Rapid evaluation of facial dysplasia in the vertical plane

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Orthodontists in increasing numbers today believe that a recognition of facial variation forms a part of modern orthodontic treatment planning. For many of them this consists of measuring and describing a given patient's facial pattern in relation to understandable and acceptable standards. While it is safe to assume that most men are willing to invest whatever time and effort seems to be productive of worthwhile results, any innovation for performing this evaluation quickly, without sacrifice of reliability, would be most welcome. Besides being convenient, the method should localize anatomically the basis of the anomaly which has significance in terms of orthodontic prognosis.

An earlier paper[1] offered an "assessment of anteroposterior dysplasia", which sought to judge how well the component parts of the face went together. The end result was a net score intended to indicate the degree by which certain disharmonies were compensated for (or reinforced) by variation elsewhere within the area of affected parts. The title defined the deliberate limitations set — one plane of space — and gave implicit promise of an extension of the plan to two of the other three planes of space. The method of assessment has won some acceptance in teaching institutions and with orthodontists in private practice, and since it proved to be something less than a perfect instrument, it has attracted comments and criticisms, all of which have been welcome. Dealing with some of them provides a kind of beginning for this paper.

THE BASIS OF ANTEROPOSTERIOR DYSPLASIA

The method of assessment relied heavily upon a previous study[2] which sought only to test for significant differences in facial morphology (other than dental) between two classes of malocclusion. Landmarks selected for the research, and linear dimensions using those landmarks later went into the formulation of standards for assessment of anteroposterior dysplasia. Because those landmarks were not in the beginning selected for ultimate application to routine appraisal, and because the samples were not selected with this in mind either, it is not surprising that better landmarks exist, nor that standards might better have been based on a different sample. No one has implied that the usefulness of the method is vitiated by these shortcomings, nor that the inherent idea of the assessment would be improved by substituting new landmarks and new samples for old standards. On the other hand, some of these suggestions seem to be well taken, and nearly all merit discussion.

SOME PROPOSED REVISIONS

It has been proposed that the "point A" of Downs[3] be substituted for the anterior limit of the maxillary denture

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base, rather than the anterior nasal spine. This suggestion is a good one, for the length of this spine varies appreciably, without having particular significance in the facial pattern, and it may furthermore be burnt out in the process of taking a lateral film. We used ANS simply because at the time it was an acceptable landmark in routine use, and point A had not yet been proposed. If this revision were to be adopted, then, "maxillary length" would be measured by projecting both point A and the pterygomaxillary fissure to Frankfort, and taking the distance between these two projections.

A similar objection has been raised to the manner in which mandibular length was defined: instead of projecting the most posterior point on the head of the condyle to the mandibular plane, it has been suggested that Bjork's[4] *articulare* be used. *Articulare* is the point where the outline of the posterior border of the mandible crosses the base of the skull, and is readily seen in lateral films, whereas the point originally defined on the posterior surface of the condyle is very often obscured.

We cannot accept, however, the suggestion that point B (Downs) should be substituted for the most anterior point on the chin and projected to the mandibular plane, on the same basis as A might be substituted for ANS. Although we frequently see patients where a Class II dental arch relationship exists, with B located posterior to its ideal position and pogonion well forward, the chin-point (unlike ANS) contributes in an important fashion to the facial pattern, and dropping it would lead to loss of information.

Still another criticism finds us in a resistant mood; that it is irrational to measure first the total length of the maxilla (from pterygomaxillary fissure to either A or ANS) and then to measure from pterygomaxillary fissure to the projection of the buccal groove of the maxillary first permanent molar. The irrationality is alleged to lie in measuring this latter distance, as we admittedly do, twice. Each measurement is necessary for this asessment: we can unmistakably identify certain orthodontic patients whose chief departure from good facial balance consists of an overly long maxilla, and others where the maxillary dental arch shows a forward placement upon the base, with the rest of the face in good harmony. While these two conditions frequently co-exist, it is desirable to measure them both, and to measure them separately. By including both of these values in the four figures, which are balanced against overall mandibular length, it is possible to arrive at the desirable end of having a zero score in the absence of anteroposterior dysplasia. That this occurs has led some to conclude that we contrived to have it that way, and that double measurement was necessary to accomplish that end. Although other reasons have been stated above for measuring both, we would still resist that idea that there is something sneaky about measuring both of these linear values; such a contention is like saying that $a+b$ is good algebra, but $2a+b$ is not.

Another suggestion is that this method of assessment would have been better with the standards based on measurements derived from normal occlusions, rather than upon a sample of Class I malocclusions for each sex. Although we have half-heartedly contended that complete normality was not necessary in the standard, but merely the absence of anteroposterior dysplasia, we would at the same time concede that subjects meeting all the desirable criteria of good occlusion and facial balance should provide still better standards of comparison.

Still another improvement in sampling might be made; instead of being content with a mean age approximately that of the typical patient at the beginning of orthodontic treatment, one would do well to limit selection of the sample entirely to a group within stated limits of age. In the work presently reported this precaution has been observed.

Before disposing finally of the previous work concerning anteroposterior dysplasia, we must reluctantly record the fact that unintentionally we confused the reader by transposing Figs. 2 and 5 in the original publication; two observant readers have written to point out this error. As published the two figures referred to in the text do not illustrate the points being made in the written account. The author might easily blame the editor for this error, except for the fact that in this instance author and editor were one and the same.

We should at this time also record the fact that we consider our original terminology poorly conceived in that we used the term "orthognathic" as the opposite of "prognathic". We have since substituted the term "retrognathic" as a more suitable antonym for "prognathic".

Measuring Faces with Angles

If you were to set out systematically to study all the available methods for analysis of headfilms which involved measurement, you would discover that angles predominate as a method of measurement, that linear values in millimeters are also used, and that in some instances one linear value is divided by another to provide an index. Some of the advantages and disadvantages inherent in common practices can now be considered.

An angle can only measure the *relative* position of the three (or four) points which locate the lines which form the angle. The angle cannot in itself provide an absolute measure, although it is conceivable that by measuring several angles a judgment could be reached as to an absolute departure from an accepted standard. For example: in the Downs analysis, the angle of convexity measures the *relative* prominence of the maxillary denture base, with respect to the chin. The angle is formed by connecting nasion (N) with the midline concavity in the labial plate of maxillary alveolar bone (A) with the most prominent point on the bony chin, pogonion (P). If the three points lay in a straight line, the angle would manifestly be zero. By definition, if the angle peaks forward, it is considered positive, or negative if A should lie behind a line connecting N and P. A positive angle of convexity connotes a face in which the maxilla is, *with respect to the mandible,* relatively prominent. The condition could be attained with the maxilla being, in an absolute sense, markedly developed in an anteroposterior direction. It could just as readily be called a recessive chin. Which is it?

By measuring another angle defined by Downs — the Y axis angle — one can speak with more assurance as to which condition is responsible for the positive angle of convexity. The Y axis passes from the center of sella (S) through gnathion (Gn), a point on the chin just below P. The angle which it forms as it intersects the Frankfort plane is measured in the Downs system of appraisal. While this angle could conceivably be large because of a forward situation of sella turcica, finding this angle to be large when the angle of convexity is positive and relatively large would confirm the suspicion that the chin was the offender in creating an unprepossessing appearance, rather than a prominent maxilla. The facial angle, formed by the intersection of the line N-P with Frankfort plane, would add further evidence towards making the distinction. Thus while angles do not, taken one at a time, provide judgments, they may reinforce one another to present an accurate impression of the craniofacial pattern.

Outweighing in large measure the disadvantages enumerated above is the convenient faculty afforded by angles for avoiding difficulties of *size;* because angles do not readily measure size, naturally enough allowances for differences in size need not be made. Thus an angular measurement will be informative whether the individual considered is large or small, and for all practical purposes it matters not whether the difference in size is based on individual variation or upon age.

The use of linear values

There has been a certain reluctance among those employing cephalometric films in the appraisal of patients to use the seemingly straightforward device of a millimeter rule in assessing component parts of the facial pattern. Broadbent clearly intended that accurate measurement of films be possible with the Broadbent-Bolton apparatus, for in the lateral film he provided a leaded millimeter scale which made possible the almost automatic compensation for the inevitable, however slight, enlargement of the image traceable to divergence of rays. The projection of this accurately calibrated scale to the film is enlarged to precisely the same degree as are midline structures of the patient, and when the apparatus is used as intended, this scale always appears on the lateral films.

Recognizing the fact that the image seen on the film is slightly larger than the anatomical parts protrayed is not, however, the chief deterrent which keeps men from using measurements of distance rather than angles. After all, if standards or "normals" are to be employed — and it is difficult to see how one could manage without some frame of reference — the problem of size distortion is best dealt with by letting the slight amount of enlargement go uncorrected in the standards, whether they are tracings to be employed with a precise method of superposition, or measurements derived from a statistical study. If some researcher has decreed that 52 mm. is a good length for the maxilla, and has contrived a method of assessment incorporating that figure, you may use it on your patient without bothering about correction for ray divergence in your patient — provided the researcher did not "correct" his original data. What then, prevents the widespread use of lengths in cephalometric appraisal, when millimeters have always been the principal units of measurement with the physical anthropologist?

The objections one is sure to hear, once one proposes the use of linear values, perhaps provides the answer to this question. Apprehension is expressed at this seeming disregard of the fact that children become larger as they grow older; a few critics also note that there are at a given age, differences in size based simply on individual variation. Actually, the second point is a more important one, and neither should be disregarded. On the other hand, the student of facial pattern who assiduously avoids linear values because of these objections runs the risk of loss of information as he seeks the shelter of angles and proportions, which are after all only relative in their manner of measurement. Our initial attempts with absolute measurements set out to discover just how far astray they might lead us, and we found that by the application of the same commonsense as is required in utilizing relative measurements, the pitfalls of linear values could also be avoided.

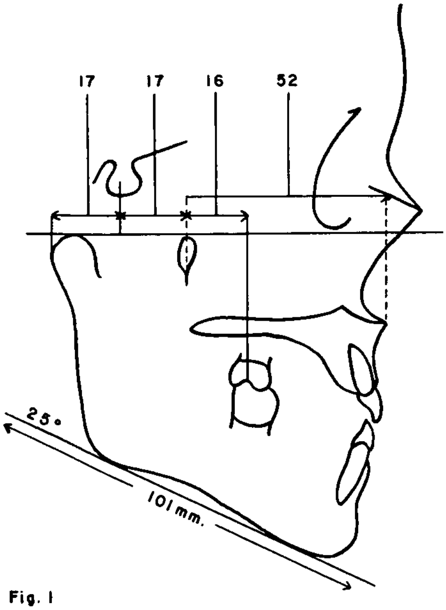

Fig. I

Fig. 1 The "standard" face pattern (female) from the assessment of anteroposterior dysplasia. Vertical dysplasia is absent.

INTERRELATIONSHIPS OF ANTEROPOSTERIOR AND VERTICAL DYSPLASIA

Our discussion of angular values stated that while it was not impossible, through the use of angles alone, to identify portions of the face implicated in a poor facial pattern, it was a somewhat roundabout procedure. In developing an assessment of anteroposterior dysplasia we sought to localize in anatomical terms the portions of the face which materially affected pattern for better or worse; the fact that we began with the anteroposterior plane of space is not too difficult to justify. The Angle classification is essentially oriented in this plane, and classifies malrelations of the arches into three categories based upon shifting tooth relationships anteroposteriorly. The Frankfort horizontal was the principal plane of reference in Simon's gnathostatics, a useful device when not pushed too far. Thus precedent was established and we expected to deal with the most rewarding plane of space with respect to facial analysis when we began with anteroposterior relationships. Hindsight demonstrated this is to be ignorance borne of lack of method, or at least it became apparent, through the use of a technique capable of measuring anteroposterior disharmonies, that the vertical plane of space was at least as important. Fig. 1 reproduces the "standard" values for a female of approximately 11.5 years; it will be remembered that there was no insistence upon adherence to these values; criteria for good facial balance would be satisfied if merely these proportions were maintained, or even if there were compensation or canceling out of an aberrant value by some other value. Under these circumstances a zero net score for A-P dysplasia, or close to it, would be obtained. Those who began to apply the method to clinical problems soon found, however, that substantial positive scores — supposedly indicative of mandibular overdevelopment or maxillary insufficiency — could be run up on cases which in no way resembled Class III malocclusions. In fact, positive scores were known to be found in cases with "Class II faces and Class I occlusion". Fig. 2 is a reconstruction of Fig. 1, achieved simply by tilting the Frankfort mandibular plane angle up from 25° to 40°, and redrawing the mandible in order to maintain the same prominence of chin as before, measured by the facial plane. These liberties have increased the effective length of the mandible from 101 to 112 millimeters, approximately 10%. Here the score would go up from zero to +11, without any increase in the prominence of the chin. This demonstrates how vertical dysplasia — the Frankfort mandibular plane angle serves to record the amount of vertical dysplasia without localizing it — intrudes upon the assessment of anteroposterior dysplasia with misleading implications.

Fig. 2 portrays a face where vertical dysplasia is high; although mandibular length is substantial, much of that length serves to balance dimensions of the maxilla as they are projected to the Frankfort.

The schematic demonstration might have a different form, had we elected not to maintain the same favorable facial angle in our reconstruction, thus permitting the chin-point to move back. While the net score might then not have increased to +11, it would still have been positive and there could well have been established what is sometimes called a "Class II face with Class I occlusion". If our fond hopes were to be attained, however, orthodontists would abandon the habit of using the Angle classification to describe faces, or at least not require the designation "Class II" to cover so much territory. This cannot be equated with "a facial pattern which I do not like, and which is not a Class III". Actually, if a search were to be made for truly retrognathic faces, i.e., those in which vertical development at the profile is relatively more marked than is depth, one should begin to search among individuals whose arch relationships are known to be Class I, not Class II.

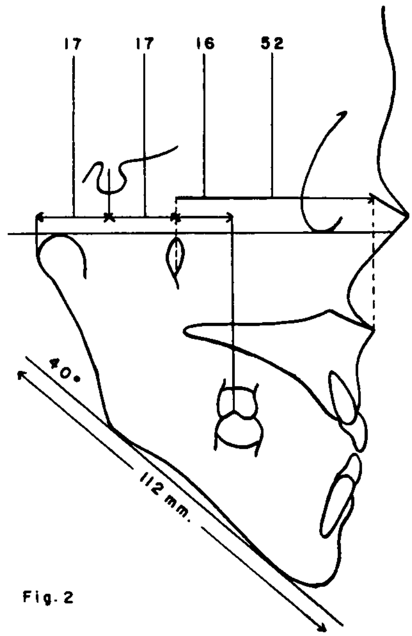

Fig. 2 The same pattern, arbitrarily redrawn, to show how more mandibular length is required to maintain an adequate profile when *vertical* dysplasia is increased. An increase in the Frankfort-mandibular plane angle may be taken as increase in vertical dysplasia.

Localizing Dysplasia Anatomically

We have said that angles fail to tell us what facial parts are aberrant in poor facial patterns. In seeking to make this identification, we might be said to be substituting anatomy for geometry.

In a previous report, one of us (ELJ)[5] showed the particular portions of facial anatomy which might be expected to vary with known alteration in the Frankfort mandibular plane angle. Accepting this commonly used criterion as one which measures vertical dysplasia without localizing it, Johnson grouped 150 untreated orthodontic patients with respect to magnitude of the Frankfort mandibular plane angle, establishing four groups in all. From the oriented lateral headfilms from which the angle was measured in each case, it was demonstrated that as the average Frankfort mandibular plane angle increased, (1) the group average for profile height increased (chiefly between the hard palate and the chin), (2) the magnitude of the angle formed by the junction of ramus and body of the mandible increased, (3) and the glenoid fossa became progressively higher in its location in the cranium. Furthermore, the group with the lowest mean Frankfort mandibular plane angle had a mean ramus height substantially larger than the means for other groups with progressively poorer patterns. Interestingly enough, however, had this one group been eliminated from consideration, lack of ramus height could not have been demonstrated to contribute, statistically speaking, to the poor facial pattern. Thus it would seem that while generous length in the mandibular ramus predisposes to a good face of a very definite type, lack of it is not uniformly a factor in the production of poor facial types. It goes without saying that individual exceptions to this statistical generalization may readily be found.

From experience gained in the study just summarized, methods became apparent for refining data in a second study, with the objective of relating findings to clinical practice. In order to keep ages of subjects within a reasonable range, and comparable with the age at the beginning of orthodontic treatment in the greatest number of individuals, films were drawn from the University of California collection of cephalometric films by means of punched card procedures, so that only children aged 11 to 13 (to the nearest birthday) would be eligible. In practice, this meant that the youngest subject would be older than 10 years and 6 months, and that the oldest would be less than 13 years and 6 months. In every instance these films had been taken as a part of pre-treatment records, and no one was included who had previously had orthodontic treatment.

In extending the work on a different sample, two new objectives were set first, to substitute for the precisely measurable value, Frankfort mandibular plane angle, a subjective rating of facial balance and harmony as the orthodontist sees it, and secondly, to arrive at a method whereby the anatomical factors contributing to facial balance in the vertical plane might be quickly and easily assessed.

The films were appraised one by one, prior to any measurements being made, and each was designated as having "good", "fair", or "poor" facial balance. This appraisal was made quite independently of the relation of the mandibular plane to the Frankfort plane, and at least as much attention was paid to the profile as to the other relationship.

Landmarks Established

Guided by the previous study in which certain anatomical parts were demonstrated to affect the Frankfort mandibular plane angle, landmarks for this one, which would presumably furnish standards, were selected. The exact location of measure-points used before have been described[5], but these well accepted points presented one disadvantage. We sought to measure these things: ramus height, the angle at which the ramus joins the body of the mandible, length of the lower border, and the height of the face — not only total height, but also the percentagewise contribution of the lower face to the total height of the face. Well established measure-points would have served, and would not have been inconvenient in a research study. However, when one contemplates the providing of a method whereby orthodontists may routinely appraise patients, there is much to be said for combining landmarks, or making one do where two or more have been used in the past. This might be extended to the point where the protractor or other measuring device could be left in one position while several determinations were made.

Ramus height was accordingly defined by locating a point on the summit of the condyle and another at the gonial angle*, and measured by taking the distance between the two. This, in itself, was not an innovation. The length of the lower border was taken

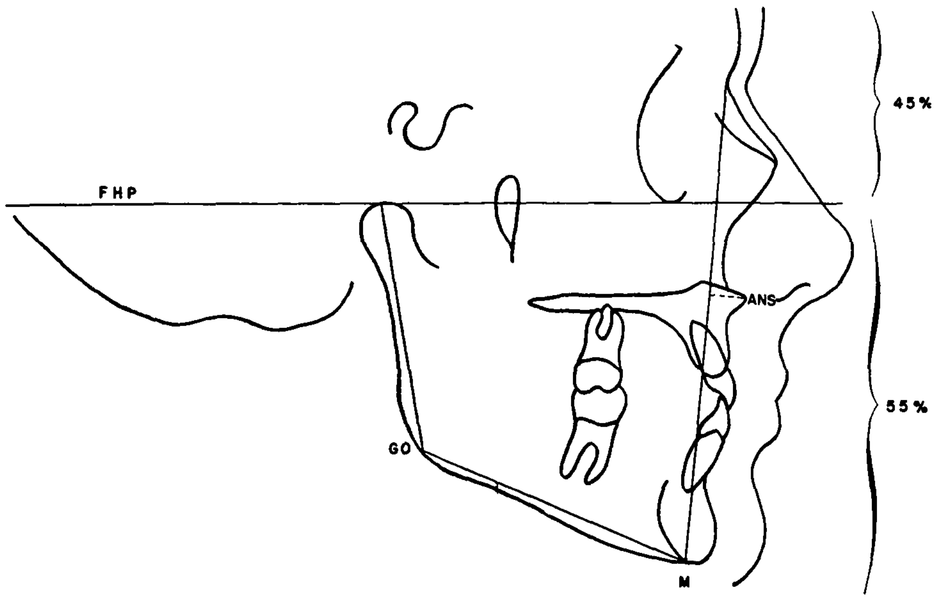

Fig. 3 Landmarks and planes used in this report: total face height at the profile is taken as the distance from nasion to menton, with a division into upper and lower face provided by a perpendicular to the line *nasion-menton* erected through the anterior nasal spine. ''Lower border'' is defined as the distance from menton to gonion, and ''ramus'' as the distance from gonion to the summit of the condyle. ''Condylar angle'' is in turn derived from the lines connecting gonion with ''condyle summit'' and ''menton'' respectively. These definitions do not coincide with previous usage, but the innovations are intended to hold the number of landmarks to a minimum so that transparencies may be based upon them for rapid evaluation of headfilms.

as the distance between gonion and menton. If this distance were independently defined, logic would probably dictate that the distance should extend forward to gnathion or pogonion. "Lower border" is terminated here, however, since total face height is defined for our purposes as the distance from gnathion to menton. So long as standards are set up with these arbitrary landmarks in mind, we can reduce to the allowable minimum the number of points with which we must be concerned. Total face height was in turn divided into lower and upper face height by a perpendicular to the line naison-menton, erected through the anterior nasal spine. These points are shown in Fig. 3.

The relation of the head of the condyle, and presumably the glenoid fossa, to the Frankfort horizontal was demonstrated to be significant in the previous study.[5] The distance was measured by taking the distance from the summit of the condyle, a point previously mentioned, to the Frankfort: the distance was arbitrarily called positive when the condyle lay above the plane, and negative when the condyle was below.

Mean values for each of the dimensions described were calculated for "good", "fair", and "poor" face patterns; these means are shown in Table I.

* Where landmarks of the left and right side do not coincide on the film, a mean point between the two was taken. Rather than belaboring this fact with repetition, we shall henceforth deal with bilaterally situated points as if they were single ones located in the midline.

Dimensions	Subjective Rating of Faces		
	Good n = 57	Fair n = 61	Poor n = 53
Condylar angle	122.49 ± 0.71	125.33 ± 0.60	129.26 ± 0.79
Lower border of mandible	67.30 ± 0.46	65.75 ± 0.55	64.24 ± 0.66
Ramus height	54.81 ± 0.56	52.13 ± 0.50	52.30 ± 0.59
Condyle to Frankfort	—0.54 ± 0.38	—0.80 ± 0.36	+0.81 ± 0.51
Upper face height	50.65 ± 0.38	48.92 ± 0.35	49.02 ± 0.46
Total face height	113.02 ± 0.67	113.43 ± 0.68	115.94 ± 1.04
$\frac{UFH}{TFH}$ x 100	43.84 ± 0.32	43.16 ± 0.26	42.31 ± 0.27

Table I: After the 171 cases of the study were grouped according to the subjective ratings indicated above, independently of measurements, means and standard errors of means were calculated (see table) for the purpose of determining whether significant differences exist. For these differences, see text.

Findings

In general, the findings of Johnson's previous work were confirmed. Differences between means were perhaps not so clean-cut, since the earlier work segregated the cases on the basis of actual measurement rather than by means of a subjective appraisal, which took into account factors other than a single measurable variable. Nevertheless ,it was shown that in good faces the condylar angle was less than it was in fair, and that in poor it was the greatest. Three possible differences (good-fair, fair-poor, good-poor) may be tested: each was significant at the .01 level.*

The lower border of the mandible is longer in good faces than in fair, and the difference is significant at the .05 level (t = 2.5): "poor" is shortest of all, although no significant difference between fair and poor can be demonstrated. The difference between good and poor is significant at the .01 level (t = 3.80).

It was shown once again that in a good face, adequate length in the ramus is necessary; the difference between means for ramus height between good and fair is significant at the .01 level (t = 3.55). As would have been suspected from a study of Johnson's previous work, mean ramus height in fair faces is no greater than in poor.

Measurements of the relation of the head of the condyle to the Frankfort plane were much more clear-cut in the earlier study when the mandibular plane angle was the criterion rather than a subjective rating of the face; a more marked difference between "fair" and "poor" (t = 2.99) can be shown than can be between "good" and "fair", where no significant difference exists. The difference between good and poor is significant at the .05 level (t = 2.09).

Johnson's earlier work showed unmistakably that, other things being equal, increased height at the profile characterized the poor face, with vertical development of alveolar process being the offending area, since lower face height increased with increase in Frankfort mandibular plane angle values, while upper face height did not. Clearly the progressive increase in total face height with worsening facial

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* The t-ratio is a statistical device that enables one to estimate how likely it would be for chance and chance alone to account for the difference observed; in samples of this size, t = 1.96 at the .05 level, and indicates that the odds against chance are 95 to 5, or 20 to 1: at the .01 level, t = 2.58, and the odds against chance are 99 to 1. when "t" increases above 3 the odds against chance become almost astronomical.

Sex Differences

Dimensions	Males n = 97	Females n = 74
Condylar angle	124.98 ± 0.65	126.40 ± 0.60
Lower border of mandible	65.92 ± 0.46	65.63 ± 0.48
Ramus height	53.54 ± 0.46	52.66 ± 0.46
Condyle to Frankfort	—0.54 ± 0.28	+0.02 ± 0.42
Upper face height	50.08 ± 0.32	48.80 ± 0.32
Total face height	114.92 ± 0.60	112.93 ± 0.65
$\frac{UFH}{TFH} \times 100$	43.62 ± 0.27	43.24 ± 0.35

Table II: A routine test for significant sex differences was carried out on the above means and standard errors of means. Only the absolute dimensions of upper face height and total face height show males to be significantly larger than females.

pattern could be attributed to contributions made below the hard palate. These same observations were to be seen in this second study, with total face height becoming increasingly large as the face pattern became worse. Once again, it can be shown that the height of alveolar process at the profile is the contributing factor, on two counts: first, a comparison of upper face height mean values shows that, if anything, in good faces somewhat more height is to be expected in the *nasal* area than in poor. Secondly, when the ratio of upper face height to total face height is expressed percentagewise, it is clear that the relative contribution of the dental area to face height, rather than absolute values, is what tells the story. Up to a point, the better the face, the more the upper face contributes to total height, and conversely, the less the dental area contributes. Each of the three differences susceptible of comparison in the bottom line of Table I is statistically significant; the t-ratio for good-fair is 4.17, for fair-poor it is 2.24, and for good-poor it is 6.05.

Sex Differences

A routine test for significant differences between sexes was made, and the sample of 171 cases was resegregated without respect to subjective rating of facial balance, into a sample of 97 males and 74 females. Mean values are shown in Table II. The only significant findings are those involving the absolute dimensions measured at the profile; mean total face height for males is somewhat larger than that for girls at this age, with a t-ratio of 2.26, significant at the .05 level. When upper face height alone is considered, the mean for males is again larger, with a t-ratio of 2.81, significant at the .05 level. When upper face height is expressed as a percentage of total face height, no significant sex difference exists.

Application of Findings

You will recall that we reduced to a minimum the number of landmarks employed, in order to apply these numerical data to a set of transparencies for the evaluation of headfilms. We sought to make this evaluation without actually measuring, and even without tracing. A previous attempt at California to use transparencies for this purpose was worked out in 1947, in which certain points on the profile were related to the nasion-sella plane. They were brought into workable form at about the time Downs[3] offered his method of evaluation, but his approach was so much more informative that transparencies were abandoned. In 1951 Dr. L. Bodine Higley encouraged us to re-examine their usefulness by point-

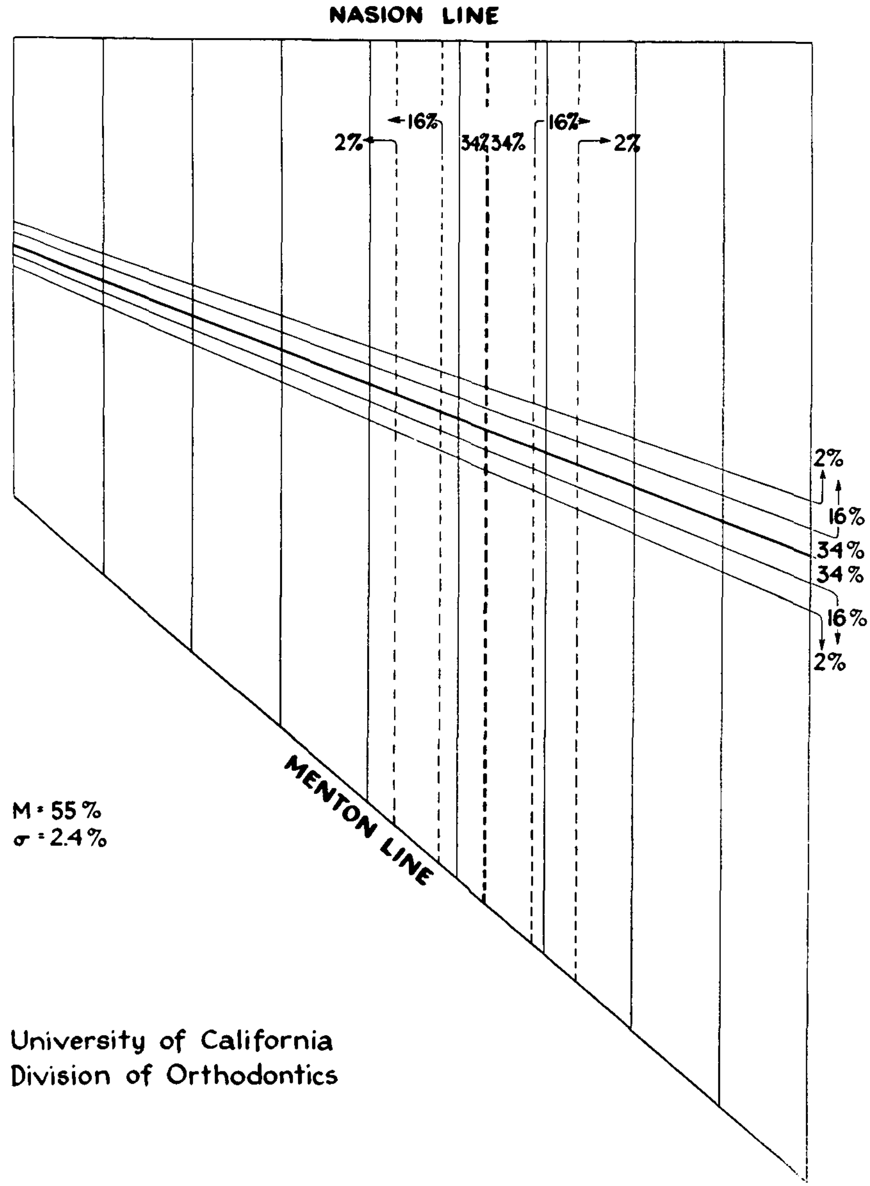

Fig. 4 When this figure is reproduced as a transparency and superimposed on a headfilm, it rapidly assesses the patient with respect to absolute size and with respect to proportions of facial height. See text for details of its use.

ing out advantages they should possess. Actually the present transparencies differ markedly from the 1947 set, but the principle remains.

Fig. 4 shows the first of two transparencies. It analyzes, without requiring specific measuring, the way in which the vertical dimension is divided into nasal and dental portions.* An ideal division, according to calculations based upon the group with good facial patterns, is 45% nasal height and 55% dental height, when nasion is the upper limit of face height, menton the lower limit, and when the anterior nasal spine serves to divide the total into nasal and dental areas. The transparency is made so that the heavy line cutting across the middle divides any one of the vertical lines into this 45-55% ratio, and would so divide any additional vertical line erected parallel to those already appearing on the chart. To use the transparency, place it directly on the lateral film. The line marked "nasion" should lie on the *nasion* of the film, with the line marked "menton" passing through *menton* of the film. Obviously, there is only one position where this will apply, and the vertical dotted lines will help to guide you to the proper placement. The size of the transparency is such that it will fit all patients. It *must* be put in place so that if a line were to be drawn connecting nasion and menton on the film, that line would be parallel to one of the vertical lines of the transparency. There is no need to draw this line, for estimation will suffice. Now note where the anterior nasal spine lies with respect to the diagonals.* You may expect to find 68% of children with good facial patterns that this division of the face occurs between the two light lines on either side of the heavy middle diagonal, 34% above the heavy line and 34% below. Other percentage figures on the transparency break down further the distribution of children with good faces — 16% lie *beyond* the first light light line, and only 2% of the entire population of good faces lie beyond the second light line. Thus we have avoided absolute measurements in our particular patient, and have made the appraisal as accurate as it needs to be — by indicating where a particular child fits into a population of good faces.

Where the vertical dimension is adequate and a tendency towards a closed bite exists, the division between nasal and dental areas will occur *below* the heavy diagnonal. A glance at the rest position film is perhaps indicated now, in the light of the work of Thompson,[7] although it should be pointed out that the transparency will be of no help here, since it has validity only for films taken in centric occlusion.

On the other hand, when the intersection of the nasal area and the dental area (as defined here) occurs *above* the heavy diagonal line, it demonstrates that the dental area, through vertical growth of alveolar process at the profile, contributes a disproportionately large amount to the total height of the face. Fig. 5 indicates strikingly the connection between the commonly-used Frankfort mandibular plane angle and

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* Brodie[6] first pointed out that in several samples studied in his laboratory, this division occurred in remarkably precise fashion.

* Actually, the division of the profile into nasal and dental areas depends upon the intersection of a perpendicular to nasion-menton, drawn through the anterior nasal spine (see Fig. 3). In many cases the actual location of ANS suffices, but where the anterior nasal spine lies well forward of the line nasion-menton, an accurate appraisal depends upon visualizing the intersection.

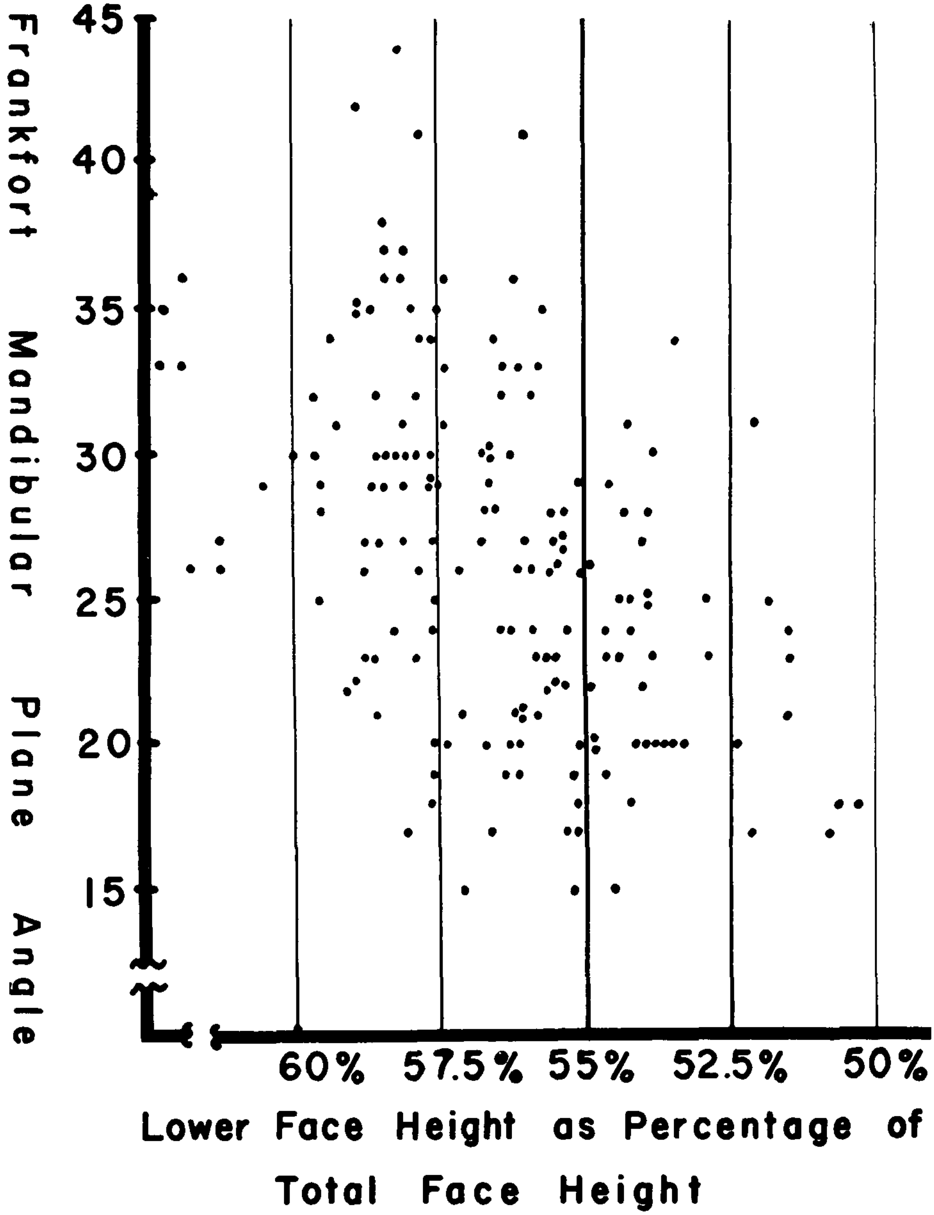

Fig. 5 The scattergram above shows the relationship between the Frankfort-mandibular plane angle, commonly used in the judgment of facial esthetics, and facial proportions at the profile as evaluated by the transparency of Fig. 4. The diagonal lines of that figure provide boundaries for five different groups; the mean mandibular plane angle for each of these groups is: 21.4, 23.5, 25.5, 29.6, 31.4 (degrees), with this angle becoming progressively larger as lower face height contributes relatively more to total face height. The coefficient of correlation for this scattergram is +0.47.

the facial attribute so quickly measured by this transparency.

So far we have not been concerned with absolute size, since this proportion of nasal area to dental area disregards size and deals with relative values. However, by taking absolute size into account while using this first transparency, we can perhaps enhance the usefulness of the other transparency which is to be discussed later. It is for this purpose that the dotted vertical lines are included. The heavy middle one represents the average total face height in "good" faces. In a population of exclusively good faces, 34% will be found between the heavy dotted line and the first of the lighter ones to the left: another 34% will be found in the corresponding zone to the right. Only 2% of such a population will be less than the length of the shortest dotted line with respect to total face height. At the other extreme, only 2% will have a total face height in excess of the length of the longest dotted vertical line on the right. Thus we arrive at a judgment of the absolute size of our particular patient, and can interpret more effectively any value which deals with absolute size. Absolute size in itself has little significance in facial esthetics: on the other hand, if this first transparency locates your patient with respect to absolute size, using as a yardstick a distribution based on good faces, the second can be used in a more meaningful way.

This second transparency appears in Fig. 6. To use it, place it so that the horizontal line lies along the lower border of the mandible and passes through the point menton. Move it to the right or left until left end of the line, where it intersects the radiating lines, lies on the mean gonion point. With the transparency in this position, three evaluations are possible: length of the lower border, height of ramus, and condylar angle. In each instance the evaluation is not precise, as it would be if a millimeter scale or protractor were used. We willingly sacrifice this precision for a gain in time, and since we consistently measure our patient by locating him in relation to a previously measured population, we need not consult an arbitrary scale of values. In our population of good faces, menton will be found 34 times out of 100 between the short heavy vertical line and the first lighter vertical to the left, with only 16% to the left of that light line. Only in 2% of the entire population of good faces will menton lie to the left of the *second* light calibration. Similar observations may be made regarding the divisions of the line to the right of the mean, except that they would of course pertain to that half of the "yardstick population" which is larger than the mean value.

How are we to interpret what we see? We recall that it has been demonstrated that the length of the lower border tends to be shorter in poor faces than in good, so that we see at a glance how our patient compares with the "good" standard. We should keep in mind, however, that we are dealing with absolute size — how did our patient compare with the "yardstick" with respect to total face height? If the patient was somewhat larger in total height than average, he should also be larger by approximately the same degree with respect to length of the lower border, for in his face a lower border of only average length will not provide ideal facial proportions. Conversely, a lower border somewhat shorter than average would not be counted as unfavorable if we had previously noted that the face seems to be small in all proportions as suggested by face height originally.

Two other assessments may be made without moving the transparency. Determine where the summit of the condyle lies, first in relation to the radiating lines. This relates the patient to

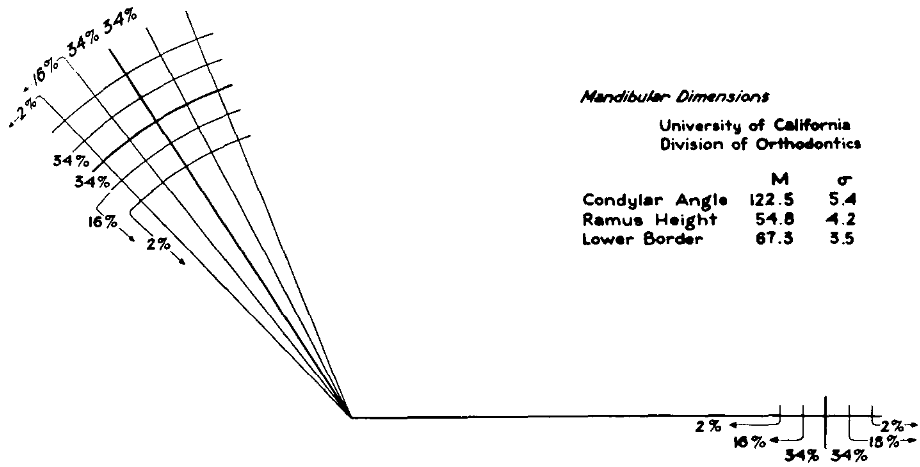

Fig. 6 This figure, used as a transparency, provides a rapid evaluation of lower border length, ramus height, and condylar angle. There has been a slight reduction in size in preparing the illustration for publication. See text for the details of using this transparency in the evaluation of cephalometric films.

our population of good faces with respect to the angle at which the ramus meets the body of the mandible. As a general rule, when this angle becomes larger, the face becomes poorer. This is independent of absolute size, so that for the moment we may disregard our initial determination of total face height.

Now note the position of the condyle summit in relation to the arcs. The heavy arc corresponds with mean ramus height in good faces, as measured from gonion to condyle summit: 34% 16%, and 2% limits are struck on either side to provide boundaries as before. It will be recalled that length in this area contributes to a good face; once again we are dealing with absolute size and we should recall what we found when we compared our patient with the "yardstick" for total face height.

Vertical Placement of the Condyle

The alert reader may have discovered that after stressing the importance of the vertical position of the condyle and/or the fossa, as a factor contributing to vertical dysplasia, we have made no provision for its assessment in an individual patient. One of the avowed objectives of this paper is to present a method of rapid assessment; Table I shows that for all practical purposes, the condyle summit should be on the Frankfort plane, or below it. We believe that this can be judged as readily by inspection as any other way.

Another circumstance argues against advancing any measuring technique — even with a transparency — being applied to this particular variable. This has to do with the fact that an artefact of technique, specifically incorrect positioning of the patient in the head-holder, may lead to the impression that matters are worse than they really are, with respect to the vertical position of the head of the condyle. Specifically, the Frankfort plane in headfilms is something of a hybrid — it depends upon orbitale*, an anatomical point, at its anterior end, and upon the ear-rod, a portion of the machine, at the posterior end. Orbitale is usually not difficult to locate accurately in a film, because it is an anatomical point. On the other hand, porion, which we would use in a skull, is simply not seen at all. The practical solution to the dilemma is to assume that the upper surface of the ear-rod is the closest possible approximation to the unseen porion, and the suggestion is valid provided the technician so orders his affairs that the patient never rises from the ear-rods. In the event that he does, all anatomical points go up with him, including the true porion, to say nothing of the angle of the jaw, orbitale and other landmarks which enter into commonly used systems of appraisal. Since the ear-rod stays down, however, the one who uses the film produced under these circumstances gets an incorrect judgment of Frankfort. When this occurs, and it goes unnoticed, the following misinformation creeps into the appraisal: the Frankfort mandibular plane angle will be measured as being larger than actually it is, and the condyle will seem to be located at a higher point in relation to Frankfort than actually obtains. Both of these erroneous observations, it will be noticed, would contribute to the view that the facial pattern is poorer than it would seem to be if the film had been taken properly. Because one cannot assume that this contretemps never occurs in one's own office, one should transfer the original Frankfort to the tracing of the final set of films, when doing a before- and after assessment of orthodontic treatment. So long as substantial errors can arise in this manner, it seems to leave this one variable for cursory, informal apprasial.

* Footnote for hair-splitters: It depends upon *left* orbitale, by strict definition; it is possible that some cephalometricians who assertedly work to *left* or *right* landmarks are able routinely to identify correctly lefts-and-rights, but they can only if they use frontal films. The rest of us are content to have Frankfort pass through a mean orbitale, situated midway between left orbitale and right orbitale.

Age and Size Difeerences

It was stated before that we selected at the outset subjects who might be considered on the threshold of orthodontic treatment, so that the findings derived from their films might be applicable in similar cases. We shall still encounter variability in actual dimensions, regardless of age, for that is the nature of the material with which we deal. Erroneous judgments based on this circumstance will be largely avoided if you simply take the trouble to use the transparencies in the sequences suggested, and if in the use of the first one you note how your patient compares in absolute size with the standard of comparison. The "zone system" of appraisal not only avoids the necessity of measuring, but also enables one to do something about the matter of size differences besides ignoring it.

Talking with Parents

Some orthodontists ask us whether the implications of cephalometric findings should be discussed with parents. Others, apparently with their minds made up on the fundamental question, want to know the best way to present such information to patients or their parents.

The answer to the first question would seem to be no different if some other aspect of professional practice were involved; it depends entirely on your willingness to clamber over a semantic barrier consisting of a substantial difference in education and experience, existing between yourself and your listener.

The attitude of parents varies all the way from "We have complete confidence in you, Doctor, and we had the films taken because you wanted them, and we don't want to hear any more about it. When can you start straightening her teeth?", to the parent so surprised at orthodontics involving anything more than teeth that a full explanation is required.

Whether one likes to volunteer information based upon cephalometric study, or is merely willing to answer questions, the transparencies seem more readily understood than some of the devices we have previously been using; the concept of "too large" or "too small" is easy enough to grasp, and lay people more readily understand severity of a condition if it can be expressed as how frequently it might occur.

Summary

Orthodontists often speak of "good" and "poor" facial patterns, usually without defining the distinction in quantitative terms, although the Frankfort mandibular plane angle and other angles are coming into increasing use in this connection. Because angles serve poorly to localize and differentiate, this study is directed at showing specifically how certain anatomical areas vary when esthetic distinctions are drawn. Lateral headfilms taken with the teeth in occlusion provided the basis for this study; 171 of these taken prior to orthodontic treatment in an age group of 11 to 13 years were segregated into 57 "good", 61 "fair", and 53 "poor", using subjective appraisal only. On each film measurements of facial height at the profile, length of the mandibular body and the mandibular ramus were made, the gonial angle was measured and the vertical placement of the glenoid fossa of the temporal bone was determined: differences between means were evaluated for statistical significance. The data show that subjective evaluation tends towards "poor" when: lower face height becomes large, when ramus height becomes short, when the angle of the mandible becomes large, and when placement of the glenoid fossa of the temporal bone is relatively high. The end product of this study is a set of transparencies for the assessment of vertical dysplasia from lateral films, so that each individual may be placed in relation to the rest of the population (with respect to a given variable) without tracings and without actual measurements being required.

Acknowledgment

This study, as well as others recently concluded or presently under way in this department, have been made possible through the generous financial support of Dr. C. W. Carey of Palo Alto, California.

Transparencies described in this article may be obtained from the Division of Orthodontics, College of Dentistry, University of California, San Francisco 22, at a price of $3.00 *for set of two transparencies.*

The Medical Center

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