# Variations In Facial Relationship:
## Their Significance In Treatment and Prognosis[1]

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A large proportion of the orthodontist's problems stem from the well known biological fact of variations within the species. This variation is particularly evident in the human face. The differences are noted in size, proportion, relationship of parts and even in growth rates. These variations have been recognized and have lead to classification of facial types, but there are no sharp demarcations. The gradations from one extreme to the other in type are innumerable. To complicate further the problem, the various types of faces may present functional and esthetic harmony and balance, or they may represent degrees of disharmony and imbalance, depending on the relationship of the component parts of the face, namely, the bones of the head, the denture and overlying soft tissue.

This paper presents the finding of a study which has been pursued by the author for the past five years. It was undertaken to determine the range of the skeletal and dental pattern within which one might expect to find the normal and further to discover whether any usuable correlation existed in such normals.

The method employed in the study was roentgenographic cephalometry and the technic was that described in various papers familiar to all orthodontists.

The control material studied was derived from twenty living individuals, ranging in age from 12 - 17 years and about equally divided as to sex. Models, photographs and cephalometric and intraoral roentgenograms were taken of each. All individuals possessed clinically excellent occlusions.

Tracings were made of all lateral head x-rays taken with the teeth in occlusion and the Bolton triangle outlined on each tracing according to Broadbent's technique, which consists of connecting the following points: (Fig. 1) Nasion to the center of sella turcica, and sella to the Bolton point, which is the superior point on the concavity behind the occipital condyles. Continuing from the Bolton point back to nasion completes the Bolton triangle, which represents the area at the base of the cranium to which the face is joined. It is believed by Broadbent to be the most stable area from which to make serial comparisons. This area itself must, of course, increase as the head grows, so Broadbent has located a point within the triangle by taking the mid-point of a perpendicualr from the Bolton plane to the center of sella turcica. He calls this the registration point. When serial tracings are studied they may be registered on this point with their Bolton planes parallel. The other landmarks and planes used in this study are shown in Fig. 1.

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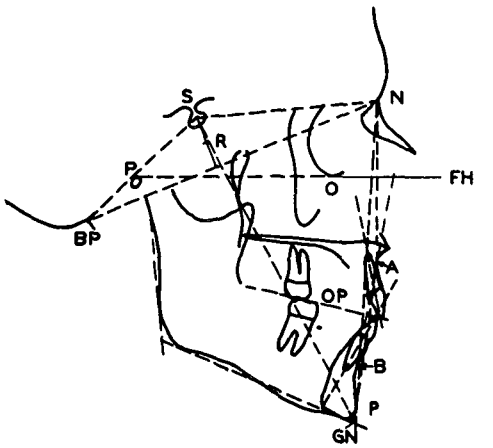


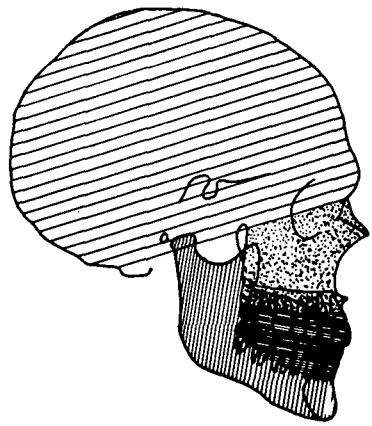



FIG. 1. The skeletal pattern—serial pictures are superimposed at R with the Bolton planes parallel.

FIG. 2. A diagrammatic breakdown of the areas of the head.

For the purpose of this study the head was divided into cranium and face. (Fig. 2) The face was further divided into (1) upper face, (2) teeth and alveolar area and (4) lower face or mandible.

As the investigation progressed two objectives developed, to appraise: (1) the pattern of the facial skeleton exclusive of the teeth and alveolar process. (2) The relationship of the teeth and alveolar process to the facial skeleton.

## OBSERVATIONS

### 1. The Skeletal Pattern In Norma-Lateralis

The skeleton pattern of the face is determined by the maxillary bones and the mandible. While the teeth and alveolar process also influence facial form, they will be considered separately as the denture.

The skeletal pattern can be laid out on lateral cephalometric x-rays as a polygon and its form or pattern described by the angular relationships of various planes. (Fig. 3) Those to be described in this study are the Facial angle, Angle of convexity, the antero-posterior relationship of the denture bases, Mandibular plane angle and the Y axis.

It is customary for orthodontists to classify facial types according to the degree of recession or protrusion of the mandible. As this attribute of facial form is determined by a skeletal foundation, it would obviously be an advantage to classify skeletal pattern in a manner consistent with facial type as this is appraised by examination of the individual or their photographs. So far it has been found that this can best be accomplished by relating certain planes of the pattern to the Frankfort horizontal plane.

*Facial Angle* (Fig. 4)

This angle is an expression of the degree of recession or protrusion of the chin. It is determined by drawing a line from nasion to pogonion, this plane being called the Facial plane. The inferior inside angle of its intersection with the Frankfort horizontal is designated as the Facial angle.

The mean value for the series was 87.8. The range was from 82° representing a recessive chin approaching the facial type usually associated with Class II malocclusion to 95° indicating a protrusive chin.

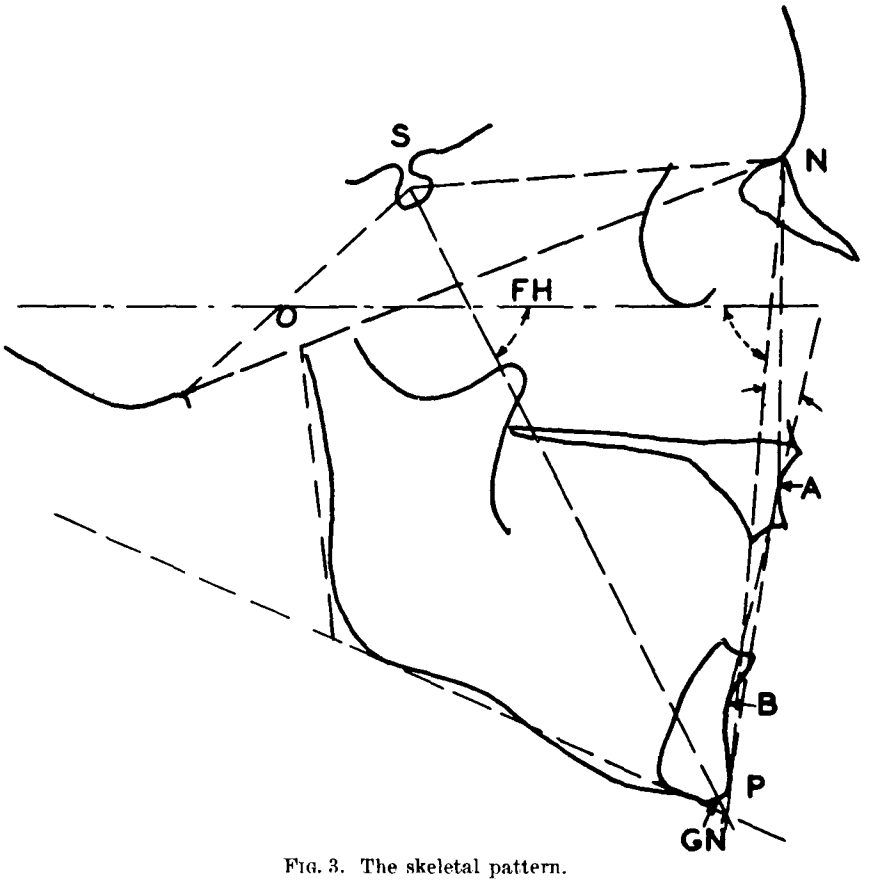
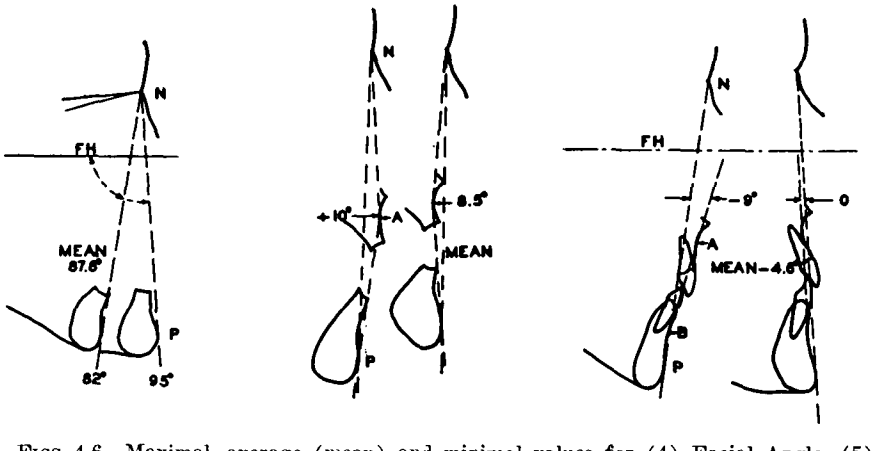



FIG. 3. The skeletal pattern.



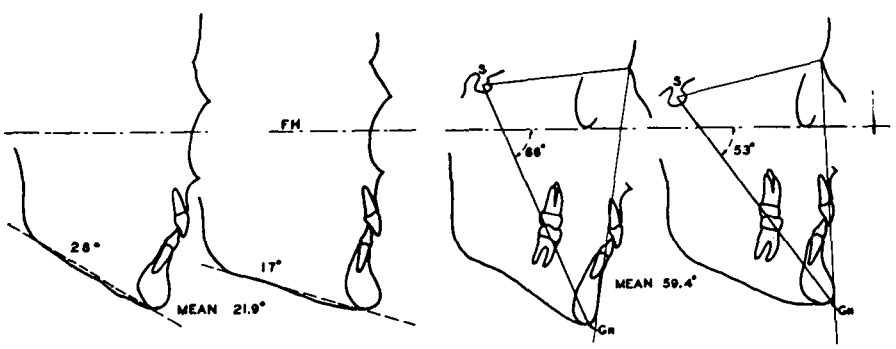

FIGS. 4-6. Maximal, average (mean) and minimal values for (4) Facial Angle, (5) Angle of convexity, (6) A-B plane to the facial plane. The last is an expression of the anteroposterior relationship of the mandibular denture base to the maxillary denture base.

*Angle of Convexity* (Fig. 5)

This is a measure of the protrusion of the maxillary part of the face to the total profile. The angle is formed by two lines, one from nasion and the other from pogonion both meeting at A. The mean of the control group was a straight line or 180 degrees. In such a case the Angle of convexity would, of course, coincide with the Facial plane and be 0. If the point A fell posterior to the Facial plane, the angle formed was read in minus degrees, and if anterior, in plus degrees. The range in the controls was found to be +10° (convex) to −8.5° (concave type).

*A B Plane* (Fig. 6)

The location of this plane in relation to the facial plane is a measure of the relation of the anterior limit of the denture bases to each other and to the profile. It permits estimation of the difficulty the operator will meet in gaining correct incisal relationships and satisfactory axial inclinations of these teeth. In the control group the relation of this plane to the facial plane was found to range from parallelism or 0° to a posterior position of B which could be read as −9°. The mean was −4.8.




FIGS. 7 & 8. Maximal, average (mean) and minimal values for (7) mandibular plane angle and (8) Y axis angle.

*The Mandibular Plane Angle* (Fig. 7)

This is a measure of the relationship between the Frankfort plane and a tangent to the lower border of the mandible, recently brought into prominence by Tweed and Salzmann as a clinical diagnostic aid. In our controls of excellent dentitions the angle formed by these two planes ranged from 28° to 17°. The mean was 21.9.

The coefficient of correlation between the mandibular plane angle and the facial angle was found to be −0.73 which is an indication that as the facial angle decreases (chin more posterior) the mandibular plane angle tends to increase (mandibular border becomes steeper).

*Y Axis* (Fig. 8)

As the face swings out from under the cranium in its growth and development from birth to maturity, it is said to grow in a downward and forward direction. A line from sella turcica to gnathion has been used as an expression of the direction of this growth and called the Y axis.

The angular relationship between the Y axis and the Frankfort plane of the control group yielded a mean of 59.4° with a range of 66° to 53°.

To recapitulate on skeletal pattern the following data gives the range and means of the angles used in the analysis.

TABLE I

| | | | | | |
|---|---|---|---|---|---|
| Facial Angle | 82 | to | 95 | Mean | 87.8 |
| Angle Convexity | +10 | to | −8.5 | Mean | 0 |
| A B Plane to Facial Plane | − 9 | to | 0 | Mean | −4.6 |
| Mandibular Plane Angle | 28 | to | 17 | Mean | 21.9 |
| Y axis to Frankfort Plane | 66 | to | 53 | Mean | 59.4 |

Within these ranges one can expect to treat a malocclusion to a well balanced face provided one maintains a balanced relationship of the denture to the skeletal pattern. Excessive deviations of any of these relationships may be considered as unfavorable variations which reduce the prospects of obtaining a harmoniously balanced face, in direct ratio to the amount of deviation.

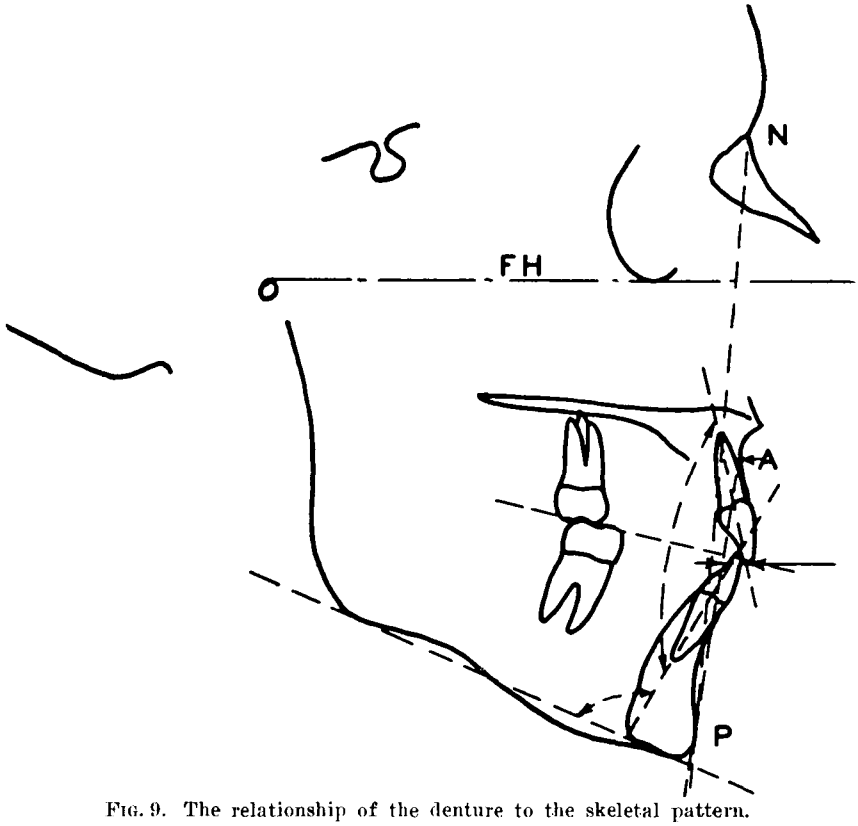
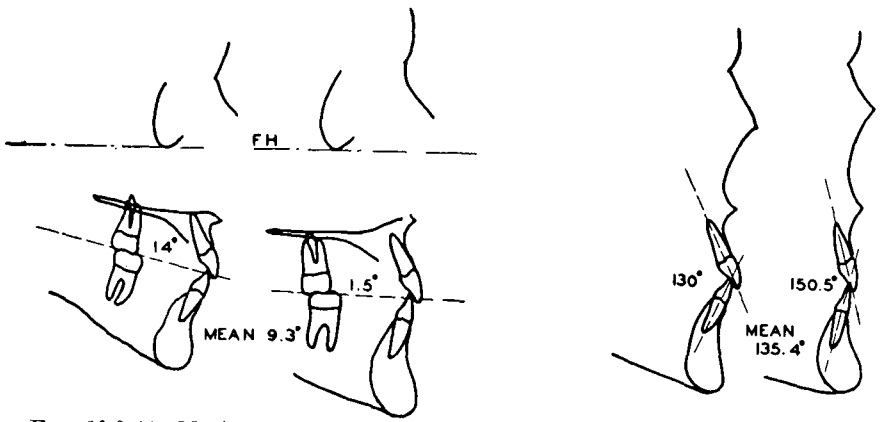



FIG. 9. The relationship of the denture to the skeletal pattern.

The second area of the face to be investigated was that comprising the teeth and alveolar process. This region has particular significance to the orthodontist because it contains the tissues which respond directly to orthodontic therapy.

The relationships (Fig. 9) which at the moment appear to be of the greatest clinical importance are (1) the cant of the occlusal plane, (2) the axial inclination of the upper and lower incisors to each other, (3) the axial inclination of the lower incisors to the mandibular plane, and (4) the amount of protrusion of maxillary incisors. These relations are obtained by the following methods.




FIGS. 10 & 11. Maximal, average (mean) and minimal values for (10) cant of occlusal plane, and (11) axial inclination of the upper to the lower incisors.

*Cant of Occlusal Plane* (Fig. 10)

In order to make angular readings the occlusal plane was represented as a straight line. It was laid out by bisecting the first molar cusp height and incisal overbite and connecting the two with a straight line. (In the appraisal of severe malocclusions, where the incisors are obviously in extreme positions of supra or infra occlusions these teeth may be disregarded and molars and bicuspids used.)

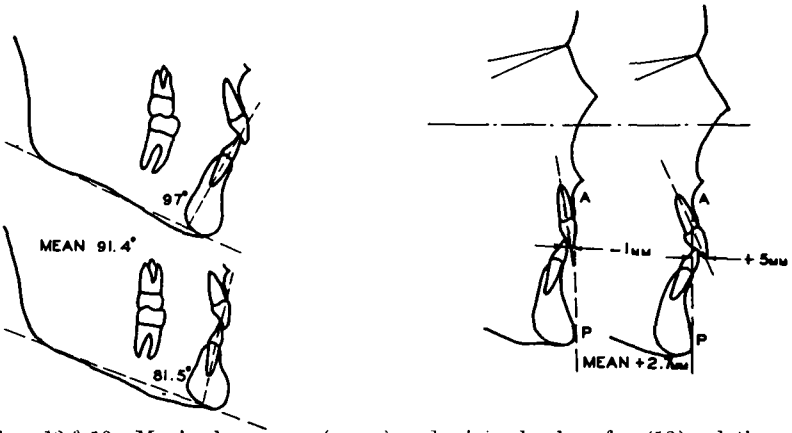
The angular relation between the occlusal plane and the Frankfort plane in the control series ranged from +14° to 1.5° with a mean of +9.3°. A coefficient of correlation of —0.78 between this plane and the facial angle indicated that there was a tendency for the planes to approach parallelism as the facial angle increases. Generally speaking, the Class II facial types have a relatively steep angle. As the facial type approaches the Class III pattern the occlusal plane tends to become more horizontal. (Should the relationship exceed parallelism through a drop of the posterior end of the occlusal plane, the readings are made in minus degrees.)

*Axial Inclination of Upper and Lower Incisors* (Fig. 11)

This is a measure of the degree of procumbency of the incisor teeth. In order to read the relation of the upper to the lower teeth, lines are drawn representing their axis. A tabulation of the inside angles of this relationship in the control cases yielded a mean of 135.4° with a range from 130° to 150.5°.

*Axial Inclination of Mandibular Incisor to Mandibular Plane* (Fig. 12)

A number of studies have been reported on this relationship, Margolis, Noyes, Rushing and Sims, Speidel with a general agreement on ranges and on a mean of 90°. Our control group yielded a mean of 91.4°. The difference in the mean can be accounted for by the slightly different method of locating the mandibular plane. All previous studies have located the mandibular plane tangent to the lower border of the mandible at gonion and the lowest anterior point which usually is found beneath the bicuspids. As the latter point is not in the midline and serial observations indicate appositional growth in this area causing an increasing bulge, the lowest point of mandible in the midsaggital plane is used as the anterior tangent point for determining the mandibular plane.




FIGS. 12 & 13. Maximal, average (mean) and minimal values for (12) relation of the lower incisor to the mandibular plane, and (13) the distance in mm. from the incisal edge of the upper central to the plane A-P.

As the average relationship of the lower incisors to the mandibular plane is approximately a right angle (90°), it appears to be more descriptive to denote the inclination of these teeth in degrees of deviation from a right angle relationship to the mandibular plane; thus a labial tip of the incisors as described as plus the number of degrees in excess of 90°, and a lingual tip as minus the number of degrees less than 90°. The range in our control series is +7° to —8.5° with a mean of +1.4°.

*Axial Inclination of Lower Incisors to the Occlusal Plane*

To further test the tip of the lower incisors, their axis may be compared with the occlusal plane. This seems to be a logical method for the incisors are then being related to their functioning surface, the occlusal plane. Further, it has been observed that the mandibular plane angle has a wide range when dealing with extremes of skeletal patterns. The axial inclination of the lower incisor to the occlusal plane has been found to be helpful in checking and interpreting the incisor mandibular plane angle. The inferior inside angle was read and the plus or minus deviation from a right angle recorded. The range was from +3.5° to +20° with a mean of +14.5°.

*Protrusion of Maxillary Incisors* (Fig. 13)

The distance of the incisal edge of the maxillary central incisor to the line A.P. is a measure of maxillary dental protrusion and is read in millimeters. In the control group it was found to vary from +5 mm. (anterior) to —1 mm. (posterior) to the A.P. line, with a mean of 2.7 mm.

The relationship of the denture to the skeletal pattern lends itself to a formulae of means and extremes similar to the one on skeletal pattern and is shown in Table II.

TABLE II

| | *Minimal* | *Maximal* | *Mean* |
|---|---|---|---|
| Cant of occlusal plane | +1.5 | +14 | +9.3 |
| $\underline{1}$ to $\overline{1}$ | 130 | 150.5 | 135.4 |
| $\overline{1}$ to mandibular plane | —8.5 | + 7 | 91.4 |
| $\overline{1}$ to occlusal plane | +3.5 | +10 | +14.5 |
| Distance $\underline{1}$ to facial convexity plane A P — 1mm. + 5mm. | | | +2.7 |

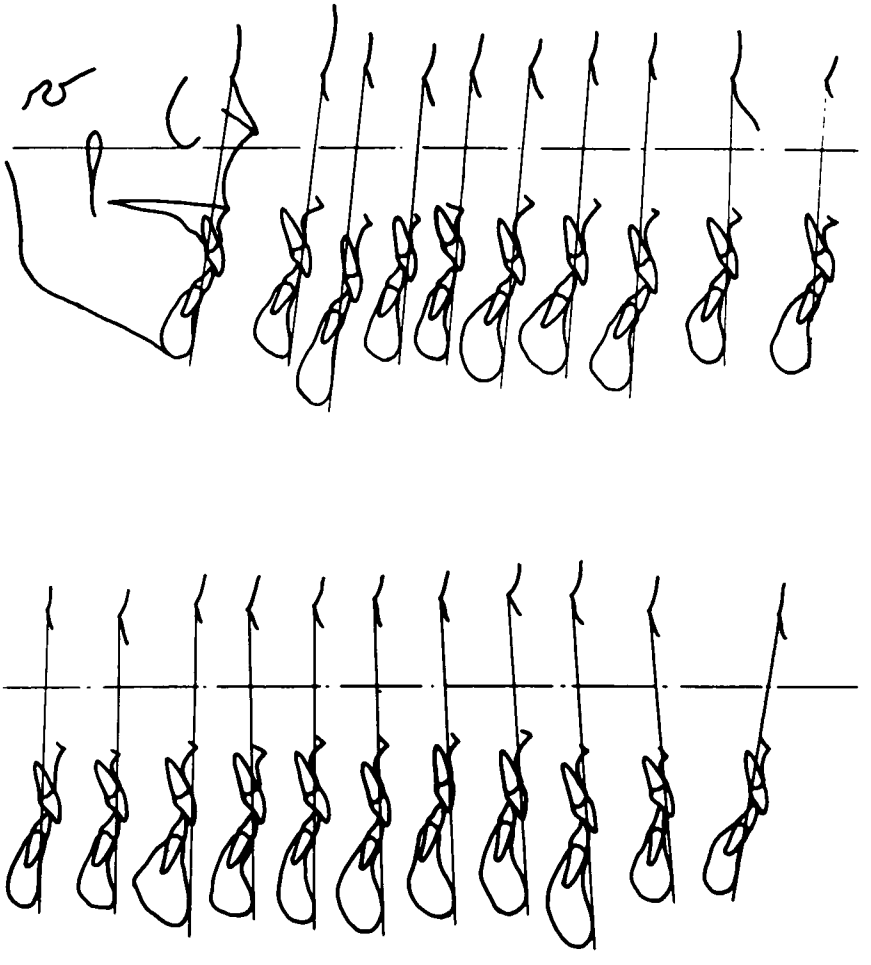


FIG. 14. The form of the mandible at the symphysis and the relationship of the incisor teeth to the facial plane in the 20 cases studied. They are arranged in the increasing magnitude of the facial angle. The first figure is reproduced at the end.

## DISCUSSION

One studying cephalometric roentgenograms soon becomes conscious that they show considerable difference in general pattern. Lateral views in particular show a wide variation in the relationship of the component parts of the face. These differences are observed in the way the face is related to the cranium, in the general contour of the profile and in the relationships of the teeth to the skeletal pattern. There develops a sense of balance and harmony in the x-rays of those individuals who possess excellent untreated occlusions. They represent standards against which malocclusions and treated cases may be judged. Fig. 14 shows the profile outlines of the cases used in this study. While differing in pattern they show a similarity in balance. Note in particular the relationship of the incisor teeth to facial plane.

The Tables I and II, giving the variations of skeletal and dental relationship, permit the expression of a facial pattern by means of figures. They are in reality formulae of classification. Figures also have the advantage of accurately expressing changes which occur during treatment or as the result of growth or both.

Exceptions will be found to the means and extremes found in this study. Facial types are known to differ racially and this study is limited to the white race. This, however, does not negate the use of the method and tables as in the last analysis the total picture of denture and facial balance and harmony can only be ascertained after evaluation of (1) skeletal pattern and the relationship of denture to it, (2) occlusion and function of the teeth, (3) function of the facial musculature.

A patient seeks orthodontic treatment because a malocclusion is present. They may have esthetically harmonious and functionally balanced facial musculature, or they may present varying degrees of disharmony and imbalance. If the former condition is present, the head plate analysis will give readings either within the normal range or with only slight deviations. As these cases do present good muscle balance, it would be desirable not to destroy this by placing teeth in unfavorable relationship to the skeletal pattern. In those cases with poor functional and esthetic balance the fault will lie in a poor skeletal pattern or in a faulty relationship of the denture to the skeletal pattern, or both conditions may be present. The cephalometric readings will locate and give the amount of disproportion.

Skeletal patterns are relationships over which we have very little control in orthodontic treatment except by the use of surgical technics. We must not forget, however, that in most of our cases maturation is going on and that there are variations between individuals in the downward and forward direction of growth of the face. In other words, there are three possibilities to consider: horizontal and vertical growth may be equal, in which case the direction of growth (Y axis) will not change; or horizontal growth will exceed vertical growth and the Y axis angle will decrease. This indicates a forward swing of the face. The other alternative would be where vertical growth exceeds horizontal growth and the Y axis angle increases. The manner in which the face grows during and after treatment has a significant bearing on the prognosis of a case.

Many of our difficulties in treatment can be directly attributed to excessive disharmony of the skeletal pattern. A recognition of such limitations forewarns the orthodontist of what he may expect if he undertakes treatment. It is much more comforting to recognize this before starting a case than to find out after months of treatment that you are not getting the nice results that other cases produce.

The denture, however, presents relationships over which the orthodontist has considerable control in the three phases of orthodontic therapy, namely; interception of malocclusion, guiding the development of the denture, and correction of established malocclusions. The knowledge of variations of the relationship of the denture to the skeletal pattern in individuals with excellent occlusions is an aid in locating areas of disharmony in malocclusion. It points out quite clearly certain tooth move-

ments that must be accomplished to recover harmony. Probably more important, serial cephalometric analysis of treated cases provides convincing evidence of what we really do with our treatment. It shows beyond question that our present abilities with an orthodontic appliances are not equal to restoring or maintaining balance and harmony of the component parts of the face without sacrificing dental units in many cases. It serves to clarify the limitations of appliance therapy.



## Summary

What constitutes harmony and balance of the component parts of the face, namely, the skeletal framework, the denture and the overlying musculature has for many years commanded the attention of the research investigator, the teacher and the clinician. A satisfactory solution is most difficult to attain, what with the innumerable variations of type, as well as the unfolding of the facial pattern from the infant to the adult.

The results of this study of twenty individuals with excellent occlusions and a review of similar investigations appears to warrant the following conclusions.

(1) There is a facial pattern that represents mean or average form for individuals possessing excellent occlusions.

(2) There is a notable deviation on both sides of the mean findings of the facial pattern. These represent the usual variation one must reckon with when appraising balance and harmony.

(3) Excessive deviations of the means and extremes found in this study usually express abnormalities of relationship which will be evident as disharmonies or imbalance of particular areas.

(4) The skeletal pattern in the lateral aspect may be described in figures and be appraised as good or bad according to the amount of deviation of the readings from the known mean pattern. Such information can be of considerable help in forming a prognosis of treatment.

(5) The relationship of the denture of any case to its skeletal pattern can likewise be compared with known relationships of good balance and harmony. Such analysis tends to point out the desirable tooth movement indicated in treatment.

(6) Serial study of cases by this method permits definite expression of anteroposterior and vertical changes induced by treatment and those occurring during retention, as well as those changes that may be attributed to growth and development.

(7) This method of cephalometric analysis has been tested for three years in the author's practice as well as in the graduate department of orthodontia at the University of Illinois. In the last year the orthodontic

departments of the University of California, Northwestern and Indiana have cooperated in testing its clinical and teaching value. Out of these experiences has come one particularly important comment. *The ten figures used in the appraisal do describe skeletal and denture relationships but single readings are not so important: what counts is the manner in which they all fit together and their correlation with type, function and esthetics.*

Graham Bldg.

This report is an abstract of the original article published in the American Journal of Orthodontics. The original includes a more complete introduction, the investigation to validate the use of the Frankfort horizontal plane, a glossary and a complete analysis of four cases to illustrate the application of the method in clinical practice.