ISSN (O) : 2582-3271
PubMed-National Library of Medicine - ID: 101766917

International Journal of Dental Science and Clinical Research (IJDSCR)

Dr. Angel Vaidic Publication

Available Online at: http://www.ijdscr.org

Volume – 3, Issue – 2, April - 2021, Page No. : 22 - 29

The Predictability of BND Angle, A Novel Parameter in Assessing Sagittal Skeletal Discrepancy – A Digital Cephalometric Study

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Citation of this Article: Dr. Rasool Karim Nizaro Siyo, Dr. Naseem KT, Dr. Binu Purushothaman, Dr. Deepa Menon, Dr. Chelza X, Dr. Gayathri MJ, Dr. Lubna P, "The Predictability of BND Angle, A Novel Parameter in Assessing Sagittal Skeletal Discrepancy – A Digital Cephalometric Study", IJDSCR – April - 2021, Vol. – 3, Issue - 2, P. No. 22-29.

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

The aim of this study was to develop a new cephalometric measurement to evaluate the sagittal relationship between the maxilla and mandible. 120 pre-treatment lateral cephalograms (40 each of Class I, II, and III) were subdivided based on ANB angle and Wits appraisal into skeletal Class I, II, and III. The new measurement is based on the landmarks C, ANS and G (centre at the bottom of the symphysis), from which the

BND angle is measured at ANS. The mean and standard deviation for the BND angle were calculated in all three skeletal groups. After using one-way analysis of variance (ANOVA) and Tukey's post hoc test, receiver-operating characteristic curves were obtained for the BND angle in both types of classifications.

The results showed that a patient with BND angle from 87.5 to 93 degrees could be considered to have a Class I skeletal relationship. A BND angle less than 87.5 degrees are considered to have a skeletal Class II relationship, and a BND angle greater than 93 degrees have a skeletal Class III relationship.

Keywords

BND Angle, skeletal class I, skeletal class II, skeletal class III.

Introduction

The concept of cephalometry was introduced in 1931 by Birdsall Holly Broadbent and Hofrath. Since then, lateral cephalogram is an important diagnostic aid in evaluating jaw relationship and it plays a major role in orthodontic treatment planning. Cephalogram helps in assessing jaw relationship in antero-posterior, transverse and vertical planes. The authenticated evaluation of sagittal jaw relationship between the maxilla and the mandible is an indispensable part in diagnosis and treatment planning in orthodontics.

In 1952, Riedel put forward the ANB angle and it became the most commonly used measurement to describe antero-posterior jaw relationship. The ANB angle which relates jaws to cranial reference planes like nasion, show inherent inconsistencies because of variations in craniofacial physiognomy. It is also greatly affected by the rotation of jaws as a result of growth or due to orthodontic treatment and variation in the length of cranial base [1, 2].

In 1975, Jacobson, devised the Wits Appraisal (University of the Witwatersrand, Johannesburg, South Africa) to overcome the limitations of ANB angle. He claimed that the degree of anteroposterior jaw disharmony can be measured using Witt's appraisal; independent of cranial landmarks. The Wits appraisal uses the occlusal plane, which is a dental parameter to describe the skeletal discrepancy. But the occlusal plane can be altered due to individual tooth eruption pattern, its development or due to orthodontic treatment intervention. [4-7]. It is also difficult to accurately locate the occlusal plane especially in patients in their mixed dentition, open bite, occlusal plane cant, impactions, skeletal asymmetries or steep curve of Spee.[8,9]

Considering these limitations, it was imperative that a cephalometric parameter which was independent of the cranial reference planes or dental occlusion was developed. In 2004, Baik and Ververidon introduced the Beta angle which gives a fair idea about the antero-posterior sagittal relationship, but it still uses point A as antero-posterior reference point and point A is affected by alveolar bone remodelling associated with orthodontic tooth movement. [10] YEN angle is a more recently introduced sagittal dysplasia indicator, but the landmarks SM and MG is again affected by growth rotation of jaws or orthodontic treatment [11]. W angle which was introduced by Bhad et al in 2011 was not based on unstable landmarks or functional occlusal plane. But, precisely tracing the pre-maxilla and locating its centre is not easy. It requires high quality cephalometric radiographs.[12]

To overcome the limitations of the above-mentioned parameters, a measurement was developed and named the BND angle. This angle does not depend on any unstable landmarks or dental occlusion and would be a reliable parameter to assess the true sagittal changes due to growth or orthodontic treatment.

A. The BND Angle

The BND angle is a new measurement for assessing the skeletal discrepancy between the maxilla and the mandible in the sagittal plane (Fig 1). The newly introduced BND angle uses the land marks: Point C, Point ANS and Point G to measure the severity and the type of skeletal dysplasia in the sagittal dimension. The BND angle can be found by, first, locating three points:

1. Point C (Posterosuperior point of the condyle),
2. Point ANS (Anterior nasal spine),
3. Point G (The centre of largest circle that is tangent to the inferior, anterior and posterior surfaces of mandibular symphysis)

The three points are joined to form a triangle and the internal angle between C-ANS line and ANS-G line is calculated, which is the new cephalometric parameter, the BND angle. The purpose of this study was to define the mean value and the standard deviation for this angle in people with the Class I, Class II, and Class III skeletal pattern.

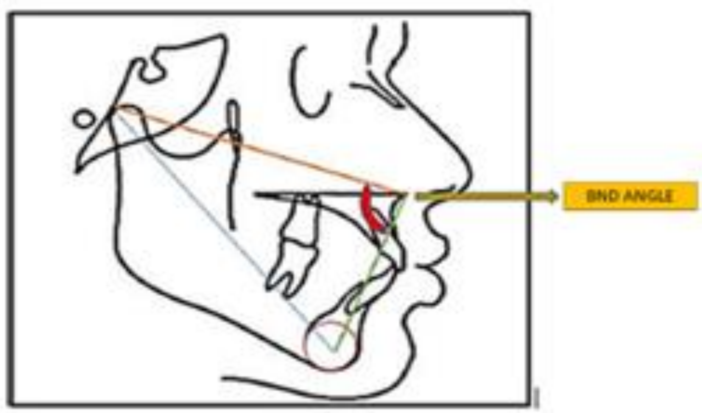

Figure 1: Construction of BND angle

Materials and Methods

Approval for the study proposal was obtained from institutional review committee. The study sample of 120 pre-treatment digital cephalograms with mean age limit of 17 – 35 years were systematically selected and screened in the Department of Orthodontics, KMCT Dental College, and Kerala. The cephalograms were sub-divided into 3 groups to assign samples to the Classes I, II, and III skeletal pattern. All lateral cephalograms were taken using DIMAX 3 CEPH (PLANMECA, Helsinki, Finland) and were obtained using 72 KvP, 10Ma, and 0.8second exposure time, with the patient in the natural head position. Source-to-film distance was 1.5 meters, with Frankfort horizontal plane parallel to the floor and midsagittal plane perpendicular to floor. After sample selection, the radiographic analysis was done using PLANMECA ROMEXIS software (Helsinki, Finland) and the ANB angle and Witt's appraisal was measured. The mean values of those measurements were calculated. For a patient to be included in the Class I, II, or III skeletal pattern group, criteria for ANB angle and Wits appraisal had to be met. 120 samples were subdivided into three groups:

- Group I: cephalograms with class I skeletal pattern (ANB angle 1-3 degrees and Wits appraisal BO ahead of AO by 1mm in males and AO coincides with BO in females). 40 lateral cephalograms which met the above criteria comprised the skeletal class I group.

- Group II: cephalograms with class II skeletal pattern (ANB angle > 4 degrees and Wits appraisal AOahead of BO). 40 lateral cephalograms which met the above criteria comprised the skeletal class II group.
- Group III: cephalograms with class II skeletal pattern (ANB angle less than or equal to -1 degree and Wits appraisal BO ahead of AO). 40 lateral cephalograms which met the above criteria comprised the skeletal class III group.

Patients with craniofacial malformations, facial asymmetry, cleft palate, prior history of orthodontic treatment and poor-quality radiographs were excluded from the study. To construct the BND angle, points C, ANS and G were located. After classifying the patients, BND angle was measured in all 120 lateral cephalograms. The mean and standard deviation of BND angle was calculated in three skeletal groups and were analysed with appropriate statistical tests.

A. Statistical analysis

Data collected were first entered to Excel (Microsoft, Redmond, Washington, USA). Collected data were screened for any missing values or outliers and for validity of distribution assumptions. To summarize the data, means and standard deviations of BND angle in three groups were calculated. The one -way analysis of variance (ANOVA) was used followed by Tukey's post hoc testing to determine whether there was a statistically significant difference between the mean values of BND angle of the three groups. A p value ≤ 0.05 was considered to be statistically significant. Receiver operating characteristics curves were run to examine the sensitivity and specificity of BND angle as a test to discriminate between the three different skeletal pattern groups. All statistics were performed in SPSS (SPSS 13, Chicago, Illinois, USA).

Results

The mean value of BND angle in the Class I skeletal group was 90.83 degrees with SD of 2.11, whereas the mean values in the Class II and III skeletal groups were 84.08 and 99.52 degrees with a SD of 3.50 and 5.52respectively (Table 1).

Maloclussion	Mean	SD	Std.Error	P value
Class I	90.83	2.07	0.32	
Class II	84.08	3.50	0.55	<0.001**
Class III	99.52	5.52	0.87	

Table 1: Comparison between class I, class II and Class III on the basis of BND Angle

The one-way ANOVA followed by Tukey's post hoc test showed that there was a significant difference in the BND angle between the three skeletal groups. Receiver operating characteristics curves (ROC) showed that the BND angle has increased diagnostic ability to differentiate the class I and class II skeletal groups. A BND angle less than or equal to 87.5 degree has a sensitivity of 90% and specificity of 100% to differentiate class I and class II skeletal pattern. A BND angle more than 93 degree has a sensitivity of 97.5% and a specificity of 87.5% for discriminating class III group from class I group (Table 2).

(I)	(J)	Mean	Std.	Sig.	95% Confidence Interval	
VAR00 001	VAR00 001	Difference (I-J)	Error	P value	Lower Bound	Upper Bound
Class I	Class II	6.75250	0.885 81	.000*	4.6448	8.6698
	Class III	-8.68750*	0.885 81	.000*	-10.8323	-6.5877

Table 2: The mean difference is significant at the 0.05 level by Tukeys Post hoc analysis. BND ANGLE shows significant differences among three skeletal groups. The p values 0.000 indicated highly significant differences among three groups.

Thus, the ROC curves showed that the cut-off point between the class I and class II group could be considered a BND angle of approximately 87.5 degree and the cut-off point between class I and III groups could be considered a BND angle of approximately 93 degree. The result also indicates that a patient with BND angle less than 87.5degree has a class II skeletal pattern and one with a BND angle of more than 93 degree has class III skeletal pattern.

Discussion

There are many ways to study maxillo-mandibular sagittal discrepancy. Various cranial reference planes have been used as baseline from which to determine the degree of jaw discrepancies. Riedel was among the earlier ones who made an effort to measure the maxilla and mandible in the sagittal plane.[1] Later Steiner popularized the ANB angle. Taylor conducted a study to evaluate the influence of changes in the relative positions of nasion, point A and point B that might have upon the ANB. He came to a conclusion that the ANB angle is not always a true indication of the apical base. As the nasion moves forward during growth, the angles SNA and SNB are reduced in value. The ANB angle also varies according to facial divergence. [13] Robert E. Binder, [14] Edward J. Beatty, Bishara et al found that research has overwhelming evidence that Nasion changes to a significant extent during treatment.

A second widely used measurement, the Wits appraisal, was introduced by Jacobson to overcome the problems related to the ANB angle. However, the Wits appraisal relates points A and B to the functional occlusal plane. It measures the linear distance between perpendiculars dropped from points A and B to the functional occlusal plane, labelled as AO and BO respectively. This generates two major problems. First, accurate identification of the occlusal plane is not always easy or accurately reproducible, especially in mixed dentition patients 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 profoundly influence the Wits appraisal.

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 antero-posterior changes of the jaws. Actually, a small variation in the occlusal plane angle causes a greater effect on the Wits measurement than on Points A and B, nasion, or ANB angle.

The Beta angle is a new measurement for assessing the skeletal discrepancy between the maxilla and the mandible in the sagittal plane. It uses 3 skeletal landmarks—point A, point B, and apparent axis of the condyle. However, precisely tracing the condyle and locating its centre is not always easy. For that reason, some clinicians might hesitate to use the Beta angle. But it uses point A and point B, which can be remodelled by orthodontic treatment and growth [15,16]. Instead of condylion, centre of condyle could be used, but approximation of centre of condyle is difficult (Baik and Ververidou, 2004). This could give a non-significant error of approximately 1 degree.

Later, Yen and W angle were developed which uses three points—point S, point M, and point G. YEN angle is measured between the lines SM and MG. W angle is measured between a perpendicular line from point M to the SG line and the MG line. However, precisely tracing the premaxilla and locating its centre (point M) is not always easy. The cephalometric x-rays must be of high quality for an accurate measurement.

All other antero-posterior parameters introduced over the years are affected by at least one of the factors, namely patient's age, jaw rotations, poor reproducibility of landmarks, growth changes in reference planes, and changes due to orthodontic treatment. To overcome some of the limitations of previously discussed parameters, the BND angle was developed. Instead of point A, point ANS (most anterior tip of Anterior Nasal Spine) is used in measuring the BND angle. ANS is not affected by orthodontic treatment changes because root position of incisors will not affect this point and it does not depend on sella- nasion line. The anterior cranial base changes do not affect this angle, particularly the position of point N which can sometimes camouflage true skeletal class I, class II and class III skeletal pattern. BND angle can be a valuable tool for planning orthopaedic or orthognathic procedures as this angle is independent of cranial base length. Also, the BND angle remains relatively stable even when the jaws are rotated or growing vertically (Fig 2).

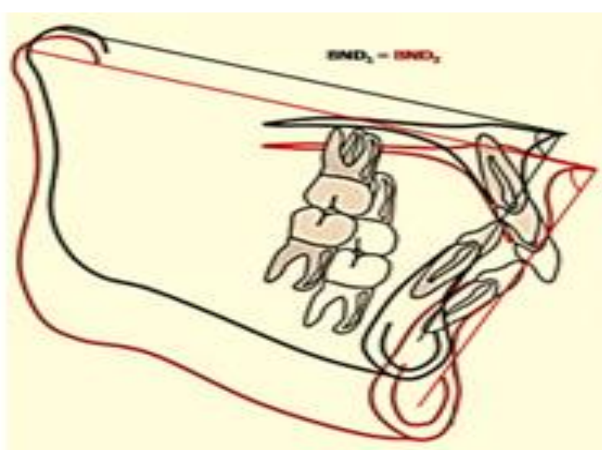

Figure 2: BND angle remains stable even when jaws are rotated.

Another advantage of BND angle over ANB angle and Wits appraisal, is that it is independent of the occlusal plane. 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, the condyles are bilateral structures and a high or a low condyle may affect the measurements of the BND angle. Also, point G is not the most anterior point on the bony chin. So, it may not indicate whether the mandible is protruded or retruded.

Cephalometric analyses based on angular and linear measurements have many limitations and hence depending on any one parameter for skeletal assessment is not encouraged. BND angle is a valuable tool for assessment of antero-posterior jaw relationship. Along with the other parameters, it should enable better diagnosis and treatment planning for patients.

Conclusion

Previously established measurements for assessing the antero-posterior skeletal relationship can often be misleading.

A new angle, the BND angle, was developed as a diagnostic tool to evaluate the sagittal jaw relationship more consistently. Subjects with a BND angle between 87.5 and 93 degrees have a Class I skeletal pattern; a BND angle less than 87.5 degrees indicates a Class II skeletal pattern and a BND angle greater than 93 degrees indicates a Class III skeletal pattern.

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