The Variations In Skeletal And Denture Patterns In Excellent Adult Facial Types*

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The purpose of this research project was to investigate the dentoskeletal patterns of Caucasian adults having excellent faces. This objective was further to be defined by studies of central tendency, dispersion, and correlation.

Aspects of dentoskeletal pattern to be considered included mandibular prominence or retrusion, profile convexity, tooth axial inclination, vertical height proportions, and structural dysplasia in the anteropostero plane.

In addition, the variations were contrasted according to sex and by comparisons with previous studies based on samples characterized by excellence of occlusion.

FACIAL ESTHETICS

The problem of facial harmony and the intrarelations of the dentofacial complex, while consistently occupying the attention of dentists and orthodontists in particular from the time of Hunter and even before, has always been an elusive concept because of the infinite range of the variations inherent in the morphogenic pattern and the nebulous and indefinite nature of the subject itself. Yet, the importance of esthetics as a basic aim of orthodontic therapy needs little elaboration. In fact, Hunter[1] in the eighteenth century had suggested that the prime objective of this treatment was to beautify the appearance of the mouth.

The question must be asked: What constitutes an excellent face? Is there any demonstrable, quantitative criterion from which an excellent face can be defined in terms applicable to the needs of the orthodontic clinician? Stoner[2] has suggested that each man's concept of facial beauty is a function of his own innermost sensibility and understanding. Yet, he points out, ". . . there most certainly is considerable agreement among many of us that certain faces fall well within the definition of . . . . harmony of form." Orthodontists generally share Angle's conviction that "The study of orthodontia is indissolubly connected with that of art as related to the human face,"[3] but does not the great universal genius of the Renaissance, Da Vinci, tell us: "The most admirable faces are those whose expression best reveals the passions of the soul."[4] It is clear that the question of facial beauty inspires sympathetic consideration as much by the scientific research worker as it does by the subjective artist, and that facial beauty is a function of the facial feature in balance and harmony.

The first American to apply the term "dentofacial orthopedics" was Calvin Case in 1896.[5] There are countless references in Case's writings of his preoccupation with esthetics and his interest in the fine arts and their influence on orthodontics.

Edward H. Angle admonished the orthodontic profession to have "fixed in our minds the outline of the perfect face . . . ." His intimate concern with the question of facial esthetics is well known to all students of the history of

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orthodontics. Angle considered that all the essentials of beauty and perfection were to be found in the statue of Apollo Belvedere.

Tweed and his followers have been the conspicuous leaders of the revival and reemphasis in recent years of improvement in facial esthetics as a practical and basic goal of orthodontic therapy. Tweed has placed esthetics first in his list of treatment objectives; to achieve this objective he has advocated in many instances the extraction of dental units. Thus, on a basis of clinical experience, he disputes Angle's dictum concerning the necessity for maintaining a full complement of teeth in order to gain the ultimate excellence of occlusion and, according to Angle, the ultimate in facial balance and harmony. Tweed has placed particular emphasis on facial esthetics because he is convinced that good occlusion is possible only where there is reasonable balance between the various component parts of the dentofacial complex, and ". . . only when normal occlusion accompanies a normal face pattern is the ultimate in balance and harmony of the facial lines possible.[6]

Beauty of facial lines does not depend alone on beautifully aligned and ideally occluded teeth but upon the sum total of intra-relationships between all the structures that enter into the formation of the dentofacial complex. Therefore, the basic etiology of malocclusions may lie in the faulty development or malrelation of these parts. Logically, Angle's major premise of ideal occlusion per se as the prime requisite for the balance and harmony of facial parts may be faulty, since the basis for ideal occlusion is the ideally coordinated development of *all* the structures of the face and cranium. The one rule in the fine arts for the application of rigid standards to the ideal face is that there are no rules: every face differs from every other one to a greater or lesser degree! Yet, there are fundamental principles in art, the expression of which signifies beauty — when lines are in *balance* and *harmony,* they possess two of the fundamental qualities which govern the degree of perfection of the product of the artist. The specialty of orthodontics revolves around a ceaseless pursuit of this.

Cephalometric Methods

The most significant advancement in orthodontics in recent years is the widespread employment of cephalometrics as an analytical tool and diagnostic aid. With the development of techniques for routine appraisal of patients, the cephalometer has been increasingly accepted as the most efficient means for studying therapeutic and prognostic possibilities and limitations. It is a convenient procedure for analyzing abnormalities, localizing and recording the degree and direction of discrepancy; it can be applied to functional and to soft tissue analysis; it makes possible the more accurate classification of facial types; it is used for the study of completed cases; it is a time-linked technique which enables the investigation of problems of growth and development through the dynamic analysis of serial studies. Downs has observed: "Cephalometrics is to the orthodontist what the dissection room is to the anthropologist and anatomist".[7] The introduction of the cephalometer in the United States as an analytical tool in orthodontics is credited to Broadbent (1931).[8]

Tweed emphasized the significance of the Frankfort mandibular plane angle in diagnosis.[9] He suggested that the steeper the plane (the higher the angulation), the poorer the prognosis insofar as improvement of facial esthetics is concerned. E. L. Johnson also affirmed this in a later and more comprehensive study.[10]

Margolis, who had been among the first to report on the axial inclination of the lower incisors[11], introduced the maxillofacial triangle in 1947[12]. He felt that the character of this triangle was sufficiently narrow so as to establish a basic facial pattern. Tweed introduced a modification of this triangle in 1954[13], using more conventional registration points and planes. In a reanalysis of his own treated cases, he came to the conclusion that the best esthetic results were obtained in those cases having a Frankfort mandibular plane angle of 25°, an axial inclination of mandibular central incisor tooth to mandibular plane of 90°, and, therefore, an angulation of 65° of mandibular central incisor tooth to Frankfort plane. This latter measurement is considered by Tweed to be of paramount importance.

The precise quantitative definition of mandibular central incisor tooth positioning devised by Tweed was the subject of an article by Wylie[14]. Wylie, reanalyzing Tweed's sample, came to the conclusion that Tweed oversimplified his treatment concept and the explanation of his results, and that the uprighting of the mandibular central incisor teeth to a 65° angulation with Frankfort plane was only one element, and not necessarily the most important, in his most successful cases. Wylie suggested that the remarkable facial changes were rather a function of Tweed's extraordinary ability to elicit mandibular growth in the majority of these cases.

Wylie[15], in a study of mandibular, nasal, and dental heights, showed that these were among the most stable of dentofacial dimensions. Accepting as valid the theses of Brodie[16] and of Broadbent[17] regarding the constancy of the proportionality of the facial parts during growth, he developed as a consequence an assessment of anteropostero dysplasia[18]. Later, Wylie and Elsasser elaborated on this in a study on the craniofacial morphology of mandibular retrusion[19]. Wylie and E. L. Johnson studied mandibular and vertical dimensions and relationships in an evaluation of facial dysplasia in the vertical plane[20].

Downs, using a sample of young adults having excellent occlusion, studied the variations in skeletal and denture relationships inherent in these facial patterns and pointed out their importance in prognosis and in treatment[21]. Riedel studied, on a somewhat similar sample, the anatomical relationships using the plane from nasion to sella turcica as the principal plane of reference,[22] instead of Frankfort horizontal (as in Downs' method). Riedel, in a later study, applied the analysis of Downs to a sample of better-than-average faces.[23]

Jensen and Palling, in a recent survey of the gonial angle, showed that, while this angle cannot by itself be responsible for marked facial disharmony, it may well reflect the coordination and proportion between the various parts that constitute the unity of the face.[24]

The outstanding advantage of applying cephalometric roentgenographic procedures to craniofacial measurements is that they facilitate measurements on living subjects which would otherwise be impossible. Indeed, cephalometrics has progressed to the point where it is no longer the tool of the research worker, but is a necessary adjunct to a complete and well planned case analysis from which a diagnosis may be derived. It is not a panacea that will supplant all other methods of analysis and answer all of the orthodontist's diagnostic problems and can never take the place of conscientious clinical observation. But so long as the science of orthodontics remains a problem of relations within the dentofacial complex in which, "all we ever find are variations, endless variations . . . ."[25] then cephalometrics will be an invaluable tool supplementing all other procedures of analysis.

Method and Materials

A total of one hundred and sixty cases, chosen by perspection as representing better-than-average Caucasian adult faces of no particular ethnic group, were photographed full view and profile view oriented with Frankfort plane, using the photographic and cephalometric facilities of the Indiana University School of Dentistry.

This rather arbitrary sample was then subjected to a critical evaluation by an impartial jury of artists from the Herron Art Institute of Indianapolis, Indiana and the Buffalo Art Institute, Buffalo, New York. The panel of artists selected those faces, fifty in number, which could be considered excellent.

The artists displayed a startling unanimity in their selection of the cases to be analyzed and, as might be expected, their conception of ideal facial harmony was rather more liberal than that of orthodontists. It was felt that a broader sampling would occur if people in the fine arts served as the jury rather than orthodontists, who might well have preconceived and somewhat prejudicial ideas of what constitutes ideal facial balance and esthetics.

When the fifty cases were submitted to the staff and graduate students of the Department of Orthodontia, Indiana University for their critical appraisal, there were some definite areas of disagreement: the artists' sample of excellent faces included some concave and some convex types — in other words, a representative sampling of diverse facial types. The orthodontists, on the other hand, tended to prefer those faces which fell within the definition of "flat" or vertical or concave profiles. The panel of artists, in their critical appraisal of the photographs, studied the face as a whole, but placed some emphasis on the profile and, in rather the same manner as the orthodontists, stressed that their attention was particularly attracted to the lower face — the area from mouth to chin — as it fitted into the entire face.

The fifty cases selected were procured from the files of current patients of the Indiana University School of Dentistry, from the ranks of students, and other personnel of the Indiana University Medical Center. The cases were, on the whole, representative of various economic and social levels. There were nineteen males and thirty-one females of ages ranging from fifteen to thirty-six and averaging twenty-three and one half years.

Every one of the fifty cases displayed Class I molar relationships. Except for Case No. 46, the sample consists of untreated cases. The photographs, orientated with the Frankfort plane, of some of the cases used in this investigation are shown in Figures 1, 2 and 3.

Method

Accurate cephalometric roentgenograms, anteropostero and lateral headplates, were taken in occlusion with the cephalometer of the Department of Orthodontia. These records were made according to the Broadbent-Bolton technique for the standardization of profile x-rays, using a fixed position of the x-ray tube and a cephalostat for positioning of the head with a sixty inch target distance.

Since all roentgenograms are enlargements and are subject to x-ray distortion, the question of error in cephalometric registrations and their consequent effect on measurements made therefrom had to be considered.

Fig. 1

Fig. 2

Fig. 3

This problem was the subject of a comprehensive investigation by Adams[26]. Adams reported that this error is within acceptable limits of experimental accuracy, even though the subjects differ in absolute size.

Tracings were constructed from the profile roentgenograms and the material analyzed according to methods suggested by Downs, Tweed, Wylie, E. L. Johnson and Riedel, as well as some modifications of their techniques which will be described as each analytical method is considered. When the means and acceptable ranges of variations therefrom were established by determining the standard deviations, polygons (after Adams and Vorhies[27])

TABLE I

The Indiana Sample: Summary of Readings according to Downs' Method.

		Combined Sample	*Males*	*Females*
FACIAL ANGLE	M	86.0	85.8	86.2
	SD.	±2.80	±1.94	±3.09
	R	80.0 to 92.0	80.0 to 89.2	80.0 to 92.0
ANGLE OF CONVEXITY	M	—1.0	—2.2	—0.3
	SD.	±5.50	±4.47	±5.88
	R	—11.6 to +14.0	—11.6 to +5.0	—10.0 to +14.0
A-B PLANE ANGLE	M	—4.1	—3.2	—4.7
	SD.	±3.10	±2.99	±3.12
	R	—10.5 to +4.5	—8.3 to +4.5	—10.5 to +0.5
MANDIBULAR PLANE ANGLE	M	25.4	24.9	25.7
	SD	±3.83	±3.62	±3.90
	R	16.5 to 36.0	16.5 to 32.8	17.0 to 36.0
Y-AXIS ANGLE	M	61.8	62.54	61.38
	SD.	±3.74	±2.94	±3.34
	R	56.5 to 70.0	57.5 to 68.0	56.5 to 70.0
CANT OF OCCLUSAL PLANE	M	8.6	7.6	9.2
	SD	±4.30	±4.55	±4.09
	R	2.4 to 19.5	2.4 to 17.0	3.2 to 19.5
$\overline{1\|}$ TO OCCLUSAL PLANE	M	15.6	14.92	16.04
	SD.	±5.69	±5.39	±5.78
	R	5.0 to 30.0	5.0 to 27.0	6.0 to 30.0
$\overline{1\|}$ TO MANDIBULAR PLANE	M	—0.4	+0.14	—0.65
	SD.	±5.83	±6.09	±5.61
	R	—15.0 to +12.4	—11.0 to +11.0	—15.0 to +12.4
$\underline{1\|}$ TO $\overline{1\|}$	M	136.1	137.3	135.3
	SD.	±8.34	±7.91	±8.79
	R	110.5 to 151.0	120.5 to 151.0	110.5 to 148.0
$\underline{1\|}$ TO A - P PLANE (in mm.)	M	3.6	3.7	3.6
	SD.	±1.95	±1.98	±1.91
	R	—0.8 to +8.6	0.0 to +8.0	—0.8 to +8.6

M = Mean
SD = Standard Deviation
R = Range

were constructed summarizing some of the measurements. Correlations were established and tests for reliability and significance were also conducted.

Observations and Findings

1. The measurements made according to Downs' technique of analysis are summarized in Table I.

2. The measurements observed according to the analytical method of Riedel, using S-N (Sella-Nasion) as plane of reference, are summarized in Table II.

3. The measurements derived from the evaluation of vertical dysplasia, according to a technique suggested by Wylie, are found in Table III.

TABLE II

The Indiana Sample: Summary of measurements related to S-N plane, according to the analytical method of Riedel.

	Combined Sample
SN - Point A	
M	81.22°
SD	±3.11
R	74.6 to 87.0
SN - Point B	
M	79.79°
SD	±3.21
R	73.0 to 86.0
Difference	
M	1.42°
SD	±2.17
R	—4.0 to +7.1
SN - Gnathion	
M	80.5°
SD	±3.79
R	71.1 to 87.0
SN - Mandibular Plane	
M	29.3°
SD	±5.50
R	15.5° to 44.0°
SN - ⌊1	
M	105.0°
SD	±6.98
R	91.2° to 122.5°

4. Data derived from an assessment of anteropostero dysplasia, according to a method suggested by Wylie, are summarized in Table IV.

TABLE III

The Indiana Sample: Summary of measurements derived from the evaluation of vertical dysplasia.

	Combined Sample
Ramus Height (mm.)	
M	59.6
SD	±5.88
R	48.2 to 73.1
Gonial Angle	
M	123.8°
SD	±6.25
R	110.5° to 138.6°
Lower Border of Mandible (mm.)	
M	79.8
SD	±4.76
R	70.0 to 90.9
Total Face Height (N-Gn)	
M	121.63
SD	±7.41
R	106.6 to 137.1
Upper Face Height (N-ANS)	
M	55.1
SD	±3.32
R	49.3 to 63.5
Lower Face Height (ANS-Gn)	
M	66.6
SD	±5.88
R	54.5 to 78.5
$\frac{UFH}{TFH} \times 100$	
M	45.5
SD	±2.34
R	40.0 to 50.8
$\frac{LFH}{TFH} \times 100$	
M	54.5
SD	±2.26
R	49.2 to 60.0

UFH = Upper Face Height
LFH = Lower Face Height
TFH = Total Face Height

TABLE IV

The Indiana Sample: Summary of measurements derived from an assessment of anteropostero dysplasia, according to Wylie's method.

	Combined Sample
Length Mandible	
M	116.5
SD	±5.93
R	102.0 to 134.1
Porion-Sella	
M	22.8
SD	±4.10
R	12.0 to 29.5
Sella-Ptm	
M	16.8
SD	±2.21
R	12.0 to 21.5
Ptm - ⌊6	
M	20.3
SD	±4.40
R	11.0 to 30.0
ANS-Ptm	
M	57.4
SD	±3.69
R	51.0 to 66.0
Unit Dysplasia Score	
M	—0.85
SD	±5.20
R	—12.0 to +13.0

Ptm = Pterygomaxillary Fissure
ANS = Anterior Nasal Spine
⌊6 = Maxillary 1st Permanent Molar Tooth

TABLE V

The Indiana Sample: Summary of readings showing the axial inclinations of maxillary and mandibular central incisor teeth related to the Frankfort horizontal.

	Combined Sample
Maxillary Central Incisor Tooth Related to the Frankfort Plane	
M	109.2°
SD	±6.01
R	96.0° to 122.0°
Mandibular Central Incisor Tooth Related to the Frankfort Plane	
M	65.4°
SD	±5.79
R	52.4° to 75.0°

M = Mean
SD = Standard Deviation
R = Range

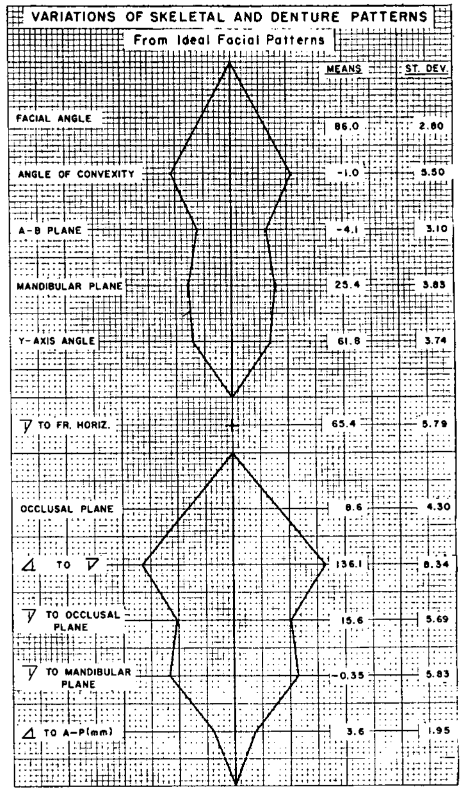

Fig. 4 The Facial Skeleton Polygon for the combined sample of 50 cases. The polygon is constructed to demonstrate two standard deviations plus and minus from the means, which are arrayed along the center line. Each scale division represents one angular degree or one millimeter as the case may be.

5. Axial inclinations of the incisor teeth related to the Frankfort horizontal are noted in Table V.

Fig. 4 shows a polygon for the combined sample of fifty cases, constructed from the ten measurements used in the original Downs' analysis and also in this report. In addition, the measurement relating the mandibular central incisor teeth to Frankfort horizontal has been included because of the interest stimulated by the work of Tweed.

A range of two standard deviations on either side of the mean is used here in lieu of the range of extremes plotted in the Indiana Polygon by Adams and Vorhies[27].

The polygon derived from the measurements observed in this study will be referred to, from now on, as the "Facial Skeleton Polygon". Generally speaking, in the polygonic method of illustrating qualitative and quantitative mathematical observations for a static cephalometric analysis, the readings falling to the left of the center line, or mean, indicate a Class II tendency; those falling to the right a Class III trend.

Comparisons of the Indiana Sample with the Analyses of Downs and Riedel

The Facial Angle The mean of the Indiana sample for this angulation is 86.0°, which is smaller than either Downs' reading (87.8°) or that of Riedel (88.6°). The differences of 1.8° between the readings for the Indiana sample and the Downs sample has a t value of 2.239. A t value of this magnitude could not occur more than five times in a hundred on the basis of chance alone. Since the .05 level of confidence is the criterion for significance used in this report, the difference for facial angle readings between the Indiana sample and Downs' findings is significant at the .05 level and the null hypothesis rejected. The difference of 2.6° between facial angle readings for the Indiana sample and Riedel's report has a t value of 4.341. A t value of this magnitude would not occur more than one time in a thousand on the basis of chance alone. The null hypothesis is therefore rejected at the .001 level, and the difference is significant. On the Facial Skeleton Polygon, on which means and variations to two standard deviations on either side of the mean of both the Downs and Riedel readings are superimposed (Fig. 5), the mean of the Indiana sample will be seen to be on the

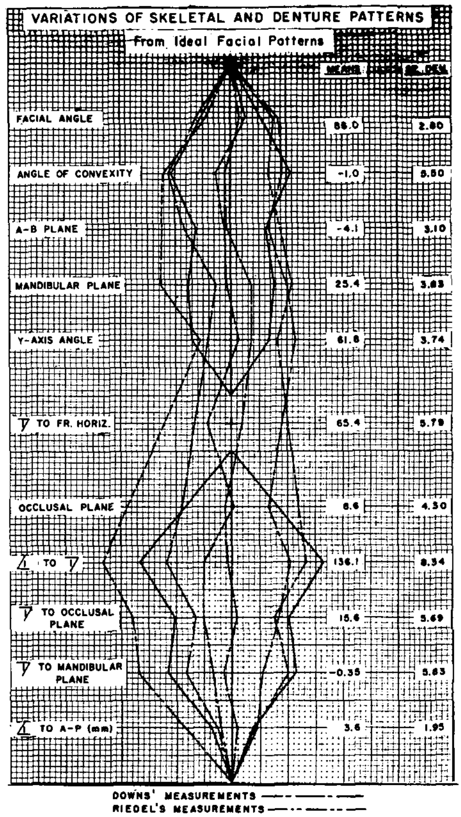

Fig. 5 Means and dispersions (two standard deviations on both sides of the mean) of the findings of the analyses of Downs and Riedel plotted on the facial polygon for the combined Indiana sample.

retrognathic side as compared with the means of Downs and Riedel.

Angle of Convexity This group shows the greatest variability of any of the measurements of the skeletal pattern within the Indiana sample. The mean is -1.0°, which is smaller than the readings of either Downs (0.0°) or Riedel (+1.6°), but neither of the differences are significant. The difference between the Indiana sample and that of Downs (1.0°) has a t value of 1.164, which does not reject the null hypothesis at the .05 level. The difference of 2.6° between the Indiana group and that of Riedel has a t value of 0.716, which also does not reject the null hypothesis at the .05 level.

The A-B Plane Angle The mean of the Indiana sample for this angulation is —4.3°. The difference of 0.5° between the readings for the Indiana sample and the Downs sample has a *t* value of 1.164. A *t* value of this magnitude does not reject the null hypothesis at the .05 level, therefore the difference is not considered significant. Riedel did not report the necessary data for this measurement to perform a test of significance. The standard deviation for the Indiana sample is ±3.10, compared with ±3.67 for Downs. The readings for the Indiana sample range from —10.5° to +4.5°, compared with Downs' ranges: —9.0° to 0.0°.

Frankfort Mandibular Plane Angle The mean of the Indiana sample for this angulation is 25.4°, compared with Downs' reading of 21.9° and Riedel's 26.2°. The difference of 3.5° between the readings for the Indiana group and Downs' reading has a *t* value of 0.967; the difference of 0.8° between the Indiana sample and that of Riedel has a *t* value of 0.598. In neither instance is the null hypothesis rejected at the .05 level of confidence, and the differences are therefore not considered significant. The standard deviation for the Indiana sample is ±3.83, for the Downs' sample ±3.24, and for Riedel's ±5.95

Y-Axis Angle The mean of the Indiana sample for this measurement is 61.8°, compared with readings for Downs of 59.4° and for Riedel 60.7°. The difference of 2.4° between the Indiana sample and that of Downs has a *t* value of 2.408. A *t* value of this magnitude could not occur more than two times in a hundred on the basis of chance alone. The null hypothesis is therefore rejected within the accepted criterion for significance, and the difference is significant at the .02 level. The difference between the Indiana sample and that of Riedel for this measurement, a difference of 1.1°, has a *t* value of 1.524. A *t* value of this magnitude does not reject the null hypothesis at the accepted level of confidence (.05) and the difference is therefore not significant. On the Facial Skeleton Polygon (Fig. 5), on which means and ranges of measurements from the Indiana sample are plotted, it will be seen that the mean of the Indiana sample for the Y-axis angle is disposed somewhat retrognathically in comparison with Downs' reading.

The Cant of the Occlusal Plane The mean of the Indiana sample for the occlusal plane angle is 8.6°, compared to readings of 9.3° for Downs' sample and 8.5° for Riedel's. The difference of 0.7° between the readings for the Indiana group and Downs' has a *t* value of 0.637. The null hypothesis is not rejected at the .05 level. The mean difference is not significant. Riedel did not report the necessary data to perform a significance test for this measurement. The standard deviation for the Indiana sample is ±4.30, compared with Downs' ±3.83. Within the Indiana sample, the mean difference between male and female readings is 1.6°. The *t* value is 0.261. The null hypothesis is not rejected at the accepted level of confidence, and the difference is not significant.

The cant of the occlusal plane, relating the slope of the occlusion to Frankfort horizontal, is conventionally placed in the list of dental measurements of the Downs' analysis. A careful examination of the measurements of this analysis for the fifty cases of the Indiana sample indicated that actually the occlusal plane angle tended to behave more in accordance with the activity of the skeletal structures than with the dental. To prove or disprove this impression, accordingly, a study of the correlations of the occlusal plane angle was undertaken, in which this angle was correlated with every other dimension of the Indiana sample analysis according to the method of Downs. This study showed that the cant of the occlusal plane was more closely correlated with the skeletal measurements than with the dental reading. A significant correlation at the .001 level was obtained between the occlusal plane angle and the facial angle, mandibular plane angle, and the Y axis. Between this angle and the axial inclination of the lower incisor with the Frankfort plane a significant correlation at the .01 level was found and one at the .05 level with the inclination of the mandibular incisor to the occlusal plane.

Angulation of the Long Axes of Maxillary and Mandibular Central Incisors The mean for the Indiana sample is 136.1° Downs' reading is 135.4°. Riedel's is 131.0°. The difference of 0.7 between the readings of the Indiana sample and that of Downs has a *t* value of 0.349. The null hypothesis is not rejected at the accepted level of confidence, and the difference is not significant. The difference of 5.1° between the readings of the Indiana sample and that of Riedel has a *t* value of 2.889. A *t* value of this magnitude could not occur more than one time in a hundred on a basis of chance alone. Accordingly, the null hypothesis is rejected and the difference is significant at the .01 level of confidence. The Facial Skeleton Polygon (Fig. 5) illustrates how the Riedel mean is disposed retrognathically as compared with the mean of the Indiana group. The standard deviation of the Indiana sample is ±8.34, compared with Downs' ±5.76 and Riedel's ±9.24.

Maxillary and Mandibular Central Incisor Teeth Axial Inclinations Related to the Frankfort Horizontal The measurements of central incisor teeth axial inclinations to Frankfort plane are not strictly within the realm of the analysis according to Downs' method. Since the landmarks of Downs are used, and also because of the interest stimulated by Tweed regarding the positioning of the mandibular incisor tooth in relation to Frankfort plane, it was deemed reasonable to include these measurements. The necessary data to perform significance tests was reported neither by Downs nor by Riedel for the positioning of the mandibular central incisor tooth.

For the angulation of the long axis of mandibular central incisor tooth to the Frankfort plane, the mean of the Indiana sample is 65.4°, with a standard deviation of ±5.79. Downs reported a mean of 66.7°. Riedel's reading is 61.0°. Within the Indiana sample, the mean difference between male and females is 1.2°. The *t* value is 0.169. The null hypothesis is not rejected at the .05 level, and the difference is not significant.

For the angulation of the long axis of the maxillary central incisor tooth with the Frankfort plane, the mean of the Indiana sample is 109.2°, with a standard deviation of ±6.01. Riedel reports a mean of 111.0°, with a standard deviation of ±5.70. Downs' reading is 111.3°; he did not report the data necessary to perform a significance test. The difference of 1.8° between the means of the Indiana sample and Riedel's study has a *t* value of 1.544. The null hypothesis is not rejected at the .05 level, and the difference is not significant.

The Angulation of the Long Axis of the Mandibular Central Incisor Related to the Occlusal Plane. For this measurement the reading of the Indiana sample is 15.6°, compared with Downs' reading of 14.5° and Riedel's 20.6°. The difference of 1.1° between the Indiana group and Downs' has a

t value of 0.802. The null hypothesis is not rejected at the .05 level, and the difference is not significant. The difference of 5.0° between the Indiana sample and Riedel's has a t value of 4.108. A t value of this magnitude could not occur more than one time in a thousand on the basis of chance alone. The null hypothesis is rejected and the difference is significant at the .001 level.

The Angulation of the Mandibular Central Incisor to the Frankfort Mandibular Plane The mean of the Indiana sample for this measurement is —0.4°. Downs' reading is +1.4°; Riedel's is +3.1°. The difference of 1.8° between the means of the Indiana sample and Downs' has a t value of 1.308. The null hypothesis is not rejected at the .05 level and the difference is not significant. The difference of 3.5° between the readings of the Indiana sample and Riedel has a t value of 2.762. A t value of this magnitude could not occur more than one time in a hundred on the basis of chance alone. The null hypothesis is rejected and the difference is significant at the .01 level. The Facial Skeleton Polygon (Fig. 5) shows the retrognathic disposition of Riedel's mean in relation to that of the Indiana sample. The standard deviation for the Indiana group is ±5.83, for Downs' study ±3.48, and for Riedel's ±6.78.

The impression is that, in those cases exhibiting excellent occlusion and/or good facial patterns, the mandibular central incisor teeth will tend to be more or less upright with respect to the Frankfort mandibular plane. The findings of the Indiana sample confirm this general impression, but further suggest that there is a wide range of variability to be found, as indicated by the standard deviation of ±5.83° and the readings which range from —15.0° to +12.4°.

The Distance from the Incisal Edge of the Maxillary Central Incisor to the AP Plane The reading for the Indiana sample is 3.6 mm., compared with Downs' reading of 2.7 mm., and Riedel's 5.5 mm. The difference of 0.9 mm. between the means of the Indiana sample and Downs' study has a t value of 1.789. Since this could occur more than five times in one hundred on the basis of chance alone, the null hypothesis is not rejected and the difference is not significant at the level of confidence used as the accepted criterion of significance (.05). The difference of 1.9 mm. between the means of the Indiana sample and Riedel's has a t value of 3.654. A t value of this magnitude could not occur more than one time in a thousand on the basis of chance alone. Accordingly, the null hypothesis is rejected and the difference is significant at the .001 level of confidence. Fig. 5 shows the retrognathic disposition of Riedel's reading in comparison with that of the Indiana sample. This particular dimension has the smallest standard deviation, the smallest range of variation of any measurement considered in this report. The standard deviation of the Indiana sample is ±1.95; that of Downs' study is ±1.80, and Riedel's ±3.15.

Correlations Within the Indiana Sample Between Various Skeletal and Denture Measurements Used in Downs Analytical Method

An examination of polygons for the cases of the Indiana sample shows a tendency for certain of the dimensions to function in a compensatory or balancing manner in opposition to the movements of other dimensions. That is to say, where one measurement was, for example, to the right or prognathic side of the mean as seen on the polygon — especially if the divergence were relatively great — it would be balanced by an equivalent discrepancy perhaps in the opposite direction of at least one other dimension.

To evaluate this tendency which had been observed by general perspection, it was deemed advisable to correlate those dimensions which most frequently seemed to function in the compensatory manner suggested.

(1) Between the facial angle and the Y-axis angle, there exists an inverse correlation of —0.500. The t value is 3.50. The null hypothesis is rejected and the correlation is significant at .01 level. The polygon is so constructed that the facial angle increases to the right or prognathic side of the mean line; the Y-axis angle decreases in that direction. This negative correlation suggests, therefore, that so far as the polygon-picture is concerned, the two angles will very often move in the same direction, although not necessarily the same degree.

(2) A coefficient of correlation of —0.909 exists between the facial angle and the Frankfort mandibular plane angle. The t value is 6.36. The null hypothesis is rejected and the correlation is significant at the .001 level of confidence. On the polygon, the Frankfort mandibular plane angle decreases to the right of the mean. The inverse correlation suggests that, as seen on the polygon, the two dimensions will very often move in the same direction with respect to the mean, again not necessarily the same degree.

(3) Between the Frankfort mandibular plane angle and the Y-axis, the coefficient of correlation is positive: +0.619. The t value is 4.33. The null hypothesis is rejected and the correlation is significant at the .001 level. On the polygon, both dimensions will be seen to increase in the same direction with respect to the mean. Since a significant positive correlation is present between these two measurements, it is suggested that they will often vary in the same direction.

(4) Between the angle of convexity and the A-B plane angle, a negative coefficient of correlation exists: —0.330. The t value is 2.30. The null hypothesis is rejected and the correlation is significant at the .05 level. Since the two measurements, as constructed on the polygon, increase in opposite directions from the mean, the significant inverse correlation indicates that the two dimensions will often vary in the same direction.

(5) The coefficient of correlation between the angle of convexity and the linear measurement of the maxillary central incisor tooth to the plane from Point A to pogonion is +0.279. The t value is 1.953. The null hypothesis is not rejected.

(6) Between the facial angle and the linear measurement of the lower border of the mandible (gonion to pogonion, which is not a landmark used in Downs' analysis), the coefficient of correlation is +0.344. The t value is 2.41. The null hypothesis is rejected and the correlation is significant at the .05 level of confidence. This significant positive correlation suggest that often, as the facial angle increases — as the profile tends to become flatter or more concave, the lower border of the mandible will increase in absolute size.

Comparison with Riedel's Analysis of Landmarks Related to the Sella-Nasion Plane

Sella-Nasion Plane to Point A The Indiana sample mean is 81.22°. The mean reported by Riedel is 82.01°. The difference between the means of 0.79° has a t value of 1.12. The null hypothesis is not rejected at the .05 level and the difference is not significant. Riedel's findings show a greater dispersion. The standard deviation reported by Riedel is ±3.89, compared with the

Indiana sample's ±3.11.

Sella-Nasion Plane to Point B. The Indiana sample mean is 79.79°. The mean reported by Riedel is 79.97°. The mean difference of 0.18° has a t value of 0.26. For this value of t, the null hypothesis is not rejected and the difference is not significant at the .05 level of confidence.

Difference Tests of significance, comparing the Indiana sample with Riedel's, can not be performed since Riedel did not report the necessary data. For the Indiana sample, the discrepancy or difference between the measurements of the sella-nasion plane with Point A and Point B is 1.42°. Riedel reports a reading of 2.04°. For the Indiana group, the standard deviation is ±2.17. The readings range from —4.0° to +7.1°.

Sella-Nasion Plane Related to the Maxillary Central Incisor For this measurement the mean for the Indiana sample is 105.0°. Riedel reports a reading of 104.0°. The value of t for the mean difference of 1.0° is 0.78. This value of t does not reject the null hypothesis and the difference is not significant at the .05 level. The standard deviation for the Indiana sample is ±6.98; for Riedel's sample, ±5.75.

Sella-Nasion Plane Related to Gnathion The mean for the Indiana sample is 80.5°; for Riedel's sample, the mean is 79.3°. The difference between the means of 1.2° has a t value of 5.284. The null hypothesis is rejected and the difference is significant at the .001 level of confidence. The Riedel reading is disposed retrognathically with relation to that of the Indiana sample. The Indiana sample shows greater dispersion: the standard deviation for the Indiana sample is ±3.79, compared with Riedel's reading of ±3.39.

Sella-Nasion Plane Related to Frankfort Mandibular Plane For the Indiana sample, the reading is 29.3°; for Riedel's sample, the reading is 31.7°. The mean difference of 2.4° has a t value of 2.27. The null hypothesis is rejected and the difference is significant at the .05 level of confidence. The dispersion is greater for the Indiana sample. The Indiana sample has a standard deviation of ±5.50 compared with ±5.19 for Riedel's sample.

Evaluation of Vertical Dysplasia

Linear Measurements. Table VI, a summary of the findings of the Indiana sample and those of Wylie and Johnson, shows that all readings of the Indiana sample, both linear and angular, are more widely dispersed than those of Wylie and Johnson.

Proportion of Total Face Height which is Upper Face Height. The mean difference of 1.7% has a t value of 3.66. The null hypothesis is rejected, and the difference is significant at the .001 level. The Indiana sample shows wider dispersion.

Gonial Angle. This angle is an anatomical entity whose dimension is defined relatively early in life and need not be expected to change appreciably with increase of age. The mean difference is not significant at the accepted level.

The Frankfort mandibular plane angle was correlated with certain denture and skeletal dimensions used in the vertical displacement study of Wylie and Johnson and in the Downs' analysis. The results of this study confirm the previous findings of Wylie and Johnson, with one exception which will be noted.

(a) As the Frankfort mandibular plane angle becomes steeper (increases in angulation), the total face height increases. The correlation is significant at the .02 level of confidence.

(b) As the mandibular plane angle becomes steeper, the percentage of lower face height to the total face height

TABLE VI

Mandibular and vertical height measurements used in the evaluation of vertical dysplasia: The findings of the Indiana sample and the study of Wylie and Johnson. With the exception of the gonial angle and the facial height proportions, all measurements are linear and reported in millimeters. Wylie and Johnson did not report ranges. Their study was undertaken on 47 children between the ages of 11 - 13 years, who were by subjective observation regarded as having good looking faces.

Measurement		*Mean*	*S.D.*	*Range*
RAMUS HEIGHT	I	59.6	±5.88	48.2 to 73.1
	WJ	54.8	±3.80	
GONIAL ANGLE	I	123.8	±6.25	110.5 to 138.6
	WJ	122.5	±4.80	
LOWER BORDER MANDIBLE	I	79.8	±4.76	70.0 to 90.9
	WJ	67.3	±3.09	
TOTAL FACE HT.	I	121.63	±7.41	106.6 to 137.1
	WJ	113.00	±4.55	
UPPER FACE HT.	I	55.1	±3.32	49.3 to 63.5
	WJ	50.7	±2.58	
LOWER FACE HT.	I	66.6	±5.88	54.5 to 78.5
	WJ	62.4		
$\frac{UFH}{TFH} \times 100$	I	45.5	±2.34	40.0 to 50.8
	WJ	43.8	±2.18	
$\frac{LFH}{TFH} \times 100$	I	54.5	±2.26	49.2 to 60.0
	WJ	56.2		

increases. The correlation is significant at the .01 level.

(c) Mandibular plane angle varies inversely with the ramus height. The negative correlation is significant at the .001 level of confidence.

(d) The mandibular plane angle varies inversely with the angulation of the mandibular central incisor tooth to the mandibular plane. The negative correlation is significant at the .02 level. This shows, in other words, the tendency of the lower central incisor tooth to become more "upright" with an increase in Frankfort mandibular plane angulation.

(e) The Frankfort mandibular plane angle varies inversely with the facial angle. The negative correlation is significant at the .001 level.

(f) The mandibular plane angle varies directly with the Y-axis angle. The correlation is significant at the .001 level of confidence.

(g) The mandibular plane angle varies directly with the cant of the occlusal plane. The correlation is significant at the .001 level.

(h) The coefficient of correlation between the mandibular plane angle and the linear measurement of the lower border of the mandible (gonion to pogonion) is +0.021. The value of t is 0.15. The null hypothesis is not rejected at the .05 level of confidence, and the correlation is not considered significant. This does *not* confirm the observation of Wylie and Johnson who reported an inverse relationship.

THE ASSESSMENT OF ANTEROPOSTERO DYSPLASIA

Tests of significance comparing the findings of the Indiana sample with those of Wylie's study can not be performed since Wylie reported no data

TABLE VII

A summary of measurements listing the means observed in the assessment of anteropostero dysplasia, and compared with the standards of Wylie.

Wylie's original analysis was reported from a sample consisting of 45 boys, 11.5 years of age, and 48 girls, averaging 11.3 years of age. These were Class I malocclusions in the late mixed dentition stages.

	Length Mandible	Porion-Sella	Sella-Ptm	Ptm-|6	Ptm-ANS	Unit Score	St. Dev.	Range
INDIANA SAMPLE:								
Male	117.0	24.7	16.4	21.3	60.0	—2.5	±4.95	—12.0 to +13.0
Female	114.6	21.7	17.1	18.7	57.0	+1.2	±4.18	—6.5 to +9.5
Combined	116.5	22.8	16.8	20.3	57.4	—0.85	±5.20	—12.0 to +13.0
WYLIE SAMPLE:								
Male	103.0	18.0	18.0	15.0	52.0	0.0		
Female	101.0	17.0	17.0	16.0	52.0	—1.0		

except the means. Wylie stressed, as a matter of clinical experience, that only a clear-cut, obvious discrepancy from his standards had clinical importance. From this point of view, the findings of the Indiana sample may be regarded as acceptable deviations from the Wylie male standard of 0.0 and the female standard of —1.0, as far as the means are concerned; but all readings have wide ranges of dispersion.

Table VII compares the findings observed in the Indiana sample with the standards established by Wylie. The unit score readings for the males is orthognathic: —2.5. The standard deviation is ±4.95. The standard error of the mean is 1.16. The range is from —12.0 to +13.0.

The unit score reading for the females is prognathic: +1.2. The standard deviation is ±4.18. The standard error of the mean is 0.77. The range is from —6.5 to +9.5.

The unit score reading for the combined sample is —0.85, which is orthognathic. The standard deviation is ±5.20. The standard error of the mean is 0.74. The range is from —12.0 to +13.0.

The Indiana Sample: Discussion of Some Specific Cases

An opportunity is afforded for comparing a set of monozygotic female twins, seventeen years, nine months old, cases 2 and 3 (Fig. 6). None of the dimensions differ appreciably between these two cases, neither in the eleven measurements plotted on the polygons, the assessment of anteropostero dysplasia, the analysis against the sella-nasion plane, nor the vertical height studies.

The greatest differentiation occurs in the absolute linear measurements for certain dimensions of the mandible — the gonial angle, the lower border of the mandible (gonion to pogonion, and the absolute mandibular length) as measured for the anteropostero displacement analysis — and the total face height. But none of these differences can be considered conspicuous.

The mandibular length for Case 2 is 114.0 mm.; the lower border of the

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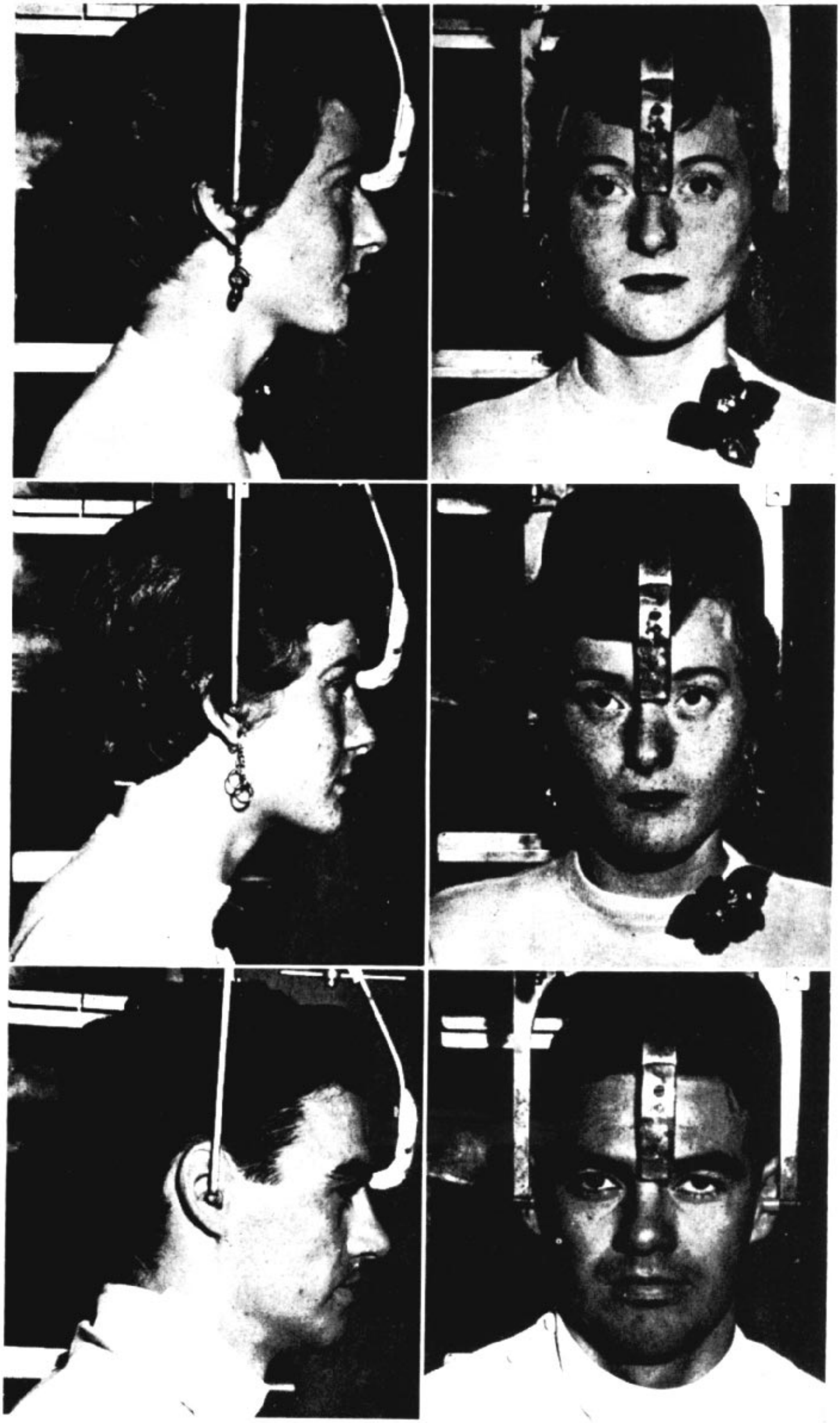
Fig. 6 Above and center, photographs of monozygotic twins, cases 2 and 3. Below, case 22. This is an example of similar skeletal and denture readings with other cases in an altogether different type of face. The twins' faces are mesognathic while case 22 is more convex.



mandible measures 75.0 mm. For Case 3 these values are 109.5 mm. and 70.4 mm., well within the wide range of expected variability. At the same time, the Frankfort mandibular plane angle and the facial angle remain substantially the same. The gonial angle of Case 2 is greater than that of Case 3: 116.2° to 113.6°, but the standard deviation is ±6.25 for the entire sample and ±6.03 for the females. The total facial height for Case 2 is 109.8 mm., compared with 106.6 mm. for Case 3, a difference principally due to a slightly greater proportion of upper face height. But the small increase in absolute size of Case 2's dimensions is not conspicuous.

Case 22 is a male, twenty-four years, two months of age (Fig. 6). This individual, whose facial contours seem, on subjective appraisal, to be slightly on the convex or retrognathic side as compared with the straight or mesognathic profiles of the twins, displays startlingly similar readings in comparison with the twins, of all of the measurements summarized by the polygons (Fig. 7).

The greatest discrepancy, which may have some bearing on the profile contour, is to be found in the dimension relating the maxillary central incisor tooth to the plane from point A to pogonion, which is 5.5 mm., compared with the twins' readings of 3 mm. and 2 mm. But even this difference is within two standard deviations. The standard deviation for this reading is ±1.95.

As might be expected, the absolute linear size of anatomical structures is greater in the male (Case 22) than for the twins. However, the facial height proportions are not greatly at variance. In case 22, the percentage of lower face height to total face height is 55.4 per cent, compared with the twins' readings: 50.8 per cent and 51.2 per cent. The mean for this reading is 54.5 per cent; standard deviation is ±2.26. Thus, the

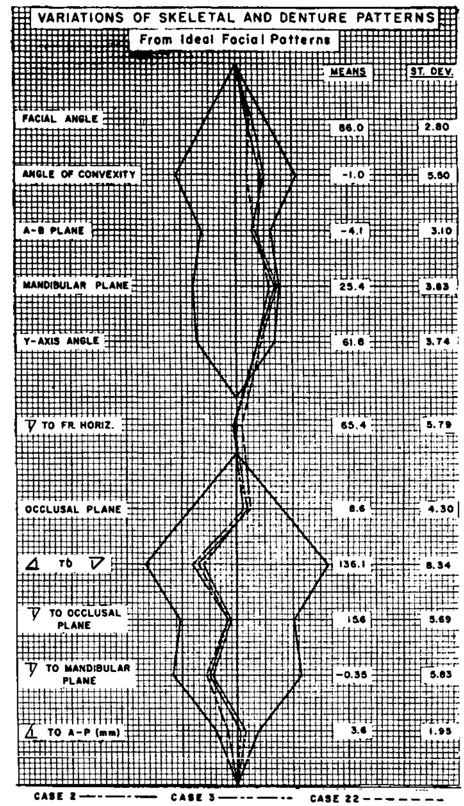


Fig. 7 Facial polygons of the twins in comparison with case 22.

face in Case 22 is disposed slightly more vertically, principally due to the greater lower face height, as compared with the twins.

Of all the measurements, the greatest discrepancy occurs in the assessment of anteropostero dysplasia. For the twins, the unit scores are +4.3 and +4.6; the score for Case 22 is —11.0.

This difference occurs because of the relative positioning of the head of the condyle and, more particularly, the maxillary first molar. The distance of these reference points from sella turcica and the pterygomaxillary fissure, respectively, is much greater in Case 22, where the high orthognathic unit score is but a reflection of the linear measurements.

The compensatory mechanism responsible for the overall excellence of the profile balance and proportion functions in two ways. The Y-axis angle and the facial angle are slightly prognathic (in relation to the mean values for these dimensions), thus placing pogonion in a relatively good relationship with respect to the facial plane. This, in conjunction with the prognathic (in relation to the mean) Frankfort mandibular plane angulation of 18° overcomes the orthognathic displacement in the anteropostero plane of space. At the same time, all polygon readings are well within the polygon limits (Fig. 7). The tendency of the skeletal measurements, including the occlusal plane angle, to be on the prognathic side of the mean is balanced by an equivalent tendency for the denture readings to be on the retrognathic side. The resulting facial patterns are in excellent overall balance.

Cases 9 and 43 illustrate an interest-

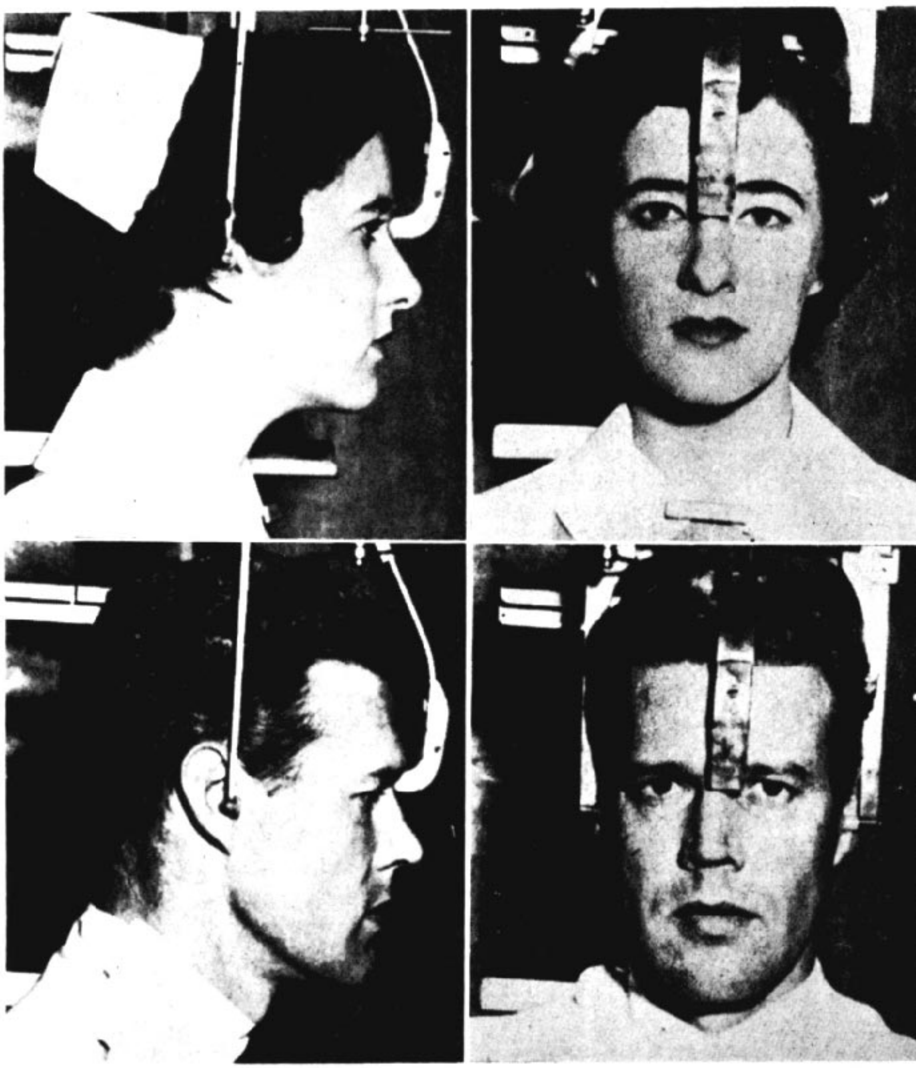


Fig. 8 Two examples of mesognathic faces.

ing contrast in dimensions within the straight or mesognathic facial type Fig. 8.

Case 9, a female nineteen years, eleven months of age is the person whose facial measurements most closely approximate the mean of every relationship investigated. This is true not only for the polygon measurements, but for all other dimensions considered (Fig. 9).

The mesognathic face of Case 43, a male thirty-six years, four months of age displays some interesting tendencies in comparison with Case 9. While the denture readings are well within the polygon limits, they are uniformly to the right (towards the Class III side)

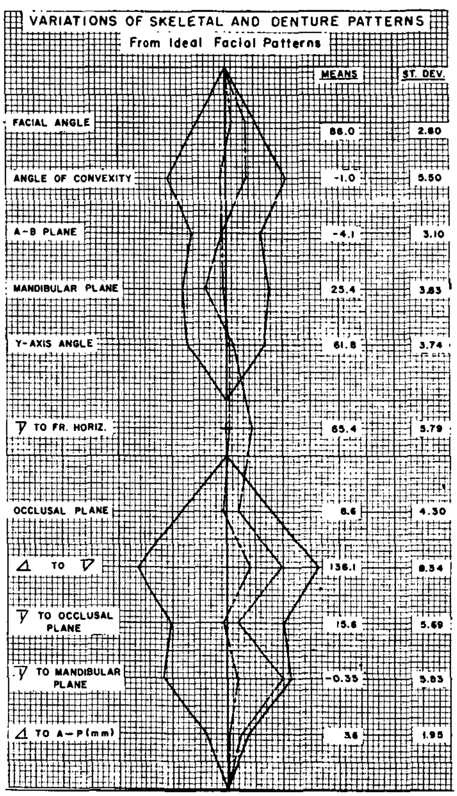


Fig. 9 Facial polygons for two cases having mesognathic faces compared with each other and with the means for the combined sample.

of the corresponding Case 9 readings. The denture measurements of Case 43 unmistakably imitate and parallel those of Case 9, but the contrasts between the dimensions are more marked, more exaggerated, as shown in Figure 9.

With regard to the skeletal readings, this imitative or parallel tendency is best illustrated on the polygon. The most conspicuous skeletal discrepancy is observed between the Frankfort mandibular plane readings: 29.2° for Case 43, and 26.0° for Case 9. The steeper Frankfort mandibular plane angle is accompanied by the corresponding increase in total facial height (which is not unexpected for the male), especially of the lower face. This is consistent with the previously noted positive and significant correlation between Frankfort mandibular plane angle and the percentage of lower to total facial height.

It would be expected that, in view of the negative correlation between the Frankfort mandibular plane angle and the facial angle, the steeper mandibular plane angle would be accompanied by a corresponding decrease in the facial angle. That this is usually true is attested by the coefficient of correlation of —0.909. In Case 43, however, the facial angle is 89.5°, as compared with the mean of the combined sample of 86.0° and the Case 9 reading of 87.0°. Since the standard deviation for this dimension is ±2.80, this difference takes on special importance. It would seem, therefore, that the facial angle in conjunction with the Y-axis angle and the readings for the angle of convexity and A-B plane, functions as a compensatory mechanism against the mandibular plane, so that, although the mesognathic face displays indices of profile contour to the right of the mean vertical line of the polygons, it remains in excellent general balance without showing tendencies toward concavity.

The unit score of anteropostero dis-

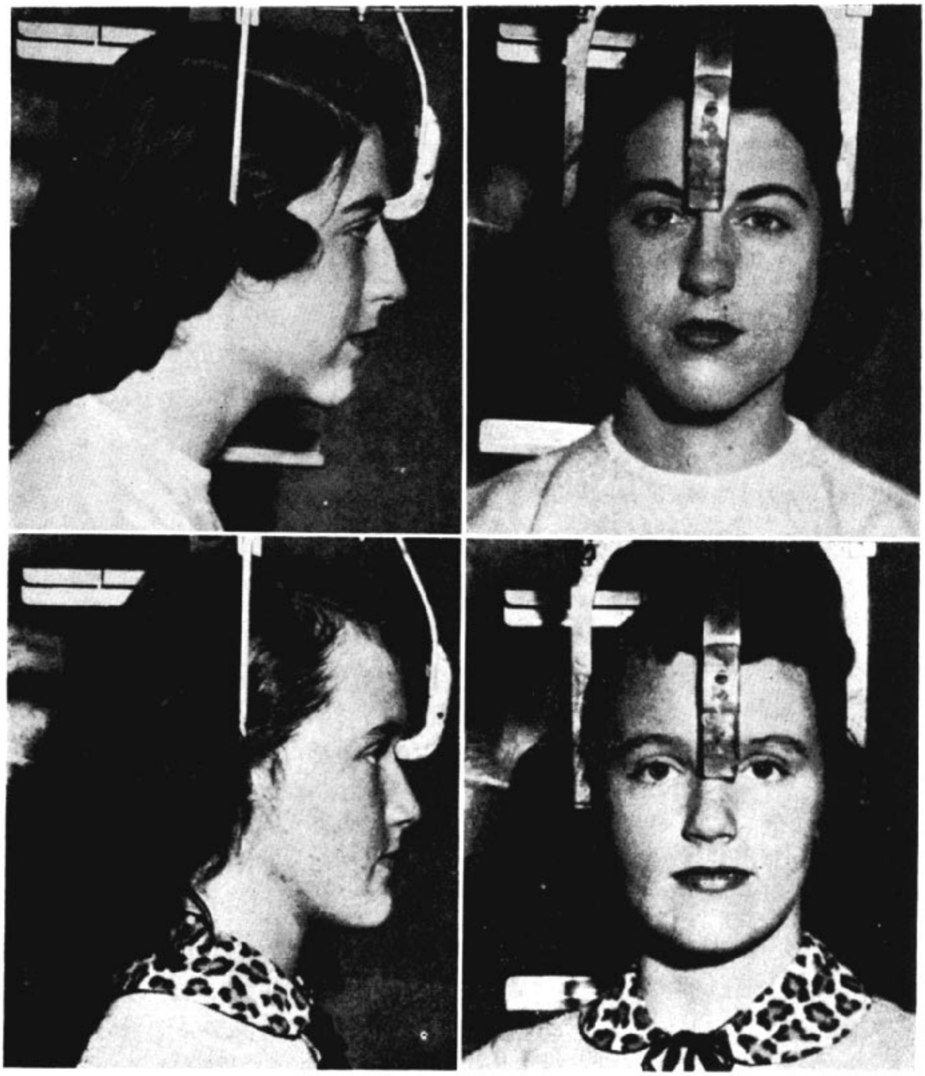


Fig. 10 Above, case 23, a convex face. Below, case 46, a concave face.

placement for Case 43 is +2.0 which from the point of view of clinical experience does not represent an important prognathic departure from the mean. This is another measurement, within the mesognathic facial type, with an ever-so-slight tendency toward the prognathic. The unit score for Case 9 is 0.0.

Cases 46 and 23, both females, afford an interesting contrast in two excellent faces subjectively rated as concave and convex, respectively, Fig. 10.

Case 23, the convex facial type, is twenty years, six months of age. Her skeletal and denture dimensions tend to fall to the left of the mean, as shown on the polygon (Fig. 11). But all readings are well within the polygonic limits. The score for anteropostero displacement is also well within the acceptable ranges, but shows a slight tendency towards the orthognathic. The reading is —2.5, which is not a significant variation from the mean.

Case 46, the concave facial type, is fifteen years of age. This is the only person of the sample who is undergoing current orthodontic treatment. The malocclusion was of the Class III type; the orthodontic problem was primarily confined to the maxillary arch due to a relative lack of growth in the anterior segment of the maxilla with a consequent displacement of anterior dental units, particularly the upper cuspids. Here, a steep Frankfort mandibular plane angle is compensated by relatively high readings of the angle of convexity and the A-B plane angle toward the Class III side of the polygon. At the same time, the facial angle also falls on the Class III side of the mean, as does the Y-axis angle (Fig. 11). The concave tendency of this facial pattern is undoubtedly a result of the lack of development of the anterior portion of the maxilla, since a facial angle of 88° is reasonably close to the mean. It would be expected that if the Frankfort mandibular plane angle were not so steep, but more in accordance with the general tendencies of the other dimensions — toward the Class III side of the polygon, the facial appearance would be markedly prognathic. This disposition of dimensions should be correlated with the unit score for anteropostero dysplasia, which is +1.5, a score which suggests again the importance of an overall comparison of the anatomical structures in order to understand the definition of the facial pattern. The displacement of parts in such a slightly prognathic relation — the mean for females is +1.2 — is another indication of the effect of the compensatory mechanism functioning between the various parts (especially in view of the Frankfort mandibular plane reading of 30°) which often results in

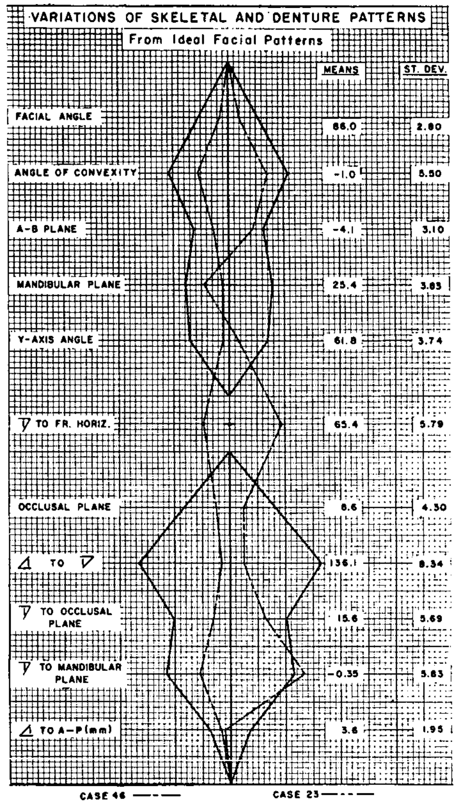


Fig. 11 Polygons of two cases showing contrast in readings between a concave (case 46) and a convex (case 23) type face.

an excellent facial pattern in spite of extreme discrepancies in individual dimensions.

The total facial heights of the two faces are similar: 120.0 mm. for Case 46 and 123.0 mm. for Case 23. The percentages of lower face height to total face height are also not at appreciable variance: 55.9 per cent for Case 46; 54.8 per cent for Case 23. This indicates how, in two different facial types exhibiting excellent overall balance and harmony, the profile proportions may be reasonably comparable even though considerable variation may be displayed with other dimensions.

With the exception of the measurement for maxillary central incisor tooth to the A.P. plane which varies only .3 mm. from the mean, all the denture dimensions of Case 46 vary directly and in opposite direction (towards the Class III side) from those of Case 23. Their support of the general concave pattern is to be expected, as is, by contrast, the larger angulation, the less "upright-ness", of the dentition of Case 23 in a convex face.

The obvious corollary to these observations is the general assumption that it is entirely conceivable and, indeed, logical that all three profile types — the concave, the convex, and the mesognathic or straight can and do occur in nature as ideal patterns with excellent balance and harmony.

Cases 31 and 38 (Fig. 12) have interesting and provocative characteristics in common for which a certain amount of speculation is justified.

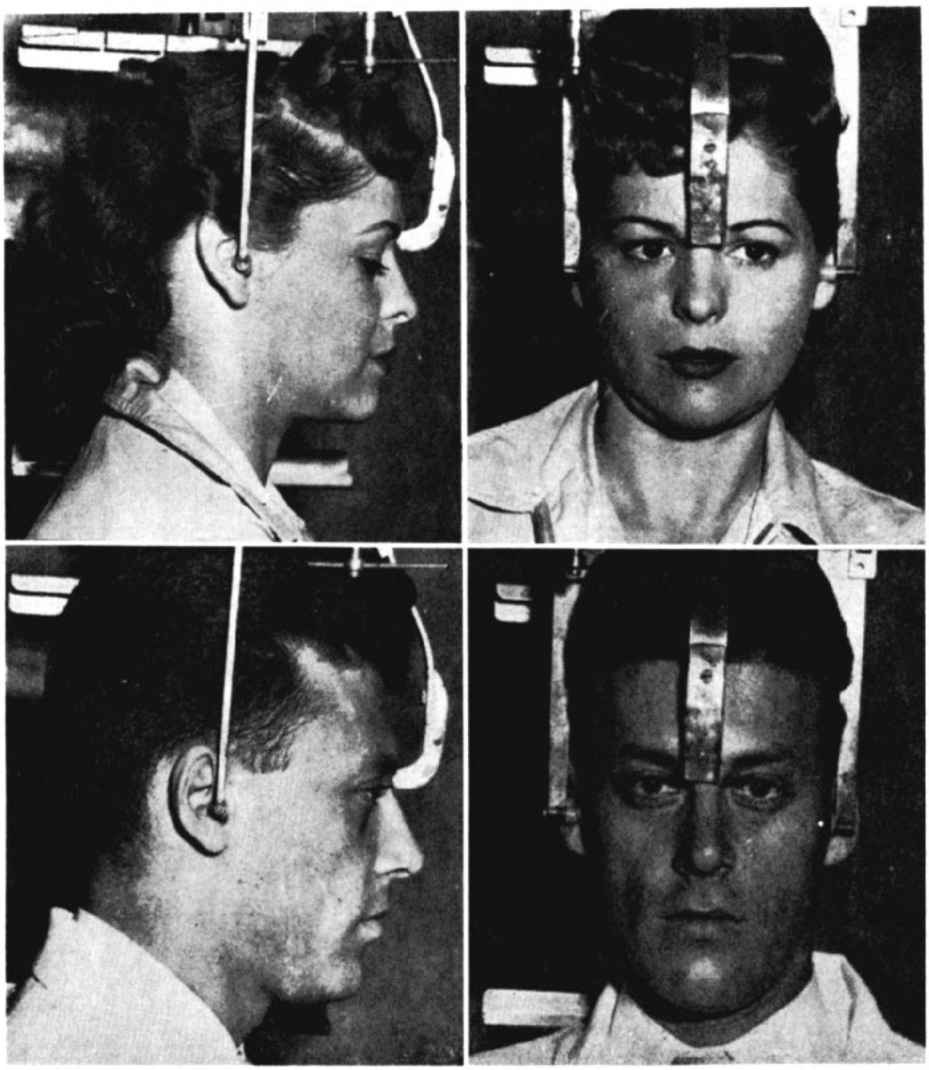


Fig. 12 Two individuals whose readings tend to be similar. The skeletal readings are uniformly excellent, being close to the mean line. Although these faces appear to be in excellent artistic balance, all denture readings, without exception, are very extreme, being on the Class II side of the polygon. Case 38, above; case 31, below.

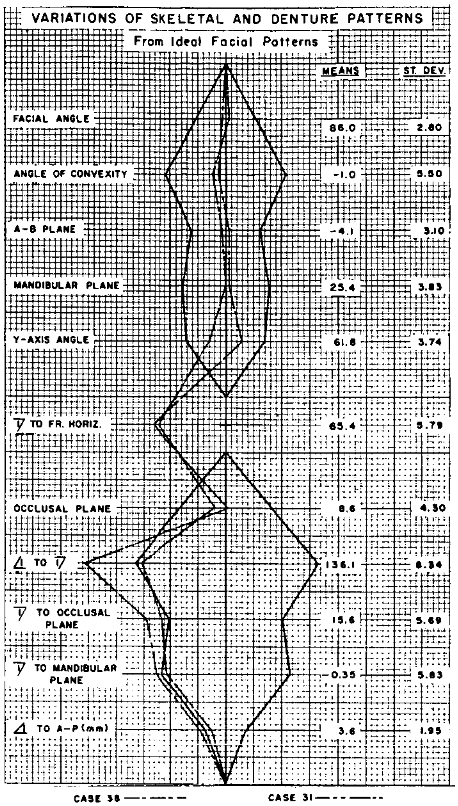


Fig. 13 Facial polygon for case 38 compared with case 31.

An examination of the polygons (Fig. 13) shows that the skeletal readings for both cases are close to the mean or well within the limits of acceptable deviations therefrom. The Case 38 skeletal readings are closer to the mean, but the difference is of no special importance; those of Case 31 tend to parallel these readings, with the greatest discrepancy showing in the Y-axis angulation. The occlusal plane angulation of both cases parallels the activity of the skeletal structures.

The curious features of these cases are in the denture patterns. Although both faces are in excellent general balance and all skeletal readings well within the acceptable ranges of variations, the denture patterns for both cases are extreme. This discrepancy is pronounced; except for the occlusal plane angle, all denture readings for Case 38 are beyond the limits of the polygon, on the left or Class II side; those of Case 31 either touch or are extremely close to the left or Class II limit of the polygon.

It must be mentioned here that the use of the term "denture readings" does not include, for purposes of interpretation, the measurement of the cant of the occlusal plane, whose curious tendency to function so often in a manner parallel with the direction of the skeletal measurements has already been noted.

Cases 38 and 31 illustrate the following maxim: the overall facial pattern may conceivably be excellent, provided the skeletal relationships are in excellent balance and proportion, even when the denture readings exhibit a wide scatter or dispersion. Thus, an excellent facial pattern may be defined with an astonishing degree of independence from the denture pattern or the disposition of the teeth.

A tendency for certain structures in the dentofacial complex to balance or compensate extremes in other dimensions to produce an overall balance and harmony in the general facial proportions has been previously noted. This compensatory property is illustrated in Cases 1, 15, 49, and 46, whose skeletal and denture polygons are shown in Figure 14.

It has been shown that there are high negative correlations between the Frankfort mandibular plane angle and the facial angle, and between the facial angle and the Y-axis angle. A study of the polygons will show the tendency of facial angle to decrease as the mandibular plane becomes steeper. At the same time, the Y-axis angle tends to increase. The compensatory mechanism is evidenced in those cases where, with a high Frankfort mandibular plane angle, the facial angle and Y-axis angle remain close to the mean, or even to the right of the mean vertical line. The alternative compensation is for the A-B plane angle and the angle convexity to deploy to the right (or Class III side) of the mean.

For these individuals it has been suggested that the compensatory property acted through a reversal or minimizing of the correlations between the facial, Y-axis, and mandibular plane angles, in addition to the disposition of the angle of convexity and A-B plane angle to the right of the mean. With these cases, the denture readings, except for Case 1, generally are to the right of the mean, with the angulation of the mandibular central incisor tooth related to mandibular plane being extreme for Case 46 — on the Class III side of the polygon. In Case 46, the occlusal plane reading functions in an opposite direction from the mandibular plane angulation, reversing, in this case, the correlation. In Cases 1, 15, and 49, the occlusal plane readings, while not correlating exactly with the positive coefficient, remain, along with the Frankfort mandibular plane values, on the left of the mean vertical line.

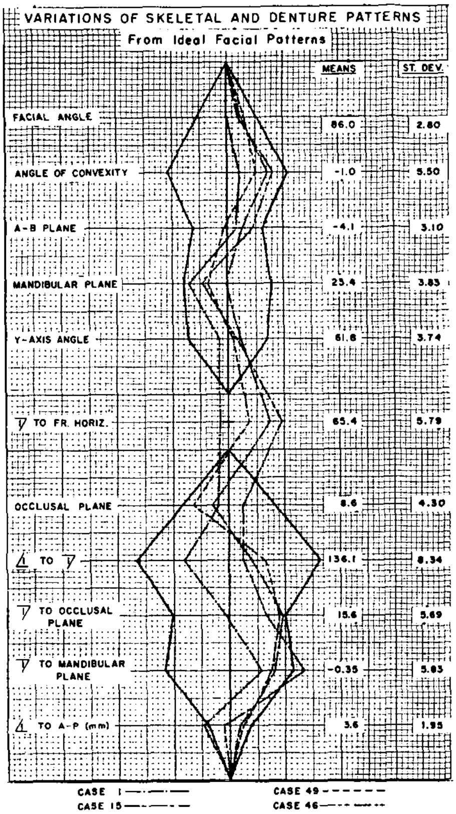


Fig. 14 Facial polygons: cases 1, 15, 49, 46.

Summary and Conclusions

1. An attempt has been made to evaluate, from lateral cephalometric roentgenograms, a sample of fifty excellent Caucasian faces, selected by a panel of artists because of the harmony of the facial balance and proportion. The opinions of the artists were remarkably uniform and included representative facial types ranging from the concave or prognathic, through the straight or mesognathic, to the convex or retrognathic.

2. A quantitative analysis was made, according to standardized cephalometric techniques, of the facial and denture patterns. Measures of central tendency and tests of confidence were established, as well as studies of dispersion in terms of the standard deviation, for each of the angular and linear measurements of the diverse anatomical dimensions.

3. The objective was further defined by studies of correlations and tests of significance of differences between males and females within the Indiana sample, and by comparisons with previous studies.

4. Means and ranges of variability to two standard deviations for the ten measurements used in the Downs' analysis and for the measurement relating the long axis of the mandibular central incisor tooth to the Frankfort

horizontal were plotted on the Facial Skeleton Polygons, constructed for the combined sample of fifty cases, the nineteen males, and the thirty-one females. The polygons are a convenient yardstick for comparison with other cases.

5. There were no significant differences between the males and the females in any of the measurements.

6. The males tended to be slightly more concave in skeletal pattern due to the more prognathic readings of the angle of convexity and the A-B plane angle; on the other hand, this was compensated by the higher facial angulation and smaller Y-axis of the females.

7. In both skeletal and denture patterns, the dispersion of the female readings was either almost identical or definitely broader than that of the males.

8. In the assessment of anteropostero dysplasia, the male unit-score was slightly more orthognathic than that of the female, but the difference was not statistically or clinically significant, and the ranges of variability were wide.

9. In the analysis according to the method introduced by Downs, the measurements of the Indiana sample were similar to those of Downs with the exception of the facial angle and the Y-axis angle where significant differences do exist. The range of extreme of all measurements of the Indiana sample is wider than that of Downs; all of Downs' denture measurements, as well as the Frankfort mandibular plane angle and the angle of convexity, have smaller standard deviations than those of the Indiana group.

10. The facial angle and the Y-axis angle of the Indiana sample were disposed slightly toward the retrognathic or Class II side of Downs' findings.

11. In the analysis according to the technique suggested by Downs, the findings of the Indiana sample were significantly different from those of Riedel in the facial angle, and in all readings of the denture pattern, with the exception of the measurement relating the maxillary central incisor tooth to the Frankfort horizontal. Riedel reported a wider dispersion in terms of standard deviation than those of the Indiana sample in all measurements with the exception of the angle of convexity, the Y-axis angle, and the relationship of the maxillary central incisor tooth to Frankfort horizontal.

12. As compared with the findings of Riedel, the facial angle of the Indiana sample was disposed retrognathically, while those denture readings significantly at variance with those of Riedel were disposed prognathically.

13. A study of the correlations between the occlusal plane angle and other measurements of skeletal and denture patterns shows that the occlusal plane angle is more closely correlated with the measurements of the skeletal pattern, rather than with those of the denture pattern, thus tending in most cases to imitate the activity of the skeletal pattern.

14. The role of the teeth in esthetics is difficult to define or assess as shown by the wide variability displayed by all denture readings. The broad dispersion of measurements of the denture pattern, as compared with those of the skeletal pattern, suggests that an excellent face is less dependent upon the denture, or that the denture pattern, in itself, is too variable and diversified an entity to be labelled of paramount importance in the maintenance of excellent facial pattern in untreated cases.

15. The hypotheses of Tweed and his followers regarding mandibular incisor positioning as index of facial esthetics cannot be substantiated in this sample of untreated cases in view of the liberal dispersion and variability of the read-

ings, i.e., while the mean of the Indiana sample for the angulation of the mandibular central incisor tooth to Frankfort plane was 65.4° (which compares favorably with Tweed's finding of 65.0°) the standard deviation was ±5.79, with readings ranging from 52.4° to 75.0°.

16. In the appraisal of landmarks measured against the sella-nasion plane (S-N), the findings of the Indiana sample differed significantly from those of Riedel's analysis in two measurements: S-N to gnathion and S-N to mandibular plane. In comparison with the findings of the Indiana sample, Riedel's measurements were disposed retrognathically. The dispersion was wider for the Indiana sample in all measurements except S-N to Point A and S-N to Point B.

17. Significant coefficients of correlation derived from the Frankfort mandibular plane angle and various skeletal and denture measurements used in the evaluation of vertical dysplasia according to the technique devised by Wylie and Johnson show that, as this angle becomes steeper (increases), the facial angle becomes smaller, the Y-axis angle increases, the gonial angle becomes larger, the ramus height decreases, the total face height — especially the lower face — increases, and the angulation of the mandibular central incisor teeth to the Frankfort mandibular plane decreases. This confirms the previous report of Wylie and Johnson.

18. There is some indication that a compensatory mechanism or balancing property functions within the dentofacial complex. This property exists in order to preserve the overall harmony and proportions of the facial pattern. Where one dimension shows an obvious discrepancy, one or more of the others will compensate by varying in such a way as to minimize the expected pattern of activity suggested by significant correlations with the dimension displaying the obvious deviation from the mean.

19. The sample used in this project is of special interest because of the varied facial types represented — a kaleidoscope of Caucasian facial types and of variations in measurements and relationships. Since the cases are, with one exception, untreated, they may be considered as being essentially anatomically stable, as compared with an equivalent number of treated cases. Yet, tremendous variation is demonstrated here.

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