The Role of Mandibular Plane Inclination in Orthodontic Diagnosis

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The concept of beauty differs between cultures and, within the same culture, individual tastes differ. Yet, there is an accepted range of what is considered "normal" rather than "ideal." Many attempts have been made to identify or classify the range of normal facial and dental relations. The main purpose of any classification is to provide a frame of reference for both the normal and the abnormal.

Angle [1] was among the first to identify the relation between normal occlusion and facial esthetics. He concluded that if the teeth are in good occlusion the face should be harmonious.

Downs[4] selected 20 individuals with clinically excellent occlusions between the ages of 12 and 17 years, equally divided as to sex. He described the mean and range for ten skeletal and dental relations in both the anteroposterior and vertical directions. In a later article Downs[5] identified three normal facial types, a straight or mesiognathic type, a retrognathic type and a prognathic type, based upon the magnitude of the angle of convexity and the facial angle.

Koski[8] described the variability of the craniofacial skeleton using different anatomical planes. He suggested that the interrelation of the neurovascular canals in the different parts of the face best describe the facial morphology.

Sassouni's[13] archeal analysis replaces a single plane of reference from the lateral cephalogram with four planes converging posteriorly at a center area "O". From the center "O", arcs are constructed intersecting the base planes. This provides a frame of reference to evaluate each patient's individual symmetry and proportion.

A parameter adopted by many orthodontists to identify different facial types is mandibular shape and/or position. Reidel[12] indicated that any changes induced by treatment in the inclination of the mandibular plane are probably not permanent unless they are in a negative direction since the MP:SN angle tends to flatten with age.

Tweed[17] selected 95 adults of random age and sex whom he considered had balanced and harmonious faces. From this sample he developed the diagnostic facial triangle as an adjunct for orthodontic diagnosis and treatment planning. Tweed placed great emphasis on the relation between the mandibular incisor, the mandibular plane, and Frankfort horizontal plane (FHP). He also indicated that the inclination of the lower incisors varies with the cant of the mandibular plane.

Schudy[14,15] investigated the interaction of anteroposterior and vertical facial dysplasias and emphasized the importance of the vertical dimension in orthodontic treatment. On a sample of 120 patients aged 11 to 14, Schudy used the MP:SN angle to divide his sample into three groups, 80 individuals in the average group (31°-34°), 20 in the retrognathic group (above 34°), and 20 in the prognathic group (below 31°). After a thorough examination of his three groups and from his clinical observations, he concluded that the MP:SN angle is useful in de-

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scribing different facial types and should be taken into consideration in treatment planning.

Isaacson[6] studied skeletal and dental relationships in patients with malocclusions and having extreme variations in the MP:SN angle. His sample contained 20 cases with an MP:SN angle of 32°, twenty cases with an angle greater than 38°, and 20 cases with an angle of less than 26°. He measured numerous dental and skeletal parameters in individuals with high and low MP:SN angles. The study emphasized the relation between the magnitude of the angle and the orthodontic management of the case.

Although there is some disagreement between two schools of thought in the orthodontic field about the possibility of permanently changing the MP:SN angle with treatment, both groups use the same angle in proving our ability or inability to influence the vertical relation.[11,14,15]

From this review of the literature it can be stated that numerous attempts have been made to classify or identify the different facial types. Clinicians and investigators have used the dentition,[1] the ANB angle,[11] facial angle,[5] and other parameters[8,13] for this purpose. The MP:SN and the FMA angles have been most frequently used in clinical orthodontics to identify functional or morphological trends.[6,14,15,17]

It is therefore the purpose of this study to 1) determine the relation (if any) between the MP:SN angle and other skeletal and dental parameters; and 2) if such a relation exists, an attempt will be made to have a more "clinically" applicable range of normal cephalometric values.

Materials and Methods

Cephalograms on 129 individuals were obtained. These individuals were all Caucasians, predominantly from a northwest European ancestry, all were male adults (22-28 years), and all had an acceptable dental occlusion and no apparent facial deformity.

Because the effect of sex and age differences on the cephalometric values is a subject of controversy,[19] it was decided to keep the sample as homogeneous as practically possible to facilitate the interpretation of the findings.

All cephalograms were taken on the same cephalostat with the teeth in occlusion and the head oriented to Frankfort horizontal plane.

The usual landmarks were used with the addition of postpogonion (Postp), the midpoint of a transverse line connecting the posterior borders of the mandibular rami at points equidistant with pogonion above the mandibular base plane,[10] and the anterior most point of occipital condyle (O), the point demarcating the anterior margin of the condyle with the precondylar portion of the occipital bone.[7] For bilateral landmarks the projected midsagittal points were used (Fig. 1).

The following twelve angular dimensions were measured: SNA, SNB, ANB, SNPog, SNANS, NAPog, NSGn, MP (GoMe):SN, long axis of lower incisors to mandibular plane ($\underline{1}$:MP), long axis of upper incisors to sella nasion plane ($\underline{1}$:SN), long axis of upper and lower incisors to each other ($\underline{1}$:$\overline{1}$), and the cranial base angle (NSO).

Seven linear dimensions were measured: N-ANS′, upper anterior face height (ANS′ being the projected point perpendicular from ANS on the N-Me line); N-Me, total face height; ANS-PTM, maxillary depth; Pog-Postp, mandibular depth; S-N, anterior cranial base; S-O, posterior cranial base length, and N-O which is a measure of total cranial base length.

Seven ratios were computed from the linear dimensions: N-ANS′/N-Me, ANS-PTM/S-N, S-N/N-Me, N-ANS′/

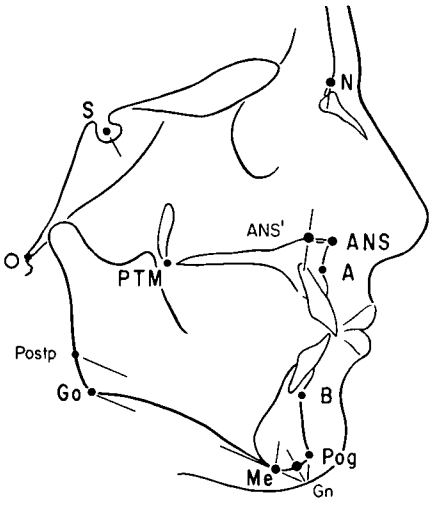

Fig. 1 Landmarks used.

S-N, ANS-PTM/Pog-Postp, S-N/N-O and S-O/N-O.

Intra- and interexaminer reliability were determined and found to be within acceptable limits. The method of determining this reliability has been described elsewhere.[3]

To determine the possible effect of the variation of the MP:SN angle on the parameters examined the mean and standard deviation of this angle were calculated for the whole sample of 129 individuals (28.5 ± 6.3). The total sample was then divided into three subgroups in the following manner:

1. The value of 1 S.D. was added to the calculated mean of the MP:SN angle for the total group ($28.5 + 6.3 = 34.8$); those individuals with MP:SN angles of 34.8° and greater constituted the subgroup designated "High MP" ($N = 18$).

2. The value of 1 S.D. was subtracted from the mean ($28.5 - 6.3 = 22.2$); those individuals with MP:SN angles 22.2° and smaller constituted the subgroup designated "Low MP" ($N = 19$).

3. The rest of the sample constituted the middle subgroup ($N = 92$) designated "Average MP" with the MP:SN angle ranging between 22.1 and 34.7°.

Means ($\bar{x}$), standard deviations (S.D.), standard error of the measurements (S.E.), and correlation coefficients (r) for the different subgroups were calculated. Comparisons between subgroup means and standard deviations were computed using the Student's t-test and the F-ratio. Significance was predetermined at the .05 level of confidence.

Findings

Table I presents the means, standard deviations, and standard error of the measurements for the high, low, and average MP subgroups.

Table II contains the details of F-ratio and t-test scores for the different subgroup comparisons.

High MP vs Average MP: Compared with the average MP subgroup, those individuals with a high MP angle have the maxilla (SNA and SNANS) and mandible (SNB, SNPog and NSGn) in a relatively more retruded position, but both jaws were well-related to each other (ANB). Individuals in the high MP subgroup also had a relatively large angle of convexity (NAPog) and more upright lower incisors ($\bar{1}$:MP).

Low MP vs. Average MP: Individuals with a low MP angle have relatively more protruded mandibles (SNB, SNPog and NSGn), more labially positioned lower incisors ($\bar{1}$:MP) and significantly shorter total face height (N-Me) as compared with individuals in the average MP subgroup.

High MP vs. Low MP: These two subgroups show the greatest frequency of statistically significant differences; only eight variables were not significantly different. In comparison with the low MP subgroup, individuals with a high MP angle have a significantly more retruded maxilla and mandible with a more convex face (NAPog) and a

TABLE I

Means ($\bar{x}$), Standard Deviations (S.D.) and Standard Error of Measurement (S.E) Calculated on the Different Parameters of the Three Subgroups Examined

		Average MP (N = 92)			High MP (N = 18)			Low MP (N = 19)		
		x	S.D.	S.E.	x	S.D.	S.E.	x	S.D.	S.E.
SNA	°	82.2	3.5	0.4	79.8	2.8	0.6	83.6	3.2	0.7
SNB	°	79.5	3.4	0.3	76.2	3.2	0.8	81.7	3.5	0.8
ANB	°	2.7	2.1	0.2	3.6	1.8	0.4	1.9	1.9	0.4
SNPog	°	80.9	3.1	0.3	76.9	3.2	0.8	84.4	2.9	0.7
SNANS	°	87.9	3.7	0.4	85.9	3.3	0.8	89.4	3.8	0.9
N-A-Pog	°	2.6	6.5	0.7	6.2	5.9	1.4	—1.9	5.1	1.2
NS-GN	°	66.2	2.9	0.3	72.5	3.4	0.8	61.7	2.7	0.6
MP-SN	°	28.2	3.4	0.3	39.7	4.2	1.0	19.6	2.0	0.4
$\overline{1}$-MP	°	95.9	6.9	0.7	91.2	4.9	1.2	100.9	6.5	1.5
$\underline{1}$-SN	°	101.7	7.4	0.8	100.9	7.3	1.7	106.1	8.8	2.0
$\underline{1}$-$\overline{1}$	°	134.0	10.3	1.1	128.2	7.0	1.7	133.4	9.3	2.1
$\overline{N}$SO	°	126.6	4.9	0.5	129.0	5.8	1.4	123.7	6.6	1.5
N-ANS'	mm	51.0	3.3	0.3	53.0	3.4	0.8	49.7	3.1	0.7
N-Me	mm	118.0	5.6	0.6	125.4	6.2	1.5	113.0	5.2	1.2
ANS-PTM	mm	55.1	3.3	0.3	54.6	3.0	0.7	54.7	3.9	0.9
SN	mm	71.2	3.1	0.3	68.7	3.5	0.8	72.0	3.3	0.8
Pg-Postp	mm	80.9	5.3	0.6	81.3	4.4	1.0	81.0	4.5	1.0
NO	mm	102.8	4.5	0.5	101.3	4.2	1.0	102.3	4.6	1.1
SO	mm	43.2	3.0	0.3	43.0	2.9	0.7	44.8	3.5	0.8
$\frac{\text{N-ANS'}}{\text{N-Me}}$	x 100	43.3	2.3	0.2	42.2	1.9	0.4	44.0	2.9	0.7

High MP subgroup has an MP:SN angle of 34.8° and greater.
Low MP subgroup has an MP:SN angle of 22.1° and smaller.
Average MP subgroup has an MP:SN angle between 22.2° and 34.7°.

larger ANB angle. The lower incisors are more upright and the cranial base angle (NSO) is larger.

The results of all these comparisons support the assumption that variations in the cant of the mandibular plane are also accompanied by significant differences in the craniofacial relations. With this established, the next step in the investigation was to find the correlation between the change in the cant of the mandibular plane and the other craniofacial parameters examined.

Table III contains the correlation coefficient (r) scores. These indicate that, for the total group, significant correlations are present between the MP: SN angle and many of the other variables examined, most of them at the .01 level of confidence. It is important to realize that, although the level of statistical significance is high, the correlation scores are generally low except for SNPog (—0.67), NSGn (0.83), N-Me (0.61) and S-N/N-Me (—0.7).

Within each subgroup fewer significant correlations were found and the values of r were, in general, lower than those for the total group.

Discussion

Orthodontists used the mandibular plane for different purposes: Tweed as part of his famous triangle for diagnosis and treatment planning; Isaacson and Schudy to describe facial morphology and to advocate certain mechanics desirable for each facial type; Reidel to evaluate posttreatment changes and finally, Thurow[16] cautioned against possible impingement on the pharyngeal spaces in certain facial types during the course of orthodontic treatment.

TABLE II

Scores of F-ratios (F) and Student t-tests (t) Resulting from Comparisons Between the Different Subgroups Examined *P < .05, ** P < .01

		High vs Average MP		Low vs Average MP		High vs Low MP	
		F	t	F	t	F	t
SNA	°	1.58	—2.66**	1.19	1.70	1.33	—3.85**
SNB	°	1.07	—4.01**	1.23	2.80*	1.16	—4.98**
ANB	°	1.38	1.70	1.27	—1.45	1.09	2.75**
SNPog	°	1.11	—5.09**	1.12	4.48**	1.25	—7.43**
SNANS	°	1.30	—2.12*	1.01	1.59	1.31	—3.01**
N-A-Pog	°	1.24	2.13*	1.65	—2.86	1.33	4.49**
NS-GN	°	1.40	8.13**	1.15	—6.24**	1.61	10.65**
MP-SN	°	1.58	12.70**	2.88*	—15.11**	4.54**	18.43**
$\bar{1}$-MP	°	1.95	—2.76**	1.13	2.90**	1.73	—5.10**
$\underline{1}$-SN	°	1.03	—0.42	1.42	2.26	1.46	—1.93
$\underline{1}$-$\bar{1}$	°	2.12	—2.32**	1.23	—0.26	1.73	—1.92
NSO	°	1.38	1.80	1.81	—2.20	1.31	2.57*
N-ANS'	mm	1.02	2.27*	1.18	—1.58	1.22	3.08**
N-Me	mm	1.24	5.03**	1.16	—3.56**	1.43	6.56**
ANS-PTM	mm	1.21	—0.59	1.40	—0.41	1.70	—0.12
S-N	mm	1.25	—3.00*	1.11	1.05	1.13	—2.96**
Pg-Postp	mm	1.42	0.27	1.39	0.05	1.03	0.21
N-O	mm	1.17	—1.31	1.06	—0.47	1.23	—0.67
S-O	mm	1.06	—0.23	1.34	1.97	1.43	—1.62
$\frac{\text{N-ANS'}}{\text{N-Me}}$	x 100	1.51	—1.75	1.60	1.29	2.43	—2.22*
$\frac{\text{ANS-PTM}}{\text{S-N}}$	x 100	1.95	1.84*	1.10	—0.89	1.76	2.44*
$\frac{\text{SN}}{\text{N-Me}}$	x 100	1.05	—6.62**	1.47	4.23**	1.54	—7.73**
$\frac{\text{N-ANS'}}{\text{S-N}}$	x 100	1.38	4.58**	1.17	—2.28*	1.18	4.84**
$\frac{\text{ANS-PTM}}{\text{Pog-Postp}}$	x 100	1.14	—0.79	1.71	—0.37	1.95	—0.28
$\frac{\text{S-N}}{\text{N-O}}$	x 100	1.63	—2.06*	3.16**	1.11	5.16**	—2.20*
$\frac{\text{S-O}}{\text{N-O}}$	x 100	1.40	0.80	2.79**	2.31*	1.99	—1.48

Beaton and Cleall,[2] on the other hand, stated that few persons fit the accepted standards of ideal occlusion or skeletodental balance and, consequently, treatment objectives set up on this type of data are usually unrealistic. They pointed to the need of "Peer Groups" in which a given patient can be matched with other individuals with similar skeletodental morphology.

The present findings indicate that changes in the cant of this angle are also associated with certain facial and dental characteristics. Thus the cant of the mandibular plane could assist in identifying facial types which in turn are the result of the cumulative effect of the various genetic and environmental factors acting during the development of an individual.

The results of this investigation, therefore, provide "normal" cephalometric standards for *three* different facial types presented by polygons in Figure 2 and polygraphs in Figure 3. The polygraphs were based on the concepts

TABLE III

Correlation Coefficient (r) Between MP:SN Angle and the other Variables examined. *P < .05, ** P < .01

		Whole Group	Average MP	High MP	Low MP
SNA	°	—0.31**	—0.12	—0.25	0.09
SNB	°	—0.52**	—0.36**	—0.38	—0.05
ANB	°	0.34**	0.33**	0.29	0.26
SNPog	°	—0.67**	—0.47**	—0.55*	—0.24
SNANS	°	—0.26**	—0.04	—0.36	—0.03
N-A-Pog	°	0.45**	0.33**	0.43	0.38
NS-GN	°	0.83**	0.58**	0.78**	0.50*
$\overline{1}$-MP	°	—0.37**	—0.02	—0.45	—0.44
$\underline{1}$-SN	°	—0.22*	—0.22*	0.08	—0.01
$\underline{1}$-$\overline{1}$	°	—0.21*	—0.14	—0.37	0.10
NSO	°	0.27**	0.09	0.27	—0.02
N-ANS	mm	0.31**	0.16	0.31	—0.01
N-Me	mm	0.61**	0.36**	0.47*	0.42
ANS-PTM	mm	—0.04	0.02	—0.25	—0.17
SN	mm	—0.29**	—0.06	—0.32	—0.18
Pg-Postp	mm	—0.06	—0.13	—0.08	—0.31
NO	mm	—0.12	—0.15	0.06	—0.30
SO	mm	—0.18	—0.25*	0.30	0.16
$\frac{\text{N-ANS}'}{\text{N-Me}}$	x 100	—0.24*	—0.14	—0.07	—0.31
$\frac{\text{ANS-PTM}}{\text{SN}}$	x 100	0.13	—0.08	0.04	—0.05
$\frac{\text{SN}}{\text{N-Me}}$	x 100	—0.70**	—0.41**	—0.66**	—0.47*
$\frac{\text{N-ANS}'}{\text{SN}}$	x 100	0.48**	0.19	0.53*	0.11
$\frac{\text{ANS-PTM}}{\text{Pg-Postp}}$	x 100	0.01	0.14	0.14	0.05
$\frac{\text{NS}}{\text{NO}}$	x 100	—0.19	0.10	—0.58**	0.12
$\frac{\text{SO}}{\text{NO}}$	x 100	—0.14	—0.22*	0.29	0.39

laid by Vorhies and Adams[18] which included reversing the values of certain parameters (e.g., NAPog, MP:SN, and NSGn) thus indicating a retrognathic tendency on the left side of the polygraph and a prognathic tendency on the right side.

Our findings also indicate that the high and low MP subgroups differed not only in most of their facial and dental cephalometric relations, but also in the cranial base angulation (NSO) and anterior cranial base length (S-N). It should also be mentioned that in the high MP subgroup both maxilla and mandible were relatively more retruded while in the low MP subgroup the mandible was relatively more protruded when they were respectively compared with the average MP subgroup.

The relation between the incisor inclination and changes in the MP:SN angle are of particular interest. For the whole group there were significant correlations between the inclination of the upper and/or lower incisors ($\overline{1}$:MP, $\underline{1}$:SN and $\underline{1}$:$\overline{1}$) and the MP:SN angle. These findings support many of Tweed's clinical concepts, since he

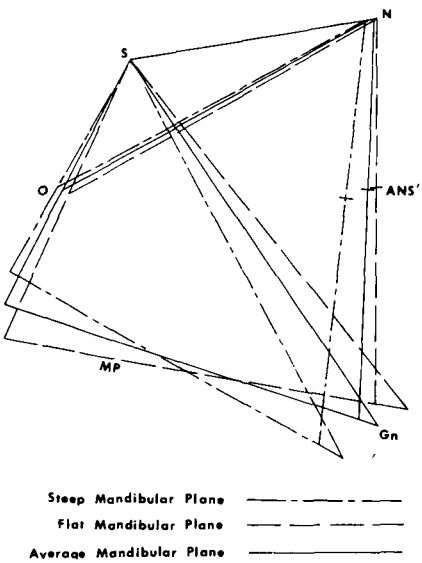

Fig. 2 Facial polygons for the steep, average and flat facial types. Superposed on SN at S.

maintained that, as the MP angulation increases, the lower incisors should be treated to a more upright position except in cases with steep MP.

The present findings also indicate that within each subgroup the inclination of the lower incisors varies greatly and, therefore, the relation between the incisor inclination and the cant of the mandibular plane does not hold true when the MP:SN angle is too steep or too flat.

The results further demonstrate that in spite of our ability to distinguish three facial types using MP:SN angle there is a great degree of variability within each subgroup; two explanations for such a finding are suggested:

a. Variations in the magnitude of the MP:SN angle could be the result of normal anatomical variation in the

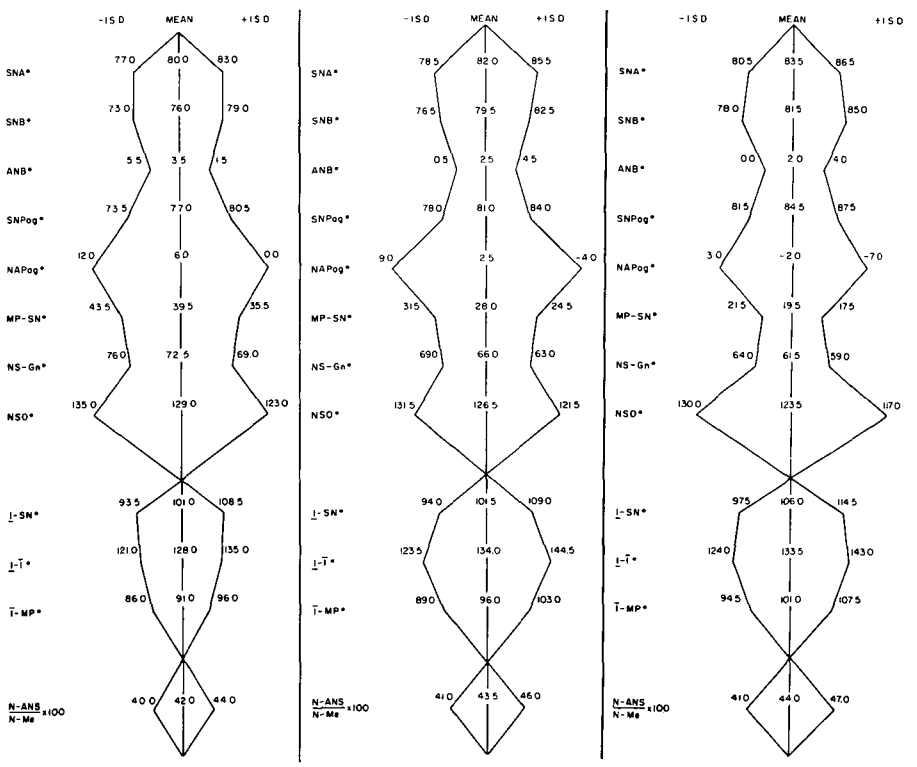

Fig. 3 Facial polygraphs (after Vorhies and Adams[18]) for the steep (left), average (center), and flat (right) MP subgroups.

position of points sella and/or nasion. Thus the magnitude of the MP:SN angle in such cases will be an inaccurate reflection of the individual's facial type. Since many orthodontists routinely measure both the MP:SN angle and the Frankfort horizontal-mandibular plane angle, comparisons of both readings to each other and to the patient's tracing can help identify these cases.

b. Although one should expect a degree of interrelation between the different structures which form the craniofacial complex, nevertheless these various structures are performing different functions. Therefore, a single parameter, like MP:SN angle, should not be expected to accurately reflect all these interactions. Future research might result in the identification of other parameters which in combination with the MP:SN angle could determine, more accurately, individual facial types.

Walker and Kowalski[19] indicated that there is a great variation in the size of the SNA and SNB angles. The variation was greater within the same group than between different age groups or between males and females. In light of the data presented here this should be expected because of the great morphological variability present in any population. More research is thus necessary to determine whether the results of this investigation are applicable at different ages for both males and females.

It must be emphasized that the outlined three subgroups are not all inclusive and, therefore, not *every* case will fit in an ideal fashion in one of the three polygraphs. The wide range of normal individual variation is such that there is no practical classification which can encompass every individual. It is thought, on the other hand, that dividing the wide normal range into three clinically pertinent facial types might offer a practical guide for the orthodontist. In addition, norms derived according to facial types could possibly be useful in the study of individuals with clefts of the lip and/or palate, since many of these individuals have a steep mandibular plane.[2]

Conclusions

Normal variation in the MP:SN angle is associated with other changes in the skeletal and dental relations. Three subgroups were identified (average, high and low MP) in an attempt to outline cephalometric norms for adult Caucasian males.

It is suggested that further research is necessary to determine the corresponding cephalometric values for adult Caucasian females, and for both males and females at different ages. If differences in age and sex are less significant than the differences in facial types, the orthodontist might be able to adopt more clinically applicable cephalometric norms.

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