Analysis of the Dentofacial Profile

William B. Downs D.D.S., M.S.
Aurora, Illinois

For many years research workers have traced, measured, and compared dozens of planes, angles, and dimensions on head radiographs. From these observations a concept gradually evolved of what constitutes acceptable balance and harmony of the component parts of the face. Much has also been learned about the complexities of facial and denture growth.

In a previous article, 1948, "*Variations in Facial Relationships, Their Significance in Analysis and Treatment Planning*"[1], a method was presented of describing facial relationship. A second report in 1952, "*The Role of Cephalometrics in Orthodontic Case Analysis and Treatment Planning*"[2], supplemented the first report and correlated cephalometric appraisal with facial typing. The second paper illustrated some of the variations of facial changes which occur during growth and orthodontic therapy.

These reports were based on a study of twenty boys and girls 14.5 ± 2.5 yrs. The sample was selected on the basis of excellent occlusion, physiological balance, and harmony of facial musculature. The anatomical points and planes used are shown in Fig. 1. The findings were divided into a description of the skeletal pattern and the denture pattern. The mean or average relationships along with their range of variation are shown in Table I.

The intent of the present paper is to further explain and simplify the first two reports and to describe additional interpretations, which seem significant in routine office use of lateral head films.

Dentofacial balance and harmony, and growth and development have been studied by many investigators in four dimensions: namely, height, depth, breadth and time, using lateral and antero-posterior radiographs to date. The lateral or profile radiograph has given us the most useful information. This is fortunate for our difficult orthodontic problems occur for the most part in the antero-posterior and vertical dimensions.

Broadbent[3] gave us the concept of the mean average facial pattern in 1937. Brodie, 1942[4], introduced the method of studying the pattern and the growth of the component areas of the head; namely, brain case, nasal area, upper dental region and mandible. He then correlated these areas as a pattern of the whole head.

Bjork, 1947[5], reported on a cross sectional investigation of facial prognathism of 322 Swedish boys, 12 yrs. of age, and 281 military conscripts, 21 and 22 years.

Facial Typings

The objective of my 1948 report was to develop a method of describing the nature of the facial skeletal pattern of normal occlusion and the manner in which the denture fits into it. If the normal pattern and its range of variation could be described, then the abnormal one could be judged by comparison. Foremost in the requirements of a method was that it should express the skeletal dentofacial profile, in correlation with that seen by looking at a

Read before the Twenty-fifth Anniversary Meeting of the Edward H. Angle Society of Orthodontia, Chicago, Illinois, November 1955.

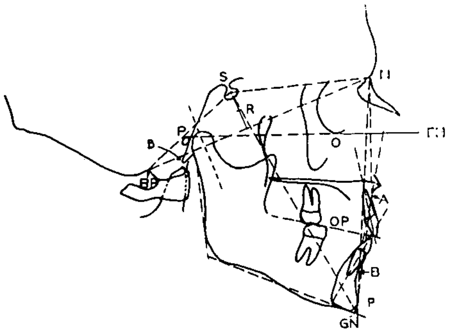

Fig. 1 The anatomical points and planes used to describe the skeletal and dental patterns.

person or his photograph. This necessitated a plane of reference comparable to both radiographs and photographs.

A number of planes were tested. The one best meeting this requirement was found to be the Frankfort horizontal plane. In spite of the known uncertainty of accurately locating porion, the Frankfort plane has proven adequate for facial typing. This conclusion was arrived at after determining the mean and range of variation of the three angles SNPo, Bolton point NPo, and FH.Po and comparing the data with the patient's profile in normal posture. The first two exhibited no correlation while FH.Po (Facial Angle) showed a high correlation. It is not, however, accurate enough for studying growth change, and is not used for this purpose. This will be taken up later when methods of serial study are discussed.

From the orthodontic viewpoint, a person's facial type is best described by the relative antero-posterior relationship of the forehead, middle face (maxilla) and lower face (mandible). The facial angle, Fig. 2, tells the relative prognathism of the mandible. The terminology used to describe facial types is mesiognathic for the average, retrognathic for the receding mandible, and prognathic for the prominent mandible. While we found a good correlation of mandibular prognathism in the radiographs and the patient's photographs by using the Frankfort horizontal as a reference plane, there were some discrepancies. That is, some patients had facial angles indicating facial types which they obviously did not possess. This lead to an investigation of the Frankfort horizontal plane as a reference plane.

TABLE I

SKELETAL PATTERN				
	MINIMAL	MAXIMAL	MEAN	S.D.
Facial angle	82	95	87.8	3.57
Angle of convexity	—8.5	+10	0	5.09
AB plane	—9	0	—4.6	3.67
Mandibular plane	17	28	21.9	3.24
Y axis	53	66	59.4	3.82
DENTURE PATTERN				
	MINIMAL	MAXIMAL	MEAN	S.D.
Cant of occlusal plane	+1.5	+14	+9.3	3.83
⌊1 to ⌈1	130	150.5	135.4	5.76
⌈1 to occlusal plane	+3.5	+20	+14.5	3.48
⌈1 to mandibular plane	—8.5	+7	+1.4	3.78
⌊1 to AP plane	—1 mm.	+5 mm.	+2.7	1.80

TABLE I
The mean and range of variation of 20 normal occlusions, age 14 yrs. 5 mos. ± 2.5 yrs.

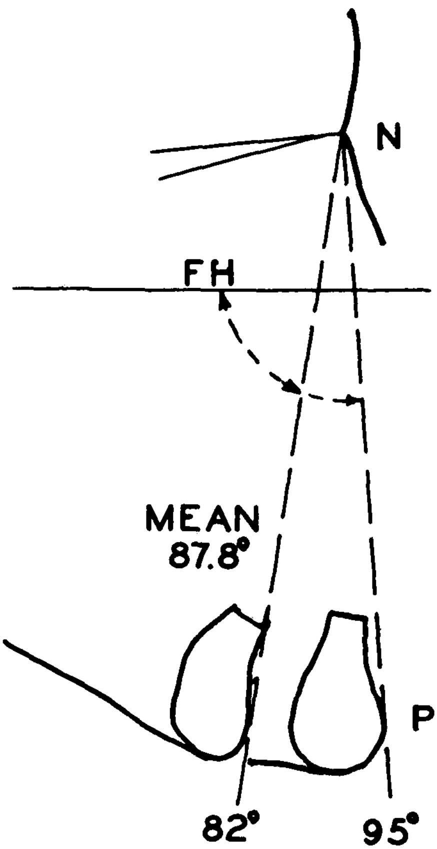

Fig. 2 Variation of the facial angle in normal occlusion.

The Frankfort horizontal is said to be level when a person is standing looking straight forward. This was tested by photographing 100 children standing and looking at their own eyes in a mirror. The Frankfort plane may be drawn on a profile photograph from the superior margin of the acoustic meatus to orbital, which is easily palpated, and its location transferred to the skin. The result of this check showed the mean position of the Frankfort plane to be an upward tip of 1.3 degrees, with a standard deviation of 5. Using two standard deviations (95% of sample), which is generally accepted to delineate the normal range of a sample, indicates that we can expect the Frankfort plane to deviate as much as 10 degrees up or down from a level position. Suspecting that a person would not assume exactly the same posture every time, three or more pictures were taken on fifteen members of the sample. In no instance did the patient assume exactly the same posture, the difference ranging from 1 to 3 degrees. When photographing children one must take into account the possibility of abnormal posture due to tenseness and excitement. It requires a bit of judgment to determine when a person is in a natural, free balance of head posture.

The occasional discrepancies between cephalometric facial typing and photographic facial typing disappear when a correction is made for those persons who do not have a level Frankfort plane. This is illustrated in Fig. 3, with posture profile photographs of three individuals.

A, with a facial angle of 81 degrees, should have a receding chin which obviously is not true. When corrected for the Frankfort horizontal deviation of +9 degrees, the facial angle becomes 90 degrees, a little above the average. Now, there is a cephalometric and photographic correlation of her facial type.

B, with a reading of 81 degrees and a level Frankfort horizontal should have a receding chin, which is verified by her photographs.

C, with a facial angle of 90 degrees, should have an average profile. His photographs show a receding chin. Since Frankfort horizontal tips down 7 degrees, this amount may be subtracted from 90° giving a corrected facial angle of 83, which denotes a receding chin.

Such a method of appraising faces permits one to say that a person has a certain type of face and to describe it in degrees of the facial angle. Obviously, there will be a wide gradation in

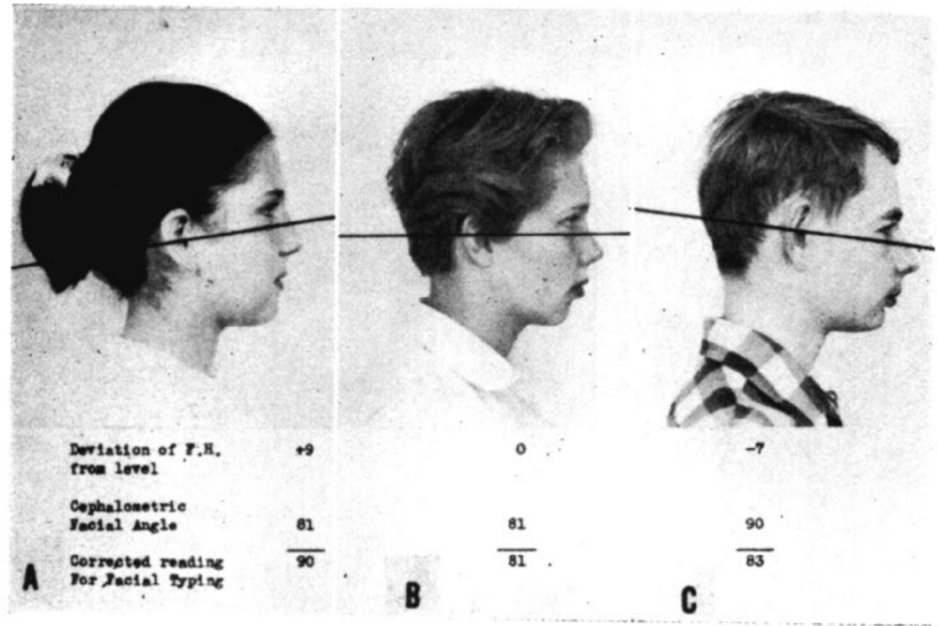

Fig. 3 Variation of the cant of the Frankfort horizontal plane.

types and there can easily be differences of opinion about merging types. The facial angle when corrected for posture permits one to define these questionable types.

The other characteristic of the profile is expressed by the angle of convexity, nasion (N), subspinale (A), and pogonion (Po).

When NA and Po fall in a straight line, there is a zero angle of convexity; when A is anterior to N and Po the angle is read as a deviation from 180 degrees and given a positive value denoting convexity. Likewise, when A is posterior to N and Po, the reading is given a minus value denoting concavity of the profile. Subspinale (point A) has been chosen to represent middle face in the profile rather than the anterior nasal spine for several reasons. The anterior nasal spine varies greatly in length; anatomically it could be considered as a portion of the nose as it projects into the septum and supports the vomeronasal cartilage. Subspinale is located on the anterior surface of the maxilla at the theoretical junction of the alveolar bone and true maxillary bone. It represents the anterior limit of the maxillary base. Its position is influenced by the central incisors and, therefore, is changeable when the teeth

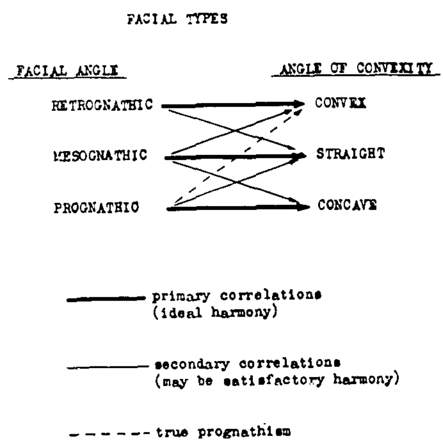

Table II Correlation of facial types.

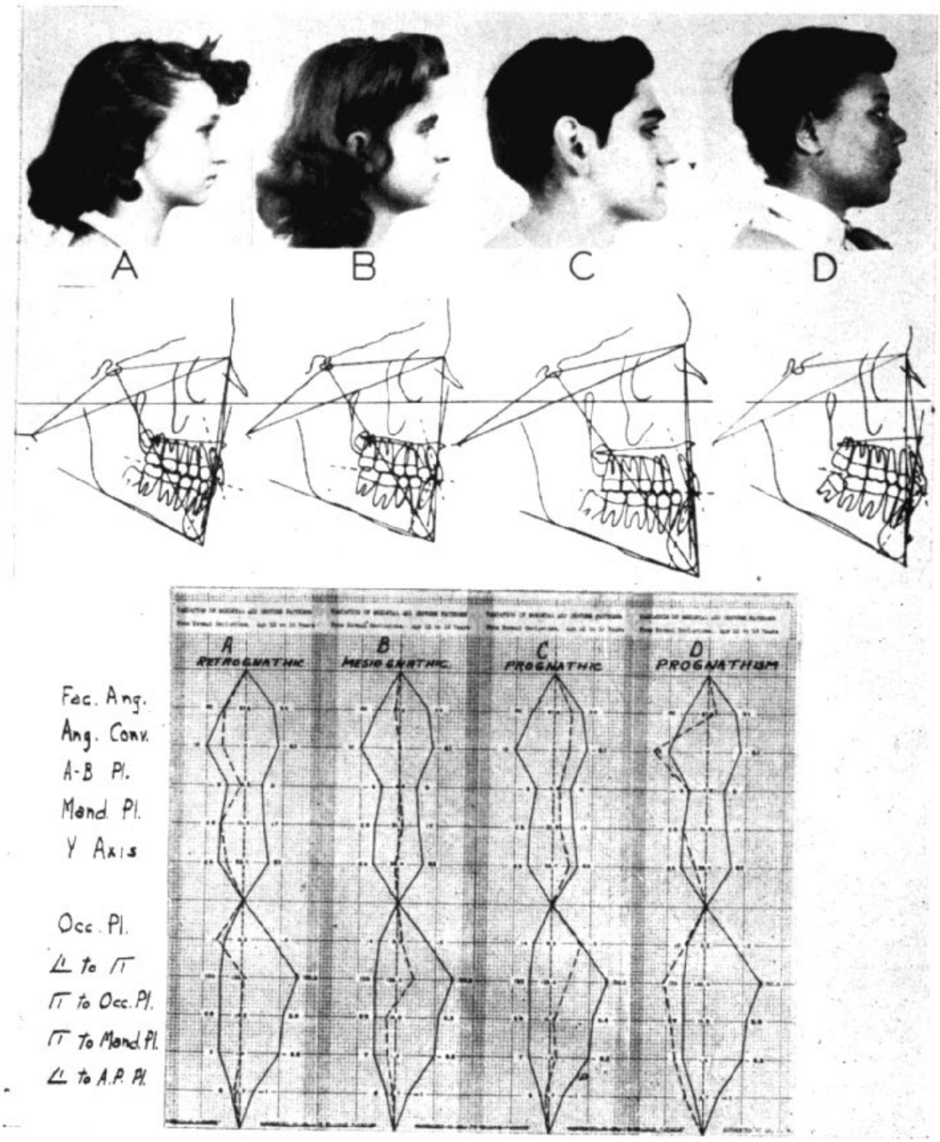

Fig. 4 Four basic facial types showing their cephalometric tracings oriented on F.H. and their dentofacial graphs. Although these patients differ in pattern, they represent balance and harmony for their type.

and their alveolar processes are shifted in an antero-posterior direction. The correlations of mandibular prognathism and the angle of convexity are shown in Table II.

There are four basic facial types; these are shown in Fig. 4, along with their cephalometric tracings. Prognathism (Case D) is not always accepted as a normal facial type; however, it is a more common type than the straight mesiognathic face that we look upon as the ideal. Individuals of this basic prognathous skeletal pattern usually have dentures located forward of the skeletal profile. This is dental protrusion, commonly shortened to the term DP. Attempts to reduce dental protrusion in prognathous facial types of good physiological balance and mold their profile to an average pattern as seen in the mesiognathic type (Case B) often result in failure, because of relapse tendencies toward their original, good *physiological* balance.

Graphing of Dentofacial Patterns

Vorhies and Adams[6], 1951, described an excellent method of plotting the dentofacial pattern on a polygon graph. They used the data of our normal occlusions, age 14.5 yrs. ± 2.5 yrs., Table I. This graph visualizes at a glance what would take several minutes to picture by a study of a group of figures. It compares the patient's dentofacial pattern to the mean and variation of acceptable relationships. It is indeed graphic in showing gross deviations. It also, when used serially, illustrates changes in growth and the results of orthodontic therapy.

Their graph is composed of two polygons, the skeletal pattern above and the denture pattern below. The center line represents the mean or average relationship. The extremes on either side are so arranged as to be in correlation. Those on the left are found in the best balanced retrognathic faces, and those on the right in prognathic faces.

The graphs of the four facial types of normal occlusions in good balance are shown in the lower part of Fig. 4. Note the regularity of their patterns and the relationship of the different facial types to the mean. Regularity of an individual's pattern is indicative of harmony and balance, except in the prognathous type such as case D. Here the high facial angle is not associated with the usual negative angle of convexity as seen in Case C. A combination of an average or high facial angle with a high angle of convexity as seen in Case D is often normal. It represents prognathism.

Prognathism is the mean or average facial pattern of the Chinese, Japanese, Negro and the Australian aborigine. Such faces represent a physiologically normal balance and harmony.

When the patient's graph line becomes irregular and wanders about, it indicates lack of balance and harmony in direct relationship to its irregularity. This is illustrated in Fig. 5, which shows the cephalometric appraisal of four malocclusions. Their graphs are a clear description of their patterns. Note the lack of correlation.

Ethnic Analysis

Dentofacial patterns differ racially sufficiently to be significant. Four graduate students at different universities have studied normal occlusions of the following groups:

Cotton[7], University of California, 20 negroes age 11 - 24 years;
Takano[8], University of Washington, 20 American born Japanese with a mean age of 21;
Wong[9], University of California, 20 American born Chinese age 11 - 16;
and Craven[10], University of Illinois, 20 Australian aboriginies exact age unknown, but thought to be teenage and young adults.

The first three were divided equally as to sex, the Australians were of unknown sex. All cases were selected on the basis of excellent occlusion and good physiological facial harmony. Wylie[11] reported on a comparative analysis of the first three groups, Negro, Japanese and Chinese, comparing them to each other and to native white Americans. I have added Craven's groups of Australians to complete the picture.

The graph of these four ethnic groups, Fig. 6, shows differences in patterns which are significant. The *mean*

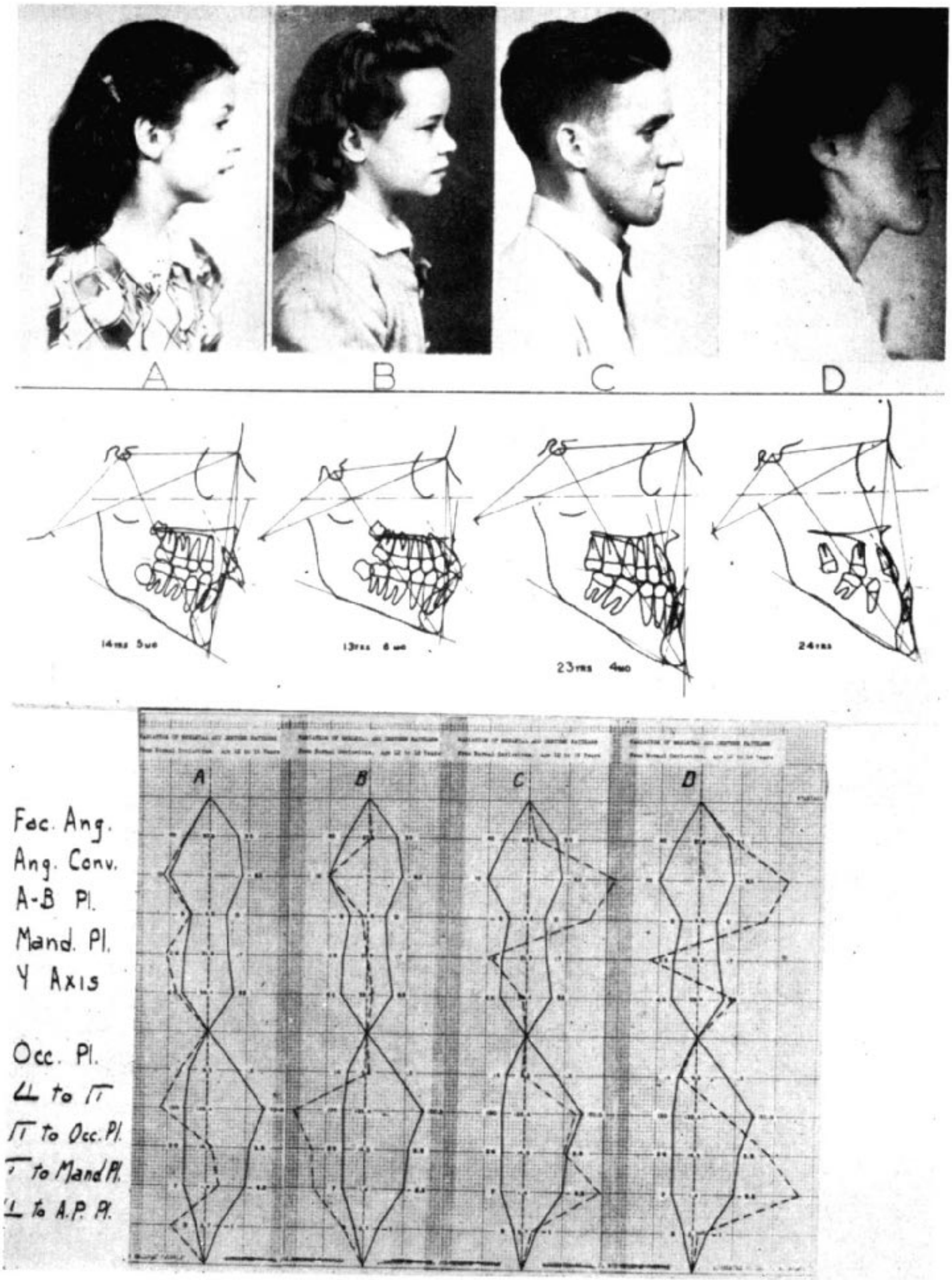

Fig. 5 Cephalometric tracings and graphs of four malocclusions.

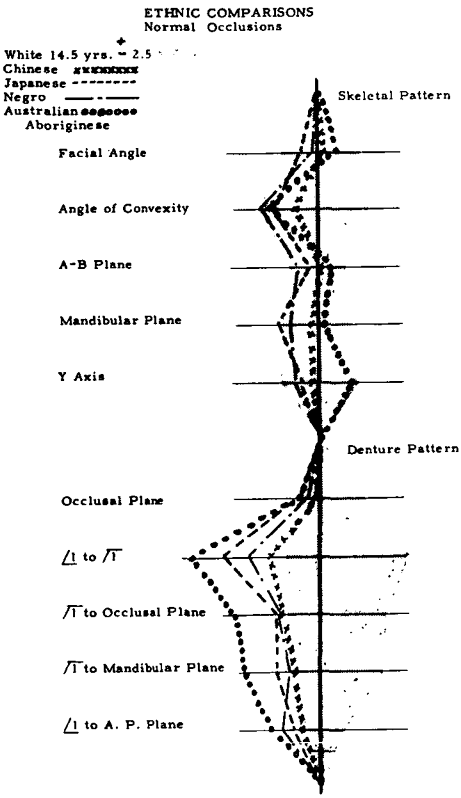

Fig. 6 The means of four ethnic groups plotted against the Downs standard.

readings of the four racial groups are plotted against the *mean* and *total* pattern for whites. An important difference appears in the much greater facial convexity. When coupled with a well developed mandible, as indicated by an average or high facial angle, it creates the facial type known as prognathism.

The position of the denture in the face is shown in the lower polygon and here there is an even more significant difference. Deviations to the left show dental protrusion and labial inclination of incisor teeth. As all of the material in these studies has been selected and checked by groups whose judgment of occlusion and facial harmony should be of a high order, we are forced to give serious consideration to the findings that prognathism and dental protrusion are normal patterns. The records indicate that the Australian aborigines have these characteristics mostly highly developed and that the Chinese facial pattern is the most similar to that of the White.

Age Difference in Dentofacial Patterns

We have long recognized an inadequacy in the sampling from which standards of normal dentofacial patterns were obtained, for they apply only to the age range, of 14.5 yrs. ± 2.5 yrs. This range in itself is larger than it should be; a plus or minus variation of one year would be more desirable. However, they have been useful in appraising early permanent dentitions, but we have had to estimate the probable differences of other age ranges.

The need for additional data at other age levels has been partially met by three studies using the same method of analysis, Fig. 7. Hapak[12] has supplied the data for the deciduous age; Hernandez Mota, working under Krogman[13], has prepared the data for the 9 yrs. 6 mos. ± 8 mos. group; and Baum[14] studied sixty-two children 12 yrs. 8 mos. ± 1.5 mos. The criteria in selecting all samples was excellent occlusion. The addition of these three age groups aids in understanding facial growth and development. They are plotted against the 14.5 yrs. graph. The three figures at the left show the comparison of the total patterns. The single figure on the right shows a direct comparison of the mean patterns of the four age groups. It furnishes evidence that in normal growth the lower face or mandible moves forward at a greater rate than the maxilla, thus increasing the facial angle from 82° to 88° and decreasing the angle of convexity from +10° to 0°. Vertical growth is greater in the area of the ramus than at the profile, thus decreasing the mandibular

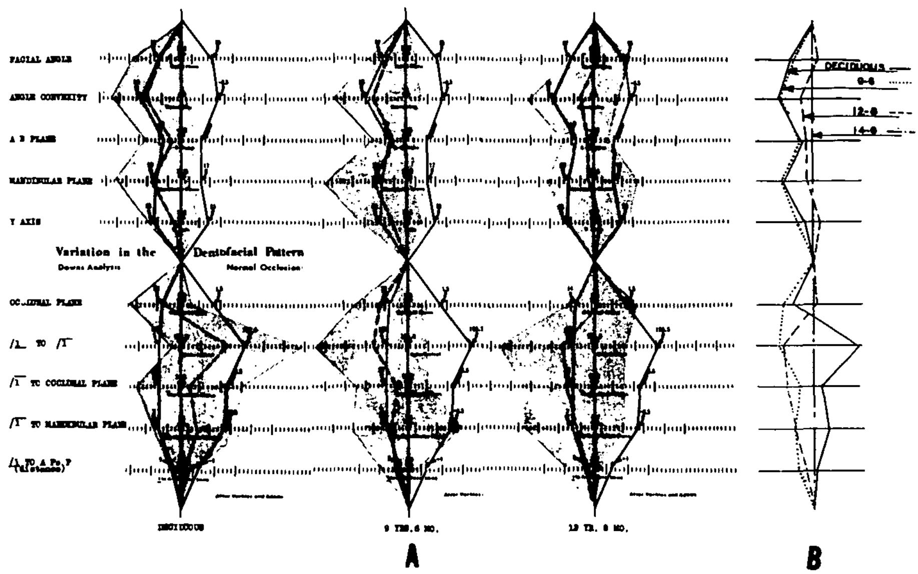

Fig. 7 A — Comparison of the total patterns of deciduous, 9 yrs. 6 mos., and 12 yrs. 8 mos. to the 14 yrs. 5 mos. pattern.
B — Composite of the mean pattern.

plane angle from 28° to 22°. The AB plane, which expresses the antero-posterior relationship of the maxillary and mandibular denture bases and the Y axis, shows the least difference for the three age groups. Note the close similarity of the skeletal pattern at the deciduous and 9.6 ages, particularly the profile, which is described in the two top readings of facial angle and angle of convexity. Then note the changes in the following three years to the 12 yrs. 8 mos. standards. As these changes are due to a greater proportional forward growth of the mandible than other profile points, it seems to indicate that in the later transition stage there is a significant change in growth gradients.

These graphs represent the average pattern of excellent occlusions. I have watched many individuals grow who did not fall in this select group and it is very common for them not to enjoy this favorable mandibular growth. When they fail to do this, they are usually difficult orthodontic problems.

An analysis of the denture pattern is also interesting and significant. The occlusal plane behaves in a manner similar to the skeletal pattern, with a reduction in its steepness. The denture profile, however, is quite dissimilar. The deciduous denture with its small teeth is retrusive. With the eruption of the permanent incisors, the denture suddenly becomes quite protrusive. It is at this age that the child's face, particularly the mouth area, becomes very full and is often mistaken for abnormal denture protrusion. This mistake is easily made if one thinks of a nine year old face in terms of the proportions of a midteen age face. Normally, these nine year old faces grow out of their dental protrusions.

These observations regarding the skeletal pattern up to the 8.6 yrs. age are in agreement with Brodie's[4] statement based on a study of growing children, 3 mos. to 8 yrs., in which he found such a similarity in individual patterns that he reported, "The morphogenetic pattern of the head is established by the third month of postnatal life, or perhaps earlier, and that once attained it does not change." Unfortunately, this finding has quite generally been taken to apply to the total range of facial growth. This assumption has not been justified, for observations of the growth behavior in the later age ranges have shown significant variations in the behavior of the dentofacial pattern. Deviations of the mean tendency are often observed either in a diminished or excessive forward growth of the mandible. A patient's profile is materially affected by his pattern of growth.

Sex Differences in Growth

Routine checking of cases following treatment has consistently shown that females have minimum facial change in size or proportion after 14 to 15 years. Males, on the other hand, consistently continue growth and development until twenty. Gnathion may move downward along the Y axis as much as one-half inch and the angle of convexity may change several degrees.

The difference between post pubertal growth of boys and girls was first brought to my attention by Dr. A. W. Moore. His statement that girls complete their facial growth at a much earlier age than boys is supported by three investigators[16] at the University of Washington. Nanda[15] in a quantitative serial facial growth study of boys and girls from 4 to 20 years of age says, "In the small sample of boys and girls studied at the Child Research Council, the girls show relatively less facial growth than the boys during adolescence." Usually male dentures become less prominent in relationship to the profile in the later stages of development. Such probable changes in the dentofacial pattern of males after 14.5 years should be considered in treatment planning. However, growth and development does not always progress in an average manner and one

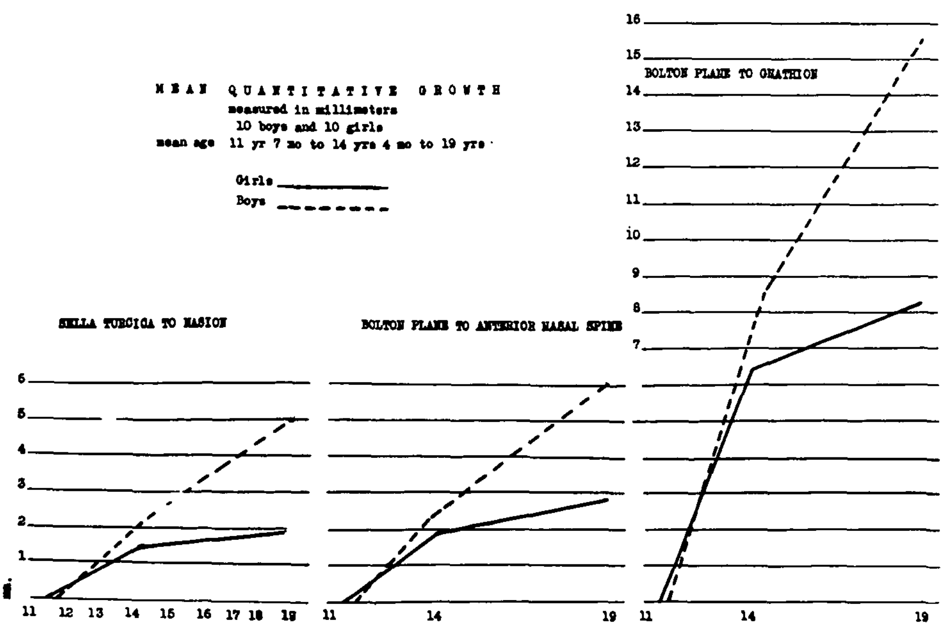

Fig. 8 Mean quantitative growth of boys and girls.

should beware of the unusual.

A small pilot study was undertaken to test the thesis of inequality of quantitative post pubertal growth of boys and girls. Three headfilms each of ten girls and ten boys were selected solely on the similarity of three age ranges, namely: 11 yrs. 6 mos. ± 12 mos., 14 yrs. 3 mos. ± 12 mos. and 19 yrs. ± 3 yrs. Three linear measurements were taken, (1) at the juncture of face and cranium, from sella to nasion. Björk[19] states that after 10 years of age, the anterior cranial fossa does not increase in size, therefore, any forward movement of nasion is due to a thickening of the cranial wall. My own observations are similar. (2) The distance from anterior nasal spine to the intersection of the Bolton plane and a line joining ANS and sella turcica. (3) A similar measurement for the mandible, from gnathion along the Y axis to its intersection with the Bolton plane.

The means of these readings plotted on a graph, Fig. 8, show that post pubertal growth of the girls is greatly reduced while that of the boys is only slightly reduced.

The most startling thing about the findings was the high degree of variation of the increase of the measurements when individually appraised. The individual measurements are shown in Table III. Only the percentage increase of boys over girls is shown for the prepubertal age.

TABLE *III*

DIMENSIONAL CHANGES
in mm.

	S — N		Bolton-ANS		Bolton-Gn	
	Girls	Boys	Girls	Boys	Girls	Boys
11 yrs. 6 mo.	3.5	6	3	10	7	20
(± 12 mos.)	4	6	2	6	8.5	13.5
	1	4	3.5	6	8	18.5
to	4	6.5	7	10	13.5	18
	1.5	3.5	2.5	8	6.5	13
19 yrs.	1	6	3	2.5	8	21
(± 3 yrs.)	.5	4.5	0	4.5	5.5	12.5
	1.5	4	2.5	4	6	16
	1	4	2.5	5	10	9
	2	6	2	5.5	8	17
	2	5	2.4	6.1	7.8	15.8
*		2.5		2.5		2
	.5	2.5	0	2.5	1	8.5
14 yrs. 3 mo.	1	3.5	0	5.5	.5	9
(± 12 mos.)	0	1	.5	1	1	3
	1	5	2	6	5	11
to	0	1	.5	4	1	8
	0	5	.5	2.5	.5	16
	.5	.5	0	1	2	1
19 yrs.	1	2	2.5	2	2	8
(± 3 yrs.)	0	1	1.5	1	1	3
	1	2	1.5	3	.5	3
	.5	2.3	.9	2.8	1.9	7
11 yrs. 6 mos. *		4.6		3.1		3.6
to						
14 yrs. 3 mos.*		1.7		1.5		1.3

* Percentage increase of boys over girls.

Profile Arc

If cephalometric radiographs are to take the place in case analysis in every office that their worth justifies, technics must be simplified, and findings must be proven reliable and helpful to the clinician. The nature of a patient's profile arc can well be considered the most important information to be gained from lateral cephalometric radiographs. To make such an appraisal it is first necessary to have a concept of what constitutes the average profile pattern according to age and race, as well as the range of variation that may be considered acceptable. Enough information is now available to make a direct observation of the facial profile useful. As stated before, the profile pattern is determined by the relationship of the forehead using nasion as a specific point, the middle face using subspinale (Point A), and the lower face using pogonion. The arc of the facial profile of twenty white children (boys and girls) 14.6 yrs. is shown in Fig. 9. This is what we may expect in well balanced faces. Convex arcs usually are found in retrognathic and prognathous faces. Concave arcs occur in an increasing ratio as faces become prognathic. There is an equation to determine the radius of the facial arc. Let A, B, C equal the sides of a triangle NAPo; then the radius of an arc passing through NAPo $= \frac{A \times B \times C}{4(\text{area}-)}$. The additional information to be gained, however, does not seem to warrant the time to solve the equation. The relationship of the denture to the facial arc is very similar in all of these normal occlusions. This suggests that such positions of the denture in the skeletal pattern might be considered as an objective in treatment. Excessive protraction or retraction of the incisors should be undertaken with caution.

Variations of the Facial Arc

The form of the facial arc and the relationship of the denture to the facial arc cover a wide range in the patients we are called on to treat. The three cases, all males, shown in Fig. 10, are oriented on a corrected Frankfort plane so that their profiles are seen in relationship to their natural head posture. To illustrate possible pattern differences in the profile and variation in growth changes, the cases were selected to cover the age range of most orthodontic treatment up to completion or near completion of facial growth.

The cases are superimposed on the basion nasion plane at basion. Many observations have shown that the Ba N and Bolton planes shift very little, if any. I have not been able to find statistics on this relationship. This has been done because it expresses head growth

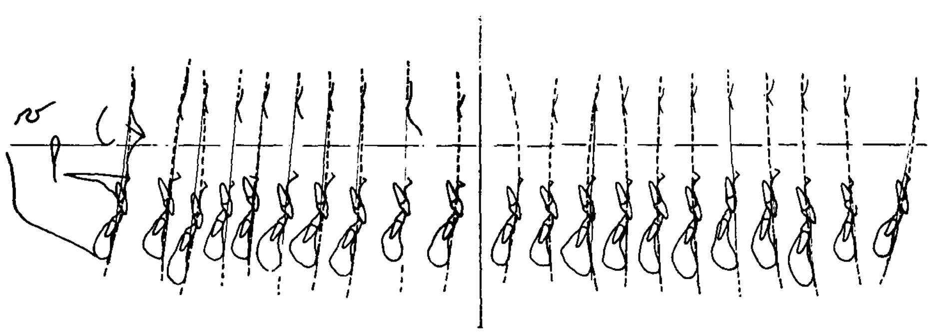

Fig. 9 The profile arc in twenty normal occlusions.

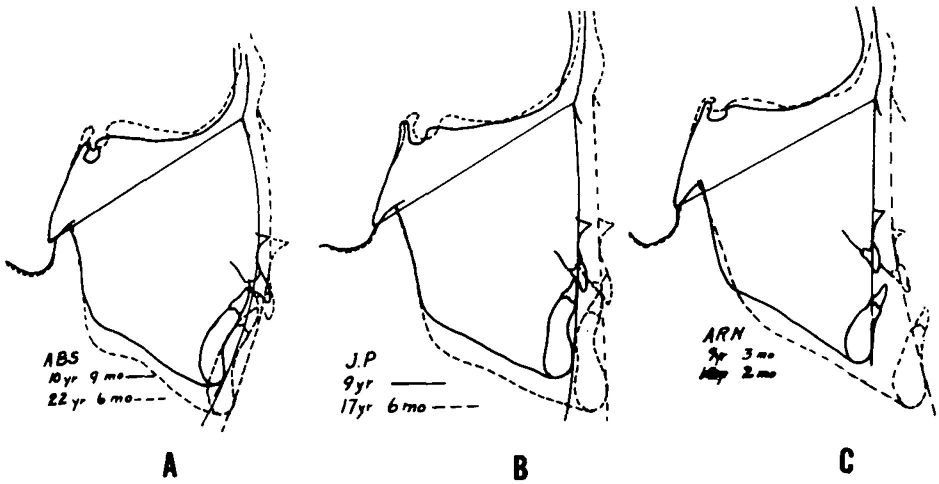

Fig. 10 Variation of the profile arc and its change during growth. B is the average pattern, A and C are the opposite extremes. Oriented on BaN plane at basion.

in relationship to its base, the occipital condyles. All head growth results in a pushing away from the vertebral column. This method expresses the total forward positioning of the profile and a noticeable difference is evident in these individuals. The middle case is non-orthodontic and is very close to the average dentofacial pattern, both statically and dynamically. The Class II case has had treatment with a very mediocre result. The Class III is awaiting surgical correction.

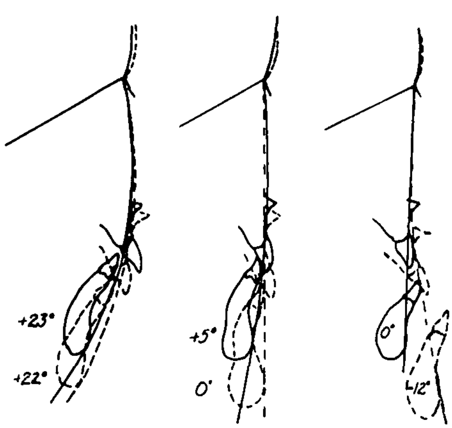

Fig. 11 Same as Fig. 10, but oriented at nasion.

The cases superimposed on the same plane, Ba N at nasion, are shown in Fig. 11. This has been done to get a better comparison of the profile arcs of each case.

Patterns similar to (B) present few orthodontic problems other than tooth arrangement. As a profile pattern deviates toward A or C, the problems of functional and esthetic balance, and growth potential increase. Conversely, the prognosis of a satisfactory treatment result decreases.

Once one is familiar with the variations of the profile arc, measurements are not essential to an analysis. They are, however, necessary if one wishes to describe a pattern or define any changes.

Axial Inclination of Lower Incisors

Much has been written about the axial inclination of the lower incisors. All of the earlier reports found an approximate 90° relationship of the lower incisor to the mandibular plane. We found a mean of 91.4° with a standard deviation of 3.78°, which indicates a rather wide range of variation extending from 83 to 98 degrees. Tweed[17] reported that he selected ninety-five adults of random age and sex who met his requirements "of good balance of facial outline rather than ideal." In a study of their incisor mandibular plane angles he found an average of 86.6° with a range of 76° to 99°, which is larger than that found in our sample. Knowing Tweed's avowed preference for a flat facial profile, it is not surprising that the majority of cases he selected possessed upright lower incisors. There is a definite correlation between upright mandibular incisors, a low Frankfort-mandibular plane angle, and a flat facial profile in the denture area.

It is the author's considered opinion that the relationship of the lower incisor to the mandibular plane is not a good criteria for interpreting its position in the denture and face because the reference plane, the lower border of mandible, is not directly associated with the profile and it exhibits such a wide range variation. Tweed also found it necessary to make a correction for mandibular planes deviating from the average. In serial studies, however, recording of the lower incisor mandibular plane angle is the method of choice for appraising changes in position of these teeth. The relationship of the lower incisor to the occlusal plane as suggested by myself has proven of little value and is being discontinued by the author.

From this same study Tweed[17] introduced another mandibular incisor relationship. He found an average of mandibular incisor to Frankfort-horizontal plane relationship of 68.2°. From this, he arbitrarily selected 65° as an ideal treatment goal and his treatment plan is aimed at attaining this figure as closely as possible.

The data on his sample shows 65.2 percent grouped between a 64° and 70° FMIA. This, obviously, is a high percentage in a small range. The remaining 23 cases were scattered from 61° to 80° with one at 56°.

It is interesting and confirming that the 20 cases of excellent occlusion from which our analysis was obtained also showed a mean of 68° with a range of 59° to 81°, with one case of 50°. This case was a definite prognathous face with a good facial angle (87°), and high angle of convexity (10°). If there had been any excuse to treat this case, I would have extracted and uprighted the incisors, but not to 65°. I would have been satisfied with 55° for this particular patient. The comparative data of the two samples is shown in the following table.

FMIA	Tweed	Downs
Average	68.2°	68°
Minimum	80°	81°
Maximum	61°	59°
	(one at 56°)	(one at 50°)

When we first learned this technic of Dr. Tweed's, we routinely checked our cases at the office. In a number of instances the demands of repositioning the incisors to 65° to the Frankfort horizontal did not seem to be justified when considered in the light of all diagnostic factors.

This raises the point that the procedure of using the Frankfort horizontal plane as a reference plane for appraising the inclination of incisors for an individual is controversial, when held to a minimum of 65°, for at least three reasons. (1). The relationship that we are really interested in is the position of this tooth in the profile of the patient, not to a cranial plane such as Frankfort horizontal. (2). All experienced workers in cephalometrics admit the probability of an error of a millimeter or two in locating porion. (3). The significant problem in the Tweed technique is the variability of the cant of the Frankfort-horizontal plane. There is a known variation of ± 12° from an average 1.3° upward tilt in normal head posture. Should two patients of very similar profiles, including denture position, show 10° difference in the cant of their Frankfort-horizontal planes, the reading of the FMIA angle would differ 10°, even though the profiles and incisors of the two cases would superimpose. The explanation is obviously due to the orientation of the eyes and ears of these patients to their respective heads. The eyes and ears can be related in a different fashion to the faces of the individuals without affecting the denture and profile relationship.

Steiner[18], in 1953, published his method of interpreting cephalometric radiographs. He very carefully appraised the methods then in use, shifted out the factors important to him, as well as adding some of his own. One of the latter was to relate the lower incisor to the profile using the line nasion to supramentale, the lower denture base, (point B). He found the average of this position to be 25°, and that the incisal edge was 4 mm. anterior to the plane NB. This method has considerable value in that it is a direct analysis of the tooth to the profile.

While Ricketts was on the staff of the University of Illinois, 1950, he suggested relating the lower incisor to the profile, specifically the lower face, using the plane subspinale (A) to pogonion (Po) Fig. 12. Since our concern in denture position is its status of balance with the profile, this method is logical and descriptive. It also permits a variation according to facial types. The more retrognathic and convex a face is, and the greater the antero-posterior differential between maxillary and mandibular denture bases, the greater will be the labial inclination of the lower incisors, even though they have the same relationship to the profile arc. The reverse occurs in straight and concave faces. An evaluation of

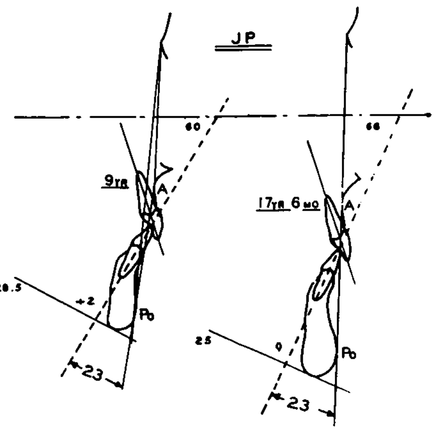

Fig. 12 Relationship of the lower incisor to the lower face (A Po plane) in a non-orthodontic normal at 9 yrs. and at 17 yrs. 6 mos. Note the constancy of the lower incisor to the A Po angle while the FMIA angle has changed 6 degrees. There has been no change of the Frankfort plane to the cranial base plane BaN.

our series of normals gave a mean of 23° with a standard deviation of 3°. Not only is the inclination of lower incisors significant but the actual distance of the incisal edge to this plane is important. The average position showed the incisal edge to fall on the profile arc with an acceptable variation of —2 mm. to + 3 mm., according to type and soft tissue balance.

Soft Tissue

Another important factor for consideration of profile balance is the overlying soft tissue. It is important because of its effect upon esthetics and its influence upon the denture. Musculature, both passively and in action, produces forces. These forces affect the position of teeth. Their status of balance or imbalance plays an important role in determining the antero-posterior position of the denture, and in the stability of treated cases.

Average, or even good, radiographs are usually deficient in illustrating the soft tissue facial mask. A number of methods have been advocated to over-

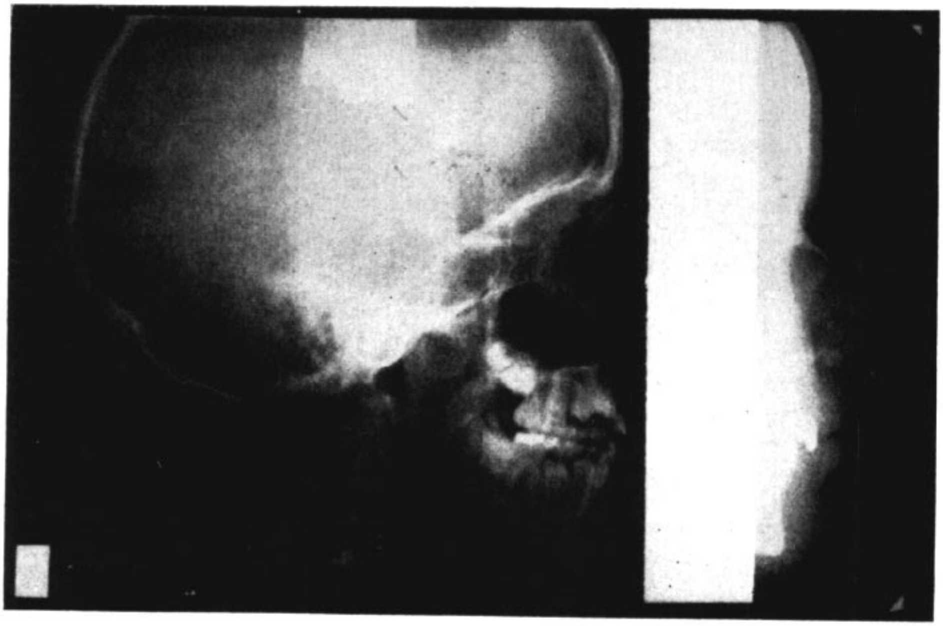

Fig. 13 Hard and soft tissue radiographs of the same patient taken simultaneously.

come this. The technic that we have adopted is simple, sure, and has the advantage of permitting the use of a greater exposure in order to bring out more clearly the deeper cranial structures that are now being studied, specifically, the cranial base. An example is shown in Fig. 13. An Eastman no-screen film is cut into four strips and one piece placed in the cassette ahead of the front intensifying screen. In this position, the film is underexposed while the full sheet of regular film, which has been placed in the usual position between the intensifying screens, receives the effect of the intensifying screens. Both regular and no-screen films are developed in the usual manner. To date no advantage has been found in using the underexposed or soft tissue radiograph for anything except the profile, hence the cutting of the film into four pieces.

Methods of Serial Study

Cephalometric radiographs offered for the first time an accurate technic for appraising growth changes in the living. Present methods of study accept the principle of dividing the head into brain case and face. The area dividing the two is called the hafting zone or cranial base. It is made up of the sphenoid, basilar portion of the occipital, the ethmoid, and the frontal at the nasal suture. That portion anterior to sella turcica is called the anterior cranial base, while the posterior cranial base extends posteriorly to basion. The anterior and posterior cranial bases form the saddle angle which is recorded by nasion, center of sella turcica and basion (on the anterior lip of foramen magnum).

At present there are two planes within the cranial base, which are commonly used for superposition in serial studies. Broadbent introduced the Bolton plane which extends from nasion to Bolton point (the superior point of the notch on foramen magnum directly behind the occipital condyles).

The Bolton plane can be considered as representing the full cranial base, that is, both anterior and posterior bases. The other plane most commonly used is SN. It represents the anterior cranial base.

We know that the cranial base may change form during growth. A. G. Brodie, Jr.[19] in a serial study of 30 cases from 3 to 18 years of age found the average cranial base angle to be 130 degrees, with a range of 120 to 143 degrees. During the growth of these children, twelve maintained the same cranial base angle, while eighteen changed, one as much as 9 degrees. Of those changing, 8 decreased, becoming more acute and 10 increased, becoming more obtuse.

Björk[20] made a study of cranial base development on 243 Swedish boys from 12 yrs. to 20 yrs. of age. At 12 years of age he found the mean cranial base angle NSBa to be 130.8° with a standard deviation of 4.2. Regarding changes during growth, he has this to say, "The age changes which take place in the cranial base angle, nasion-sella-basion, from 12 to 20 years have a standard deviation of no less than 1.9 degrees, with a variation range of 10.5 degrees. In other words, the cranial base angle tends to widen in some cases and in others it closes."

Such changes present the problem illustrated in Fig. 14. A change of the angle NSBa means that the angle SNBa must also change; thus, there is a shift in the relationship of planes SN and BaN. Since the BaN and Bolton planes do not show appreciable change of relationship, we have accepted Brodie Jr.'s findings as evidence that the cranial base triangle, Bolton, sella turcica, nasion, may change form. Direct superposition of a large number of cases verifies this deduction. Therefore, it makes considerable difference whether the Bolton plane or the SN

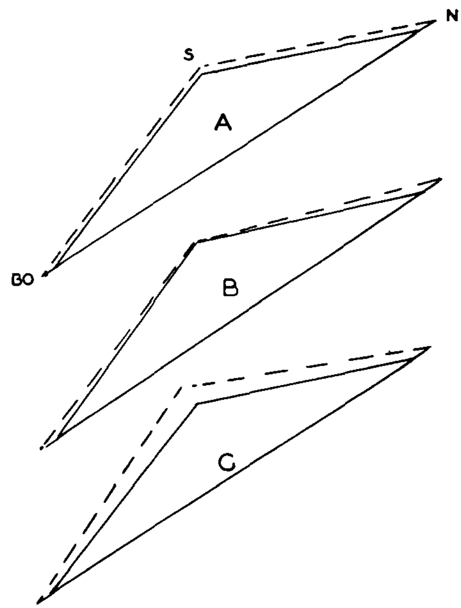

Fig. 14 Possible changes of the Bolton triangle during growth.

plane is registered for serial studies in those cases in which the saddle angle changes during growth. An example is seen in Fig. 15 showing growth of a boy from 8 yrs. to 16 yrs. in which there is a 4 degree increase in the saddle angle. Superimposed on SN, he would appear to have had resorption of the occipital bone and its condyles. This is difficult to rationalize. Superimposed on the Bolton plane, cranial growth seems more logical. The opposite effect is seen when the saddle angle decreases. The patient then appears to be losing forehead and getting excessive growth at the occipital area.

The effect on the profile is seen in Fig. 16. This is important to the orthodontist as he is concerned about the ratio of antero-posterior growth at nasion, maxilla and mandible. This ratio determines the individual's profile. These illustrations and experience in correlating cephalometric appraisals

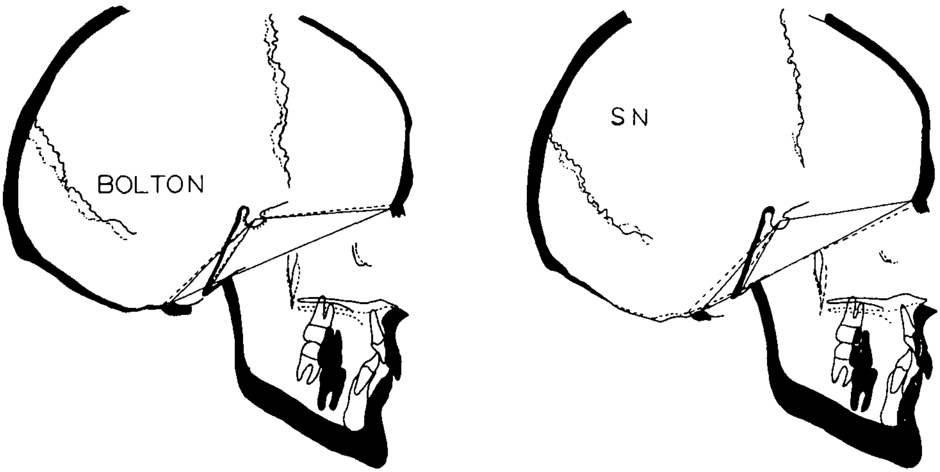

Fig. 15 Two current methods of superposition in serial studies illustrating how changes in the saddle angle affect interpretation of cranial and facial growth.

with photographs indicate that the full cranial base, or Bolton plane, is the better on which to superimpose when studying the profile in relationship to facial typing. I believe the BaN plane will prove to be equally good and easier to locate.

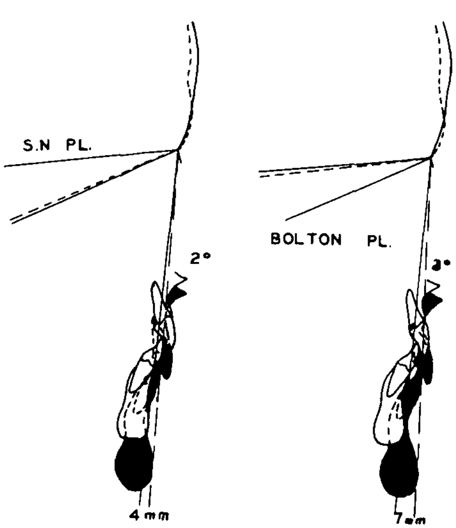

Fig. 16 Same case as Fig. 15 showing effect upon mandibular prognathism of superposition on Bolton and SN planes. Registered at nasion.

EXAMPLE OF A PROFILE ANALYSIS

One case will be sufficient to illustrate the use of cephalometrics in the analysis of the profile. The soft tissue profile of a 14 yr. 4 mo. old boy is shown in Fig. 17, left. The radiograph is oriented with a 2° upward tip of the Frankfort plane as this was his photographic deviation while in normal head posture. By comparison with our concept of the average we see that:

(1) We are dealing with a retrognathic, highly convex face.
(2) That the lower denture base is well back of the maxillary base.
(3) The upper and lower incisors are procumbent and their crowns well ahead of the facial arc.
(4) That lips are bulky and not in harmonious balance.

One should get much help in planning treatment from these simple observations.

For a detailed analysis, the full lateral radiograph was traced and angles of the Downs' analysis plotted on the polygon graph suggested by Vorhies and Adams, Fig. 18.

We now find that our first opinions

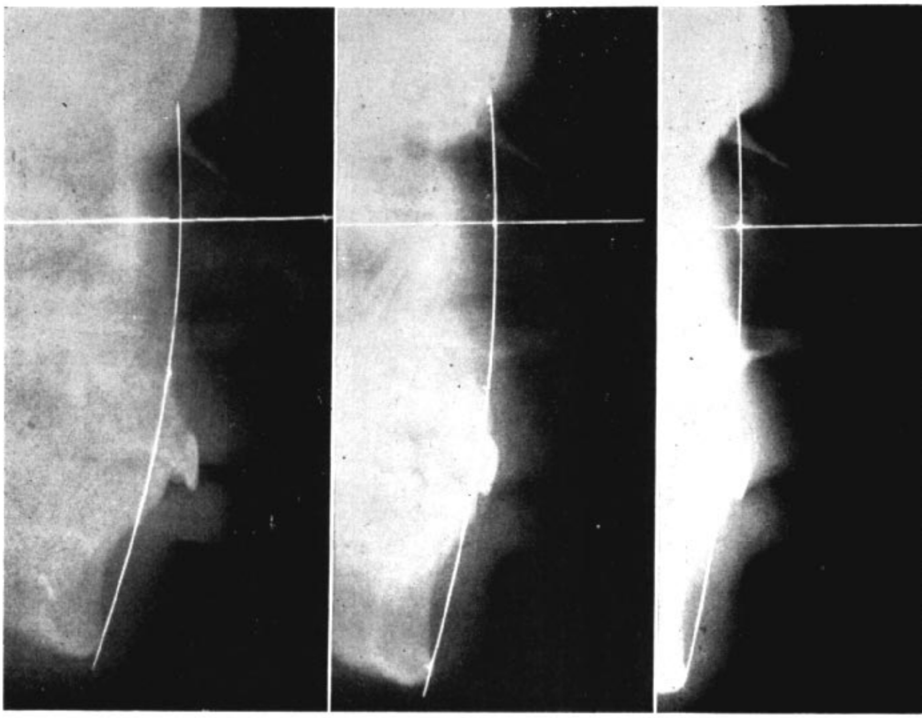

Fig. 17 Soft tissue progress radiographs of treated case illustrating the facial arc and denture profile position.

were correct and we are able to define the amount of deviation of the patient's pattern from the average. This tells us that his profile is more convex than is usually found in excellent occlusions, but not enough to be classed as dysplastic. Further, and of considerable importance, there is a good correlation of the profile, even though excessively convex. The low Y axis for this highly convex face and the not too high mandibular plane are significant, for they are two of the factors indicating that we may expect satisfactory growth of the facial pattern.

The denture pattern should be on the same side of the graph for the best profile balance. Although this is true, it is much too far out of line. It records the amount of dental protrusion which is evident in the profile tracing. Treatment should include a considerable reduction of the dental protrusion.

The result of treatment upon the profile and the changes that took place after release from retention up to the age of 17 years are shown in the soft tissue profiles, center and right Fig. 17. It is obvious that there was considerable denture retraction and improvement in tissue balance made possible by a four bicuspid extraction. The retention period was short, and a satisfactory functional balance was obtained with a minimum amount of occlusal equilibration. The case remained stable up to the last record at 17 years of age.

For a detailed analysis of treatment and the subsequent observations the recordings are shown in Fig. 18. The upper polygon of the skeletal pattern shows a steady change toward the mean. The facial angle has increased 3° and the angle of convexity has reduced by 5° until now the pattern lies within the range of the normal stan-

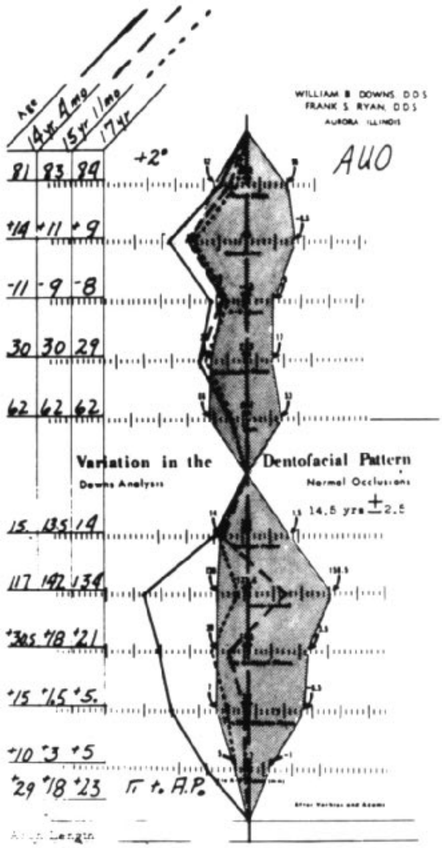

Fig. 18 Composite graph of case before treatment, at retention and subsequent to release of retention.

dards and is well correlated for his type.

In the denture pattern at retention, the dash line shows a 7 mm. lingual movement of the upper incisor, 13.5° uprighting of the lower incisors, and a 11.5° lingual tipping of the upper incisor, resulting in a 25° change of ⌊1 to ⌈1 . This places his denture position very close to the mean, which does not correlate well with his high degree of facial convexity. At the last record, thirteen months later, the dotted line, there has been a relapse to what I interpret to be a better balance with his skeletal pattern.

The patient's photographs, Fig. 19, agree with the cephalometric analysis of the profile. Undoubtedly, some will object to the fullness of the mouth area. He has about three years to mature, however, and his records have shown that his mandible is moving forward faster than the maxilla. Thus, his profile is changing in the direction of average pattern. We hope this will be accompanied by soft tissue improvement. Should his occlusion hold as well as it has to date, we have reason to expect a satisfactory functional and esthetic balance as an adult.

Summary

Cephalometric recording has provided a method of accurately expressing many of the relationships of the component parts of the face and the changes which occur during growth and development. This led to a statistical evaluation of the average and provided

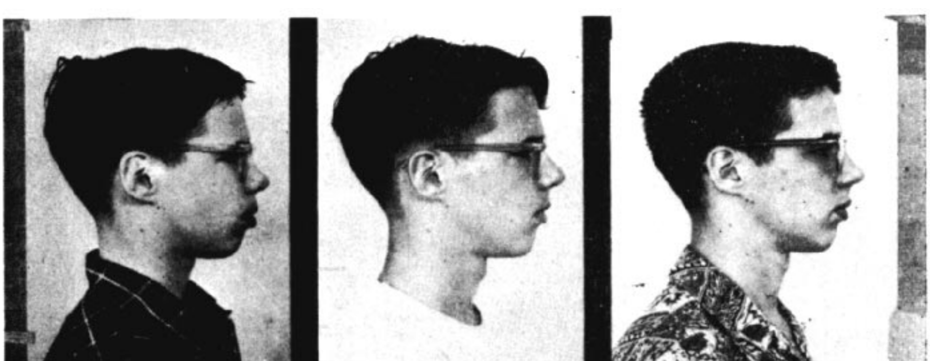

Fig. 19 Photographs of patient shown in Figs. 17 and 18.

a means of expressing deviations from such averages. Extensive studies by a number of workers have shown our orthodontic problems to be very complex when viewed in terms of the variations of the dentofacial pattern. Likewise, we are dealing with large variations, both quantitatively and qualitatively, in growth and development. While individuals vary greatly in facial type and pattern, those possessing optimum oral health, functional balance and esthetics have certain common profile characteristics.

Malocclusions present two general problems; either the patient has a good profile balance including physiological muscle balance, or an imbalanced profile and perverted muscle tensions. In the first instance most malocclusions are characterized by inadequate arch length. The problem then is to create a functionally balanced occlusion at the same time maintaining the satisfactory profile balance.

In the other group the patient presents both profile imbalance and malocclusion. Here one has the double task of creating the best possible profile balance and occlusion. If both of these can be attained during the active treatment, the patient has the best chance of gaining the full benefits of treatment. This paper has endeavored to analyze and differentiate between good and poor dentofacial profiles.

314 North Lake St.

References

1. Downs, W. B., 1948: Variations in Facial Relationships: Their Significance in Treatment and Prognosis, Am. J. of Ortho. 34: 813-840.
2. Downs, W. B., 1952: The Role of Cephalometrics in Orthodontic Case Analysis. Am. J. of Ortho. 38: 162-182.
3. Broadbent, B. H., 1941: Ontogenetic Development of Occlusion. Angle Orthodontist, 11: 223-241.
4. Brodie, A. G., 1941: On The Growth of the Human Head From the Third Month to the Eighth Year of Life. Am. J. of Anat., 68 No. 2, Mar. 15.
5. Björk, Arne, 1947: The Face in Profile Svensk Tandläkare—Tiddskrift, Vol. 40, No. 5B.
6. Vorhies, J. M., 1951, and Adams, J. W.: Polygonic Interpretation of Cephalometric Findings. *Angle Orthodontist* 21: 194.
7. Cotton, W. N., 1951: Variations in Facial Relationships in American Negroes of the San Francisco Bay Area. Unpublished report, University of California College of Dentistry, Division of Orthodontics.
8. Takano, W. S., 1950: A Study of Variations in Facial Relationships in the Adult Nisei with Excellent Occlusions. Master's Thesis, University of Washington.
9. Wong, W. M. W., 1950: Cephalometric Appraisal of American Chinese of San Francisco, Unpublished report, University of California College of Dentistry, Division of Orthodontics.
10. Craven, A. H., 1952: Department of Orthodontia, University of Illinois, Unpublished data.
11. Wylie, W. L., 1951: Discussion of "Ethnic Variations in Downs Analysis", Angle Orthodontist, 21: 214.
12. Hapak, F. M., 1953: Department of Orthodontia, Dental College, Indiana University. A Study of Normal Deciduous Occlusions. Unpublished.
13. Krogman, W. M.: 1953 Progress report D87-D87-(C3) Philadelphia Center for Child Research, Philadelphia.
14. Baum, A. T., 1951: A Cephalometric Evaluation of the Normal Skeletal and Dental Pattern of Children With Excellent Occlusion. *Angle Orthodontist* Vol. 21: 96-103.
15. Nanda, R. S., 1955: The Rates of Growth of Several Components Measured From Serial Cephalometric Roentgenograms. Am. J. of Ortho. Vol. 41: 658-673.
16. Petraitis, B. J., 1951: A Cephalometric Study of Excellent Occlusion and Malocclusion of Children and Adults. Master of Science thesis, University of Washington.
Baird, F. P., 1952: A Cephalometric Evaluation of the Skeletal and Dental Patterns of Seven to Nine Year Old Children with Excellent Occlusions. Master of Science thesis, University of Washington.
Barnes, J. Q., 1954: A Serial Cephalometric Study of Children with Excellent Occlusion Using Angular and Linear Measurements. Master of Science thesis, University of Washington.

17. Tweed, C. H., 1954: Frankfort Mandibular Incisor Angle (FMIA) in Diagnosis Treatment Planning and Prognosis. *Angle Orthodontist* Vol. 24: 121-169.

18. Steiner, C. C., 1953: Cephalometrics for You and Me. *Am. J. of Ortho.* Vol. 39: 729-755.

19. Brodie, A. G., Jr., 1955: The Behavior of the Cranial Base and Its Components as Revealed by Serial Cephalometric Roentgenograms. *Angle Orthodontist,* Vol. 25: 148-160.

20. Bjork, Arne, 1955: Cranial Base Development. *Am. J. of Ortho.* Vol. 41: 198-225.