F-H to AB plane angle (FABA) for assessment of anteroposterior jaw relationships

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The importance of correctly identifying the anteroposterior (A-P) jaw relationship cannot be overemphasized in orthodontic diagnosis. The clinician uses this relationship to establish detailed treatment goals and proper treatment mechanics.

It has often been observed that the intermolar relationship is not necessarily related to the facial profile. When analyzed cephalometrically, many patients with a Class I molar relationship show an obvious Class II or Class III pattern in their facial profile. Most of these cases show abnormal rotation of the jaws relative to the cranial anatomy. Headgear therapy during orthodontic treatment of a patient with Class II malocclusion is not always effective, especially when the palatal plane is not taken into consideration in the determination of the true A-P relationship of the jaws.

The horizontal relationship of the denture bases can be defined using the angles[1-10] or distances[11-15] between the reference planes of the craniofacial complex and the points A and B, which are representative of the anterior limits of the denture bases. The skeletal A-P relationship is probably affected by the vertical jaw relationship. In other words, the degree of the A-P relationship can vary in response to the vertical change of the facial dimension.

Accordingly, it might be said that the skeletal sagittal aspect could be described more adequately by the angles between the craniofacial reference planes and the A-B plane, which is supplemented by a consideration of both vertical and horizontal distances between points A and B concurrently. The aims of this study, therefore, were 1) to examine statistically and geometrically the different cephalo-

Abstract

The horizontal relationship of the jaws has been defined as the angles or distances between the reference planes of the craniofacial complex and points A and B, which are representative of the anterior limits of the denture bases. The aims of this 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 APDI and Wits appraisal are parameters for evaluating the anteroposterior relationship of the dentition rather than the jaws. FH to AB plane angle (FABA) may provide not only a reliable cephalometric measurement of the anteroposterior relationship of the jaws but also a clue to the facial profile.

Key Words

FABA • Horizontal relationship of the jaws • Vertical jaw dimension • Facial profile • Jaw rotation

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Table 1
Measurements in Korean children with normal occlusion

Measurement	Males Mean	Males SD	Males Range	Females Mean	Females SD	Females Range	t-value
SN to AB (degree)	73.28	3.44	16.0	72.64	3.19	15.0	1.02
FH to AB	80.92	2.43	10.5	80.57	2.57	10.5	0.62
PP to AB	81.01	2.91	14.0	81.25	3.21	13.5	-0.41
OP to AB	93.05	2.91	13.0	93.22	2.93	12.5	-0.33
MP to AB	70.79	3.58	18.5	70.43	3.81	18.5	0.52
AFB	6.5	5.26	1.61	5.5	-0.35	5.15	1.70
S-GN to AB	36.36	2.43	10.0	36.65	2.59	11.5	-0.61
PP to FH	0.23	2.34	9.0	0.53	2.30	11.5	-1.71
A,B to SN	11.41	2.35	10.5	11.48	2.23	10.5	-0.17
A,B to FH	6.27	2.16	7.5	6.33	2.01	7.0	-0.14
A,B to PP	6.20	2.05	9.5	5.90	2.25	10.0	0.73
A,B to OP	-2.05	1.87	10.0	-2.15	1.91	8.0	0.30
A,B to MP	-13.14	2.98	18.5	-12.99	2.79	12.5	-0.26

male subjects, n=55; female subjects, n=55; P=NS

metric 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.

Materials and methods

Cephalometric radiographs of 110 Korean children with normal occlusion were evaluated. The sample consisted of 55 boys and 55 girls between 8 and 13 years of age. The mean age was 10 years 6 months, with a standard deviation of 1.39. The measurements subjected to evaluation were as follows:

Angular measurements

1) SN to AB (Taylor and Hitchcock [1]): SN plane (S-Na) to AB plane (point A-point B)
2) FH to AB: Frankfort Horizontal plane (Or to Po) to AB plane (FABA)
3) PP to AB: Palatal plane (Ans-Pns) to AB plane (PABA)
4) OP to AB (Bushra [2]): Occlusal plane to AB plane
5) MP to AB: Mandibular plane (Me to Go) to AB plane
6) AFB (Freeman [4,5]): The angle formed from point A to point AF (the point of perpendicular contact on the F-H plane from point A) to point B
7) S-Gn to AB (Sarhan [6]): S-Gn to AB plane
8) FH to PP: F-H plane to palatal plane

Linear measurements

9) AB to SN distance (Taylor[11]): The distance between perpendiculars drawn from point A and point B onto the F-H plane
10) AB to F-H distance (Chang[12])
11) AB to PP distance (Ferrazzini[13])
12) AB to OP distance (Wits appraisal[14,15])
13) MP to AB distance

Means and standard deviations of the above variables were established. Coefficient correlations among measurements were tabulated to determine which combination would produce a higher value.

Results

Statistical data relating to measurements, such as means, standard deviations, ranges, the student's t-tests, and correlation coefficients are presented in Tables 1 to 3. No statistically significant relationship was found between the ages of male and female subjects (t=-1.81, P>0.05). There were no statistically significant differences between sexes in any of the measurements (Table 1). The coefficients of variability of the parameters were quite different (Table 2). The measurement with the most homogeneous distribution was FABA, followed by OP to AB and APDI; the least homogeneous was the palatal plane angle. Statistically significant and highly correlated relationships were found among measurements. The correlations were very high, 0.980

Table 2
Range of measurements of pooled group (n=110)

Measurement	minimum	maximum	mean	SD	Coefficient Variability
SN to AB (degree)	63.5	81.5	72.96	3.32	4.55
FH to AB	75.5	86.0	80.75	2.50	3.09
PP to AB	74.5	88.5	81.13	3.05	3.76
OP to AB	86.5	99.5	93.13	2.92	3.13
MP to AB	60.0	80.0	70.61	3.68	5.21
AFB	2.0	8.5	5.20	1.65	31.73
S-GN to AB	31.0	42.5	36.50	2.50	6.84
FH to PP	-4.5	7.0	0.38	2.34	615.78
A,B to SN	5.5	17.5	11.45	2.28	19.91
A,B to FH	3.0	10.5	6.30	2.08	30.01
A,B to PP	1.0	11.0	6.05	2.15	35.54
A,B to OP	-7.0	3.0	-2.10	1.89	90.0
A,B to MP	-25.5	-7.0	-13.06	2.88	22.05

Table 3
Correlation coefficients between angular and linear measurements

	SN-AB	FH-AB	PP-AB	OP-AB	MP-AB	AFB	SGn-AB	FH-PP
A,B to SN	0.936**	0.695**	0.605**	0.472**	0.137	0.712**	0.524**	0.071
A,B to FH	0.674**	0.969**	0.651**	0.531**	0.191	0.980**	0.541**	0.306
A,B to PP	0.581**	0.654**	0.977**	0.546**	0.215	0.691**	0.518**	0.432**
A,B to OP	0.494**	0.559**	0.570**	0.991**	0.573**	0.524**	0.644**	0.040
A,B to MP	0.229	0.227	0.227	0.456**	0.952**	0.155	0.578**	0.012

Sig level * P<0.01; **P<0.001

between FABA and AFB, and 0.570 between PABA and the Wits appraisal (Table 3).

Discussion

Numerous factors other than the skeletal pattern influence the facial profile. Size and shape of the nose, thickness and posture of the lips, the morphology of tissues over the symphysis, and the inclination of incisors are some of the factors that contribute to the soft tissue profile. Nevertheless, the skeletal A-P relationship of the jaws is the most significant factor.

From the orthodontic viewpoint, a patient's facial profile is best described by the relative A-P jaw relationship with respect to the cranial anatomy. Various cranial reference planes have been used as baselines from which to determine degrees of jaw dysplasia. In spite of the known uncertainty of accurately locating porion in cephalometrics, the Frankfort plane has proved adequate for facial typing. This conclusion was drawn after comparing the several cranial reference planes.[7-9]

In addition, Frankfort horizontal (F-H) plane cuts across the face and hence would be a more reasonable choice for a study of relationships involving only the face, which is the focus of the orthodontist's interest.

A reasonable prediction of the A-P jaw dysplasia should be possible by means of the angles (FABA, AFB[4,5]) or the distance (AF-BF[12]) between points A and B in relation to the F-H plane.

An absolute measurement of the distance between points A and B projected onto the F-H plane was suggested by Chang[12] and termed the AF-BF distance (Figure 2). This measurement, however, does not take into account the vertical relationship between points A and B. Actually, the vertical relationship of the jaws seems to affect A-P jaw dysplasia as well as the facial profile. The shorter the vertical distance between points A and B, the more retrusive the

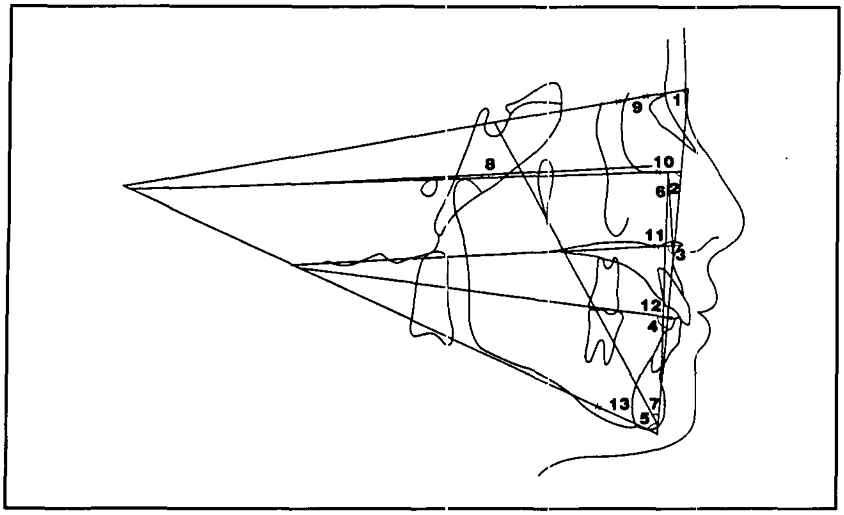


Figure 1

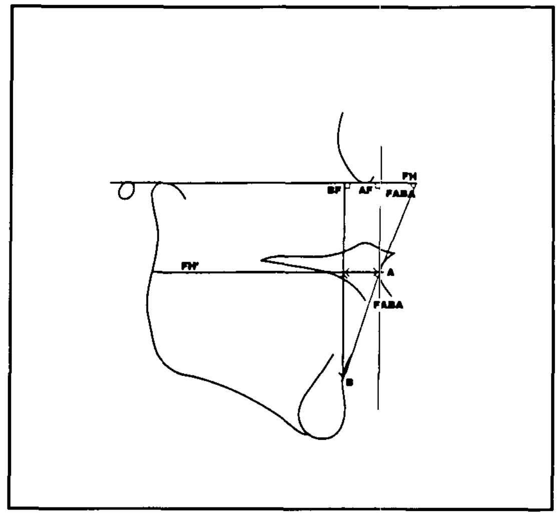


Figure 2

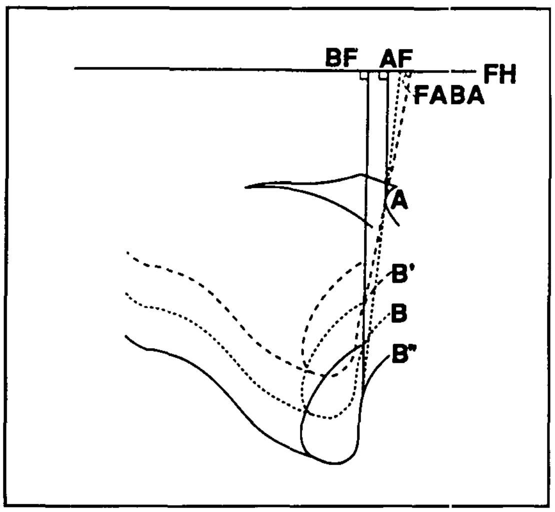


Figure 3

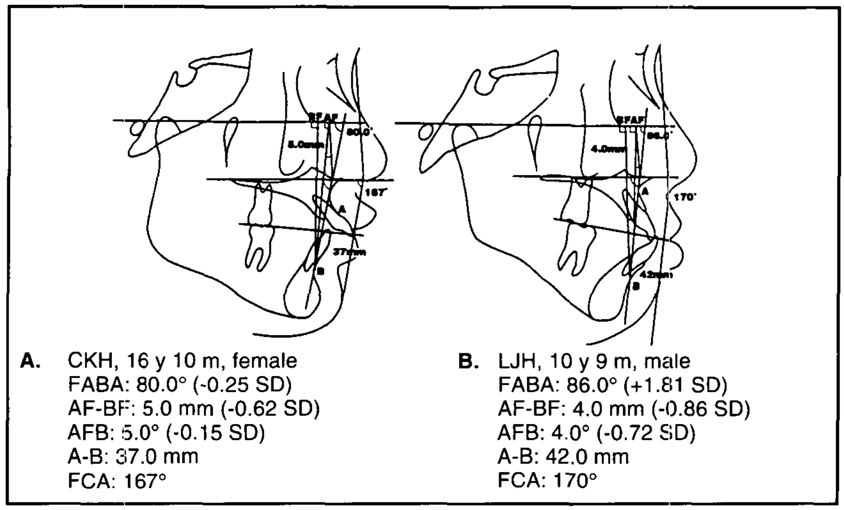


Figure 4

Figure 1
Thirteen measurements used in this study. Numbers 1 through 8 are angular measurements and numbers 9 through 13 are linear.

Figure 2
FABA, formed by Frankfort horizontal plane and the line connecting points A and B. FABA is equal to the angle determined by AF-BF and the vertical distance between points A and B. Angles greater than the norm (81°) indicate tendencies toward Class III skeletal patterns; angles less than 81° reflect Class II jaw discrepancies.

Figure 3
As the distance between points A and B decreases, the facial profile becomes more retrusive and the facial contour angle decreases. As the vertical dimension increases, the profile appears more prognathic, the facial contour angles decreases, and FABA becomes greater.

Figure 4
Even when AF-BF and AFB are almost identical and within normal ranges, profiles can be quite different. FABA, however, differentiates the two with figures of 81° in case A and 86° in case B. Facial contour angle (FCA) is greater in B (170°) than in A (167°).

facial profile. Conversely, as the vertical dimension of the jaws increases, the facial profile appears more prognathic (Figure 3). As an example, Figure 4 shows two cases that demonstrate different skeletal patterns even though the AF-BF distances are almost identical and within the range of normal. The patient on the right presents a more prognathic profile than the one on the left, due mainly to the difference in the vertical dimension of the jaws (A-B distance).

On the other hand, Freeman[4,5] described a method to evaluate the A-P jaw relationship to eliminate point Na for a more accurate evaluation. This is illustrated in Figure 5A. When the point A is fixed and the point B is variable, the AFB angle is correlated geometrically with FABA (Figure 5B), as evidenced by the statistical data (Table 3). That is, the larger the AFB value, the smaller the FABA reading, and vice versa. However, when point A moves along

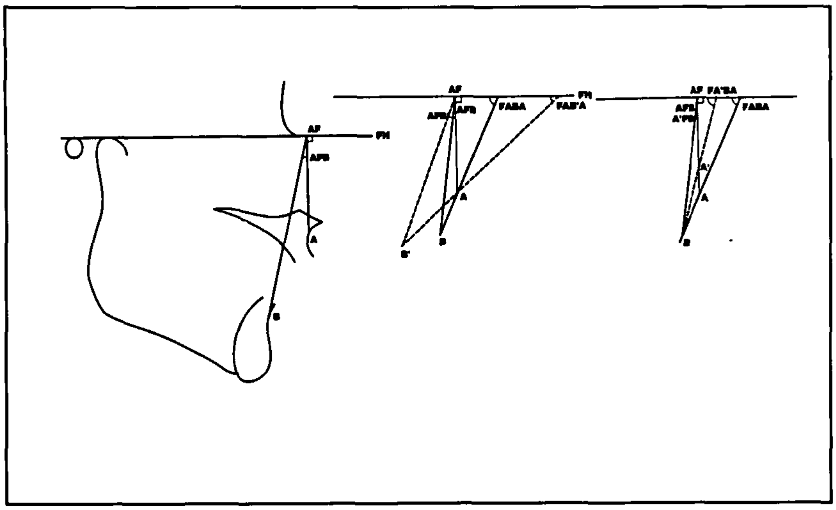


Figure 5

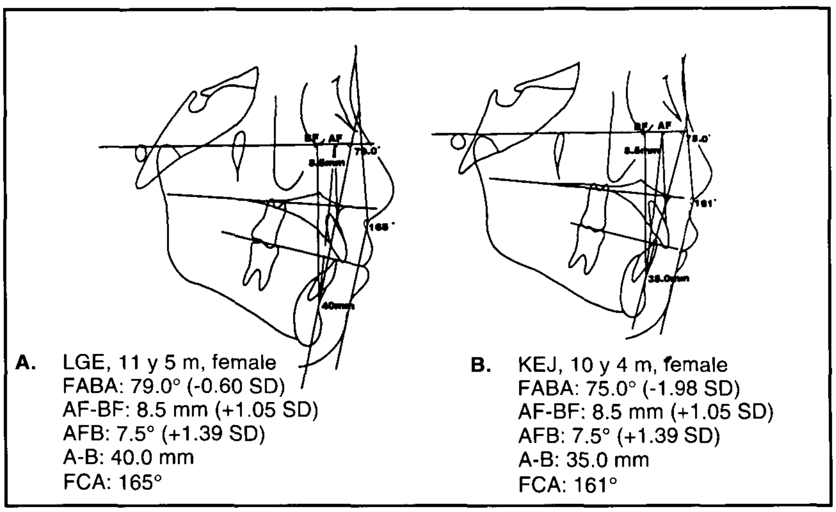


Figure 6

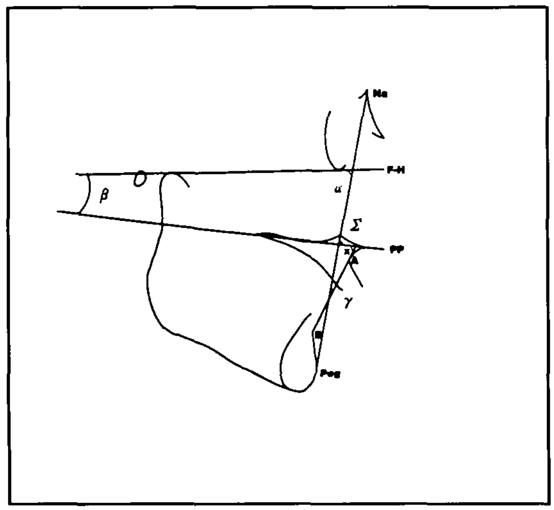


Figure 7

the AF plane vertically, the angle AFB remains constant, whereas FABA shows different values in response to its vertical displacement (Figure 5C). This means that AFB does not take into consideration the vertical relationship between points A and B.

In Figure 6, AF-BF distances and AFB angles are identical, yet the profiles are different. The first patient has a more retrusive profile, with an AB distance of 35 mm, than the second patient, at 40 mm. Variation in the vertical position of points A and B helps differentiate the two profiles. Because FABA is formed geometrically by both AF-BF and the vertical dimension between points A and B (Figure 2), FABA would be a more accurate measurement to use in predicting A-P skeletal dysplasia and/or facial profiles than AF-BF or the AFB angle.

In addition, FABA statistically has the lowest coefficient of variability among the

Figure 5
A: A perpendicular line from point A to F-H plane establishes point AF. A line from point AF to point B forms the angle AFB.
B: When point A is fixed and point B is variable, angle AFB is correlated geometrically with FABA. As AFB increases, FABA decreases, and vice versa.
C: Angle AFB remains constant irrespective of the vertical displacement of point A, while FABA shows different values.

Figure 6
Even when AF-BF and AFB are equal, the facial profiles can differ. Case A shows a normal facial pattern with a FABA reading of 79°, while case B demonstrates a retrusive profile (FCA 161°) with a FABA of 75°.

Figure 7
Geometric interpretation of APDI. According to the geometric theorem, $\alpha+\beta=\Sigma$, $\chi+\gamma=\Sigma$; therefore, $\alpha+\beta=\chi+\gamma$, or $\chi=\alpha+\beta-\gamma$. Note that A-B plane has a negative value in case of forward location of "A" point, relative to Na-Pog. As a result, PABA = FA + A-B + PPA = APDI. α=Facial angle (FA), β=palatal plane angle (PPA), γ= A-B plane angle (A-B), χ=palatal plane to A-B plane angle (PABA).

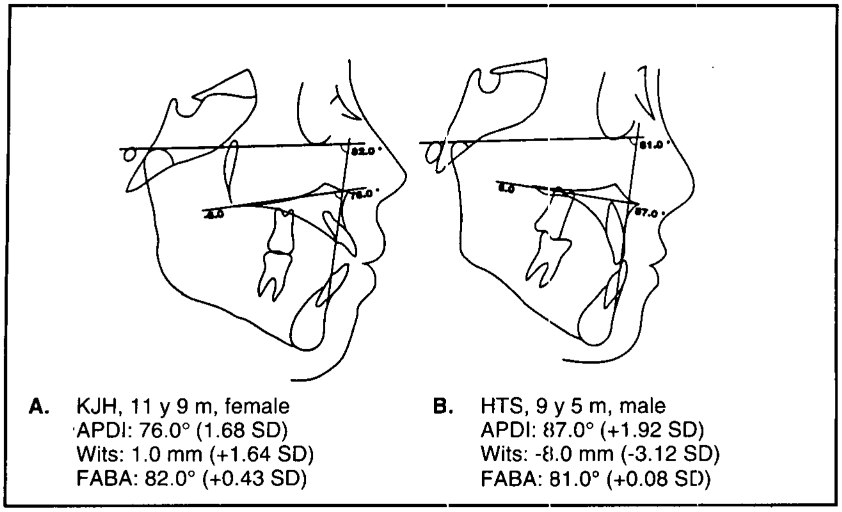


Figure 8

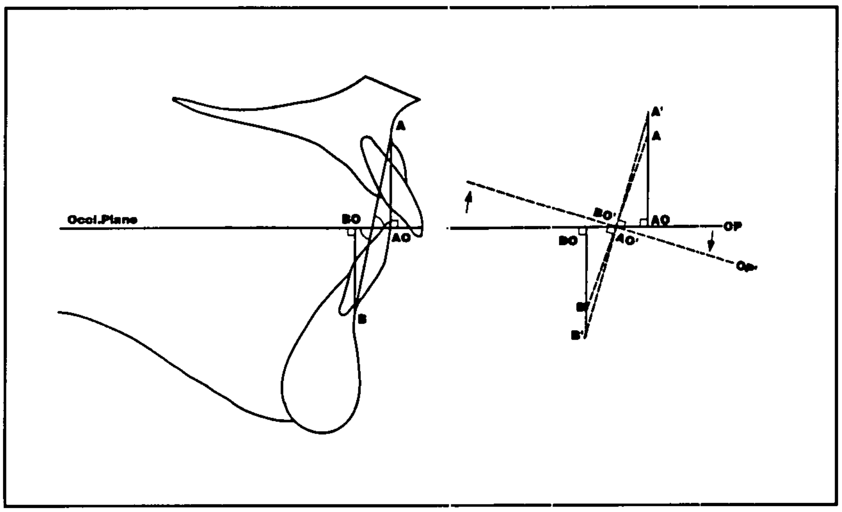


Figure 9

Figure 8
Although the FH to AB plane angles are almost identical, a distocclusion and an open bite are shown in case A, mainly because the palatal plane is inclined upward anteriorly -6°. Case B demonstrates a palatal plane angle of 6° with a resultant mesiocclusion and deepbite.

Figure 9
Wits appraisal.
A: AO and BO are points of contact of perpendiculars dropped from points A and B onto the occlusal plane. Distance AO-BO depends on the angle AB-OP and distance A-B.
B: Alteration of the occlusal plane leads to a decrease of Wits measurement. The Wits reading remains constant irrespective of the various vertical dimensions between points A and B.

cephalometric parameters measured, indicating that it is the most homogeneously distributed parameter (Table 2).

Kim,[3] on the other hand, suggested the anteroposterior dysplasia indicator (APDI) be used as a differential diagnostic aid to the skeletal A-P dysplasia. This indicator is obtained from a combination of singular measurements, such as the facial angle, A-B plane angle, and palatal plane angle, which are considered pertinent to interpretation of the horizontal aspect of skeletal patterns. Figure 7 shows the geometric interpretation of the APDI.

α = facial angle (FA)
β = palatal plane angle (PPA)
γ = A-B plane angle (A-B)
χ = palatal plane to A-B plane angle (PABA)

According to the well known theorem of elementary geometry (Figure 7), $\alpha+\beta=\chi+\gamma$ or $\chi=\alpha+\beta-\gamma$.

When point A is located forward of the facial plane (Na-Pog), the A-B plane angle has a negative value by definition. As a result, PABA = FA + A-B + PPA

The last formula states that PABA equals APDI. This geometric relationship holds true for all variable situations irrespective of the palatal plane inclination and/or the location of point A relative to Na-Pog.

Thus, APDI may be considered to be the angle formed by the A-B plane in relation to the palatal plane. Although the palatal plane is nearly parallel to the F-H plane, with a slight discrepancy of about 0.4° (Table 2), the palatal plane angle possesses a wide range of readings even in the sample of normal occlusion, from a minimum of -4.5° to a maximum of 7.0°, with a coefficient of variability of 615.78 (Table 2). This means that the inclination of the palatal plane is so variable that the palatal plane would be unsuitable for use as a reference plane for the sagittal relationship of the jaws and APDI, which is determined definitively by the palatal plane, would be less dependable as a measurement of the A-P jaw relationship.

Nevertheless, the palatal plane is believed to be an important factor affecting the occlusal relationships horizontally and vertically. For example, as illustrated in Figure 8, when the palatal plane slopes upward and forward in relation to the F-H plane, the existence of a Class II molar relationship and an openbite is a strong probability. Conversely, when the palatal plane inclines downward and forward, the occlusion is more likely to be a Class III molar relationship with a deep overbite. The

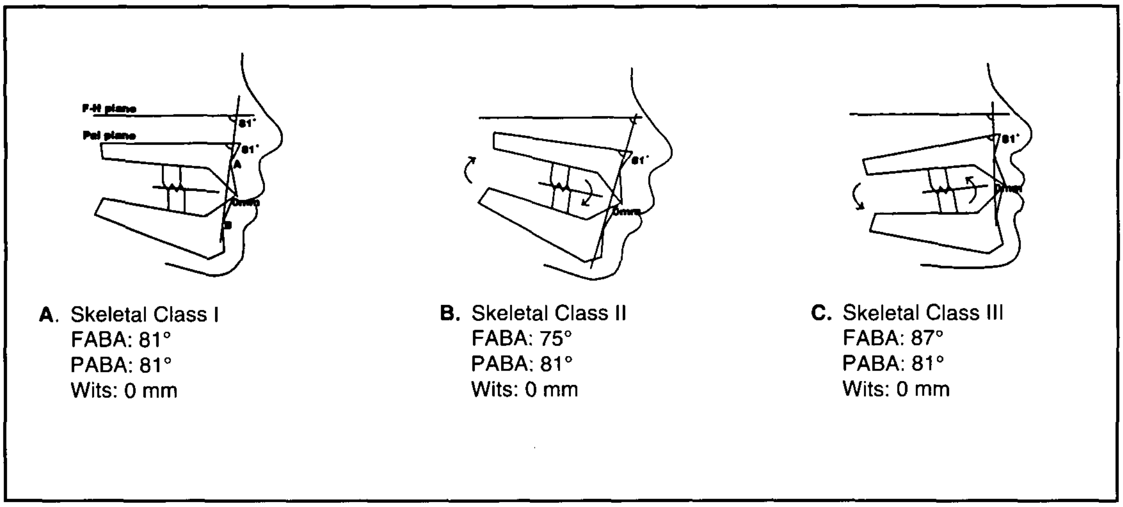


Figure 10

Figure 10
A: Diagrammatic representation of the effect of jaw rotation.
B: Clockwise rotation of the jaw relative to the F-H plane produces a retrusive Class II profile.
C: Relative counterclockwise positioning of the jaws gives the facial profile a more protrusive, Class III pattern even though the dentition maintains a Class II molar relationship.

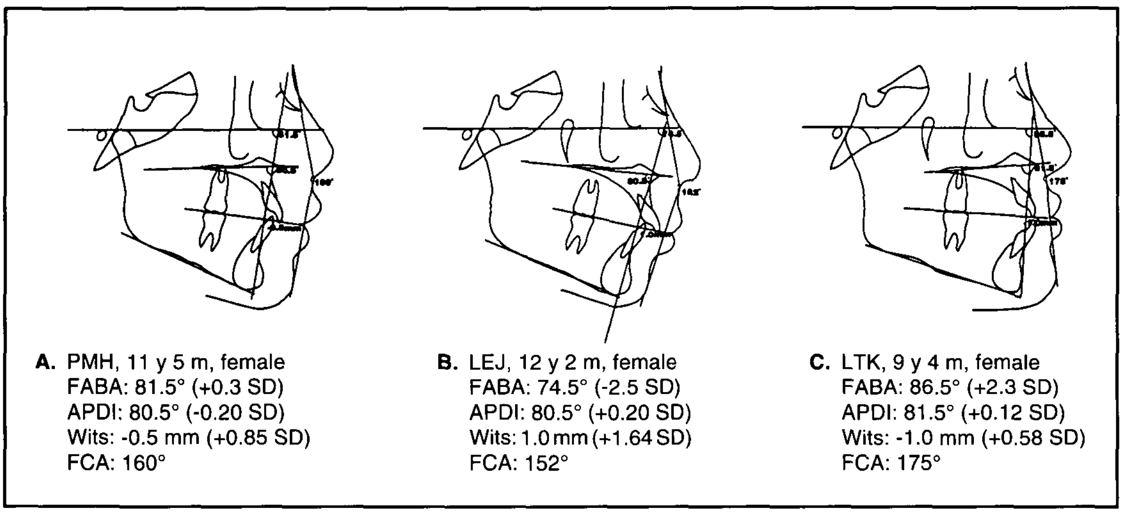


Figure 11

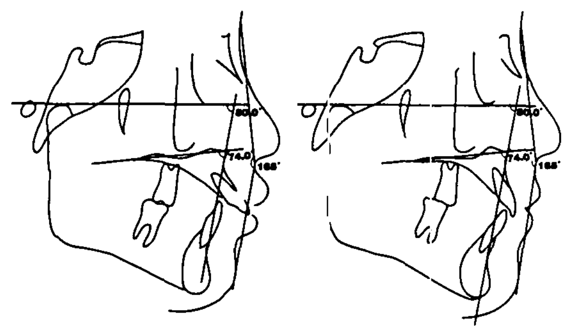
Figure 11
Although the APDI and Wits readings for A, B, and C are all within normal values, B shows a retrognathic Class II profile while C demonstrates a prognathic Class III type. This phenomenon is explained by the rotational effect of the jaws.

APDI reading for the case on the left is 76°, showing a Class II molar relationship, while the case on the right demonstrates a reading of 87° and a Class III dental pattern.

To overcome the influence of the anatomic variations of nasion on the sagittal relationship of the jaws, Jacobson[14,15] presented the Wits appraisal. This measurement entails drawing perpendiculars from points A and B onto the occlusal plane. The contacts are labeled AO and BO, respectively (Figure 9). The Wits measurement (AO-BO distance) can be calculated by means of the following formula: Wits appraisal (distance AO-BO) = distance A-B ´ cos (AB-OP). The distance AO-BO apparently depends on both the angle (AB-OP) and distance A-B. As a result, the Wits appraisal is affected by the vertical dimension of the jaws and the cant of the occlusal plane.

The palatal plane and the occlusal plane may be highly correlated anatomically to one another. For example, the steeper the inclination of the palatal plane, the greater the cant of the occlusal plane, and vice versa. Statistical correlation between the two planes is more or less higher, with a correlation coefficient value of 0.570 (Table 3).

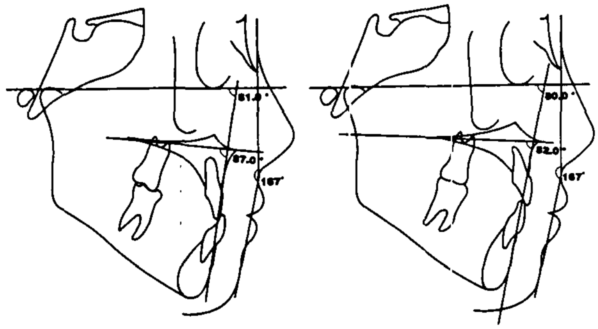
As mentioned previously, the APDI and Wits appraisal have been analyzed geometrically and are the angles determined by the A-B plane in relation to these variable reference planes: palatal plane and occlusal plane. Furthermore, clockwise or counterclockwise rotation of the jaws relative to the F-H plane radically affects the true skeletal jaw relationship. Figure 10 is a diagrammatic representation of the effect of jaw rotation. Cephalometric examples showing the rotational effect of the jaws are shown in Figure 11. The APDI and Wits readings differ only slightly, i.e., 80.5°, 1.0 mm (Figure 11B) and 81.5°, -1.0 mm (Figure 11C), respectively. The facial profiles, how-



A. YYC, 11 y 9 m, male
APDI: 74.0° (-2.34 SD)
Wits: 3.5 mm (2.43 SD)
FABA: 80.0° (-0.25 SD)
FCA: 165°

B. YYC, 13 y 5 m, male
APDI: 74.0° (-2.34 SD)
Wits: 1.5 mm (1.90 SD)
FABA: 80.0° (-0.25 SD)
FCA: 165°

Figure 12



A. HTS 9 y 5 m, male
APDI: 87.0° (+1.92 SD)
Wits: -8.0 mm (-3.12 SD)
FABA: 81.0° (+0.08 SD)
FCA: 167°

B. HTS 11 y 2 male
APDI: 82.0° (+0.28 SD)
Wits: -4.0 mm (-1.0 SD)
FABA: 80.0° (-0.25 SD)
FCA: 167°

Figure 13

Figure 12
A: Although marked distoclusion is present, FABA revealed a Class I skeletal pattern.
B: Correction attained without orthopedic application.

Figure 13
A: Skeletal Class I with a Class III molar relationship.
B: The same patient following treatment.

ever, show a completely different picture. In Figure 11B, the jaws are assumed to be rotated in a clockwise direction relative to the F-H plane. The rotation has had the effect of producing a Class II type of jaw relationship. FABA has been reduced to 74.5°. On the contrary, the relative counterclockwise positioning of the jaws, relative to the F-H plane, produces the opposite effect—a Class III type of jaw relationship—in spite of the jaws maintaining an identical Class I molar relationship (Figure 11C). In this respect, neither APDI nor Wits appraisal provides sufficient information to determine the horizontal relationship of the jaws, even if they do have significant value in the differential diagnosis of the intermolar relationship. The correlation against molar displacement was statistically the highest in APDI and Wits appraisal among the number of measurements representing the A-P intermolar relationship.[3]

As an example, patient YYC (Figure 12), an 11.9-year-old boy, had a Class II, Division 1 malocclusion with an APDI value of 74 . A FABA measurement of 80° indicated a definitive Class I skeletal pattern. This case, therefore, warranted the extraction of maxillary first premolars without orthopedic application. After 18 months of treatment, the dentition was finally brought into a more functional and stable occlusion.

In another example, patient HTS (Figure 13) presented a dental Class III malocclusion. Treatment proceeded without extractions and the correction was easily obtained and remained stable. The posttreatment APDI reading showed a decrease of 5°, which assured stability of the occlusion. Actually, the case was a skeletal Class I malocclusion, as an initial FABA reading of 81° definitely indicated.

In this regard, the FABA formed between the AB plane, which is closely associated with the horizontal and vertical relationships of the jaws, and the F-H plane, as the reference plane of the craniofacial complex, was found to represent the A-P relationship of the denture bases. The FABA reading, therefore, could be an important criterion in determining a proper diagnosis and selecting reasonable treatment mechanics.

Conclusions

1. APDI and Wits appraisal are parameters for the evaluation of the anteroposterior relationship of the dentition rather than the jaws.
2. FABA may provide not only a reliable cephalometric measurement of the anteroposterior relationship of the jaws but also a clue to the facial profiles.

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