Dental and Skeletal Variation Within the Range of Normal

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Cephalometric values for a sample of normal occlusions shows variation far beyond mean values often used as treatment goals.

This study is an evaluation of the range of variation in various dental and skeletal parameters in patients with untreated ideal occlusions. In addition, the interrelationships among different deviations from mean values in those untreated individuals are considered.

REVIEW OF THE LITERATURE

Most of the cephalometric norms in use today were developed from 1945 to 1955, when cephalometrics was first gaining importance as an orthodontic diagnostic aid.

Downs[4] published his cephalometric norms based on a sample of 20 children in 1948. While his sample size was small, it represented all of the individuals in the 12-17 age range meeting his criteria for a "clinically excellent occlusion" that he could find after an extensive search over several years. Nevertheless, his means and ranges are very close to those reported later by others for larger samples.

The cephalometric norms developed by Steiner[2] are a distillation from various sources adapted as he says to "express our concept of a normal average American child of average age." They were not taken from any sample, but were chosen from those available at the time that he felt useful to his clinical perceptions of therapeutic goals.[3] Steiner's values are clinical guides, not mathematical derivations from some sample group, so there are no statistical means, standard deviations or ranges.

He emphasizes that the norms he has developed are intended only as starting points for treatment planning, so they must be modified and adapted for the individual patient on the basis of other factors such as age, sex, race and growth potential. It is interesting and important to note the emphasis placed by Steiner on understanding and developing a diagnostic system that would accommodate for variation.

In 1954 Tweed[1] reported on a sample of 95 cases. The basis for selecting his sample was "entirely from the standpoint of satisfactory facial esthetics . . . good facial outline rather than ideal." He used cephalometric radiographs and facial photographs of individuals who had a "face that I thought was pleasing." Some were taken from among his older treated cases, but the majority had not been treated orthodontically.

No consideration was given to the occlusion. Tweed's only criterion was facial esthetics as defined from his subjective viewpoint. Norms were derived from this sample for the FMA, IMPA, and FMIA (Frankfort/Mandibular plane Angle, Incisor/Mandibular Plane Angle and Frankfort/Mandibular Incisor Angle) of the Tweed triangle.

While most people are familiar with the norms for each of the angles used by Tweed, it is interesting to note the wide range for each of the measurements even within his own highly selected sample. For instance, while his recommended application of the Tweed triangle suggests maintaining an FMIA within the narrow 3° range between 65° and 68°, the original sample on which those values are based had a 24° range (56° to 80°). Table 1 lists the mean values and ranges for the Tweed sample.

Sassouni[5] developed his cephalometric norms in 1955 using a sample of 50 white children, principally of Mediterranean extraction, ranging from 7-15 years of age with normal occlusions. He states that no Class I, II or III malocclusion existed in the sample from which he developed his arcial cephalometric analysis. In describing his results, Sassouni lists the number of subjects who fell in front of or behind his arcs, but he does not quantify the extent or range of these deviations.

Table 1

Tweed Sample Values

	Low	Mean	High
FMA	15	24.6	36
IMPA	76	86.9	99
FMIA	56	68.2	80

Methods and Materials

The subjects selected for this study were 79 Caucasian adults with ideal occlusions and no history of previous orthodontic treatment. Occlusal interdigitation was normal, with no more than 1.5mm of crowding or spacing in the mandibular arch. Fig. 1 shows the face and occlusion for a typical patient in this sample.

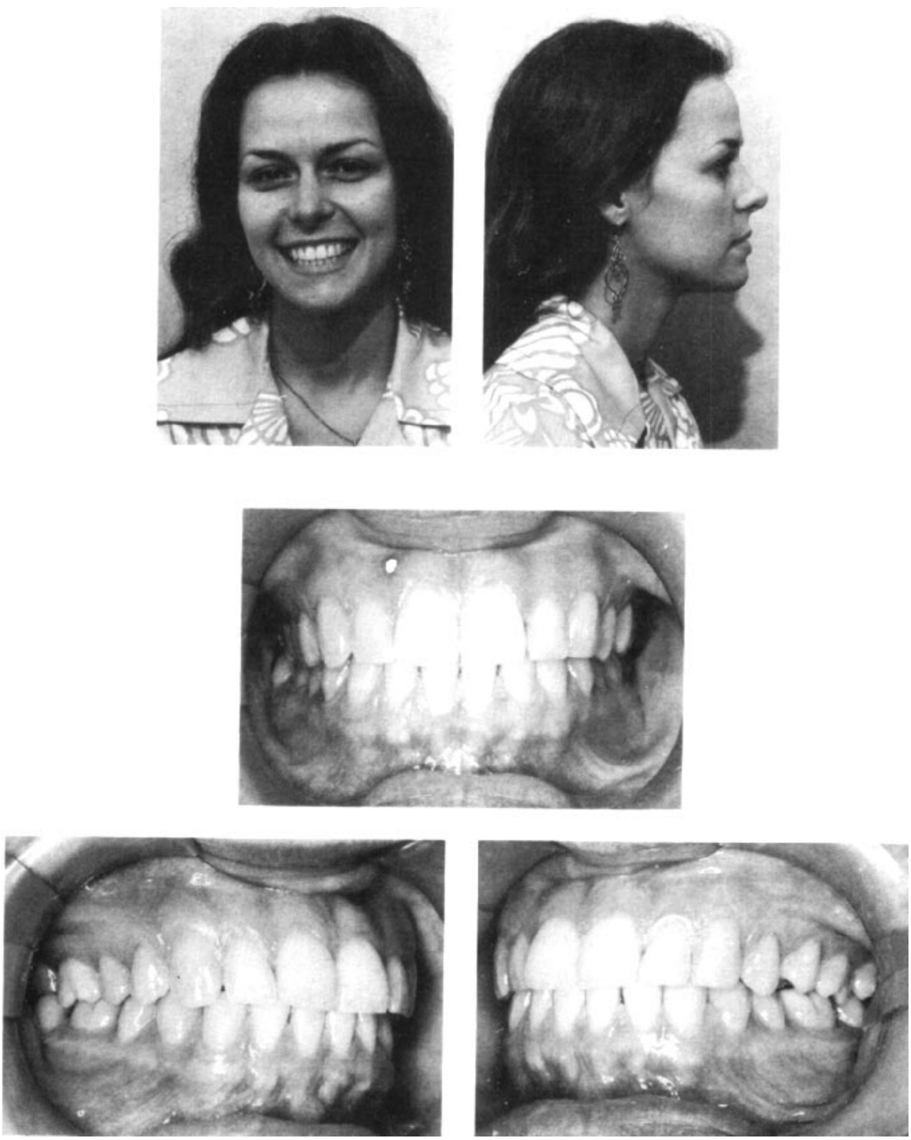

Fig 1 Profile and occlusion of a typical patient in the sample used in this study

Complete orthodontic records were made, including cephalometric and panoramic radiographs, casts, and intraoral and profile photographs.

Thirty of the more common cephalometric values were measured and analyzed by computer. The mean, standard deviation, mode and range were determined for each. Correlation coefficients were calculated among all of the 30 parameters. The level of acceptable statistical significance for these correlations was set at $P < .001$.

Results

The mean, standard deviation, mode and range for 10 of the more commonly used cephalometric measurements are listed in Table 2.

Significant positive and negative correlations with eight specific cephalometric measurements are shown in Table 3.

All of the individual cephalometric measurements for these normal individuals showed a wide range of variation. Such variation is normal in the human population.

The A-N-B angle on these ideal occlusion subjects ranged from −3° to +8°, covering an 11° range. The interincisal angle swept over a 47° range from 107° to 154°. Those values are all normal in the faces in which they were found.

An evaluation of the correlations for some of the more common cephalometric readings reveals an interesting pattern of accommodation to variation within this sample.

Discussion

The data from this sample clearly shows a large range of normal variation in many of the dental and skeletal relationships in people who have ideal occlusions. Figs. 2-4 compare the cephalometric tracings for the subjects with the lowest and highest values for the A-N-B angle, the S-N/MP angle and the FMIA.

Table 2

Ideal occlusion sample
Ranges, means, modes and standard deviations

	Low	Mean/Mode	High	Range	S.D.
A–N–B	−3	1.9/3.0	8	11	2.1
S–N/MP	15	29.2/27.0	41	26	5.7
FH/N–Pog	79	87.9/88.0	95	16	3.6
U1/L1	107	126.2/120.0	154	46	9.7
U1/S–N	93	107.4/108.0	120	27	5.9
L1 to A–Pog (mm)	−4	2.2/1.0	6	10	2.1
FMA	16	23.7/24.0	35	19	4.7
IMPA	83	96.8/106.0	106	23	6.0
FMIA	46	59.8/62.0	75	29	6.6

Table 3

Positive and negative correlations
at $P < .001$
with 8 cephalometric measurements.

S–N/MP

Positive	Negative
S-N/Occl. pl.	S-N-A
FMA	S-N-B
A-N-B	N-B to Pog (mm)
L1/N-B	FMIA
L1 to N-B (mm)	U1/L1
L1 to A-Pog (mm)	

FH/N–Pog

Positive	Negative
S-N-B	S-N/Occl.pl.
FMIA	FMA
U1/S-N	A-N-B

FMIA

Positive	Negative
S-N-B	S-N/Occl. pl.
FH/N-Pog	S-N/MP
U1/L1	A-N-B
	FMA
	L1/N-B
	L1 to N-B (mm)
	L1 to A-Pog (mm)
	IMPA

IMPA

Positive	Negative
L1/N-B	FMIA
L1 to N-B(mm)	U1/L1
L1 to A-Pog (mm)	

A–N–B

Positive	Negative
S-N-A	FMIA
S-N/Occl. pl.	FH/N-Pog
S-N/MP	U1/N-A
L1/N-B	U1 to N-A (mm)
L1 to N-B (mm)	
FMA	

U1/S–N

Positive	Negative
S-N-B	S-N/Occl.pl.
FH/N-Pog	U1/L1
U1 to N-A (mm)	
U1 to A-Pog (mm)	

U1/L1

Positive	Negative
FMIA	S-N/MP
	U1/N-A
	U1 to N-A (mm)
	L1/N-B
	L1 to N-B (mm)
	IMPA

L1 to A–Pog (mm)

Positive	Negative
S-N/MP	FMIA
U1/S-N	U1/L1
U1/N-A	
U1 to N-A (mm)	
L1/N-B	
L1 to N-B (mm)	
IMPA	

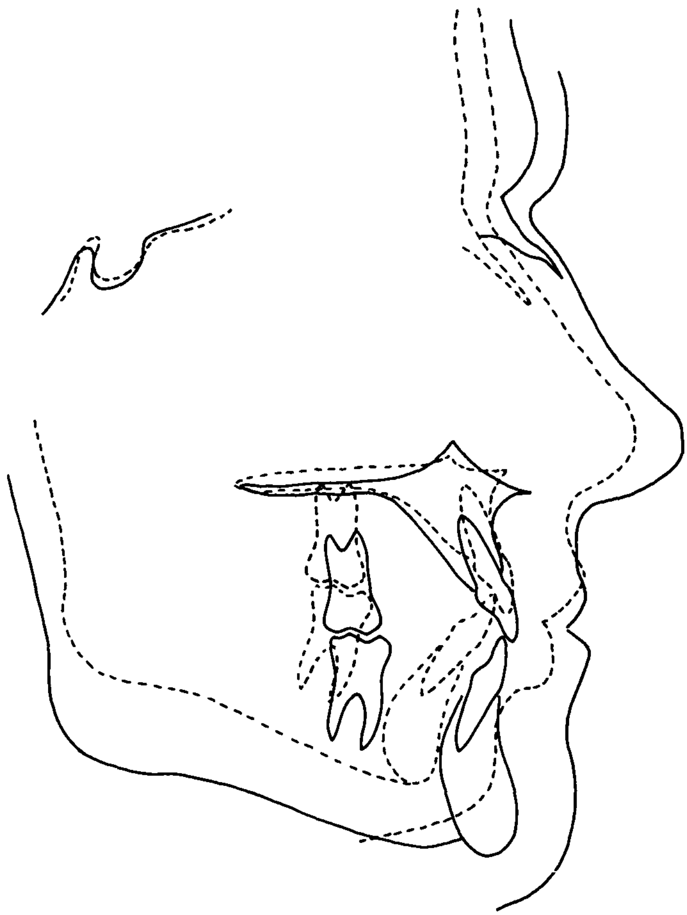

Fig 2 Composite of patients with high (+8°) and low (−3°) A–N–B values

The significant amount of variation among those with normal occlusions becomes readily apparent in these superimpositions. Many current systems of cephalometric evaluation which are limited to mean values would classify many of these patients as abnormal and possibly in need of correction.

An evaluation of the correlations with the eight parameters shown in Table 3 reveals an interesting pattern of accommodation. When the A-N-B angle is high, the mandibular plane is steeper, the cant of the occlusal plane is high and the incisors are more upright in the maxilla and more protrusive in the mandible.

Figs. 2 & 5 graphically illustrate the general pattern related to the A-N-B angle.

It is interesting to note that Steiner intuitively identified this pattern of incisor compensation as the primary accommodation to anterior-posterior skeletal discrepancies in his original

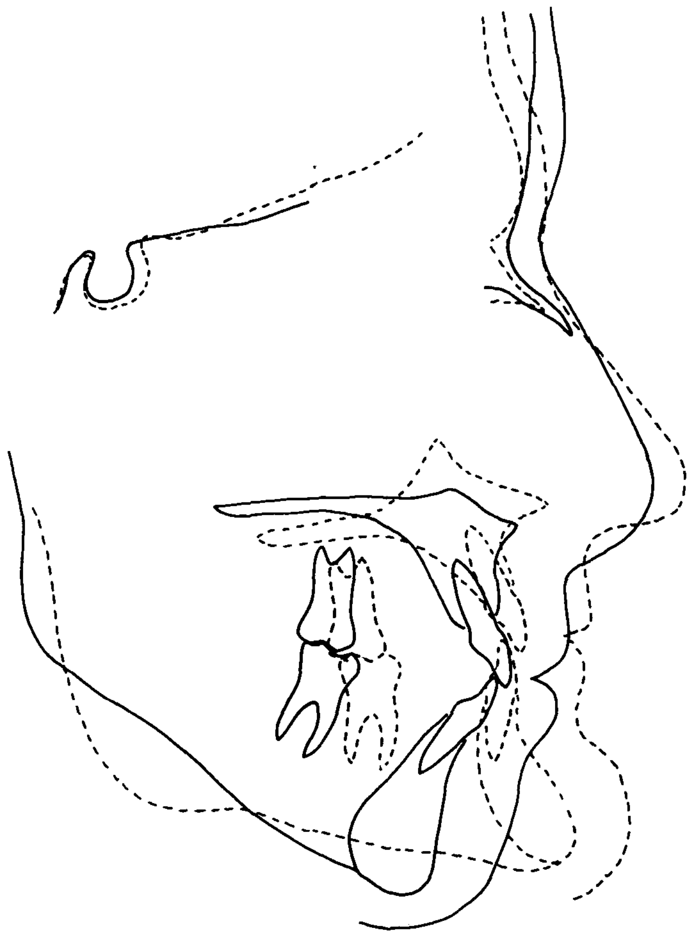

Fig 3 Composite of patients with high (41°) and low (15°) S–N/MP values

work. Also, the highest A-N-B angle that he uses in his system of acceptable compromises is 8 degrees, which is exactly the same as the highest A-N-B difference recorded in this sample.

While the mean for the FMA in this study corresponds closely to that recorded in Tweed's sample, there was almost a 10° difference in the means for the IMPA and FMIA. This difference may be accounted for by Tweed's selection of his sample on the basis of soft tissue profile rather than dental relationships.

Understanding natural accommodation to variations in nearby structures can be a useful diagnostic aid, along with consideration of variations in other factors such as age, sex, race and growth potential as Steiner mentioned long ago.

It appears that the information gained from this study can be helpful to the clinician in a number of ways.

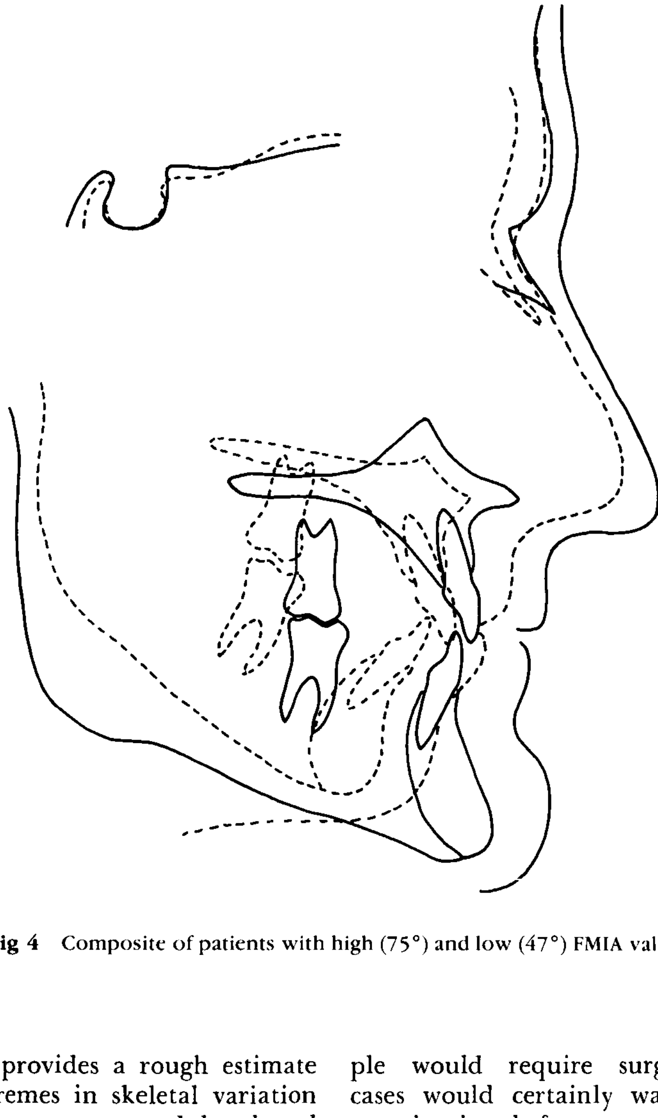

Fig 4 Composite of patients with high (75°) and low (47°) FMIA values

First, it provides a rough estimate of the extremes in skeletal variation that can be compensated by dental adjustment. In evaluating those cases that fall on the borderline between orthodontic correction with and without surgical adjustment, these ranges in skeletal variation provide an additional basis for differentiation.

While it is not possible to say that any case with skeletal deviation that exceeds the ranges seen in this sample would require surgery, those cases would certainly warrant close examination before proceeding with an orthodontic treatment plan based on tooth movement alone. In planning treatment for adults, this data points out some of the compensations that would be required for existing skeletal discrepancies, and in this manner provide a direction for treatment.

In growing patients for whom we have the potential for reducing skele-

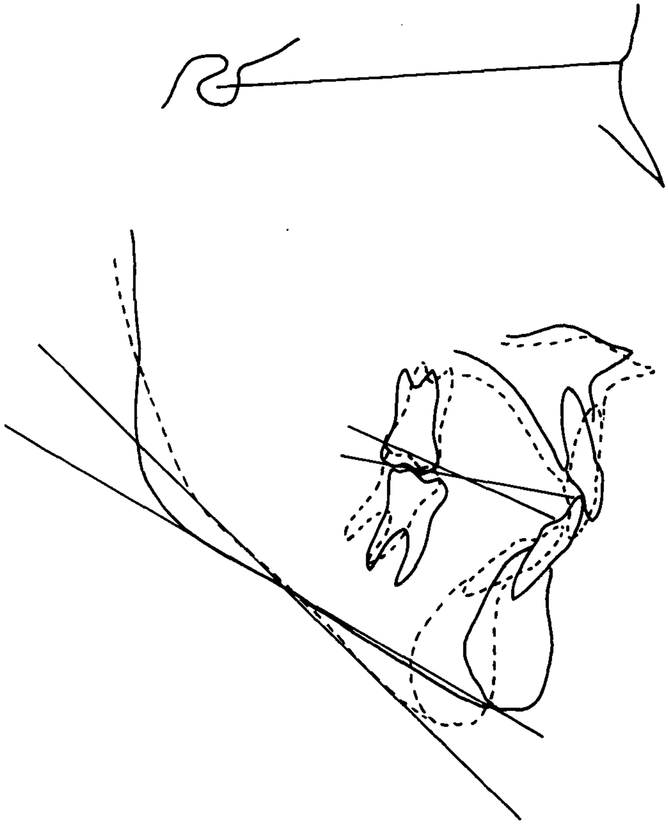

Fig 5 Pattern of accommodation related to the A–N–B angle.
Note the incisor protrusion and the angulation of the incisors, occlusal plane and mandibular plane.

tal discrepancies by orthopedic means, it seems reasonable to establish mean skeletal relationships as a goal of treatment, as has been traditionally taught. Examination of the data in Table 2 shows a close relationship between the means and modes for each of the cephalometric parameters recorded. This further supports the philosophy of treating toward, if not precisely to the mean in growing patients whose facial musculature is still immature and more adaptable than in the adult.

The subjects in this study were untreated adults selected only on the basis of an ideal occlusion. It is reasonable to ask whether some of the more extreme variations recorded in this study would result in an unacceptable profile. While profile evaluation is to a large degree a subjective assessment, and while it was not a specific part of this study, a subjective evaluation of the sample revealed no patients with extremely poor or unacceptable profiles.

This is illustrated in Figs. 6, 7 and 8, which shows the profiles for the patients with the most extreme values for the A-N-B, S-N/MP and FMIA measurements.

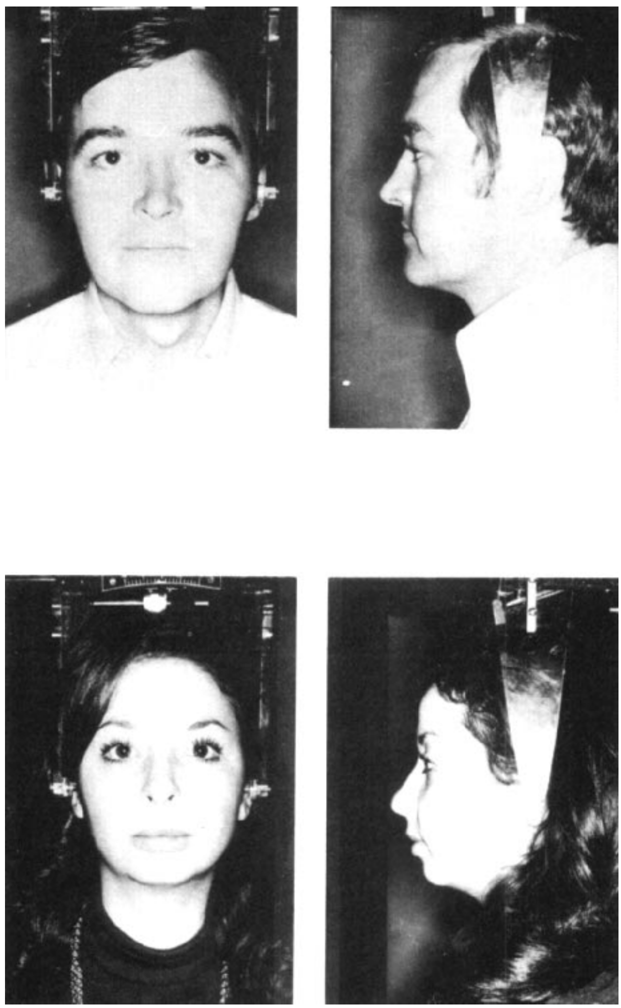

Fig 6 Patients with lowest (−3°, top) and highest (+8°, bottom) A–N–B angles

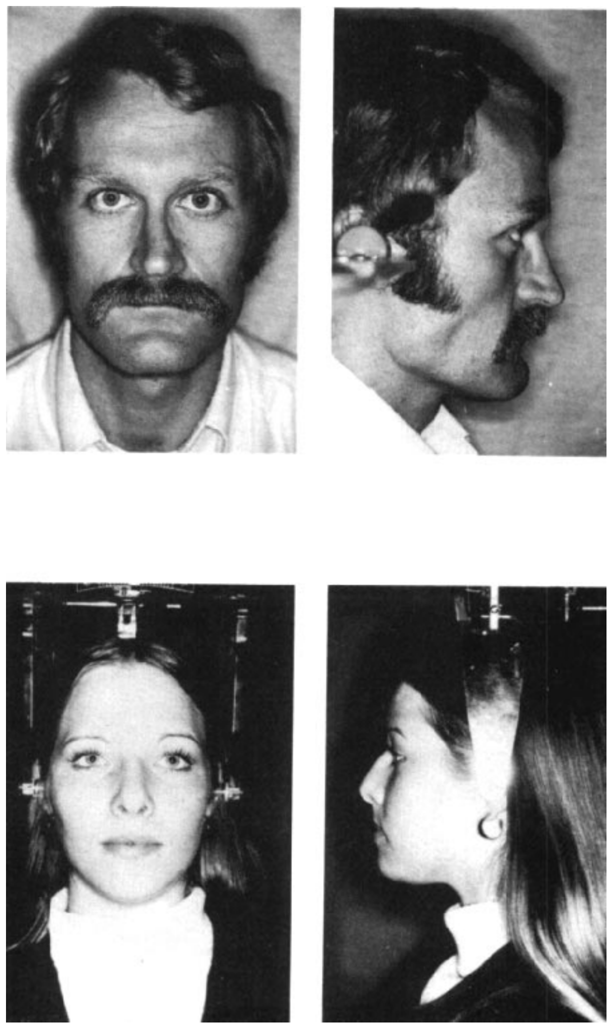

Fig 7 Patients with lowest (15°, top) and highest (41°, bottom) S–N/MP angles

Fig 8 Patients with lowest (47°, top) and highest (75°, bottom) FMIA angles

Summary

The cephalometric radiographs of 79 patients with untreated ideal occlusions were evaluated. The means, standard deviations, modes and ranges for 10 of the most popular cephalometric measurements were recorded. While the means for many of the measurements are close to those reported by previous studies, the ranges vary widely.

Correlation coefficients were used to identify and evaluate dental and skeletal adaptations associated with these variations. These closely resemble those proposed by Steiner, although showing a somewhat greater degree of variation.

While profile evaluation was not a basis for inclusion in this study, a subjective evaluation revealed no patient having extremely poor or unattractive profiles.

While it appears reasonable to use mean relationships as an initial goal of treatment in the growing patient, an understanding of limitations, natural adaptation and normal variation should provide additional help in diagnosing and treatment planning. This can be especially important in adult patients. Ranges recorded for individual skeletal relationships can also provide a rough guide in helping the clinician differentiate between those patients who can be treated orthodontically and those who might need supplementary surgical correction for skeletal deformities.

As in any system of diagnosis, the information provided in this study must be adapted and modified on the basis of individual patient needs as it is integrated into a comprehensive diagnosis.

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