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Reliability of W-angle to assess sagittal skeletal dysplacia in class I, class II, class III, patients: A Cephalometric study

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Abstract
The aim of the paper is 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. The Materials and Methods used are a Sample comprised of 99 pre-treatment lateral cephalograms of Hyderabad subjects which were divided into 3 groups: Group I- Class I skeletal pattern (n=33), Group II- Class II skeletal pattern (n=33), Group III – Class III skeletal pattern (n=33) and traced for different sagittal relationship parameters. The age of subjects were ranged from 15-30 years. The results obtained from the t-test analysis was performed and highly significant differences were found in ANB angle, Beta angle and W-angle in all the 99 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. From the above study it is concluded 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.

Keywords: Sagittal skeletal dysplacia, patients, cephalometric

Introduction
In orthodontic diagnosis and treatment planning various angular and linear measurement are done to assess accurate sagittal relationship of maxilla and mandible. In the early 1900's, before Edward H. Angle introduced his classification of malocclusion to the profession the anteroposterior relationship of mandible to maxilla was a most important diagnostic criterion [1]. In 1931, Introduction of cephalometer by the Broadbent made such films available, although they were used primarily for research and growth studies until the late 1940's [2]. In treatment planning and evaluation, Broadie preferred angular measurements over linear as it eliminates differences which are due to absolute size [2]. It was stated by Down's that "Single readings are not important, what counts is the manner in which they all fit together and their correlation with type, function and esthetics [2]."
It has often been observed that the intermolar relationship is not necessarily related to facial profile. When analyzed cephalometrically, many patients with class I molar relationship show an obvious class II or class III pattern in their facial profile. Most of the cases show abnormal rotation of the jaws relative to the cranial anatomy. The skeletal anterior posterior relationship vary in response to the vertical change of the facial dimension [2].
In 1948, Down's 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. 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]. The rotation of jaws by either growth or orthodontic treatment canals of change the ANB reading.

In 1975, Jacobson[3]introduced the Wits appraisal 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]. Therefore, consecutive comparisons of the Wits appraisal throughout orthodontic treatment might be of limited value because they also reflect changes in the occlusal plane instead of pure anterior posterior changes of the jaws [8].

In 2004, Baik and Ververidou [8] introduced the beta angle, which reflects true anterior posterior changes as a result of growth and orthodontic intervention, without being influenced by changes in occlusion. It depends on point C in condyle, the precise tracing of which is not always easy or its centre is not clearly visible. On the other side, it uses point A as a reference point for the anterior 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]. During this period there were many different measurements available in literature in sagittal direction 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. The skeletal landmarks G and M points were originally introduced by Nanda and Merrill and later used by Braun and co-workers, being 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 [8, 9]. These points are not affected by local remodelling secondary to dental movements, unlike points A and B. In 2009, YEN angle was introduced by Neela *et al*. [11]. It measures an angle between line SM and MG, but rotation of jaw because of growth or orthodontic treatment can mask true basal dysplasia [12]. In 2011, 'W' -angle has been developed by Bhad *et al*. to overcome these problems. 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 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 [8, 12]. The present study on 'W' angle is a specific measurement for the apical base difference. The measurement is independent of cranial reference planes or dental occlusion in determining the apical base relationship. The present study is for comparison of W angle in class I, class II and class III patients using pre-treatment lateral cephalograms and to assess the reliability.

Materials and Methods

This study was conducted in Government Dental college and Hospital, Hyderabad.

Criteria for selecting the cases

- Total 99 cases were selected within the age group of 15 to 30years 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 3 groups

- Group I - Class I skeletal pattern group (n=33)
- Group II - Class II skeletal pattern group (n=33)
- Group III - Class III skeletal pattern group (n=33)

Inclusion criteria for categorization of study groups

The following inclusion criteria was taken for the Class I skeletal pattern group:

- ANB angle of 1° to 3°,
- Wits appraisal between 0 to -3 mm,
- Beta angle between 27º to 35º degrees, and
- W angle between 51º to 56º

The following inclusion criteria was taken for the Class II skeletal pattern group:

- The ANB angle was above 4°,
- Wits appraisal greater than 0 mm,
- Beta angle less than 27°,
- Wangle less than 51° and, the profile having a Class II appearance.

The following inclusion criteria was taken for the Class III skeletal pattern group:

1. ANB angle was below 1^0
2. Wits appraisal lesser than -3 mm
3. Beta angle greater than 35^0
4. Wangle greater than 56^0 and the profile having class III 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, Beta angle, and W-angle were measured to find out the skeletal relationship and the most reliable parameter amongst them.

Discussion

There are various parameters available to assess the sagittal relationship but none can be universally applied with reliability. A study by William *et al*., 1985 and Jacobson, 1988 [3, 4] shows that the angular measurements are affected by changes in face height, jaw inclination and total jaw prognathism and linear variables can be affected by the inclination of the reference line. In the present study the ANB angle in class I is 2.4^0, class II is 6.12^0 and in class III is -2.51^0 (Table 1, 2, 3). In accordance to a study by Ruchi Sharma *et al.* [5] shows that the ANB angle in class I is $.17^0$ and in class II is 5^0 which is similar to our study. In accordance to study by Md. Khursheed Alam *et al.* [3] show ANB angle in class I is 2.5^0, in class II is 5.6^0 and in class III is -1.4^0 which is similar to our study. The studies conducted by Brown, Chang and Jacobson [4, 14] claimed that any change in the SN plane would affect the ANB angle. In the present study the Wits appraisal in class I is -0.27 mm, in class II is 4.27 mm and in class III is -4.18 mm. In accordance to a study by Ruchi Sharma *et al*., [1] shows that Wits values among class I is 1.52 mm and class II is 2.18 mm which is similar to our study. In accordance to a study by Md Khursheed Alam *et al.* the Wits appraisal in class I was 0.34mm, in class II is 1.72mm and in class III is-

1.25mm which is close to our study. A low "Wits" reading should not always be interpreted as being a malocclusion that is easily corrected. Factors such as posterior vertical dimension, ramus width, symphyseal thickness etc. must be taken into account in predicting growth trends. In the present study Beta angle in class I is 32.61^0, in class II is 24.68^0 and in class III is 58.36^0. In accordance to a study by Ruchi Sharma *et al.* [1] the Beta angle values were among Class Iis 27.04^0 and in Class II is 23.56^0, which is not similar to our study in class I but coincides with our study in class II. In accordance to a study by Khurshed Alam *et al.* the Beta angle in class I is 30.21^0, in class II is 24.55^0 and in class III is 35.35^0which is similar to our study in class I, class II but not in class III. In accordance to a study by Shobha *et al.* [1] the Beta angle in class I is 31^0, in class II is 24^0 and in class III is 43^0 which is similar to our study in class I and class II but not in class III patients. Beta angle may not be a reliable tool for assessment of sagittal jaw discrepancy in patients exhibiting vertical growth patterns with skeletal Class I and Class II malocclusions. However, Beta angle is a reliable indicator of sagittal dysplasia in normal and horizontal patterns of growth. Interestingly, skeletal class III malocclusions showed 100% adherence to Beta angle values irrespective of the growth pattern. To overcome some of the limitations of the previously discussed parameters, the W angle was developed.

In the present study the 'W' angle in class Iis 53.7^0, in class II is 48.9^0 and inclass III is 58.7^0. In accordance to a study by Ruchi Sharma *et al.* [1] 'W' angle in class I is 54^0 and in class II is 49^0 which is similar to our study. In accordance to a study by Md. Khursheed Alam *et al.* the 'W' angle in class Iis 55.22^0, in class II is 50.85^0 and in class III is 54.56^0 which is similar for class I and class II but not similar in class III.

In accordance to a study conducted by Rina Muraoka *et al.* to study the validity of 'W' Angle and Yen Angle in a Sample from Pakistani and Bangladeshi populations. The results show that all the measured values were highly significant among class I, class II and class III groups in both the populations which is similar to our study.

In accordance to a study by Bhad *et al.* [12] the coefficient of variability was found to be highest for Wits appraisal and least for 'W' angle in both class I, class II and class III groups similar to our study. This shows that Wits appraisal is highly variable parameter and 'W' angle is least variable parameter on intra-group comparisons similar to our study.

Results

Table 1: Coefficient of variability in class 1 patients

Class I (n=33)	Minimum	Maximum	Mean	Standard deviation	Co-efficient of variability
ANB Angle	-1	4	2.45	1.00	0.40
WITS Appraisal	-2	1	-0.21	0.65	3.06
BETA Angle	28	39	32.61	2.42	0.07
W Angle	51	56	52.61	1.45	0.02

Table 2: Coefficient of variability in class 2 patients

Class II (n=33)	Minimum	Maximum	Mean	Standard deviation	Co-efficient of variability
ANB Angle	4	10	6.12	1.53	0.25
WITS Appraisal	1	8	4.27	1.56	0.36
BETA Angle	11	31	24.48	3.63	0.14
W Angle	39	52	46.39	2.51	0.05

Table 3: Coefficient of variability in class 3 patients

Class III (n=33)	Min	Max	Mean	Standard deviation	Co-efficient of variability
ANB Angle	-10	1	-2.15	2.33	-1.08
WITS Appraisal	-11	0	-4.18	2.70	-0.64
BETA Angle	36	52	41.70	3.74	0.08
W Angle	48	65	58.36	2.93	0.10

Table 4: Correlation coefficient in class I patients

Class I (N=33)		Anb Angle	Wits Appraisal	Beta Angle	W Angle
Anb Angle	R-Value	1	0.057	0.076	-0.366*
	P-Value		0.75	0.674	0.36
Wits Appraisal	R-Value	0.057	1	-0.154	-0.091
	P-Value	0.75		0.39	0.61
Beta Angle	R-Value	0.076	-0.15	1	0.32
	P-Value	0.674	0.39		0.06
W Angle	R- Value	-0.366*	-0.09	0.32	1
	P-Value	0.036	0.61	0.064	

Table 5: Correlation coefficient in class II patients

Class Ii (N=33)		Anb Angle	Wits Appraisal	Beta Angle	W Angle
Anb Angle	R-Value	1	0.60**	-0.49**	-0.59*
	P-Value		0.00	0.00	0.00
Wits Appraisal	R-Value	0.60**	1	-0.55**	-0.48*
	P- Value	0.00		0.001	0.00
Beta Angle	R-Value	-0.49**	-0.55**	1	-0.61**
	P-Value	0.04	0.01		0.00
W Angle	R-Value	-0.59**	-0.48**	-0.61**	1
	P-Value	0.00	0.00	0.00	

Table 6: Correlation coefficient in class III patients

Class Iii (N=33)		Anb Angle	Wits Appraisal	Beta Angle	W Angle
Anb Angle	R-Value	1	0.63	-067	-0.62
	P-Value		0.00	0.00	0.00
Wits Appraisal	R-Value	0.63	1	-0.80	-0.66
	P-Value	0.00		0.00	0.00
Beta Angle	R-Value	-0.67	-0.80	1	0.66
	P-Value	0.00	0.00		0.00
W Angle	R-Value	-0.62	-0.66	-0.66	1
	P-Value	0.00	0.00	0.00	

Scope for future study

The assessment of anteroposterior sagittal dysplasia is an important diagnostic tool in orthodontic diagnosis and treatment planning. The 'W' angle is a reliable parameter in assessing the sagittal discrepancy and can be used in routine evaluation by orthodontist and surgeons for clinical purpose. It is found to be relatively stable unaffected by growth patterns unlike other landmarks. It utilizes stable points S, G, M corresponding to centres of sella, pre maxilla and mandibular symphysis respectively which are easy to identify and unaffected by alveolar bone remodelling and orthodontic intervention.

Summary and Conclusion

The data was analysed with Statistical Package for Social Sciences (SPSS) for Windows 20.0 (SPSS, Inc. Chicago, Illinois). The results showed that in class I subjects 'W' angle is within the range of 51^0 - 56^0, class II less than 51^0 and class III more than 56^0.

Based on this study it can be concluded that:

1. Previously established measurements for assessing the sagittal jaw relationship can often be misleading.
2. Anewangle, the 'W' angle, was developed as a diagnostic tool to evaluate the AP jaw relationship more consistently.
3. Subjects with a 'W' angle between 51 and 56 degrees have a Class I skeletal pattern, less than 51 degrees indicates a Class II and greater than 56 degrees indicates a Class III.
4. The 'W' angle cannot determine which jaw is prognathic or retrognathic. To clarify this, clinician should be aware of importance of other cephalometric measurements.
5. The results from the study show that ANB angle, beta angle and 'W' angle are reliable in evaluation of skeletal pattern. The results were found to be highly significant for 'W' angle and least significant for Wits appraisal.
6. The coefficient of variability is highest for Wits appraisal in class II subjects and least for 'W' angle in class I, class II and class III subjects. This shows that Wits appraisal is highly variable parameter and 'W' angle is least variable parameter.

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