assessment of antero-posterior jaw relationship. Along with other parameters, it should enable better diagnosis and treatment planning for patients.

References

1. Downs WB. Variations in facial relationships: Their significance in treatment and prognosis. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1948; **34**: 812-823.
2. Riedel RA. The relation of maxillary structures to cranium in malocclusion and in normal occlusion. *Angle Orthodontics*. 1952; **22**: 142-145.
3. Jacobson A. The "Wits" appraisal of jaw disharmony. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1975; **67**: 125-138.
4. Jacobson A. The application of the 'Wits' appraisal. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1976; **70**: 179-89.
5. Haynes S, Chau M. The reproducibility and repeatability of the Wits analysis. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1995; **107**: 640-647.

6. Rushton R, Cohen AM, Linney FD. The relationship and reproducibility of angle ANB and the 'Wits' appraisal. *British Journal of Orthodontics*. 1991; **18**: 225-231.

7. Sherman SL, Woods M, Nanda RS. The longitudinal effects of growth on the 'Wits' appraisal. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1988; **93**: 429-436.

8. Baik CY, Ververidou M. A new approach of assessing sagittal discrepancies: the Beta angle. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2004; **126**: 100-105.

9. Arvysts M G. Nonextraction treatment of severe Class II division 2 malocclusion: part 1. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1997; 510–521.

10. Nanda R. Biomechanics and esthetic strategies in clinical orthodontics. Elsevier, St. Louis. 2005; 38-73.

11. Neela PK, Mascarenhas R, Husain A. A new sagittal dysplasia indicator: the Yen angle. *World Journal of Orthodontics*. 2009; **10**: 147-151.

12. Bhad WA, Nayak S and Doshi UH. A new approach of assessing sagittal dysplasia: the W angle. *European Journal of Orthodontics*. 2011; 1-5.

13. Brown M. Eight methods of analyzing a cephalograms to establish anteroposterior skeletal discrepancy. *British Journal of Orthodontics*. 1981; **8**: 139-46.

14. Chang HP. Assessment of anteroposterior jaw relationship. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1987; **92**: 117-22.

15. Rotberg S, Fried N, Kane J, Shapiro E: Predicting the " Wits appraisal from the ANB angle. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1980; **77**: 636-42.

16. Moore RN, DuBois LM, Boice PA, Igel KA. The accuracy of measuring condylion location. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1989; **95**: 344-347.

17. Ishikawa H, Nakamura S, Hiroshi I, and Kitazawa S. Seven parameters describing anteroposterior jaw relationships: postpubertal prediction accuracy and interchangeability. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2000; **117**: 714-720.