A summary five-factor cephalometric analysis based on natural head posture and the true horizontal

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A simple and clinically practical five-factor cephalometric summary analysis is described that is based on the true horizontal and natural head posture. Special reference is made to the AB/horizontal angle as an improved method for the assessment of the sagittal skeletal pattern. A Class I clinical normal range of 12° to 18° was established. In comparison to analyses based on conventional intracranial reference planes, the new methods are more valid in two important respects: (1) the true horizontal reference plane displays less variance when the head is observed in natural posture; (2) the new methods better describe the dentoskeletal and profile features as they appear in life. Hence, they are more clinically meaningful. Data from a large cephalometric population study were used selectively to illustrate the benefits of the new methods. Previous conventional cephalometric analyses of the Chinese male had shown the average pattern to be skeletal Class II, with retrognathic mandible, when compared to the Caucasian male. However, when observed in natural head posture and using the methods based on the true horizontal, the true life skeletal pattern has been shown to be Class III. Analysis of individual subjects produced differing interpretations of craniofacial form, depending upon whether the conventional intracranial planes were used as reference or the true horizontal. It was concluded that conventional methods may result in significant errors in analysis, diagnosis, and treatment. The new methods produce valid supplementary data. (AM J ORTHOD DENTOFAC ORTHOP 1988;93:213-23.)

Natural head posture is the reproducible, natural, physiologic position of the head obtained when the relaxed subject looks ahead at an external eye reference—for example, a wall mirror. Alternatively, a comfortable "self-balance" position of the head may be defined without resort to any external eye reference. The true vertical and the true horizontal derived from it are usually used to define natural head posture and are themselves defined by the free position taken up by a weighted plumb line.

When observed in natural head posture, the angulation of conventional intracranial reference planes to the true vertical, in both Caucasian and non-Caucasian populations, varies widely.[1-5] The variance of these planes has been shown to be in the range of 25° to 36°, with standard deviations close to 5° to 6°. Within individuals, these planes display only weak correlations to each other.[6] Different clinical cephalometric analyses will therefore provide differing interpretations of morphology, depending upon the particular intracranial plane adopted as the "reference."

Conventional intracranial reference planes also vary over time, within individuals, and relative to each other. Longitudinal growth studies of both selected[7] and nonselected (random)[8,9] population samples have quantified the average changes in the angulations of the planes to each other during growth. Average angular changes, between 6 and 16 years, ranged from 2° to 5° for angles containing the mandibular plane, and up to 8° for angles measured relative to the occlusal plane. These average data mask the likely larger changes in some persons. Conventional cephalometric interpretation may therefore change, depending upon the age at which the analysis is completed.

Natural head posture (NHP) has been shown to be highly reproducible in both adults and children, males and females, Caucasian and non-Caucasian subjects.[1,2,5,10] The reported method errors were close to

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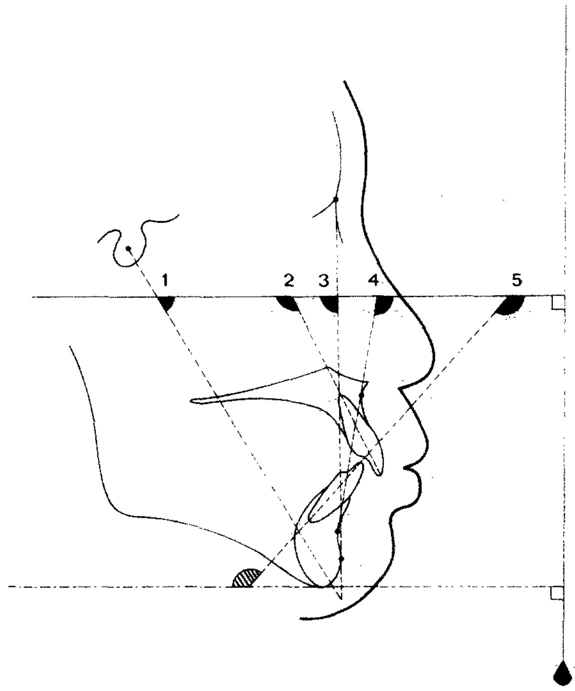

Fig. 1. Five-factor summary analysis in which all the angular measurements are based on the true horizontal and natural head posture. The true horizontal reference plane has been shown to be six times less variable than conventional intracranial reference planes.

2°. The variance, which is the square of the method error, was therefore 4°. In contrast, the variance of conventional intracranial reference planes to the true vertical in NHP ranged between 25° and 36°. The variability of the true horizontal as a cephalometric reference plane in NHP thereby represents at least a sixfold improvement in reliability in relation to the variability of previously used intracranial planes. Analyses based on NHP and the true horizontal also should be more clinically relevant. They would better describe morphology as it truly appears in life.

Several researchers have argued that NHP is the logical reference and orientation position for the evaluation of craniofacial morphology.[3,4,5,11,12] This article presents a simple and clinically practical five-factor cephalometric summary analysis based on NHP and the true horizontal, which includes an improved method for the assessment of the sagittal skeletal pattern. The summary analysis has been applied and evaluated in a cephalometric population study of 240 Chinese (Hong Kong) and 80 Caucasian 12-year-old schoolchildren.[5]

To highlight the benefits of the new analytic methods and to draw attention to possible "errors" in conventional methods, some selected examples taken from the large population study will be presented. The new methods will be applied to both individuals and to groups.

METHOD

Five-factor summary analysis (Fig. 1)

All five variables may be "read" by reference to a single horizontal line. This line may be drawn in any vertical position. The location shown, close to the Frankfort plane, has been selected both for visual clarity and because some of the analogous previous variables used the Frankfort plane as their reference. Comparison between the old and the new variables, now based on the true horizontal, becomes conceptually easier. If the film edge truly lies at right angles to the ground, the new horizontal reference plane may be drawn parallel to the upper or lower border of the radiograph. If not, the horizontal is constructed at right angles to the registered true vertical.

Angle 1 is the anteroinferior angle between the Y axis and the true horizontal. It is exactly analogous to the conventional Y-axis angle, previously measured to the Frankfort plane and interpreted by many clinicians as forecasting the likely growth direction of the chin. Use of the new variable would enable the growth direction of the chin to be expressed in terms of the true posture of the head. A horizontal tendency, for example, would mean that the chin was likely to grow in a forward direction relative to the face as observed in life. The previous conventional measure, by virtue of using an intracranial reference plane, may not describe the growth direction as it would manifest itself clinically in life.

Angle 2 is the angle between the upper incisor and the true horizontal. It describes the upper incisor inclination as it appears in life and should be interpreted in the same way as the conventional method, which adopts either the maxillary plane or the sella-nasion plane as the reference plane.

Angle 3 is the NHP equivalent of the facial angle and should be interpreted in the equivalent manner. However, by adopting the true horizontal reference plane, the new angle now measures the position of the chin and the type of the face as they truly appear in life. The conventional facial angle describes the internal dentoskeletal architecture, whereas the new method describes the dentoskeletal architecture as it appears to others when the head is in a natural posture.

Angle 4 is the angle between AB line and the true horizontal, devised as an improved method to assess the anteroposterior (sagittal) skeletal pattern.[4] If expressed as the anteroinferior angle minus 90°, then the figure obtained is conceptually comparable to the much

Table I. Means and standard deviations for the five-factor summary analysis angles found in random population samples of 12-year-old children in Hong Kong

	Angle 1 *Y axis/horizontal* *mean ± SD* *(°)*	*Angle 2* *UI/horizontal* *mean ± SD* *(°)*	*Angle 3* *Facial plane/horizontal* *(mod. facial angle)* *mean ± SD* *(°)*	*Angle 4* *AB/horizontal* *mean ± SD* *(°)*	*Angle 5* *LI/horizontal* *mean ± SD* *(°)*
Chinese male subjects (n = 120)	62.3 ± 4.2	117.7 ± 7.1	86.9 ± 4.4	8.4 ± 5.7	127.6 ± 7.5
Chinese female subjects (n = 120)	63.9 ± 5.2	115.3 ± 7.0	85.6 ± 4.9	9.4 ± 6.1	127.1 ± 7.7
Chinese male and female subjects (n = 240)	63.1 ± 4.8	116.5 ± 7.2	86.2 ± 4.7	8.9 ± 5.9	127.3 ± 7.6
Caucasian male subjects (n = 40)	63.9 ± 4.5	107.8 ± 7.0	82.1 ± 4.7	13.9 ± 5.5	126.9 ± 6.5
Caucasian female subjects (n = 40)	65.1 ± 3.2	106.6 ± 7.1	80.8 ± 3.1	15.5 ± 5.5	127.8 ± 6.3
Caucasian male and female subjects (n = 80)	64.5 ± 3.9	107.2 ± 7.0	81.5 ± 4.0	14.7 ± 5.5	127.3 ± 6.4
Method error (n = 32)	0.3	1.1	0.6	0.8	1.5

used ANB angle and thereby becomes more meaningful and easier to interpret by the clinician. As the sagittal skeletal pattern is probably the most frequently assessed cephalometric variable, further consideration of the new AB/horizontal measure will be discussed later in this article.

Angle 5 is the angulation of the lower incisor to the true horizontal. This new measure allows the true protrusion of the lower incisors to be expressed and understood in the same dimensions as adopted for the upper incisor. No corrections are required for variations in the maxillary/mandibular planes angle and the angle provides an instantly understood expression of how the lower incisors appear in life.

This new five-factor analysis to the true horizontal requires no new sets of "norms" or figures to be learned by the clinician. Only the reference plane has been changed to eliminate the errors inherent in analyses that use conventional intracranial reference planes. Conventional methods describe well the internal architecture of the face, but in describing true life appearance they are subject to errors, the magnitude of the errors depending upon the particular intracranial reference plane selected and its relationship in that person to the true vertical when in natural head posture.

Where appropriate, and this would be in persons in whom any conventional intracranial reference plane was not angulated within the average range to the true vertical in NHP, the new five-factor analysis may be used to supplement the conventional data. In this way information is obtained that describes both the internal relationships of the person and also the morphology as it appears in life. The data derived using the new method to the true horizontal may serve as "checks" and prevent fundamental misinterpretations in diagnosis and treatment, especially in patients who deviate markedly from the usual cephalometric "norms."

Conventional assessment of the anteroposterior (sagittal) skeletal pattern and the new AB/horizontal measure

Many authors have shown that the angular measure ANB distorts the true relationship in cases in which nasion is markedly deviant in position from "average."[13-15] Corrections to the observed measure, devised from geometric principles, have not proved completely satisfactory.[16-19] The Wits method has gained acceptance but it measures distances, not angles, and does not correct for vertical variations in the location of points A and B.[20] The clinical reproducibility of the functional occlusal plane is poor.[21] None of the methods adopting intracranial reference planes allow for the previously described large intra- and interpopulation variances of the plane to the true vertical in NHP.

The new AB/horizontal measure is simple and practical, and with the construction of the same horizontal line, a further set of useful descriptive variables is readily obtained. It eliminates nasion and the use of intracranial reference planes. AB/horizontal further eliminates reference points relating to the teeth and to the occlusion that are difficult to locate accurately and reproducibly on cephalometric radiographs.

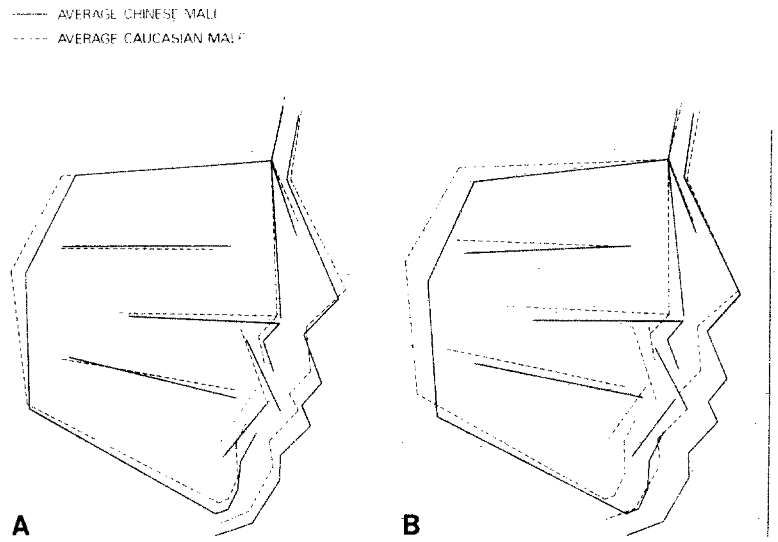

Fig. 2. Comparisons between the average craniofacial outline form of the Chinese (n = 120) and Caucasian (n = 40) males when superimposed on the sella-nasion plane **(A)** and on the true vertical (in natural head posture) **(B)** at nasion. In natural head posture, all the intracranial reference planes slope down more caudally in the Chinese males ($P \leq 0.001$).

Fig. 3. A, Lateral profile photograph of Caucasian female subject (no. 14782).

The data for the AB/horizontal angle were correlated with the conventional ANB angle, a "corrected" ANB angle, the angular Wits appraisal, and the AB line to the occlusal plane.[5] For both samples studied, Chinese and Caucasian, the AB/horizontal angle was only weakly correlated to the other methods with coefficients of correlation in the range of 0.5 to 0.7. This degree of correlation has no clinically predictive value. In this sense it cannot be considered as a minor variation of the other methods. The angle AB/horizontal must be viewed as a fundamentally new clinical assessment of the skeletal pattern.

"Normal" AB/horizontal values for clinical use

In clinical use the skeletal pattern is said to be Class I when the ANB angular difference lies between 2° and 4°. Examination of Caucasian combined male and female data (Table I) showed that this Class I range embraces approximately the mean value for ANB ± half of the standard deviation. Applying the same method to the AB/horizontal data for Caucasians, the comparable range was 15° ± 2.8°. Expressed as rounded, easily applied clinical figures, the range for Class I skeletal pattern, using the AB/horizontal measure, would be 12° to 18°. Until further experience using the new method has been accumulated, the following standards are suggested.

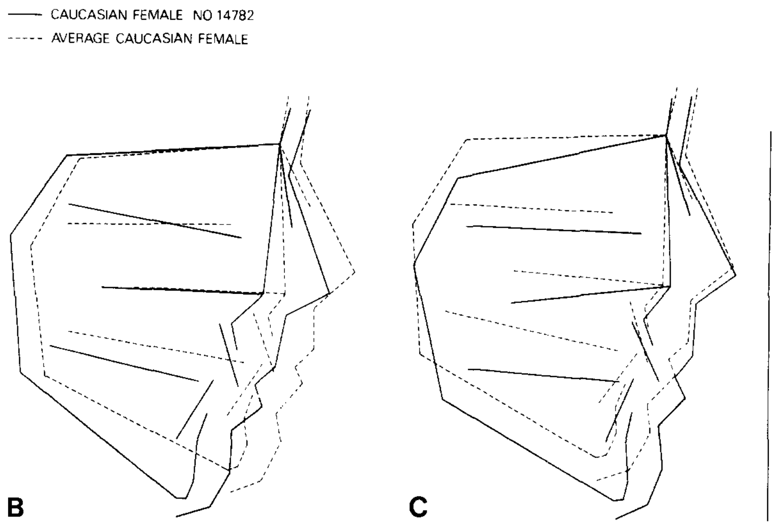

Fig. 3 (Cont'd). Comparisons between the craniofacial outline form of female subject in **A** and the average Caucasian female (n = 40). The outline forms are superimposed on the maxillary plane at nasion **(B)** and on the true vertical at nasion (in natural head posture) **(C)**.

Table II. Means and standard deviations for selected conventional dentoskeletal cephalometric variables in groups and individual subjects selected from population samples of 12-year-old children in Hong Kong

	SNA (°)	*SNB (°)*	*ANB (°)*	*Y axis (°)*	*Facial angle (°)*	*MxP/MnP (°)*	*UI/MxP (°)*	*LI/MnP (°)*	*UI/LI (°)*	*LI tip to A/Po (mm)*
Chinese male subjects (n = 120)	83.5 ± 3.9	79.9 ± 4.2	3.6 ± 2.5	65.8 ± 5.9	83.5 ± 5.7	26.3 ± 4.8	118.1 ± 6.2	100.9 ± 7.0	114.7 ± 9.6	+5.3
Caucasian male subjects (n = 40)	81.8 ± 3.0	78.7 ± 2.9	3.2 ± 1.9	61.6 ± 3.7	84.4 ± 3.6	26.0 ± 4.7	110.5 ± 5.1	98.2 ± 5.6	125.3 ± 8.5	+2.2
Caucasian female subject (no. 14782)	71.3	71.0	0.4	60.4	85.9	36.0	110.2	84.4	129.5	+0.1
Chinese female subject (no. 30124)	83.2	74.9	8.3	70.2	79.3	33.7	111.0	99.8	115.6	+0.5
Caucasian male subject (no. 13747)	85.3	83.7	1.5	57.0	89.1	13.3	108.9	102.0	135.8	0.0
Method error (n = 32)	0.8	0.5	0.5	0.7	0.9	0.7	1.2	1.7	2.1	0.4

Variable AB/horizontal (anteroinferior angle minus 90°)

Skeletal Class I	12° to 18°
Skeletal Class II	>18°
Skeletal Class III	<12°

This would produce the same proportion of persons belonging to the different classes as is currently produced when applying the conventional ANB angular measure to a Caucasian population.

CLINICAL APPLICATION

The benefits of the new analyses and the inherent errors in conventional methods are highlighted by analysis of selected examples applying both methods. Both

Table III. Means and standard deviations for variables related to the true vertical and horizontal in selected groups and subjects from population samples of 12-year-old children in Hong Kong

	SN/vertical (°)	*FH/vertical* (°)	*MxP/vertical* (°)	*FOP/vertical* (°)
Chinese male subjects (n = 120)	83.2 ± 5.6	86.6 ± 6.9	90.3 ± 4.5	100.9 ± 4.6
Caucasian male subjects (n = 40)	87.6 ± 5.6	92.3 ± 5.2	92.6 ± 5.5	101.8 ± 4.7
Caucasian female subject (no. 14782)	78.2	91.8	84.1	94.6
Chinese female subject (no. 30124)	71.3	76.5	81.2	92.3
Caucasian male subject (no. 13747)	91.7	94.6	96.4	96.0

individual subjects and population groups have been selected. All the data are condensed from a computerized cephalometric study of 240 12-year-old Chinese children in Hong Kong and a comparative group of 80 British Caucasian children also living in Hong Kong.[5]

The Chinese sample was a partially stratified random sample based on schools. All subjects spoke Cantonese with parents originally from Guangdong, the most southern province of China, which adjoins Hong Kong and from where the great majority of the Hong Kong population has originated. The consent rate was 87% and the sample comprised equal numbers of boys (n = 120) and girls (n = 120). None of the children had had previous or current orthodontic treatment. The comparative Caucasian group comprised 40 boys and 40 girls of British parentage. Two expatriate schools were selected and the final sample randomly drawn from the children consenting to the study. The consent rate averaged 54%. Although no selection was made on the basis of dental occlusion or physical appearance, a number of British children (four boys, 8.7%; six girls, 12.5%) had to be rejected from the initial sample because of previous or current orthodontic treatment.

All radiographs were recorded with the subject standing in the "orthoposition" NHP as originally defined by Mølhave[22] and as later adopted and modified by Solow and Tallgren,[2] and others.[5,10,23] A General Electric 1000 x-ray unit with a Wehmer CI-2 cephalometer was used and the true vertical marked on each film by a wire plumb line. Ear posts were inserted and the subjects looked into a mirror located 200 cm ahead after first tilting the head forward and backward with decreasing amplitude until a comfortable position of natural balance was found. Special care was taken to ensure that the head was not moved when the ear posts were carefully inserted. To prevent the children swaying, it was necessary also to define the feet position as "a comfortable distance apart and slightly diverging."[5] All radiographs were recorded in the morning by the same operators. To further standardize the recording procedures, a pilot study involving more than 100 children was completed before the start of the present study.

The method error of the head positioning was 1.9° for the Chinese sample. This was determined from repeat recordings and repeat measurements on subjects in a complementary methodologic study of NHP reproducibility. The time between the repeat recordings was 4 to 10 minutes (n = 30) and 1 to 2 hours (n = 30).[5] Dahlberg's formula, method error = $\sqrt{\frac{\Sigma d^2}{2n}}$, was applied to the difference between the initial and repeat radiographs for each subject.[24] For clarity, the profile photographs and the superimposed summary graphics are presented, but not all the detailed cephalometric data. In the original study, 49 linear and 56 angular hard- and soft-tissue variables were analyzed. However, only five variables have been used in this proposed new summary analysis (Fig. 1).

Comparison between Chinese and Caucasian male subjects

The graphics in Fig. 2 and the data in Tables I through III were derived from a study of 120 randomly selected 12-year-old Chinese boys and a comparative group of 40 British Caucasian boys[5] in Hong Kong. In Fig. 2, *A* the mean craniofacial outline forms of the two groups have been superimposed on SN at nasion, and in Fig. 2, *B*, the outline forms have been super-

MnP/vertical (°)	Angle 1 Y axis/horizontal (°)	Angle 2 UI/horizontal (°)	Angle 3 Facial plane/horizontal (mod. facial angle) (°)	Angle 4 AB/horizontal (°)	Angle 5 LI/horizontal (°)
116.6 ± 5.4	62.3 ± 4.2	117.7 ± 7.1	86.9 ± 4.4	8.4 ± 5.7	127.6 ± 7.5
118.7 ± 4.8	63.9 ± 4.5	107.8 ± 7.0	82.1 ± 4.7	13.9 ± 5.5	126.9 ± 6.5
120.0	62.2	116.1	84.1	7.9	114.4
114.9	56.7	119.7	92.8	7.5	124.7
109.7	61.6	102.6	84.6	12.1	121.7

imposed on the true vertical also at nasion. In changing from 2, *A*, to 2, *B*, the Chinese face is seen to swing anticlockwise with the chin rotating forward and upward. The reason for this change lies in the variation of the reference plane sella-nasion to the vertical when the two groups are analyzed in NHP. For the Chinese male subjects, SN/vertical was found to be 83.2°, whereas for the Caucasian male subjects, it was 87.6°, a difference of 4.4°, which was highly significant with $P \leq 0.001$.

Methods of analysis that effectively superimpose on the SN plane, and the SNA and SNB angular measures are good examples, have the effect of rotating the Chinese cephalometric tracing almost 5° out of line with the true life appearance of this population group. This effective rotation also produces a net effect of rotating the observed angulations of the incisors, the Y axis, and many other commonly assessed variables. While 4.4° may not at first appear substantial, it must be realized that the normal Class I range for the ANB angle is within 2° to 4° and that a 4.4° rotation is equivalent to changing a mild skeletal Class II case into a mild skeletal Class III. Similarly, alterations in the growth direction of the Y axis by only a few degrees during treatment are considered very significant clinically. The actual magnitude of 4.4° may be directly visualized from the two superimposed graphics.

Previous analyses of the data have shown that the differing SN/vertical angulations cannot be explained away as being dependent upon, or resulting from, relative differences in spinal posture. Nor may the observed differences be explained in terms of the cranial base saddle angle, which showed no significant intergroup difference.[5] The more caudal angulation of the SN/vertical angulation in NHP, and of the other intracranial reference planes, appears to represent a true morphologic and ethnic difference and supports the observation of Yen[25] on a Taiwanese male population.

Conventional analysis shows the Chinese male to be skeletal Class I with an ANB of 3.6° (Table II). This is slightly on the Class II side of the Caucasian ANB value of 3.2° and is in agreement with the general view of previous studies of the Chinese face—namely, that the skeletal pattern tends toward Class II with the chin appearing retrognathic.[26-33] The new measure for the assessment of the sagittal skeletal pattern, the AB/horizontal angle, expressed as the anteroinferior angle minus 90°, clearly shows that in life the Chinese male is skeletal Class III (Table III). At 13.9°, the Caucasian value lies within the 12° to 18° normal Class I range, while the Chinese AB/horizontal value, at 8.4°, is clearly Class III.

In addition to the SN/vertical angle being significantly different between the two male groups, significant differences were also found in relation to the Frankfort plane ($P \leq 0.001$), the maxillary plane ($P \leq 0.05$), the occlusal plane ($P \leq 0.001$), and the mandibular plane ($P \leq 0.05$). This may be interpreted to mean that use of any of these planes as the reference plane will produce errors in the interpretation of the true life interpopulation differences between the Chinese and Caucasian male subjects. Detailed analysis provided examples of many errors in conventional analyses, including the masking of the true extent of the prognathism in the Chinese subjects and erroneous interpretation of the Chinese soft-tissue profile. A different interpretation emerged when the groups were observed and analyzed in NHP.[5]

Fig. 4. A, Lateral profile photograph of Chinese female subject (no. 30124).

Analysis of individual subjects

The individual graphics presented in Figs. 3 through 5 have been selected as examples in which the nonaverage angulation of a conventional reference plane to the true vertical, when the subject is in natural posture, may lead to errors in diagnosis and treatment.

Caucasian female subject (no. 14782) (Fig. 3, Tables II and III). The maxillary plane is at 84.1° to the vertical in relation to the group mean of 94.9°, SD 4.2°. Sella-nasion and the occlusal planes are also more caudally angulated in NHP, but the Frankfort plane is close to the group average angulation.

Conventional analyses portray retrognathic maxilla and mandible, a Class I sagittal skeletal pattern (corrected ANB = 3.5°), and normally angulated upper and lower incisors to the maxillary and mandibular planes, respectively. In contrast, use of the five-factor summary analysis based on the true horizontal and NHP shows that in life the maxilla is not retrognathic, the mandible is relatively prognathic, the sagittal skeletal pattern is Class III (AB/horizontal = 7.9°), the upper incisors are 10° proclined, the lower incisors almost 14° retroclined, and the likely growth direction of the chin less vertical than previously assessed. Conventional analyses will also form an erroneous view of the steepness of the lower mandibular border.

Chinese female subject (no. 30124) (Fig. 4, Tables II and III). This girl is characterized by a low Frankfort plane to the true vertical angulation of 76.5° in relation to the group mean of 88.9°, SD 5.7°. The FH/vertical angulation lies between 1 and 2 SDs from the mean and the subject is certainly not representative of an extreme of normal variation. All the other intracranial reference planes slope down caudally more than the group averages.

Conventional analyses describe a marked skeletal Class II problem (ANB 8.3°), set-back maxilla and mandible, retrognathic profile (facial angle 79.3°), vertical Y axis (70.2°), normally angulated upper incisors, and proclined lower incisors. The five-factor summary analysis shows the true life craniofacial form with a Class III skeletal pattern (AB/horizontal = 7.5°) and a mandible that is certainly not set-back. In relation to the true horizontal, the facial angle now describes a prognathic chin (facial angle/horizontal = 92.8°); the Y axis/horizontal shows the subject to have a strong tendency to horizontal growth; the upper incisors are proclined; and the lower incisors show average angulation. In life the lower border of the mandible is more horizontal.

Caucasian male subject (no. 13747) (Fig. 5, Tables II and III). This subject has been selected as an example of persons in whom the sella-nasion plane angulation to the vertical is greater than 90° when observed in natural posture. Results from the main study[5] and previous studies evaluating NHP have shown that these persons are representative of a substantial portion of the population.[1-3,34,35] In this subject the SN/vertical angulation is 91.7° in relation to the Caucasian male group mean of 87.6°, SD 5.6°. This value was within a single standard deviation of the group mean. The subject is by no means an example of extreme variation.

Conventional analysis describes a skeletal Class III pattern (ANB 1.5°) with a prognathic chin (facial angle 89.1°), horizontal mandibular growth tendency (Y axis 57.0°), average angulation of upper incisors, and slight (4°) proclination of the lower incisors. From the profile the lower part of the face, below the nose tip, appears relatively protrusive.

When observed and analyzed in NHP, the profile is very close to the group average. The five-factor sum-

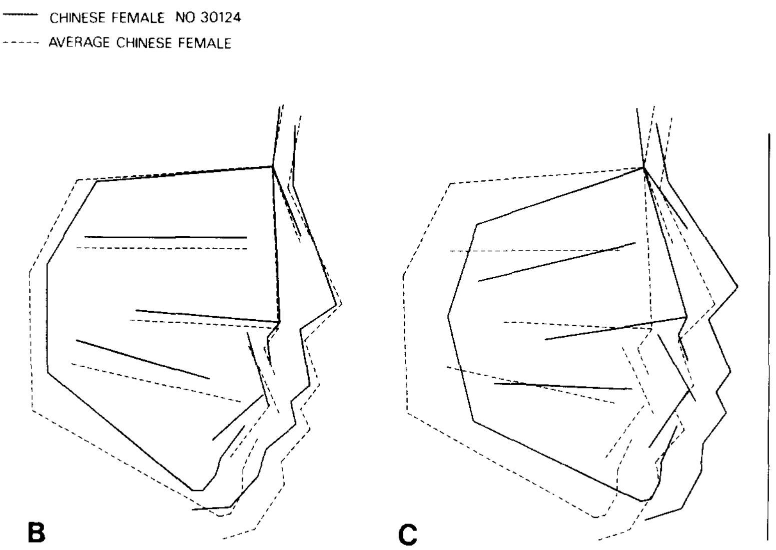

Fig. 4 (Cont'd). Comparisons between the craniofacial outline form of female subject in **A** and the average Chinese female (n = 120). The outline forms are superimposed on the Frankfort plane at nasion **(B)** and on the true vertical at nasion (in natural head posture) **(C)**.

mary analysis shows that in life the skeletal pattern is Class I (AB/horizontal = 12.1°) and the facial angle/horizontal is normal with the chin not prognathic and with an average growth direction tendency for the chin (Y axis/horizontal = 61.6°). The upper and the lower incisors are 5° retroclined compared with the group means.

SUMMARY AND CONCLUSIONS

1. A five-factor summary dentoskeletal analysis, based on the true horizontal and natural head posture, has been described and then applied selectively to data from a large cephalometric population study.

2. Analysis of individual subjects produced differing interpretations of craniofacial form, depending upon whether the conventional intracranial planes were used as "reference" or the true horizontal and NHP. The new five-factor method provided data that more closely described the morphology and appearance of the subjects as they truly appeared in life. Hence, the data were more meaningful clinically.

3. Previous (conventional) analyses of the craniofacial form of the Chinese male had shown the average skeletal pattern to be Class II with retrognathic mandible in comparison with the Caucasian male. However, when observed in NHP and using the new method of analysis based upon the true horizontal, the true life skeletal pattern has been shown to be Class III in relation to the Caucasian male.

Fig. 5. A, Lateral profile photograph of Caucasian male subject (no. 13747).

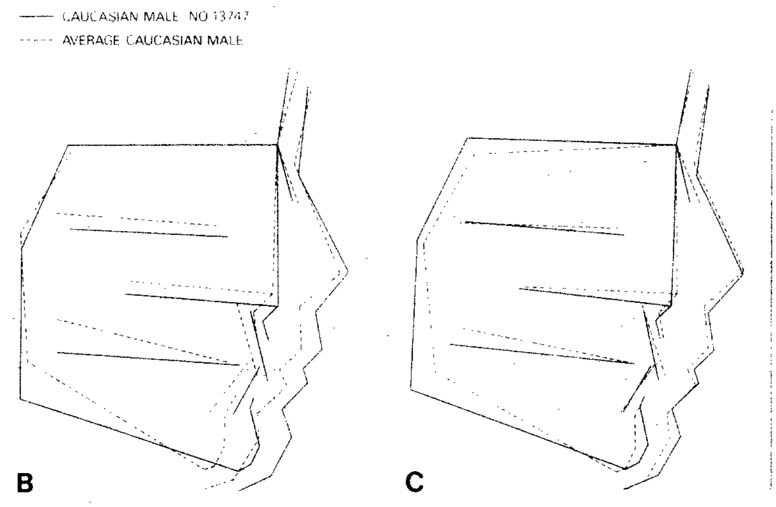

Fig. 5 (Cont'd). Comparisons between the craniofacial outline form of male subject in **A** and the average Caucasian male (n = 40). The outline forms are superimposed on the sella-nasion plane at nasion **(B)** and on the true vertical at nasion (in natural head posture) **(C)**.

The previous erroneous view had arisen because of the different angulations of the SN plane to the true vertical in NHP between the two population groups (difference = 4.4°, $P \leq 0.001$).

4. Special reference has been made to the AB/horizontal angle as an improved method for the assessment of the sagittal skeletal pattern. A suggested Class I clinical normal range of 12° to 18° was established.

5. In individuals or groups in whom any conventional intracranial reference plane is not angulated within the average range to the true vertical in NHP, the new five-factor summary analysis produces useful valid supplementary data. This data may serve as "checks" and prevent significant errors in analysis, diagnosis, and treatment.

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