Facial Pattern and Anterior Apical Base

H. U. Luder

A cephalometric study finding significant associations between variations in facial pattern and three measurements commonly used to evaluate apical base relationships (the horizontal distance between points A and B, and angles A–N–B and A–B/Occlusal plane).

KEY WORDS: • Apical base • Cephalometrics • Facial pattern •

Cephalometric diagnosis of anterior apical base relationships has attracted considerable attention for many years. The angle A–N–B (Riedel 1952) and the limitations on its application have been the subject of special scrutiny (Taylor 1969, Jacobson 1975, Ferrazzini 1976, Panagiotidis and Witt 1976, Gebauer 1979, and Freeman 1981) because it does not consistently reflect the impression of sagittal jaw relations obtained from observation of the facial profile or plaster casts. Based on geometric considerations, the authors cited above demonstrate a considerable dependence of A–N–B on the length of the anterior cranial base (S–N), maxillary prognathism (S–N–A) and angulation of the jaws (S–N/ANS–PNS, S–N/Occ, and S–N/Go–Me).

Some proposed alternatives have been the angle A–B/Occ (Taylor and Hitchcock 1966) and linear measurements from point A to point B, referred to either the occlusal plane, the maxillary plane or the Sella–Nasion line.

Geometric considerations are not adequate for determining the effects of facial pattern on sagittal intermaxillary measurements, because for all trigonometric calculations or constructions it must be assumed that only one criterion for facial type is subject to change, while all others remain stable. Yet, it is well known that there are clearly defined associations within the face. For example, maxillary prognathism and inclination ("rotation") of the occlusal plane, and vertical divergence of the jaws are closely correlated.

Author Address:

Dr. H. U. Luder
Department of Orthodontics
Dental Institute
University of Zurich
Plattenstrasse 11
8028 Zurich
SWITZERLAND

Dr. Luder is Senior Research Associate in the Department of Orthodontics at the University of Zurich, Switzerland. He is a Dental graduate of the University of Zurich, and holds a Dr. Med. Dent. degree in Orthodontics from the same institution.

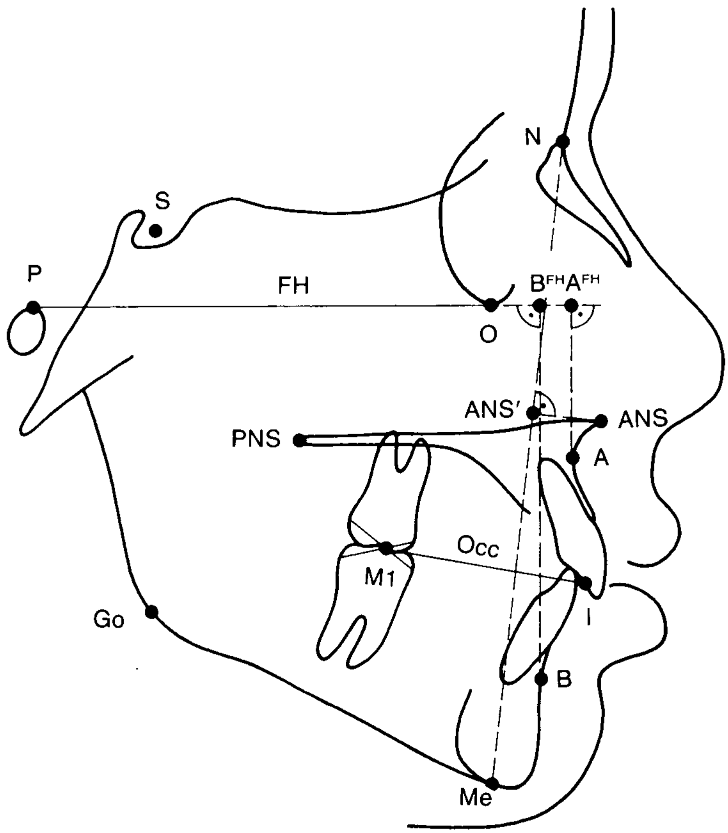

Fig. 1 Cephalometric landmarks and planes used in this study.

Multiple regression analysis is therefore considered to be the most adequate means for examining such relationships. Multiple regression has been used previously by PANAGIOTIDIS AND WITT (1976) and GEBAUER (1979) to study A-N-B and A-B/Occ; however, only the relationships to maxillary prognathism (S-N-A) and mandibular angulation (S-N/Go-Me) were studied.

It is the aim of the present study to use a more detailed characterization of facial type to examine the relationships between facial pattern and the averages of cephalometric measurements used to describe apical base relationships.

— Materials and Methods —

This study was carried out on a sample of 299 children, 139 girls and 160 boys, selected according to their date of birth within an age range of three years. Their ages ranged from 8.7 to 11.8 years for the girls and 8.7 to 11.9 years for the boys. None had undergone orthodontic treatment.

A lateral headfilm, taken at a 2m focus-film distance, was available for each individual. Tracings of the radiographs were made, using the landmarks and planes displayed in Fig. 1. The points are defined according to SALZMANN (1966), with the exception of Mo, the first molar point, which was determined according to the method of Demisch et al. (1977).

Further analysis was accomplished with the aid of computerized measurement and analysis, using both the sella-nasion line (S–N) and the Frankfort horizontal (FH) as reference planes. Measurements describing the sagittal intermaxillary relation included the angles A–N–B and A–B/Occ, and the linear distance A^{FH}–B^{FH} (Bimler 1975). The following measurements are used to assess the facial pattern:

Angles —
- S–N–A
- FH/N–A
- S–N/ANS–PNS
- FH/ANS–PNS
- S–N/Occ
- FH/Occ
- S–N/Go–Me
- FH/Go–Me
- ANS–PNS/Go–Me

Linear measurements —
- S–N
- N–ANS′
- N–Me
- ANS′–Me

From these raw data, means and standard deviations were calculated separately for boys, girls, and the whole sample. A U-test (Wilcoxon, Mann and Whitney) served to establish the significance of differences between the sexes. A possible age dependence of the different cephalometric features was examined using a singular linear correlation analysis, because data shown by Riolo et al. (1974) suggested that, if present, this dependence was close to linear during the age period investigated in this study.

The degree of dependence of these cephalometric measurements of sagittal intermaxillary relationship on the facial pattern was established by a multiple linear regression analysis. Separate analyses were performed for the boys, girls, and the whole sample, using A–N–B, A–B/Occ and A^{FH}–B^{FH} as dependent variables, and age, S–N–A, FH/N–A, S–N/ANS–PNS, FH/ANS–PNS, S–N/Occ, FH/Occ, S–N/Go–Me, ANS–PNS/Go–Me, FH/Go–Me, S–N, N–ANS′, N–Me and ANS′–Me as independent variables.

The respective optimal regression was evaluated step by step, reducing the number of independent variables and reconsidering, on each level, the variables discarded previously. This was done until all regression coefficients were significantly different from zero.

The correspondence of the diagnosis of sagittal intermaxillary relation applying the three different cephalometric criteria was evaluated by correlating the deviations of A–N–B, A–B/Occ and A^{FH}–B^{FH} from their respective averages. Three correlation analyses were made for each:

1. Using the deviations from the means in the whole sample
2. Using the deviations from the corrected means, the regression values obtained with the S–N reference system.
3. Using the deviations from the corrected means, the regression values obtained with the FH reference system.

— Results —

Means and standard deviations of the different cephalometric measurements for the whole sample, together with indications of the level of significance for differences between the sexes and for age dependence, are summarized in Table 1.

Significant differences between boys and girls were found with respect to the angles S–N/Go–Me and FH/Go–Me, and the distances S–N, N–Me and ANS′–Me.

S-N/Go-Me and FH/Go-Me were 1.2° lower, the linear measurements generally were 1.3mm-1.9mm larger in the boys than in the girls. Furthermore, it was noted that these differences between the sexes were more pronounced in the older individuals.

A significant correlation was found between many cephalometric measurements and age, but the age dependence differed considerably between males and females. Positive correlation coefficients were found for all linear measurements with age in both sexes. In the girls, no significant correlation was found for any angular measurement, whereas in the boys, significant negative correlations with age were found for S-N/ANS-PNS, S-N/Occ, and S-N/Go-Me.

Because of this evidence, the multiple regression analyses for A-N-B, A-B/Occ and A^{FH}-B^{FH} were carried out separately for males and females. All parameters of the respective regression equations were, however, almost identical. Therefore, Table 2 displays regression coefficients, intercepts, multiple correlation coefficients and standard errors of estimate as obtained from the whole sample.

Two regression coefficients for corrected A-B/Occ in the FH system, and seven for A^{FH}-B^{FH}, associated with different indicators of facial pattern, proved to be significant.

The coefficients of the correlations between the deviations of A-N-B-, A-B/Occ and A^{FH}-B^{FH} from their respective uncorrected and corrected averages are

Table 1

Means, Standard Deviations (SD) and Ranges for the Whole Sample (N=299)

Levels of significance for sex differences (♂ ♀) and for linear correlation with age are also shown.

	Mean±SD	Range	♂ ♀	Age
A-N-B (°)	3.8±2.0	−1.1− 9.3	ns	ns
A-B/Occ (°)	88.6±4.3	76.3−101.5	ns	ns
A^{FH}-B^{FH} (mm)	7.4±3.2	−1.9− 17.5	ns	ns
S-N-A (°)	80.4±3.2	72.3− 88.2	ns	ns
S-N/ANS-PNS (°)	7.4±2.9	0.6− 15.3	ns	**
S-N/Occ (°)	18.3±3.8	7.0− 27.9	ns	***
S-N/Go-Me (°)	34.7±4.9	19.5− 49.9	*	ns
FH/N-A (°)	89.7±3.1	78.3− 99.3	ns	ns
FH/ANS-PNS (°)	−1.9±3.3	−12.9− 7.6	ns	ns
FH/Occ (°)	8.9±3.6	−5.0− 20.0	ns	ns
FH/Go-Me (°)	25.4±4.6	10.6− 41.4	*	ns
ANS-PNS/Go-Me (°)	27.3±5.0	11.7− 44.4	ns	ns
S-N (mm)	68.8±2.8	60.7− 77.6	***	***
N-ANS' (mm)	48.1±3.0	36.6− 60.0	ns	***
N-Me (mm)	109.4±6.0	95.8−128.2	**	***
ANS'-Me (mm)	61.3±4.8	49.6− 75.8	*	***

* p<0.05
** p<0.01
*** p<0.001
ns: p>0.05

summarized in Table 3. Correlation coefficients between deviations from uncorrected means ranged from 0.64 to 0.75 (absolute values). When the averages were corrected by means of the appropriate multiple regression, they increased to above 0.9, the highest being −0.99 between A-N-B and A-B/Occ in the S-N system.

— Discussion —

The aim of this study is to identify correlations between variations in facial pattern and the averages of some of the cephalometric measurements used to judge sagittal intermaxillary relation. Two to seven cephalometric factors characterizing facial pattern proved to be significantly related to these averages. Not all of the facial pattern factors, however, showed a significant relationship to the means of intermaxillary measurements.

The mean A-N-B angle in the S-N reference system was significantly related to the angles S-N-A, S-N/Occ, S-N/Go-Me and ANS-PNS/Go-Me, as well as the distances S-N and N-ANS′. The regression coefficients obtained for S-N-A (characterizing maxillary prognathism) and S-N/Go-Me (characterizing mandibular divergence) parallel those found by PANAGIOTIDIS AND WITT (1976) and GEBAUER (1979) for the same measurements.

Table 2

Significant Parameters of the Multiple Regression Equations

Regression Coefficients associated with the cephalometric measurements describing facial pattern

R — Intercepts, Multiple Correlation Coefficients
SEE — Standard Errors of Estimate
for corrected A–N–B, A–B/Occ and A^{FH}–B^{FH}

	S–N System		FH System		
	A–N–B	A–B/Occ	A–N–B	A–B/Occ	A^{FH}–B^{FH}
S–N–A	0.41***				
S–N/ANS–PNS					
S–N/Occ	0.15***	0.58***			
S–N/Go–Me	0.28***	−0.66***			
FH/N–A			0.46***		0.15**
FH/ANS–PNS					−0.45***
FH/Occ			0.16***	0.64***	0.19**
FH/Go–Me			0.11***	−0.18**	0.16**
ANS–PNS/Go–Me	−0.14***	0.36***			
S–N	0.11**	−0.28**	0.09***		0.12*
N–ANS′	−0.15***	0.28**	−0.09**		−0.26***
N–Me					0.14**
ANS′–Me					
Intercept	−38.2°	96.7°	−43.8°	87.5°	−23.7mm
R	0.63***	0.37***	0.67***	0.43***	0.69***
SEE	1.5°	4.1°	1.5°	3.9°	2.3mm

* $p<0.05$
** $p<0.01$
*** $p<0.001$

In addition, S-N/Occ and N-ANS', which measure angulation of the occlusal plane and vertical development of the upper face, entered significantly into the regression equation with coefficients compatible with the trigonometric deductions. However, the regression coefficients associated with ANS-PNS/Go-Me and S-N would have been expected to have signs inverse to those found in this study, suggesting that these two factors compensate for the other measurements.

For the average A-B/Occ angle, a regression equation with five significant factors was established. From the six factors affecting mean A-N-B, only maxillary prognathism (S-N-A) was missing. The inverse signs of the regression coefficients associated with A-B/Occ, compared to the equation for A-N-B, are readily explained by the fact that it is larger when A-B/Occ is smaller.

In accordance with results reported by GEBAUER (1979), however, the multiple correlation coefficient for A-B/Occ, although significant, was considerably smaller than for A-N-B, indicating that A-B/Occ is more independent of facial pattern than A-N-B. However, the fact that S-N/Occ, S-N/Go-Me and ANS-PNS/Go-Me are all significantly related to mean A-B/Occ clearly shows that sagittal intermaxillary measurements referring to the occlusal plane are not independent of angulations of the jaws, as was postulated by JACOBSON (1975) and GEBAUER (1979).

Obviously, in reality such variations in angulation are not combined with fixed vertical and sagittal intermaxillary relations, as is assumed for trigonometric calculations. Rather, they are associated with differences in other values, as vertical divergence, which do affect *true* apical base relationship and consequently the average of any sagittal intermaxillary measurement.

This view is also supported by the findings of the correlation analyses performed on the deviations from the means of A-N-B, A-B/Occ and A^{FH}-B^{FH}. The deviations were chosen because they were considered more applicable to diagnosis

Table 3

Linear Correlation Coefficients between Deviations from Uncorrected and Corrected Means of A-N-B, A-B/Occ and A^{FH}-B^{FH}

	A-N-B	A-B/Occ	A^{FH}-B^{FH}
Uncorrected Means			
A-N-B	—	−0.71***	0.75***
A-B/Occ		—	−0.64***
Means Corrected in the S-N Reference System			
A-N-B	—	−0.99***	
Means Corrected in the FH System			
A-N-B	—	−0.9***	0.95***
A-B/Occ		—	−0.92***

$*** p<0.001

of intermaxillary jaw discrepancy than the absolute measurements. When calculated for the deviations from the uncorrected averages, the correlation coefficients were about 0.7, confirming the previously reported discrepancies of the diagnoses with the different measurements.

However, as soon as the corrected, pattern-dependent means were applied, the correlation coefficients increased to above 0.9. The coefficient of −0.99, found for the correlation between A–N–B and A–B/Occ in the S–N system, indicates that for a given A–N–B measurement, the corresponding deviation of A–B/Occ can be predicted with an accuracy of 98%.

Consequently, if facial pattern-dependent *ranges of normal* are defined for A–N–B, A–B/Occ and A^{FH}–B^{FH}, these ranges are highly interdependent and the cephalometric diagnoses agree, regardless of the criterion chosen. Obviously, the discrepant judgments, when either A–N–B or A–B/Occ is used, are mainly due to the varying dependence of the two different measurements on facial type.

On the basis of the present results, however, no conclusion may be drawn as to whether or not such a diagnosis coincides with findings on the casts. A good agreement in this respect has been demonstrated by Demisch et al. (1977) for judgments based on A–B/Occ.

Regarding the pattern-dependent ranges of normal, the histograms in Figs. 2-4 show that they cannot be simply defined in terms of a mean ± the standard error of estimate, because the interval of a mean ± one standard error of

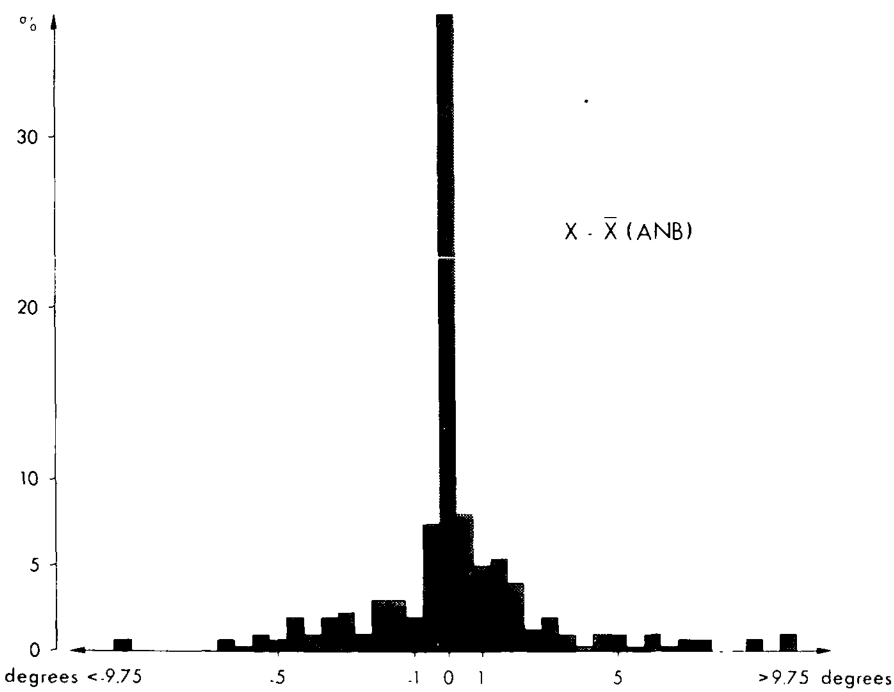

Fig. 2 Histogram showing the distribution of deviations from the corrected averages of A–N–B.

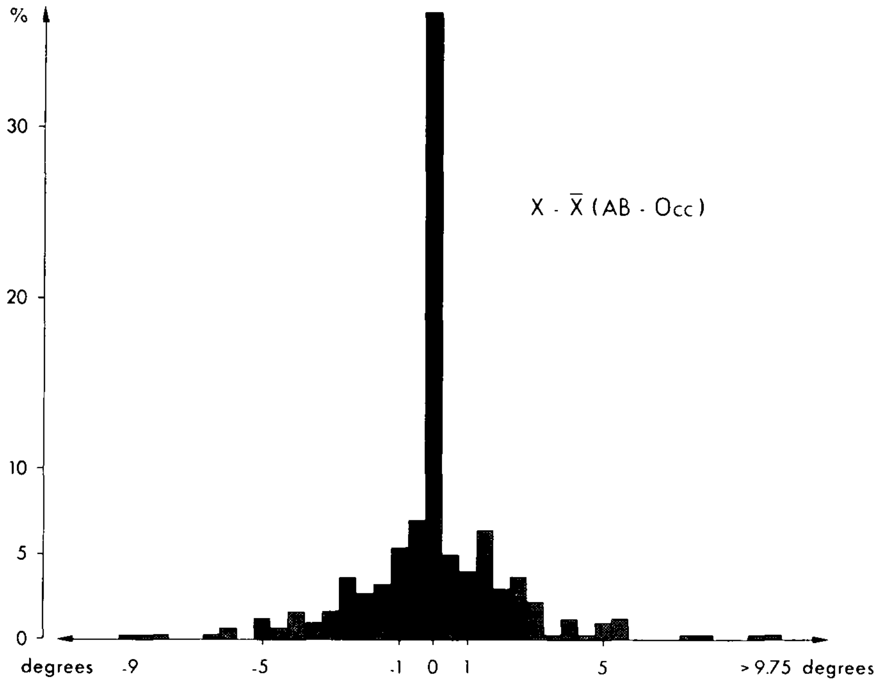

Fig. 3 Histogram showing the distribution of deviations from the corrected averages of A–B/Occlusal plane.

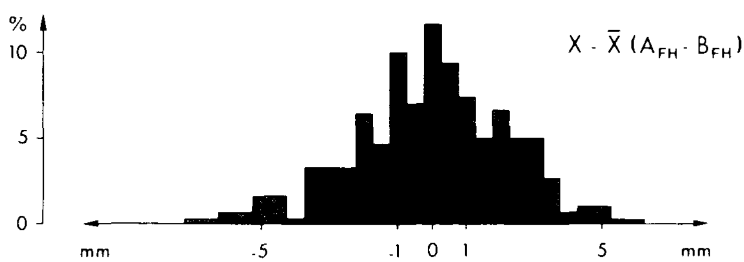

Fig. 4 Histogram showing the distribution of deviations from the corrected averages of A^{FH}–B^{FH}.

estimate does not contain the average 66%, and the mean ± three standard errors does not exclude the most extreme 1% of the individuals.

A possible solution could be the application of confidence limits calculated in connection with the regression analyses to decide whether a given measurement should be taken as indicative of a Class I, II or III relation.

— Summary and Conclusion —

This cephalometric study is based on a random sample of 169 boys and 130 girls, aged 8.7 to 11.9 years. The relationship of variations in facial pattern to the averages of three cephalometric measurements commonly used to assess apical base relationships are examined using multiple regression analyses. Measurements used are the angles A–N–B and A–B/Occ, and linear dimension A^{FH}–B^{FH} (the distance from A to B drawn parallel to the Frankfort horizontal).

The findings allow the following conclusions to be drawn:

- The averages of all three measurements are significantly related to two measurements characterizing facial type that are based on the sella-nasion line, and to seven measurements related to Frankfort horizontal.
- If individualized by application of facial pattern-related *ranges of normal*, the diagnoses of apical base discrepancy agree regardless of whether A–N–B, A–B/Occ, or A^{FH}–B^{FH} is selected as the criterion.

This study was supported by a grant of the Foundation for Scientific Research of the Swiss Society of Dentists.

References

Bimler, H. P. 1975. Lineare Messungen am Fernröntgenbild. *Fortschr. Kieferorthop.* 36:34-45.

Demisch, A., Gebauer, U., and Zila, W. 1977. Comparison of three cephalometric measurements of sagittal jaw relationship: angle ANB, "Wits" appraisal and AB/occlusal angle. *Eur. Orthod. Soc. Trans.* 269-281.

Ferrazzini, G. 1976. Critical evaluation of the ANB angle. *Am. J. Orthod.* 69:620-626.

Freeman, R. S. 1981. Adjusting A–N–B angles to reflect the effect of maxillary position. *Angle Orthod.* 51:162-171.

Gebauer, U. 1979. Verhalten des Winkels ANB als Mass der sagittalen Relation der Kiefer bei simulierter Lageänderung des Punktes N. Ein Vergleich zwischen dem Winkel AB/OKK und dem individualisierten Winkel ANB. *Fortschr. Kieferorthop.* 40:304-315.

Jacobson, A. 1975. The "Wits" appraisal of jaw disharmony. *Am. J. Orthod.* 67:125-138.

Luder, H. 1978. Vergleichende Untersuchung über 4 kephalometrische Messungen zur Darstellung der sagittalen intermaxillären Relation unter spezieller Berücksichtigung der IV-Begutachtung. *Schweiz. Mschr. Zahnheilk.* 88:295-307.

Panagiotidis, G., and Witt, E. 1976. The individualized ANB angle. *Eur. Orthod. Soc. Trans.* 255-260.

Riedel, R. A. 1952. The relation of maxillary structures to cranium in malocclusion and in normal occlusion. *Angle Orthod.* 22:142-145.

Riolo, M. L., Moyers, R.E., McNamara, J.A., Jr., and Hunter, W.S. 1974. *An atlas of craniofacial growth.* Monograph Number 2, Craniofacial Growth Series. Center for Human Growth and Development. Ann Arbor.

Salzmann, J. A. 1966. *Practice of Orthodontics,* Vol. 1. Philadelphia:J.B. Lippincott.

Taylor, C. M. 1969. Changes in the relationship of nasion, point A, and point B and the effect upon ANB. *Am. J. Orthod.* 56:143-162.

Taylor, W. H., and Hitchcock, H. P. 1966. The Alabama analysis. *Am. J. Orthod.* 52:245-265.