Update on the *Wits* Appraisal

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A review of various aspects of the application of the *Wits* appraisal of anteroposterior apical base relationships since its introduction in 1975.

KEY WORDS: · CEPHALOMETRICS · DIAGNOSIS · WITS APPRAISAL ·

Since the introduction of the angle A-N-B by RIEDEL in 1952, it has become one of the most popular means for evaluating the cephalometric evaluation of the anteroposterior (A-P) relationship of the apical bases. In spite of its well-known shortcomings, it is still used by many as an absolute determination of sagittal skeletal disharmony, and it is doubtful that all such determinations are made with full awareness and compensation for the often significant effects of variations in the vertical and sagittal jaw dimensions relative to the cranial base.

JENKINS recognized this as early as 1955, and so elected to use the functional occlusal plane as a reference base for the measurement of jaw disharmony. He reasoned that all phases of dentistry traditionally use this plane as a primary plane of orientation, since all masticatory forces are focussed on this plane and intimately related to it. He argued that even Angle used this as a 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 incisor edge (Fig. 1). To determine the extent of anteroposterior jaw dysplasia for the different angle classifications, he formulated a range of values for each of these measurements from *a plane*.

In an attempt to predict growth patterns of the jaws, HARVOLD (1963) likewise used the occlusal plane. He projected points A and B onto the occlusal plane and termed the resulting measurement the A-B difference. A negative value is assigned

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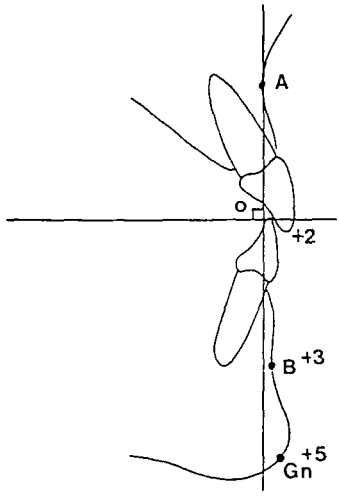

Figure 1
Favorable relations of incisor, point b, and gnathion to the "a" plane, according to Jenkins.

to measurements in which point B is posterior to point A. From age 6-9 years, point B moved forward relative to point A; however, he recognized the effect of the inclination of the occlusal plane on the A-B reading, which in extreme cases could change so much that the projection of point B could fall behind point A.

TAYLOR, (1969) also pointed out that the A-N-B angle did not always indicate true apical base relationship. Varied horizontal discrepancies of points A and B could give the same A-N-B measurement because variation in the vertical distance from nasion could compensate for other variation. A relative forward or backward position of nasion would likewise change the A-N-B reading, as would the forward or backward positioning of the maxilla and mandible.

BEATTY (1975) also reported that the A-N-B angle is not always an accurate method of establishing the actual amount of apical base divergence. As an alternative to the A-N-B angle for measuring apical base discrepancy, he devised the A-X-D angle, where point X is formed by projecting point A onto a perpendicular to the S-N line, and point D is located in the bony symphysis as described by (STEINER 1955). The two variables Nasion and point B were eliminated. He also introduced a linear measurement A-D_1 to describe the A-P relationship of the jaws. Point D_1 is the point which represents the shortest distance from point A on a line perpendicular to S-N passing through D. (Fig. 2).

JÄRVINEN (1985) attributes the variation in the A-N-B angle to factors other than apical base difference, stating: "the use of the apical base should be replaced by a better method to determine sagittal apical base difference." The *Wits* appraisal is among the possible alternatives that he mentions as a replacement for this angle.

The Wits Appraisal

Relating the jaws anteroposteriorly to the cranial reference planes presents inherent inconsistencies because of variations in craniofacial physiognomy. The rotational effect and the anteroposterior positions of the jaws relative to the anterior cranial base are illustrated in Figures 3, 4 and 5, and described at length in earlier publications (JACOBSON 1975, 1976).

In an attempt to eliminate the inherent variations and problems associated with relying on A-N-B, the Author suggested an alternative method of assessing sagittal or A-P jaw relationship which is independent of apical base relationships to cranial landmarks. The method entails projecting points A and B perpendicularly onto the functional occlusal plane (figure 6). The points projected onto the occlusal plane are identified as AO and BO respectively.

The measured distance between these points on the occlusal plane is termed the *Wits* appraisal. In the original study on Caucasian adults with excellent occlusions, points AO and BO in females coincided, the reading consequently being zero. In male subjects points BO is approximately 1 millimeter anterior to point AO, the *Wits* reading thus being −1 millimeter.

In Class I type malocclusions, points AO and BO generally tend to coincide on average; in Class II type skeletal dysplasia, point BO is posterior to point AO (positive value in millimeters); and in Class III skeletal disharmonies, point BO is forward of point AO (negative *Wits* reading).

Follow-up Studies on A-N-B Angle and Wits Measurements

Since the introduction of the *Wits* appraisal, various papers dealing with the subject have been published. KIM AND VIETAS (1978) in a study of A-P dysplasia indicators, used the AO→BO measure as an adjunctive procedure. They found that the mean measurement of the *Wits* appraisal in an adolescent Caucasian control group of 51 boys and 51 girls with normal occlusion is comparable to the values found by JACOBSON (1975) in adults.

Using part of the sample from the Foundation for Orthodontic Research, comprised of 41 males and 81 females over the age of 16 years and possessing "ideal" facial esthetics and "ideal" untreated class I relationships, McNamara and Ellis (1988) recorded mean *Wits* measurements of −0.72 in males and +0.93 in females.

A similar study of a South Wales population was undertaken by ROBERTSON AND PEARSON (1980), using 25 headfilms of 15yr-old females. Their results were likewise very similar to those of the prior studies.

By varying one measurement of the "average cranium" to an extreme sample cranial value, FERRAZZINI (1976) demonstrated empirically (qualitatively) and in a geometric-mathematical manner (quantitatively) that the angle A-N-B depended not only on the A-P relationship of the jaws but on the inclination of the palatal plane, maxillary prognathism, and vertical facial dimension. He stressed that "too much importance should not be given to the A-N-B angle, nor should it be considered the absolute measurement of anteroposterior relationship of the jaws. Rather it should be judged always in respect to other variables which have been cited."

By arbitrarily varying the positions of points, lines and angles on cephalometric drawings, BINDER (1979) likewise recognized the geometric effects at work in the A-N-B angle. He showed that for every 5mm anterior displacement horizontally, the A-N-B angle changed 2.5°. A 5mm upward displacement of nasion altered the A-N-B angle 0.5°; a downward displacement of nasion changed the A-N-B angle 1°. In a diagrammatic illustration, BISHARA ET AL. (1983) similarly showed the effect on the A-N-B angle of moving nasion forward or backward 1/2 inch (12.7mm) (Fig. 7), and vertically up or down by the same amount.

In differential treatment planning for mandibular prognathism SPERRY ET AL.

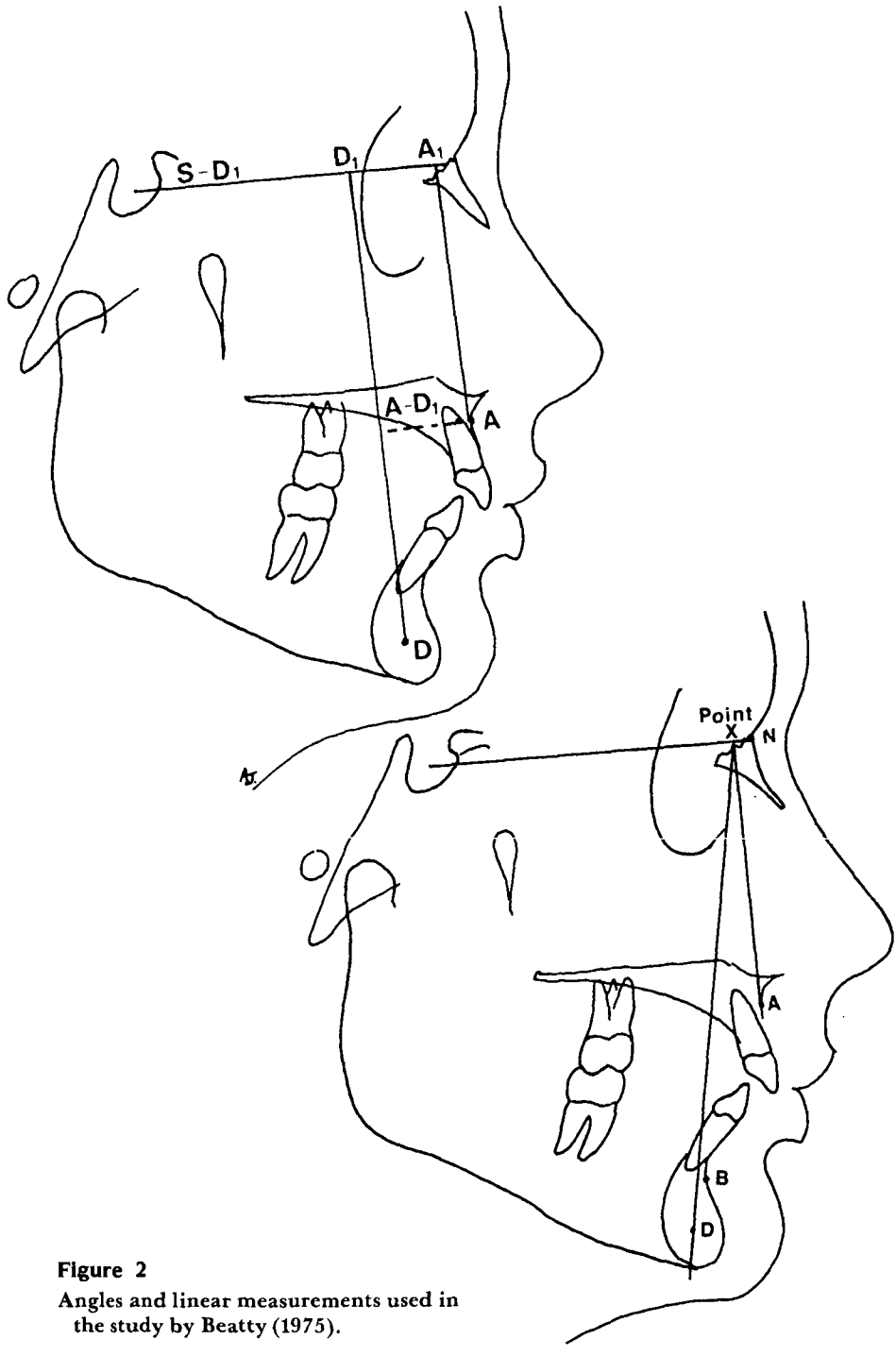

Figure 2
Angles and linear measurements used in the study by Beatty (1975).

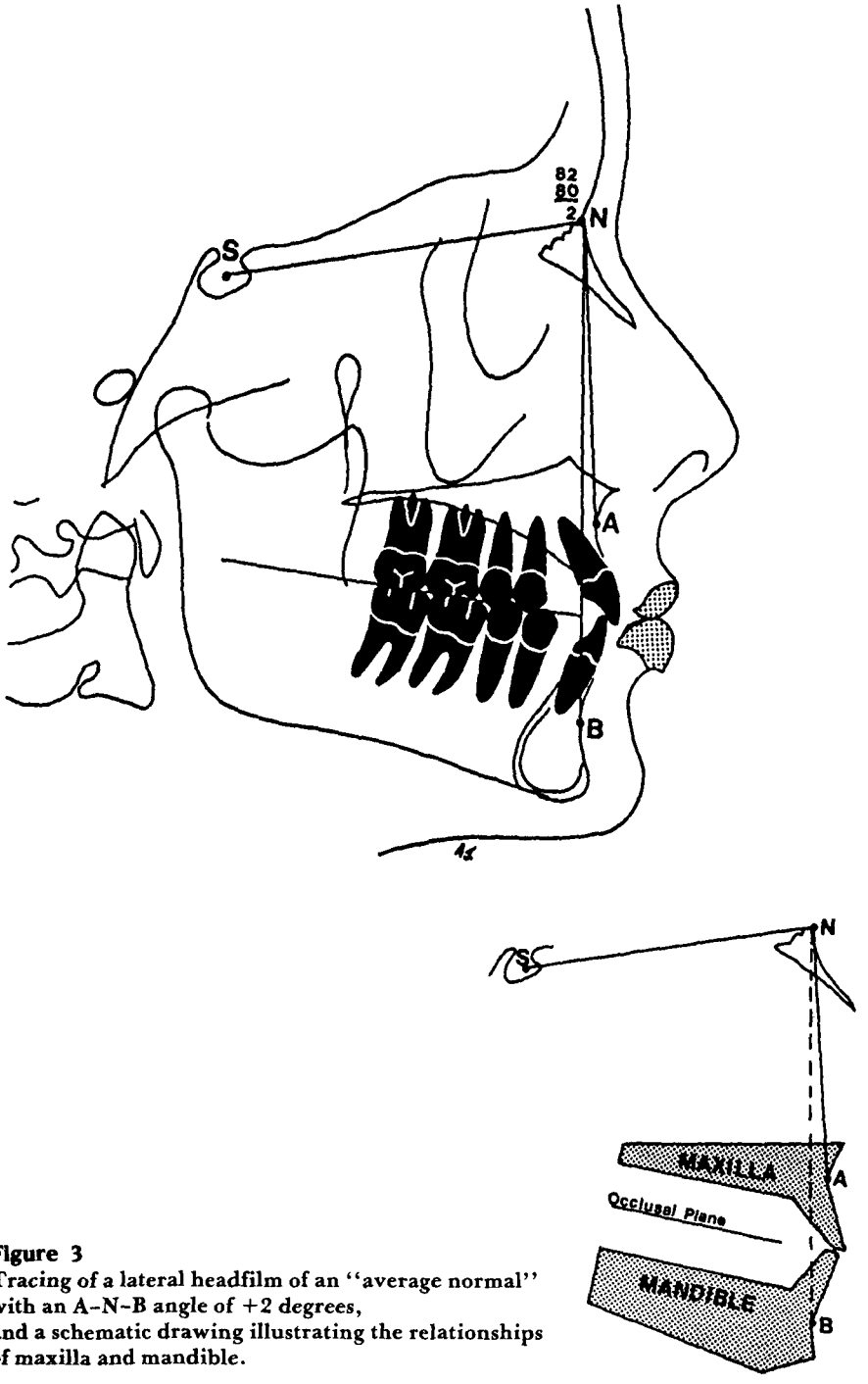

Figure 3
Tracing of a lateral headfilm of an "average normal" with an A-N-B angle of +2 degrees, and a schematic drawing illustrating the relationships of maxilla and mandible.

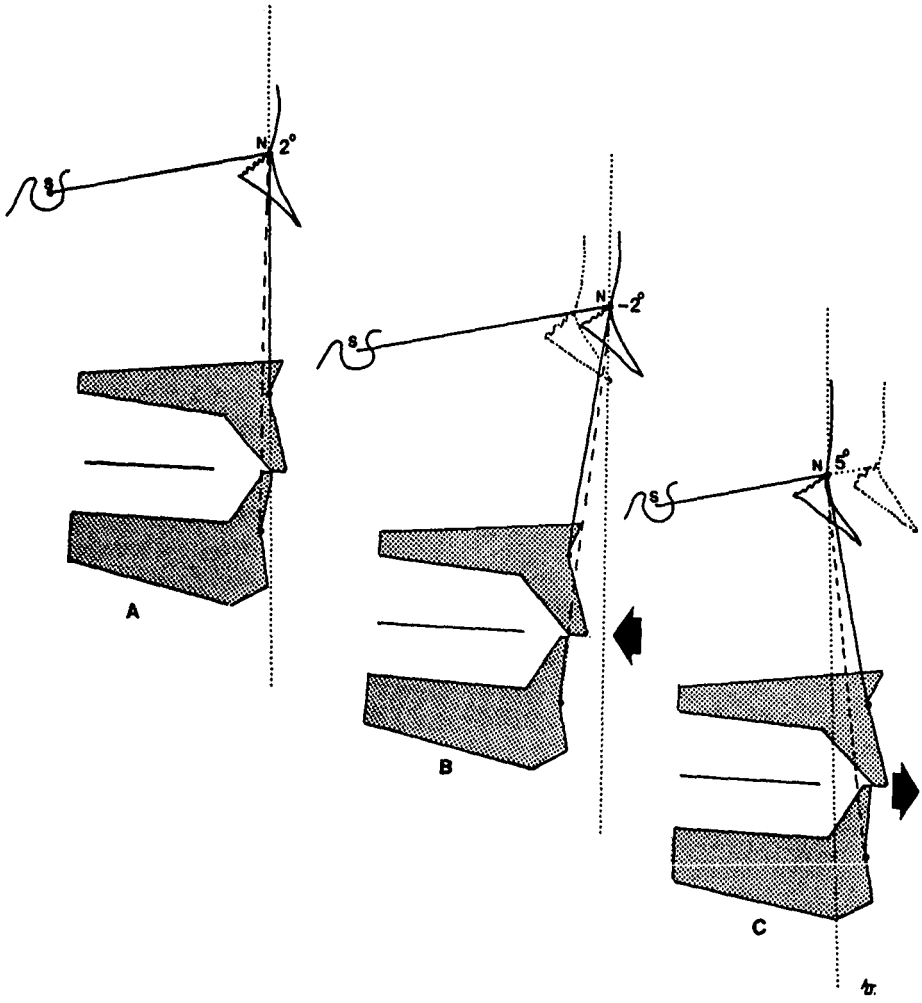

Figure 4
The effect of the A-N-B angle on apparent jaw relationships based on Nasion.

A. "Average normal" relationship of jaws to cranial base, with an A-N-B angle of +2 degrees.

B. Nasion farther forward, due to long anterior cranial base (S-N) and/or retropositioning of both jaws in the skull, resulting in a reduction of A-N-B to −2 degrees.

C. Nasion retropositioned, due to a short anterior cranial base and/or a forward positioning of both jaws relative to the cranium, resulting in a larger A-N-B angle (+5 degrees in this intance).

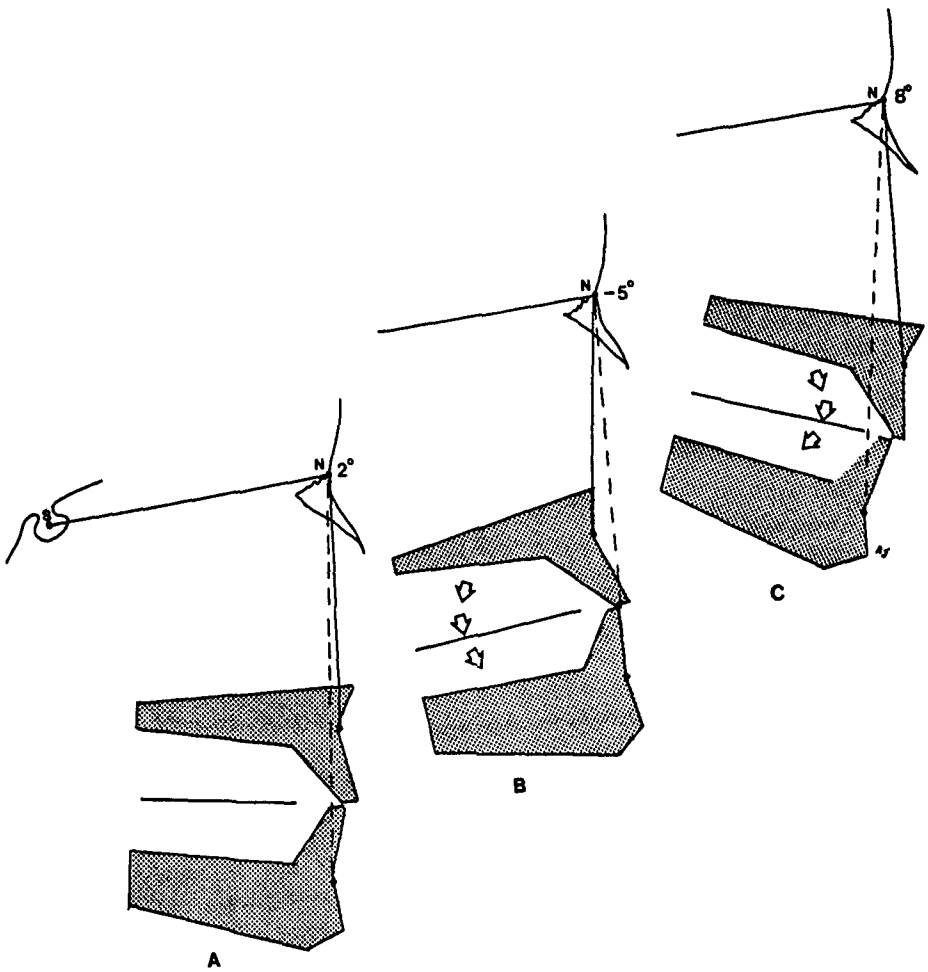

Figure 5
Effect of angulation of the jaws and occlusal plane on jaw relationship evaluations based on Nasion.

A. Average "normal" relationship of the jaws, with an A-N-B angle of +2 degrees.

B. Effect of "counterclockwise" rotation of the lower face; in this instance the A-N-B angle is reduced to −5 degrees.

C. Effect of a "clockwise" rotation of the lower face, with a resultant increase of A-N-B to +8 degrees.

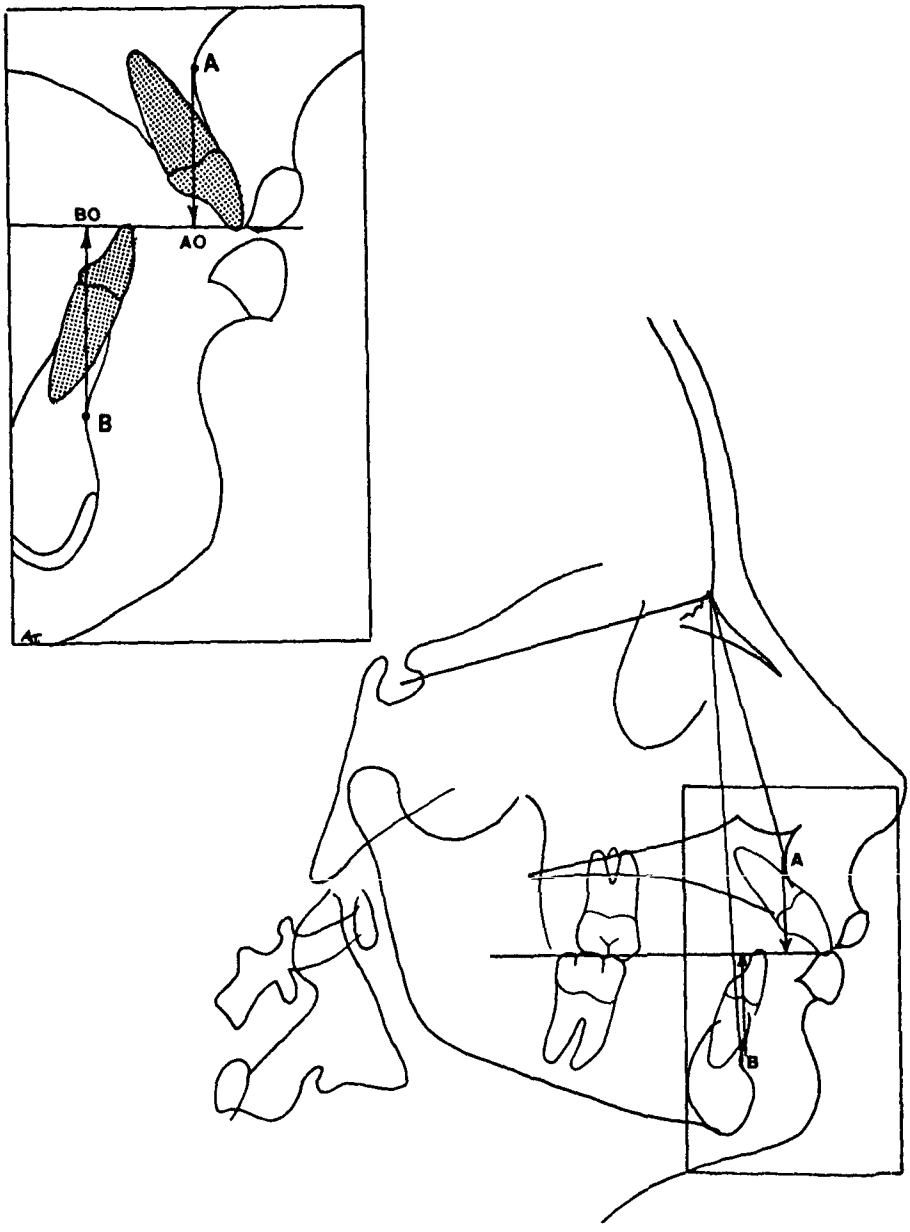

Figure 6

The *Wits* appraisal is acomplished by erecting perpendiculars from points A and B to the occlusal plane, with the occlusal intersections identified as AO and BO.

The measured distance between points AO and BO represents the *Wits* appraisal value.

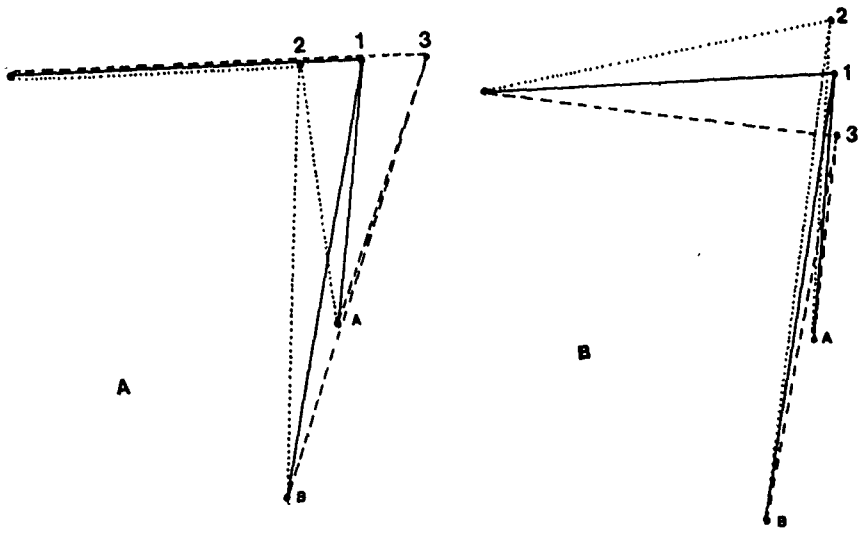

Fig. 7
Effects on the A-N-B angle of changes of 0.5″ (12.7mm) in the position of N,
with A and B held constant.
A. Horizontal shifts result in A-N-B angles of +4.5°, +9.0°, and −0.5°
B. Vertical shifts result in A-N-B angles of +4.5°, +4.0°, and +3.5°
(according to Bishara et al. 1983)

(1977) concluded that anteroposterior dysplasia should be assessed relative to the cant of the occlusal plane, and that true denture base discrepancies can be noted relative to the occlusal plane. ROTBERG ET AL. (1980) attempted to correlate the *Wits* appraisal with A-N-B differences on a group of patients to see how accurately one can predict the *Wits* value given the latter. The findings reflect no correlation between the two values when the *Wits* measurement is negative. When the positive A-N-B measurement is less then 4,° the *Wits* values could be either positive or negative. When the A-N-B angle is between 4° and 8,°all *Wits* values were positive. When both values were positive and the A-N-B values ranged between 1° and 8,° the investigators were able to predict the *Wits* measurement with 38% accuracy. If the A-N-B range is narrowed to 4° to 8,°all *Wits* values were positive and could be predicted in 28% of the cases. The latter figures, although not too relevant, do suggest the clinical uselessness of the relationship between the two parameters.

A later study by BISHARA ET AL. (1983) showed the correlation coefficients between the A-N-B angle and the *Wits* appraisal to be significantly correlated, but the r values were relatively low (0.63 in males and 0.56 in females). The findings of both studies underscore the necessity of applying both parameters to accurately estimate anteroposterior apical base relationship.

ROTH (1982) and MARTINA ET AL. (1982) recognized the A–N–B angle as an invalid measure of sagittal skeletal disharmony because of its being affected by rotations and variations in the sagittal and vertical jaw dimensions relative to the cranial base. The interdependency of the *Wits* appraisal and the vertical dimension of the jaws might be expected because of the geometrical relationship between the distance A→B and angle A–B/Occ which is related to the *Wits* appraisal by a cosine function. The mean value of the measured *Wits* appraisal, according to Roth, is 0.27, which corresponds to the mean value of zero found in the original 1975 JACOBSON study. A slightly greater distance is found in male subjects than in female, but this difference is not significant.

During the period of the investigation (mean 3.62 years) there is a significant mean annual change of 0.59mm in the *Wits* measurement. The angle A–B/Occ decreased 0.29° per year during the same period. This is contrary to the findings of BISHARA ET AL. (1983), who concluded that the A–N–B angle changes significantly with age, whereas the *Wits* appraisal does not.

Two factors that Roth suggests will affect the *Wits* reading are the occlusal plane angle and the vertical alveolar dimensions. The positive summation effect of increasing the distance A→B and decreasing the occlusal plane angle are demonstrated in Figure 8. Alteration of the vertical jaw relationships (increasing the distance between points A and B) leads to a further increase in the A→B distance or *Wits* reading. To eliminate the influence of the vertical relationship of points A and B to the occlusal plane, Roth provides an alternative procedure whereby a standardized distance of 50mm is used along the A–B line, in effect constructing phantom points with a consistent dental relationship that eliminates the effects of deeper skeletal relationships.

Roth contends that it would be interesting if the anteroposterior effect of the *Wits* appraisal of treatment changes in the occlusal plane could be used for determining, or predetermining, changes in molar relationship relative to the occlusal plane. Referring to the diagram in Figure 9, showing the alteration of *Wits* appraisal applied to the molar relationship, and assuming an identical alteration of the occlusal plane (−10 degrees) the anteroposterior molar relationship is positively correlated with the length of the distance A→B if the upper molar moves on an arc (RA) with the anterior point A, and the lower molar on the arc (RB) with the center point B. Starting from a Class I molar relationship (shaded blocks), the Class II effect in the molar region is larger with the greater distance A→B (right) than with the smaller distance A→B (left).

The above assumptions, however, are only possible if the upper and lower molars move on arcs with centers at A and B respectively as a consequence of therapeutic change in the occlusal plane. There is no scientific change for such an assumption, nor is there justification for suggesting that the distance from points A to B in one individual is likely to be 2.5 times greater than that of another as shown in the illustration. Also, a 10° occlusal plane difference, be it a discrepancy between the two observers or "treatment" induced, is quite unlikely. A 10° change in the occlusal plane as a result of treatment would cause the lower incisors to be flared by the same amount relative to this plane, and unless the lower incisors were lingually inclined at the beginning of treatment because of instability, it is unlikely that this would be the effect of a treatment of choice.

CHAN (1985), in a study to determine how much the *Wits* measurement

changed as a result of treatment, found that the occlusal plane is not a principal cause of the AO→BO (*Wits*) change, but that the change is more likely due to growth or actual A-P correction resulting from treatment mechanics.

BISHARA ET AL. (1983) conducted a study to determine the changes in the A-N-B angle and *Wits* appraisal between five years of age and adulthood in both male and female subjects, and to determine whether the changes are significantly different from each other. Their findings support the contention that the A-N-B angle does not accurately describe the maxillary and mandibular apical base relationship, owing to normal variation in the spatial positions of both sella and nasion.

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

In studying the longitudinal effects of growth on the *Wits* appraisal in a sample of 40 Class I and Class II, division 1 subjects ranging from 4 to 24 years of age, SHERMAN ET AL. (1988) found the overall mean changes for the Class II group to be quit definite; but the mean changes in both males and females in the Class I group were less than 1 millimeter. They contend, however, that the mean figures mask a wide range of variation and conclude that the direction and magnitude of any change in the *Wits* appraisal will depend on the direction of facial growth and any treatment mechanics involved. They caution that sagittal changes may be diguised by changes in the angulation of the occlusal plane, and that the *Wits* appraisal should be used only in conjunction with other methods of assessing apical base relationships, and with due regard for the likely effects of changes in its component parts.

Using a sample of 104 Brazilian teenagers of both sexes, ARANHA ET AL. (1985) tried to identify a possible relationship between the *Wits* appraisal and the I-line of Interlandi among selected groups. Their study showed that the simultaneous use of the *Wits* appraisal and the I-line evaluation can offer a simple objective and rapid view of the maxillo-mandibular relationship and the incisor discrepancy. The I-line extends from P_1 to E (Figure 10), where P_1 is located at the intersection of N-A line with the nasal floor, and E lies at the intersection of a perpendicular from the mandibular plane to the most forward position on the mandibular symphysis. The use of the I-line is intended to determine the "ideal" position of the mandibular incisors in relation to the maxilla and the mandible. Values between -2.5mm and $+2.5$mm are considered normal for the I-line (dental protrusion is indicated by a negative I value).

Instead of the "I" line, RICKETTS (1982) (Figure 11) proposes the A-Po line, a similar measurement derived from the Downs analysis, to evaluate lower incisor position.

— Conclusion —

Assessment of antero-posterior apical base discrepancy by applying the *Wits* appraisal is largely dependent upon correct location or representation of the occlusal plane. This can present a problem in some aspects, in that the occlusal "plane" is not a plane, and the left and right sides of the posterior teeth do not always coincide or superimpose correctly.

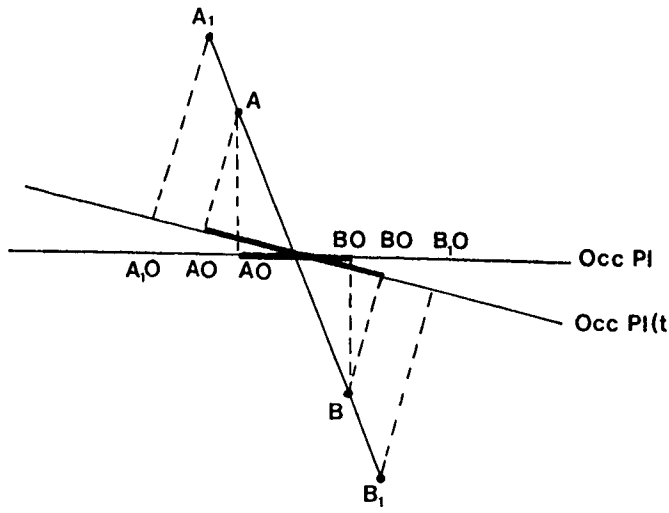

Figure 8

The effect on the *Wits* value of differences in the angle of the occlusal plane and the distance between points A and B.

(after Roth)

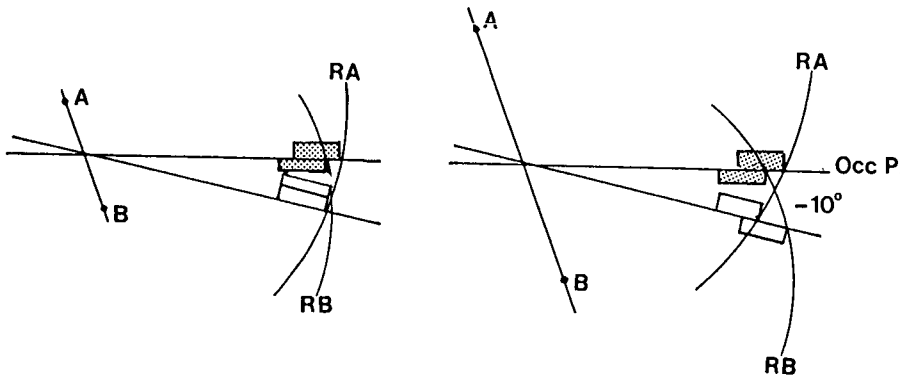

Figure 9

Roth's modification of the *Wits* appraisal to describe molar relationships.

(Note that this is a left-side view)

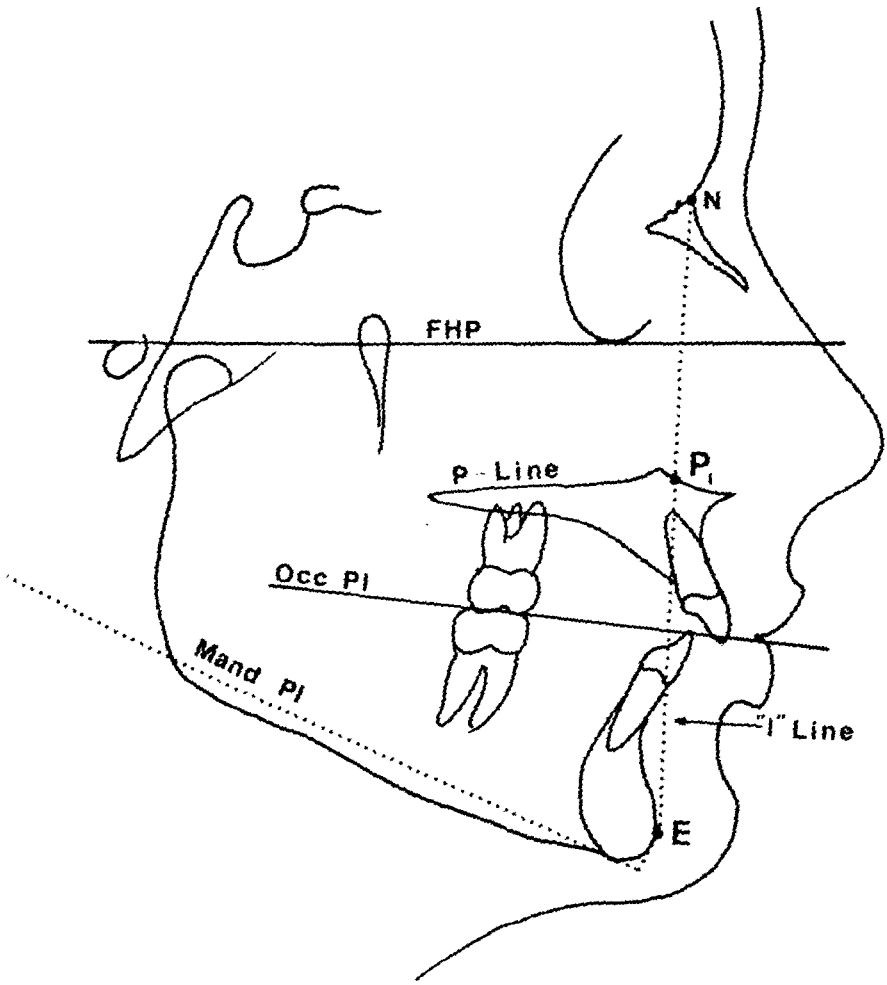

Figure 10
Cephalometric tracing showing the "I" line of Interlandi, with points P_1 and E which define it.

The latter problem may be due to true dentofacial asymmetry, asymmetric location of the external auditory meati, and/or incorrect positioning of the head in the head-holder. Such factors, among others, can limit the accuracy and precision of all cephalometric measurements, but excellent information can nevertheless still be obtained from these radiographic procedures.

Traditionally, the occlusal plane is extended from the cuspal image overlap of the first molars to the middle of the incisor overlap. However, because of the possible incisor supra- or infra-eruption in malocclusions, a more appropriate plane would be a representative functional occlusal plane drawn through the cuspal overlap of the maxillary first molars and first bicuspids. In the event of a vertical discrepancy between the left and right sides of the posterior teeth, a plane is drawn midway between the two posterior segments. In the mixed dentition, a horizontal plane can usually be drawn through the overlap of the cusps of both deciduous molars and the permanent first molars.

Further inherent problems associated with cephalometric methods include identification of landmarks (BAUMRIND AND FRANTZ 1971, JACOBSON AND JACOBSON 1980) and interpretation of findings on a three-dimensional object using a two-dimensional image. Landmarks, points or planes on lateral headfilms cannot be regarded as truly stable, particularly in growing individuals. All move in varying degrees relative to each other. Evaluating growth and/or treatment changes entails superimposing radiograph tracings of sections of the craniofacial complex with minimal growth to demonstrate areas of relative change due to growth or treatment.

No single parameter in cephalometrics should be relied on entirely and interpreted as an absolute value. Conventionally used angular and linear measures

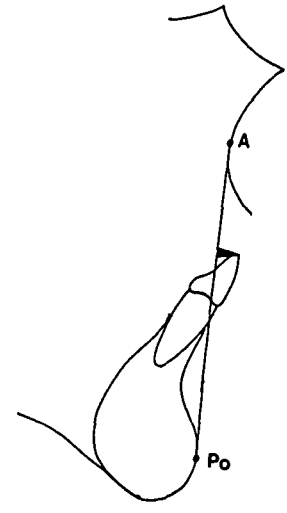

Figure 11
The A-Po line of Ricketts and the lower incisor measurement

are highly correlated and overlap to the extent that two or more measures often reflect the same underlying anatomic condition in slightly different terms. It is not proper to treat all angular or linar measures as if they were of equal reliability. While there is no compatibility between angular and physical units, the study of BAUMRIND AND FRANTZ (1971) showed that the absolute values of errors and the variability among replicated estimates tend to be greater for angular measures than for linear measures.

The *Wits* appraisal is a linear measurement, and not an analysis per se. It is simply an adjunctive diagnostic aid which may prove useful in assessing the extent of anteroposterior skeletal dysplasia and in determining the reliability of the A–N–B angle.

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