An Evaluation of the reliability of the Beta Angle in assessing the Maxillary-Mandibular Relationship Cephalometrically

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INTRODUCTION

The "ANB angle". A cephalometric parameter used to determine the maxillo-mandibular relation. Introduced in 1953, it still holds good in the world of communication among orthodontists. But, the gnawing questions are, is it reliable? Is it the best? Or is it the only one to relate the skeletal bases?

An evaluation study done by Dr. Alex Jacobson[18] in 1975 to assess the reliability of this analysis threw to light some interesting observations.

- The stability of the N point – the N point was found to vary with growth. It moved either vertically or sagitally with growth. This movement was found to alter the ANB angle.
- The chances of the head, being held by the cephalostat during the process of taking a cephalogram, rotating sidewards or upwards changed the ANB reading.
- The antero-posterior positioning of the jaws relative to the cranium, did alter the ANB angle. For example, in prognathous faces (where the jaws are positioned forward relative to the cranium) the ANB angle increased giving a deceptive class II skeletal pattern and vice versa. This occurred because of the relative closeness of point A to N, than point B.
- A clockwise rotation of the jaws (in a patient facing right) would cause the ANB angle to increase giving a class II pattern, and vice versa.

Dr. Jacobson[18] having made these findings felt that considering the functional occlusal plane as a reference plane to assess points A and B would eliminate the controversies surrounding the N point. The reference plane is drawn through the overlapping cusps of first premolars and first permanent molars.

But there were difficulties with this analysis also. To quote –

1. The occlusal plane, especially in mixed dentition cases where the teeth are not fully erupted, was difficult to trace.

2. 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.

Having recognized the flaws with two of the commonly used measurements to assess the sagittal jaw relationship, it is now clear that a measurement independent of the cranial reference planes or dental occlusion would be a desirable adjunct in determining the apical base relationship. Comparison of the pre-treatment and post-treatment sagittal relationship would then be reliable, as it would reflect the true antero - posterior changes as a result of growth and orthodontic intervention without being influenced by changes in occlusion.

Such a measurement was recently projected and named the *Beta angle*[8]. A line is extended form the center of condyle ‘C’ to B point, another line from A to B and a perpendicular from C-B line through point A. The angle formed between the A-B line and the perpendicular constitutes the Beta angle.

Is it flawless? Is it the last and best in the frontier of cephalometric analysis? This study might throw some light on the reliability and dependence on this parameter.

REVIEW OF LITERATURE

Wendell L. Wylie (1947)39 presented a method whereby discrepancies in size of facial bones occurring in the antero - posterior plan of space may be assessed quantitatively in terms of millimeters. The method of assessment presented makes possible a net score of antero-posterior dysplasia which is approximately zero where such dysplasia is either non-existent or compensated for by variation in different parts, and which is negative in the type of face where relative mandibular insufficiency exists, and positive in cases of mandibular prognathism. It permits the localization of this dysplasia in one or more of five different areas, an application which is probably more valuable than the derivation of a net score. Intelligent interpretation of the results of these scores makes it possible not only to measure the amount of antero-posterior dysplasia which exists in the face, but also indicates the necessity of looking elsewhere for existing dysplasia.

Freeman (1950)12 found that the ANB difference can very often be misleading when one is assessing the difference in apical bases. In his thesis he demonstrated very clearly the importance of nasion and showed how its relative position can influence the value of the angle. With this in mind, he introduced angle AXB. This was accomplished by dropping a perpendicular from Frankfort plane to point A, X marking the point of intersection on Frankfort resulting in the formation of the angle AXB. This provided information similar to that obtained from ANB and at the same time eliminate one of the three variables. He also discussed the forward and backward divergent faces and the effect that such facial types would have on apical base difference.

Richard A. Riedel (1952)25 was among the earlier ones who made an attempt to measure the maxilla and mandible in the sagittal plane. As a measure of the relative antero-posterior position of the maxilla, the angle Sella-Nasion to Point A was constructed. Using this measure and others of a similar nature, the author found no significant difference in the antero-posterior relation of the maxilla to the cranial base in patients presenting excellent occlusion and malocclusion of the teeth. The relative antero-posterior position of the mandible was measured by the angle Sella-Nasion to Point B, and various other angles. The antero-posterior relation of the mandible to the cranial base was found to be significantly different in patients exhibiting excellent occlusion when they were compared with individuals possessing malocclusion. The most marked difference occurred in Class II, division 1 malocclusions where the mandible was less prognathic than in normal occlusions. The relative difference in the antero - posterior relations of Points A and B on the maxilla and mandible appeared to be the most significant finding in this study. This difference is measurable, in part at least, by the difference between the angles S-N-A and S-N-B. In normal occlusions this difference was found to be approximately 2° and in malocclusions to vary considerably. This angle of course may be measured directly as the angle A-N-B. A third measure, thought to be important in orthodontic diagnosis, is that of the relative cant of the mandibular plane to the sella- Nasion line (NS-GoGn).

Cecil Steiner (1953)5 says that, to assess the sagital position of the maxilla and the mandible, the method of Richard Reidel best serves the purpose, that method being the employment of the angles SNA and SNB. The author comments that he is interested in, but not greatly concerned about, the angle SNA because it merely shows whether the face protrudes or retrudes below the skull. The author is greatly interested in the angles SNA and SNB, which in reality is the angle ANB, because the lines NA and NB are related to the same thing and the difference in their relationship gives a direct reading of the relationship of the patient’s chin to other structures of his face. It is the patients chin and not his sella turcica that interests his/her parents. As to why he chose SN as the reference plane, the author says the points S and N are located in hard, non yielding tissue, are directly and easily visible in a profile xray picture and particularly because they are located in the mid -sagital plane and therefore are displaced to a minimum degree by movement of the head, he has chosen SN as the reference line.

He very carefully appraised the methods then in use, shifted out the factors important to him, as well as adding some of his own. One of the latter was to relate the lower incisor to the profile using the line nasion to supramentale, the lower denture base, (point B). He found the average of this position to be 25°, and that the incisal edge was 4 mm. anterior to the plane NB. This method has considerable value in that it is a direct analysis of the tooth to the profile.

Charles H. Tweed (1954)6 secured forty-five samples and had measured the angles and found the following averages: the FMA averaged 24.9°; the incisal inclination when related to the lower border of the mandible was 86.6° and the FMIA (the angle formed by the long axis of the mandibular incisor with the Frankfort plane) was found to be 68.6°. These findings indicated that the author’s minimum requirement of an FMIA of 65° is not harsh and that the dividing point between extraction and non-extraction an FMI angle of 62°, is quite liberal. The findings of these 45 samples indicated that 25° as a norm for FMA, 90° as the norm for incisal inclinations and 65° for the FMIA norm were workable figures.

In virtually all instances where conditions would allow the author to attain the minimum requirement of 65° for FMIA, he found the facial changes both in Class I and Class II cases, whether extraction or non-extraction, to be dramatic. Where he was unable to fulfill this requirement for reasons, at times, beyond his control, facial esthetics were not as pleasing and disharmony seemed to be in proportion to the degrees that he failed to approach an FMIA of 65°. A dotted line starting at the apex of the mandibular incisor is drawn upward to intercept the Frankfort plane at an angle of 65°. The distance between the solid line, which is the existing inclination of the mandibular incisor, and the dotted line, which is the desired incisal inclination (measured at the incisal edge of the mandibular incisor), is the distance in millimeters that the mandibular incisors must be tipped lingually to satisfy the minimum requirement for an FMIA of 65°. Experience has demonstrated that if the case is Class II, there will be a 5° anterior displacement of the inclinations of the mandibular incisors in making the Class II correction. Therefore, anchorage preparation in the mandibular arch must be such that the inclinations of the mandibular incisors when related to the Frankfort plane are 70° prior to the beginning of Cl. II mechanics in the treatment of Cl. II malocclusions.

The short comings of the ANB angle were recognized as early as **1955 by Jenkins**19, who elected to use the functional plane as a reference base for the measurement of jaw disharmony. He assessed that all planes of dentistry traditionally use this plane as a primary plane of orientation, since all masticatory forces are focused on this plane and intimately related to it. He argued that even Angle used this plane of reference for his classical classification of malocclusion. Jenkins established the ‘a’ plane drawn through point A at right angles to the occlusal plane, and then measured from the ‘a’ plane to point B, gnathion and the mandibular incised edge. To determine the extent of the antero-posterior dysplasia, he formulated a range of values for these measurements from the ‘a’ plane.

Wendell L. Wylie (1955)40 while debating on the role played by the lower incisor on the facial esthetics, says that modification of the facial profile by orthodontic means depends on other factors besides the inclination of anterior teeth, so much so that diagnostic criteria based solely on this factor are likely to be unreliable. The author says that the examination of Tweed’s treated cases shows, unmistakably that clinically he does what he sets out to do. It also shows, however, that skillful treatment and a seeming ability to elicit mandibular growth is more responsible for his success than merely the establishment of a specific angulation for the mandibular incisor. Caution must always be observed in assigning cause and effect relationships, particularly when results are good, lest we assign credit to the wrong factor and fail to obtain the results we admire. Those who admire Dr. Tweed’s results are advised to direct their attention to the painstaking clinical procedures he has developed over the years, rather than to the Frankfort mandibular incisor angle.

William B. Downs (1956)41 says that since our concern in denture position is its status of balance with the profile, the method of relating the lower incisor to the A-Pog line is logical and descriptive. It also permits a variation according to facial types. The more retrognathic and convex a face is, and the greater the antero-posterior differential between maxillary and mandibular denture bases, the greater will be the labial inclination of the lower incisors, even though they have the same relationship to the profile arc. The reverse occurs in straight and concave faces. An evaluation of his series of normals gave a mean of 23° with a standard deviation of 3°. Not only is the inclination of lower incisors significant but the actual distance of the incisal edge to this plane is important. The average position showed the incisal edge to fall on the profile arc with an acceptable variation of -2 mm. to +3 mm., according to type and soft tissue balance.

According to **Robert M. Ricketts (1957)**27 the arrangement of teeth is planned from the occlusal plane. During normal growth the cant of the occlusal plane will decrease, i.e., it will drop faster in the back than in front. Cervical elastic traction applied at the maxillary molars will be in accordance with this tendency. The application of inter-maxillary Class II elastic works in a reverse direction and tends to rotate the plane an average of 3° from the mandibular plane. This action elevates the lower first molar an average of 2.5 mm. while the anterior teeth elevate more slowly, are held in place vertically or are depressed, depending upon growth factors and anchorage values. Simply bisecting the height increase of the lower face and assuming changes in one way or another depending upon the avenues of treatment provides a base line for the arrangement of the teeth. Once the occlusal plane is established, the new point A-pogonion plane is erected and the lower incisor is placed one mm. forward to it and at a 22° inclination.

Krogman (1958)21 stated that there were three basic types of roentgenogrpahic analysis –linear, angular and positional. The linear analyses are based on the direct or projected measurements, expressed in millimeters. On the lateral x-ray film, direct measurements are usually in the midsagital plane, whereas the projected measurements are lateral to the midsagital plane. For accuracy, the midsagital or direct measurements are preferable, when possible, for they involve only two planes of space - sagital and vertical. The projected measurements must be approached cautiously, for they involve three plans of spaces - sagital, vertical and transverse.

Ricketts (1960)26 in his sample of 1,000 orthodontic cases, found that the average lower incisal tip was located approximately 0.5 mm anterior to the A-Pog plane. One standard deviation was 2.7 mm. The range of variation was found to be +10 mm. to - 10 mm. A line through the long axis of the lower incisor was also measured to the A-Pog plane for recording the inclination of that tooth. The incisor was noted to incline at an average angle of 20.5 degrees to this line. One standard deviation of inclination was 6.4 degrees. It had been the author's clinical impression that the lower incisor seemed to maintain a consistent relationship to the A-Pog plane, once it erupted into the mouth. In other words, as convexity decreased with growth, the lower incisors became more upright and retracted slightly. This was borne out by the find ings. The lower incisor erupted at +0.4 mm. and thence to +0.7, and settled at nearly 0.0 to the A-Pog plane on the average.

Salzman (1964)29 in an attempt to evaluate the limitations of cephalometrics, reached a conclusion that practically all commonly used landmarks are variable. The author says the only thing of which one can be certain about cephalometric measurements is that they will vary from patient to patient. He also states that 'serial cephalometric records can be used to determine a pattern that may be projected into the future, but it must be recognized that such a pattern may change at any time, either spontaneously or as a result of influence of orthodontic therapy.

Charles M. Taylor (1969)7 made a study for which the material was taken from 225 orthodontic patients selected from the practices of five separate orthodontists. In this study the data were used to evaluate the influence which changes in the relative positions of nasion, point A and point B might have upon the ANB difference - one method of establishing the sagital jaw relationship. He divided the material into three groups according to facial divergence

- Forward (SNA 860 and over)
- Backward (SNA 770 and less)
- Normal (SNA between 770 – 860)

The author comes 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 A – B1 (B1 is the perpendicular from point B to SN plane) measurement offers an accurate measurement of the apical base relationship and provides a more critical evaluation of the changes taking place at points A and B. The author also states that the ANB angle varies according to facial divergence; case with an SNA of 860 and over were found to have the largest average ANB angle while those with an SNA of 770 and less had the smallest.

While talking about the influence of points A and B on the ANB angle, the author beautifully quotes "An angle is literally a figure formed by two lines diverging from the same point. The longer these lines are extended, the farther apart they become in relation to each other. With this in mind, it is easy to see that as the distances between nasion to points A and B increases in length, the linear distances between the latter also increases. However, the angle itself (in this case, ANB) is not affected by the sides forming it. In this way, it is possible for two patients to have dentinal ANB values but A–B1 distances that vary according to the length of the faces".

Jack h. Okun (1970)15 chooses to use the NP plane as a reference plane to determine the relation of the denture to the skull. As in many previous analyses, he chooses to use the position of the lower central incisors as a key to the position of the denture in the skull. The simple millimetric measurement of the distance of the incisal edge of the lower incisor to the NP plane clearly locates the position of the denture. The following discussion will show the reasoning behind the use of the foregoing landmarks and the use of this approach as a diagnostic aid for orthodontic treatment planning. Throughout the orthodontic literature the stress has been on the positioning of the lower incisor in the skull. It has been correctly assumed that the rest of the dentition can be placed in relation to the lower incisor. Thus even upper incisor position is related to the lower incisor and its position can be determined by relating the upper to the lower incisor if the lower incisor is to be used as a key for denture position.

Alex Jacobson (1975)18 demonstrated that the 'wits' appraisal of jaw disharmony is a simple method whereby the severity or degree of antero-posterior jaw dysplasia may be measured on a lateral cephalometric head film. Briefly, the method entails drawing perpendicular form points A and B on the maxilla and mandible, respectively on to the occlusal plane. The points of contacts of the perpendiculars onto the occlusal planes are labeled AO and BO respectively. In a sample of 21 male and 25 female adults selected on the basis of excellence of occlusion, it was found on the average, that in females, points AO and BO coincided and in males, point BO was located 1mm ahead of point AO. In skeletal class II dysplasias, point BO would be positioned well beyond point AO (positive reading) whereas in class III skeletal jaw disharmonies, the 'wits' reading would be negative, that is with point BO ahead of AO.

Edward J. Beatty (1975) 11 found numerous evidences in the literature that points A and B are influenced by treatment. He also found that research has overwhelming evidence that nasion changes to a significant extent during treatment. Convinced that the angle ANB is not always a true indicator of the apical base relationship, he understood that there is a need for a technique which will eliminate or reduce the inaccuracies in the presently used landmarks. He was partly successful in replacing the landmarks N and B (of ANB) with X and D respectively (where X is the point of intersection of the perpendicular dropped from point A to SN plane). Of the fifty cases evaluated by the author, he found that the AXB values were more reliable than the ANB values. The author also gives us some of the linear measurements to compare the pre-treatment and posttreatment results. The linear measurements that he used were as follows-

- The distances from the centre of Sella turcica to Nasion (S – N) to evaluate the amount of growth of the N point during treatment.

- The distance form S to A1 and D1 (where A1 and D1 are perpendicular from points A and D to the SN plane) to evaluate the linear change in the maxillary and mandibular apical bases respectively.

- The distance from point A to D1, drawn horizontal and parallel to the S – N plane, which according to the author offers an accurate method of assessing the actual horizontal distance between the apical bases.

By arbitrarily varying the position of points, lines and angles on cephalometric drawings, **Binder (1979)**3 likewise recognized the geometric effects at work in the ANB angle. He showed that for every 5mm anterior displacement of the N point horizontally, the ANB angle changed 2.5 degrees. A 5mm upward displacement of the nasion altered the ANB angle by 0.5 degrees and a downward displacement of the nasion changed the ANB angle by 1 degree.

Bishara et al (1983)4 conducted a study to determine the changes in the ANB angle and wits appraisal between 5 years of age and adulthood in men and women, and to determine whether the changes are significantly different. Their findings support the contention that the ANB angle does not accurately describe the maxillary and mandibular apical base relationship, because of normal variation in the spatial positions of both sella turcica and nasion.

They determined statistically that ANB angle changes significantly with age, whereas the wits appraisal does not. By virtue of this fact, it can be said that the ANB and the wits change differently over time. These findings explain the discrepancies in some cases between the measured value of the ANB and the clinical judgement of the orthodontist. The Investigators concluded that both ANB angle and the wits appraisal should be used to help arrive at a more accurate diagnosis of antero-posterior base relationship.

Michael Chateau et al (1983)23 say that there is an easy way to determine ANB angle using a simple linear measurement with a ruler directly on a cephalogram, and no need for a tracing or an angular measurement with a protractor. The principle is that, at a distance of 57.2mm, a one-degree angle opening equals 1mm, since a circle with a radius of 57.2mm has a circumference that is close to 360mm.The average distance between Nasion and A Point is about 57mm in children in the orthodontic age group. Therefore, the distance between A Point and the Nasion-B Point (NB) line expressed in millimeters represents the value of ANB angle expressed in degrees.

Rocco J. Di Paolo et al (1983) 28 put forth his quadrilateral analysis. Because of an increase in surgical-orthodontic awareness among orthodontists and surgeons, cephalometric analysis is becoming an important diagnostic tool in detecting the degree of skeletal dysplasia present. It is important to recognize not only the skeletal problem as it affects the jaws but also the location and the magnitude of the disharmony. Most orthodontists and surgeons are making diagnoses on the basis of cephalometric measurements, which we believe to be unreliable. Over the past 20 years, the authors by means of the quadrilateral analysis analyzed more than 10,000 cephalometric films. On the basis of previous studies, the authors believe that this method of cephalometric diagnosis offers a more accurate and reliable assessment of those orthodontic patients who may have an underlying skeletal problem. The quadrilateral analysis determines the direction and extent of the skeletal dysplasia in millimeter measurement, which is more understandable in surgical orthodontics than angular measurement. The location of the skeletal problem and its effect on jaw relations must be determined before proper orthodontic and/or surgical planning can be made.

Hussels and Nanda (1984)14 say that the cephalometric analyses based on angular and linear measurements have obvious fallacies, which have been discussed in detail by various authors. However, the clinical application of such an analysis by the orthodontic profession in treatment planning is widely accepted. Variations of angle ANB are commonly used to determine relative jaw relationships in most of the cephalometric evaluations. Several authors have also showed that the antero-posterior position of point N relative to points A and B influences angle ANB, as does rotational growth of the upper and lower jaws. In addition, various authors point out that growth in a vertical direction (distance N to B) and an increase of the dental height (distance A to B) may contribute to changes in angle ANB. For a Class I relation (Wits = 0 mm), a mathematical formula has been developed which enables the authors to study the geometric influence of angle ANB caused by the following four effects: (1) rotation of the jaws and/or occlusal plane relative to the anterior cranial base; (2) anteroposterior position of N relative to point B, (3) vertical growth (distance N to B); (4) increase in dental height (distance A to B). It was observed that, contrary to the common belief that an ANB angle of 2 ± 3.0° is considered normal for a skeletal Class I relation, the calculated values of angle ANB will vary widely with changes in these four controlling factors under the same skeletal Class I conditions (Wits = 0 mm). Therefore, in a case under consideration, angle ANB must be corrected for these geometric effects in order to get a proper perspective of the skeletal discrepancy. This is facilitated by comparing the measured ANB angle with the corresponding ANB angle calculated by a formula for a Class I relationship. The corresponding calculated angle ANB can be taken from the tables which are based upon the formula using the same values for SNB, w (angle between occlusal plane and anterior cranial base), b (which is distance N to B) and a (dental height measured as perpendicular distance A to occlusal plane plus perpendicular distance occlusal plane to B). The difference between actual and calculated angle ANB is a measurement of the severity of the skeletal discrepancy. This leads to a new definition of what denotes skeletal Class II and III relationships, since an angle ANB calculated for a skeletal Class I (Wits = O mm) can vary widely and can be either negative or positive. Therefore, when a Class II skeletal relation exists, the actual ANB is larger than the calculated measurement, whether or not the calculated value of angle ANB is positioned in the positive or negative part of the scale. The reverse is true for a Class III relation; the actual ANB is smaller than the calculated ANB. The clinical application of this method in the analysis of jaw disharmonies must be cautious, as the premise of this analysis is based on the occlusal plane and Wits values being equal to zero. It has been found that the cant of the occlusal plane is subject to growth changes independent of the forward or backward jaw rotations. The article highlights the complexity of the problem and recommends consideration of all the variables that may affect angle ANB.

James A. Mc Namara (1984)22 has described a method of cephalometric analysis which is currently used by the author in the evaluation and treatment planning of orthodontic and orthognathic surgery patients. In the analysis of a single film, the positions of the maxilla and mandible are related to cranial structures and to each other. Since the vertical reference line employed to orient the maxilla and the mandible is dropped from the point N, once again any variation in point N can influence the results. Criteria for evaluation of the antero-posterior and vertical positions of the upper and lower incisors are provided, as is the documentation of the standards for each of the measures. In addition, the analysis of serial films is considered and a step - by-step outline of the cephalometric procedure is presented.

Jarvinen et al32 made a study in **1985** in which the variation of the ANB angle was studied in a sample which consisted of 138 orthodontically untreated children 7 to 15 years of age with Class I, Class II, or Class III (Angle) malocclusion. A regression analysis was used in order to describe the proportion of the distorting variation caused by some usual changes in the cranial and facial skeleton. The results revealed that a part of the variation of the ANB angle could be attributed to factors other than the actual apical base difference, among these factors being the rotation of the S-N plane, the relative length of the S-N plane, and the rotation of the jaws. Because the ANB angle can vary without any marked abnormalities in the sagittal jaw relationship, the use of the so-called normal limits for the ANB angle is not justified. The authors feel that it would be better to replace the ANB angle with a more accurate indicator.

Stephen Williams et al (1985) say that in cephalometrics both angular and linear variables have been proposed in the analysis of sagittal jaw relationship and jaw position. Angular measurements can be erroneous as a result of changes in facial height, jaw inclination, and total jaw Prognathism; linear variables can be affected by the inclination of the reference line. In the present article, a method of geometric correction of linear analysis of sagittal jaw relationship and jaw prognathism (based on a standardized occlusal plane) is described. The method is applied to radiographic material (from King's College Hospital, London) of 33 children who, at the age of 19, exhibited Class I occlusal patterns. While uncorrected linear measurement suggested stability of the sagittal jaw relationship from the age of 11 to 19 years, the geometrically corrected value demonstrated a marked reduction in sagittal jaw relationship. The authors also say that the method is developed further to demonstrate the increase in jaw prognathism measured as lined parameters with origin at point sella, the results illustrating again the advisability of correction of geometric errors.

Seppo Jarvinen et al (1988)33 in their study, tested the hypothesis that the relationship between the ANB angle and the Wits appraisal can be expressed by measuring the individual variations in their reference systems and by constructing a model of regression between them and a few parameters describing the reference systems, with material consisting of 30 lateral cephalometric radiographs of untreated orthodontic patients with different types of skeletal and/or dento-alveolar malocclusions. According to the authors the results indicated that approximately 93% of the variation of the Wits appraisal could be explained by the variation of the ANB, NSL/OL, and SNA angles. The study also showed that the results given by different measurements with different reference Systems, such as the ANB angle and the Wits appraisal, cannot be directly compared. To obtain comparable interpretations, one should correct the results of both measurements in relation to the variations in their reference systems.

Stephen Sherman et al (1988)34 made a study in which the longitudinal changes occurring between the ages of 4 and 24 years in the Wits appraisal and its component parts were evaluated in 40 persons. Contrary to what may have been believed previously, the Wits appraisal was not found to remain stable throughout the growth period. When the findings of the Wits apprais al were studied in individual subjects, there was a wide range of variation. Real changes in the Wits appraisal were found to be disguised clinically by the differential sagittal growth of pogonion in relation to B point, especially in male subjects. Furthermore, the appraisal was found to be affected profoundly by changes occurring in the angulation of the occlusal plane. The authors concluded that if the Wits appraisal is to be used, it should be used in conjunction with other methods of assessment of apical base discrepancies and with due regard for the likely effects of changes in its component parts.

O.A. Sarhan (1990)31 after recognizing the drawbacks of the various measurements used to evaluate the dental base relationship, he felt that a new cephalometric angle based on the sella turcica structure and a relatively stable chin point (Gnathion) when measured against Subspinale (A) and Supramentale (B), would be a suitable candidate for assessing the relative retrusion or protrusions of both jaws. The angle formed by Sella Gnathion, A and B showed considerable sensitivity in distinguishing between Class I, II and III malocclusions. Values of the angle Sella Gnathion, A, B for Class I are between 30 degrees and 38 degrees; Class II values are between 39 degrees and 54 degrees; Class III values are between 26 degrees and 30 degrees. According to the author, Sella Gnathion line could be used for superimpositions in longitudinal studies and hence, points A and B could be readily compared.

Husamettin Oktay et al (1991)13 in their study evaluated the relationships among ANB, Wits, AF-BF, and APDI measurements used in the assessment of the antero-posterior jaw disorders, on the cephalometric radiographs of 6 male and 82 female subjects, and high correlations were found among them. Furthermore, relationships were explored between these parameters and some measurements that were thought to have influenced them. The results of the geometric studies could not be proved on the basis of statistical evaluation.

According to Anthony D. Viazis (1992)1 the True Horizontal (TH) has been established as the most reliable and clinically relevant reference line in cephalometric analysis. Thorough research has documented the reproducibility of this plane and proven its superior effectiveness to SN and the Frankfort horizontal. The purpose of this article is to describe an assessment of the antero-posterior position of the jaws based on measurements that use TH as their reference line. The means for these measurements were derived from approximations of the Michigan standards, from the observations of Proffit and White in a recent book and from a sample of 15 male and 15 female patients with Class I dental and skeletal relationships, good facial esthetics, and orthognathic profiles. Proffit and White propose combining TH with McNamara's nasion perpendicular in assessing antero-posterior relationships. They find three linear measurements- from A, B, and Pg to nasion perpendicular to TH- to be more accurate for surgical treatment planning than angular measurements. The angles between NA and NPg and TH, based on measurements from the Bolton standards, have also been used to evaluate the antero-posterior position of the jaws. NB provides an additional assessment. If points A and B are projected on perpendiculars to TH, they form points a and b. The distance a-b may be termed "TH Wits", as opposed to the original Wits measurement on the occlusal plane. TH Wits provides a clearer picture of the anteroposterior relationship of the jaws than the original Wits, which can be affected by the inclination of the occlusal plane or Frankfort horizontal.

Jennifer Hall-Scott (1994)20 gave a new plane, geometrically derived from the dental base planes, has been tested as an occlusal plane substitute for the measurement of anteroposterior jaw relationships. It lies close to but at an angle and inferior to the traditional occlusal planes and is highly reproducible at all times. Lateral cephalograms of 36 young adults (25 men and 11 women) and 43 10- to 12-year old children (24 girls and 19 boys) were selected and the Wits technique of antero-posterior measurement was used to compare A-B values measured to the new plane with those measured to the functional occlusal plane (FOP) and to the traditional or bisecting occlusal plane (BOP). Because of the downward cant of the bisector anteriorly, B is projected onto it ahead of A in normal occlusion and coincides with A in skeletal malocclusion. Mean values for normal occlusion were found to be approximately – 4 mm for the children (–4.2 mm girls and –4.0mm boys)and –4.5 mm for the adults (–4mm women and–4.7 mm men).

Ram Nanda et al (1994) 24 made this investigation mainly to evaluate if palatal plane could be used as a skeletal plane of reference in lateral cephalometric radiographs to evaluate sagittal maxillo -mandibular relationship. Various cephalometric landmarks in the maxilla and the mandible were projected to the palatal plane, and the linear distances between them were measured. In this three-part study, the first part evaluated changes in the inclination of palatal plane and in the linear distances from the age of 6 to 24 years in longitudinal records of 86 patients (46 male, 40 female). The second part established acceptable adult norms by evaluating 111 white dental students (89 men, 22 women) with Class I molar relationships, no history of orthodontic treatment, and good facial balance. The third part evaluated the proposed measures in pretreatment radiographs of 445 patients (171 men, 274 women) with a variety of malocclusions to compare the results of various diagnostic criteria for assessment of sagittal jaw relationships. The authors say that the first part indicated the inclination of the palatal plane was stable throughout the growth period studied and that the distance between projections from points A and B on the palatal plane (App-Bpp) was found to be the best indicator of sagittal jaw relationship. This was the least variable of the four measures considered in part two of the study. When compared with the angle ANB, the Wits appraisal and measurement of landmarks to a perpendicular from nasion in 50 patients, it was a more reliable diagnostic criterion than the other measures. Among the patients whose malocclusions were incorrectly diagnosed, Wits appraisal was consistently biased in the Class III direction. The methods using the ANB angle and the nasion perpendicular plane did not indicate any definitive trend.

According to **Sang D. Yang et al (1995)**30 the horizontal relationship of the jaws has been defined as the angles or distances between the references planes of the craniofacial complex and points A and B, which are representative of the anterior limits of the denture bases. The aims of their study were (1) to examine statistically and geometrically the Different cephalometric measurements which are used to indicate the A-P jaw relationship, and (2) to provide a more reliable parameter by means of comparative cephalometric analyses with various clinical examples. The authors feel that the APDI and Wits appraisal are parameters for evaluating the antero -posterior relationship of the dentition rather than the jaws. FH to AB plane angle (FABA) may provide not only a reliable cephalometric measurement of the antero-posterior relationship of the jaws but also a clue to the facial profile.

David Judy et al (1995)10 made a retrospective, longitudinal study to determine the mean Caucasian American AF-BF values at ages 8 and 18 years for 30 male and 32 female participants of the Bolton Growth Study. Mean AF -BF values (± s.d.) for males were 7.3 ± 2.7 mm at 8 years and 6.5 ± 4.2 mm at 18 years. Mean AF-BF values (± s.d.) for females were 6.7 ± 2.1 mm at 8 years and 5.2 ± 2.9 mm at 18 years. No significant difference was found between the mean AF-BF values for males and females at either age group ($P < 0.05$).

The decrease in AF -BF mean values with increasing age both for males and females was statistically significant. The correlation (r) for the AF-BF values was 0.49 ($P < 0.05$) for females and 0.86 ($P < 0.05$) for males. With increasing age, the mean difference between ANB values for females was 1.40 ± 1.60 and 1.10 ± 1.40 for males. The correlation of ANB angle and AF-BF provides a clinically useful tool for the cephalometric assessment of antero -posterior sagittal discrepancies of maxillary and mandibular denture bases.

Sydney Haynes et al (1995)35 quote that ever since the introduction of the Wits analysis, the validity of the method has been questioned, as the functional occlusal plane in particular has been cited as a major source of error. This may be either subjectively placed or defined by existing cephalometric methods. A study is therefore reported of the repeatability (intraobserver comparison) and reproducibility (interobserver comparison) of the Wits assessment on the basis of a double series of tracings by each of two observers. No statistically significant difference was found for the repeatability of distance AO -BO by either observer, but interobserver repeatability was less satisfactory, and the mean values varied by approximately 75%. The authors found that the highest single error between two series of tracings was 3.1 mm (observer A) and 5.8 mm (observer B).

Thomas D. Creekmore (1997)36 presented the 'Simplified Radney Analysis' where the maxillary incisors are positioned at 5mm ± 2mm and 22° ± 5° to NA for all skeletal patterns. The measurements increase as the ANB angle decreases, and decrease as ANB increases. For the lower anteriors position the mandibular incisal edges at 0.5mm ± 2mm to NA and 25° ± 5° to NB, with values decreasing as ANB decreases and increasing as ANB increases. Changes in the jaw relationships during treatment will change the incisor-to-NA position and should be anticipated in the treatment plan. If an ideal overbite and overjet have been established during treatment and the incisal edge of the mandibular incisor is aligned with NA, the maxillary incisor must be well positioned in the maxilla and the mandibular incisor must be properly positioned on the mandible to compensate for the difference in the jaw relationship.

Timothy F. Foley et al (1997)38 evaluated in their investigation the reliability and validity of three antero - posterior skeletal measurements using the maxillarymandibular (MM) Bisector, the functional occlusal plane (FOP), and the bisected occlusal plane (BOP) as reference Planes in the assessment of antero-posterior discrepancies. The authors have compared the measurements in both treated and control samples of Class II Division 1 patients. The data were collected from pre-treatment, post-treatment, and 2 years post-treatment lateral cephalograms of 36 Class II Division 1 subjects whose treatment was non-extraction with low or straight pull headgears. Comparisons were made to an untreated control group of 15 Class II Division 1 subjects. In their study the MM Bisector was found to be a highly reproducible reference plane whose greater stability was demonstrated by a lack of change in its cant during growth or during growth and treatment, compared with the BOP or FOP. With the ANB angle used as a standard, the MM Bisector antero-posterior measure was a more reliable and valid indicator of the skeletal antero -posterior relationship of the jaws, especially longitudinally during growth and treatment, than the Wits appraisals made with either the FOP or BOP.

SUMMARY AND CONCLUSION

The values of the Beta angle as quoted by the authors (Chong Yol Baik and Maria Ververidou in AJO 2004, 126: 100- 105) have been valued in the cephalograms of 180 patients from our department. Beta angle values of 52, 41 and 55 patients of Class I, Class II and Class III skeletal pattern respectively, correlated with the ANB and Wits measurements while 8, 19 and 5 patients of Class I, Class II and Class III patients respectively, did not correlate with the ANB and Wits values. Since a significant number of patients belonging to the Class II skeletal population did not correlate with the ANB and Wits values, an attempt was made to reason out the cause and a few reasons have been quoted regarding the same. Statistical report showed that there is a statistically significant difference between the Beta angle values of patients belonging to Classes I, II and III. The statistical report also revealed that there is no significant difference between the mean Beta angle values of the male and female sample. The evaluation of lower incisor position using the C-Pog line has opened new vistas in the estimation of lower incisor position. The C-Pog line was found to be reliable for reasons quoted in the discussion section. Moreover an alteration in the sagittal / vertical position of Pog due to growth does not alter the C-Pog line to an unreliable extent. Further clinical studies on the post treatment cephalograms of ideal occlusion can be done to validate the reliability of the Beta angle, the lower incisor to C-Pog angle and the linear measurement of the lower incisor to the perpendicular to C-Pog at Pog.

To conclude;

- Beta angle values of patients belonging to Classes I, II and III correlated well with the ANB and Wits values.

- The difference between the mean values of Beta angle of Classes I, II and III were statistically significant.

- The difference between the mean Beta angle values of male and female samples were not statistically significant.

- With further research, the C-Pog line could be used to evaluate the lower incisor position.

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