The Assessment of Anteroposterior Dysplasia[1]

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Among the students of human craniofacial morphology, many of whom are orthodontists, there is a growing conviction that there is no such single entity as a "normal" facial pattern, and that dentofacial anomalies are in a large measure occasioned by a random combination of facial parts, no one of which is abnormal in size when taken by itself, but each one of which may fit badly with the other parts to produce a condition which may be called dysplasia. This paper is an attempt to provide for one plane of space a method of weighing such dysplasia, and to make the application to a group of Class II, div. 1 malocclusions. The material included herein was originally presented at the first Reunion Meeting of the Department of Graduate Orthodontia, University of Illinois, as representative of work currently being done at the University of California. Therefore, at the risk of being anecdotal, one may refer to the last time that Illinois and California department heads appeared on the same rostrum. Instead of presenting findings of recent researches, each man chose to present his concept of the fundamental basis of malocclusion and craniofacial disharmony, a sort of synthesis of many different researches. There was no collusion between them and neither one knew that the other was presenting a paper. At the same time the two papers said essentially the same thing, and even went so far as to cite from exactly the same passages in the literature. Since no one would have had the temerity to suggest that the teacher would crib from the student, it was fortunate that the program was arranged so that Dr. Brodie followed the author with his paper. Had it been the other way around, I would have been obliged to develop acute laryngitis and to destroy the manuscript, lest a well-meaning but over-zealous chairman attempt to pinch hit for me.

One of these papers has been published,[1] and the other is in press,[2] so there is not need to quote from them at length. The bibliographies published to document those papers will spare us the necessity of a long one here. What the two papers said was this: a satisfactory explanation of malocclusion and displeasing craniofacial pattern has eluded orthodontists because of the basic misconception inherent in the thinking about the problem. Observing the epidemiologist who identifies a specific vector or organism with a specific malady, and the endocrinologist who describes a pat syndrome to go with a specific hormonal dysfunction, they hoped for similar specificity with respect to dentofacial disturbances. Wylie contended that a morphological problem (and there you have clinical orthodontics) is distinctly different from a metabolic one, with far less rigid standards of normality, demanding a different point of view altogether. Brodie put it succinctly enough in his title; doubtless having in mind countless musicians who have written variations upon a theme he chose to write "A Theme on Variation". Both sought to show that variation was the very heart of morphology, that considerable variation both in size and in form is found in the parts of the craniofacial complex, and that further-

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more these variations are random, with little dependence or predictability in the variation between parts. Thus a Class III malocclusion, for instance, need not necessarily be a specific pathological entity, but merely an unfortunate combination of facial parts. Were it possible to take those same structures and dissociate them from one another, redistributing them among other individuals, it might be possible to create from them entirely acceptable dentofacial patterns. This explanation is simplicity itself, and when the concept is compared with some of the elaborate explanations for malocclusion advanced on *a priori* grounds, it seems banally obvious.

This series of papers drawn from the Illinois meeting refers to the way in which Baldridge[3], Elman[4] and Adams[5] made a quantitative study of the anomaly known as Class II, division 1. They established, statistically speaking, that the maxillary first permanent molar bears the same relation to the cranium in Class II, division 1, as it does in Class I, that the mandibular first permanent molar bears the same relation to the lower border and posterior border of the mandible in the two classes, and that the chin point is significantly farther back in Class II, division 1 than in Class I. These studies, using angles and proportions, may profitably be studied in connection with more recent work of Elsasser and Wylie[6] who added certain cranial dimensions and worked primarily with lineal values. They found, statistically speaking, that in males the maxilla was definitely longer in Class II, division 1 than in Class I, with the maxillary first permanent molar farther forward in relation to the cranium. Incidentally, the maxillary first permanent molar is situated *on the maxilla* in the same fashion in both classes; while it is somewhat farther forward in relation *to cranium* in Class II, division 1, statistically speaking the molar is situated in the same fashion on the maxilla in both classes, since the maxilla is larger in that class than in Class I. None of these differences was found in females, but the mandible was found to be significantly smaller in Class II, division 1 females than in Class I female, statistically speaking. This difference in mandibular size was limited to females only. No significant differences were found in measurements of the cranial base. What do these things mean?

That question takes us into statistical territory, a land where a special terminology rolls sonorously off the tongue, a realm in which the unsuspecting clinician may find himself confused, if not actually waylaid. The joker in the preceding paragraph is the phrase "statistically speaking." We cannot presume identity because we know there is "no statistically significant difference." As a matter of fact, the more variation found within two groups under comparison, the more difficult it becomes to show a statistically significant difference. Although no significant difference is found between means for mandibular length in Class II, division 1 and Class I males, we cannot conclude that we would therefore never find a male whose mandible was undersized for the rest of his face. Neither can we assume, because a significant difference was found in mandibular size in females, that all Class II, division 1 females fall in that class because of an insufficiency of mandibular structure.

This would require the assumption that every individual in the group behaves as does the mean for the group, which is demonstrably untrue. We cannot, then, depend upon studies of mean values alone for an explanation of a given craniofacial anomaly.

If we forget mean values and delve more deeply into these different studies of the malocclusion, we find that there is variation in each of the dimensions under study. The anteroposterior position of the upper six-year molar, regardess of how you measure it, is not the same in different individuals. It has been shown that the mandible varies in anteroposterior length to a rather marked extent, but it has also been shown that a relatively constant relationship of the first permanent mandibular molar to the lower border and posterior border of the mandible obtains. Obviously, then, reduction in size of the overall length of the mandible will oblige the tooth to be situated farther posteriorly with respect to the maxilla if the proportionate position on the base as demonstrated by Elman is to be maintained. Thus we have visualized two potential mechanisms for the production of Class II dental arch relationships: an overly large maxilla, or a mandible less than average in size. In line with the suggestion of Brodie,[7] we can visualize still another situation which would lead to a Class II relationship: maxilla and mandible well-proportioned in size, with the maxillary bone well situated with respect to the anterior cranial base, but with unusual length in the cranial base itself between the tuberosity of the maxilla and the glenoid fossa of the temporal bone. It does not matter that Elsasser and Wylie failed to find significant differences between Class I sample and Class II, division 1 samples in this cranial base area. One needs little familiarity with the statistical method to understand that failure to demonstrate significance of differences between means does not eliminate a variable as a potential factor in the production of an anomaly. If a particular anomaly such as Class II, division 1, in which there is considerable outward resemblance among all cases so classified, is actually produced through the interaction of five or six anatomical variables, then it might well be possible that the statistician would fail to find significant differences between the anomalous group and the control group with respect to a given variable, due to the fact that the other four or five factors would be throwing enough variation into the picture to make the demonstration of a statistically significant difference difficult or impossible. Inspection of tracings of actual Class II, division 1 cases and the measurements based on those tracings make it plain that the interaction of these various factors provide the basic for Class II anomalies, and there is evident need for some system of assessment.

A good start toward such a method of assessmment may be made by summing up some of the possible generalizations. We may say that each of the following factors, when greater than average in size, dispose toward a Class II relationship: the length of the cranial base between the glenoid fossa of the temporal bone and the tuberosity of the maxilla, the overall length of the maxilla, and the position of the maxillary first permanent molar as measured forward from the tuberosity of the maxilla. The only other factor involving absolute size which is to be considered is the overall length of the mandible, which of course predisposes to the Class II relationship when it is undersized.

All of these variables were measured by Elsasser and Wylie, and all but the last was measured as a projection to the Frankfort horizontal plane. All of these points were projected to Frankfort: the most posterior point on the head of the mandibular condyle, the center of sella turcica, the pterygomaxillary fissure, buccal groove of maxillary first permanent molar, and the anterior nasal spine. The critical portion of the cranial base is divided into two parts by taking first the distance from the posterior surface of the head of the condyle (calling it glenoid fossa)* to the projection of sella, and secondly, from the projection of sella to the pterygomaxillary fissure. Overall maxillary length is the distance between the projection of pterygomaxillary fissure and anterior nasal spine, and the anteroposterior position of the maxillary first permanent molar is the distance between pterygomaxillary fissure and the buccal groove of the maxillary first permanent molar as projected to Frankfort. Overall mandibular length was taken by drawing a line tangent to the lower border of the mandible and projecting to it the most posterior point on the head of the condyle and the most anterior point on the chin. It should be noted when overall mandibular length is measured in this fashion, we consider not only the length of the bone between gonion and gnathion, but also the length between gonion and the head of the condyle, and the magnitude of the gonial angle itself. All three of these factors govern the *effective* length of the mandible.

Futher study revealed that good facial balance obtained if these various facial dimensions were combined in a face as indicated in the table below and in Fig. 1:

Dimension	*Male*	*Female*
Glenoid Fossa to Sella	18	17
Sella to Ptm	18	17
Maxillary Length	52	52
Ptm — 6	15	16
Mandibular Length	103	101

These are simply the mean values for males and females of samples of Class I cases with a mean age of 11.5 years, with each of the mean values rounded out to the nearest whole number in millimeters. It should be clearly understood that no standards of "normality" are being set up which demand that each of these dimensions correspond exactly to the values in the table. It is true that when proportions such as these obtain, good facial balance prevails; the entire list might be enlarged or reduced in proportionate fashion, in which case "pattern" would remain the same. Furthermore, as we shall see later, it is not even necessary that these relative proportions be maintained, since it is possible for one dimension to vary sharply in a given direction without undesirable consequences in the facial pattern, provided some other variable obligingly compensates by departing from average size in an appropriate direction. For instance, if an overly large maxilla is to be compensated for by a variation in the cranial base, the cranial base must be reduced from average length. On the other hand, compensation in the mandible would require that the mandible be commensurately larger than average. With these concepts clearly understood, it is not difficult to work out a quantitative method for the assessment of anteroposterior dysplasia. The term "dysplasia" is not new in biology, but it has usually been applied to man in reference to gross malformations such as cleft palate. Here it is used to denote the random combination of craniofacial parts which are in themselves neither abnormally large nor abnormally small, but which, when taken together, produce an undesirable combination of parts.

The form shown in Fig. 2 is simply an expansion of the foregoing table.

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* An actual cranial landmark would be preferable, but none presents itself in this area. The presumption that the glenoid fossa lies directly above the condyle head may be challenged in certain cases, but it seems at present to be a safe compromise between strict accuracy and expediency.

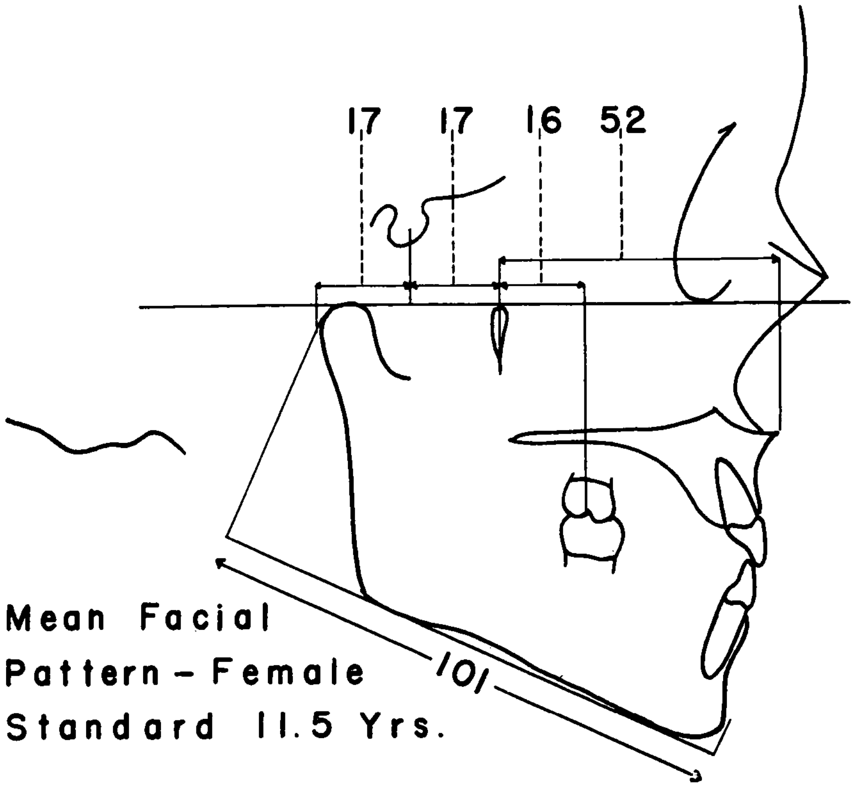

FIG. 1.

The standard values for the particular sex are entered, and there is a column for entering the particular values from the individual's headfilms. In using this technique of assessment, the patient's value is compared with the standard. If the particular value for "glenoid fossa to sella" is larger than standard, assuming for the moment that all other values correspond with the standard, the effect of the variation in that particular dimension will be to make the face relatively more orthognathic. Hence the difference between the individual's value and that of the standard is entered in the column "Orthognathic". Had the value been less than the standard value, it would have been entered in the column labeled "Prognathic".* It will readily be seen that the next three dimensions behave in the same fashion, i.e., other things being equal, wherever these values exceed the standard they will create an orthognathic tendency. Only when we come to the last value, "mandibular length," do we find the opposite condition, where a value *less* than that of the standard leads to orthognathism. When each of the values for the patient has been entered in the chart, and each compared with the standard value for that dimension, it becomes rather evident whether a given dimension leads to orthognathism or to prognathism and one may proceed to add up the number of points in each column. The difference between the totals of the columns yields a net score which expresses disproportion in one plane of space. A lack of anteroposterior dys-

* A discussion of this terminology appears later in the paper.

ASSESSMENT OF ANTEROPOSTERIOR DYSPLASIA

Female

Dimension	Standard	Patient's	Difference Orthognathic	Difference Prognathic
Glenoid fossa to sella	17	17		
Sella to ptm.	17	15		2
Maxillary length	52	60	8	
Ptm. – 6	16	25	9	
Mandibular length	101	113		12
		Totals:	17	14

P.S. ♀ Age 13

Units of anteroposterior dysplasia = prognathic-orthognathic: -3

FIG. 2.

plasia leads to zero scores, as does a combination of dimensions which happen not to conform with standard values, but which fortunately cancel one another out. A Class III tendency is manifested in positive values, while a Class II tendency is reflected by negative values.

We may now profitably analyze the application of this method of assessment to a group of patients. The first four (Figs. 2-5) are those having Class II, division 1 malocclusion. Models and photographs are not shown since they were deliberately selected as typical Class II, division 1 cases and easily recognized as such by an orthodontist. In both portions of the cranial base area (See Fig. 2) the value for the patient is substantially larger than that of the standard, with a total of 11 mm. of excessive length. Natural anatomic variation tends to separate the maxilla from the glenoid fossa. The next two lines in the chart show a tendency for compensation of a slight degree, with the maxilla slightly shorter than standard and the first molar situated distally by 2 mm. as compared with the standard. Of real benefit is the fact that the mandible is 5 mm. longer than the standard, for when the patients have as many as 11 points of orthognathism in the cranial base area, compensatory tendencies in other craniofacial areas are very desirable.

Fig. 3, with its net score of zero, might seem to contradict the statement that the case is a Class II, division 1. It was included at this point because it shows a relatively large departure from the standard value for ''sella to Ptm'', although there is adequate compensation in the other half of the cranial base area under consideration. The two maxillary dimensions cancel one another out, and the mandible is somewhat short. This case illustrates excellently the fact that all Class II, division 1's are not anteroposterior dysplasia; what is not shown in the chart, because the dysplasia is vertical rather than anteroposterior, is the fact that vertical

ASSESSMENT OF ANTEROPOSTERIOR DYSPLASIA

Female

Dimension	Standard	Patient's	Difference Orthognathic	Difference Prognathic
Glenoid fossa to sella	17	9		8
Sella to ptm.	17	22	5	
Maxillary length	52	54	2	
Ptm. - 6	16	14		2
Mandibular length	101	98	3	
		Totals:	10	10

C.K. ♀ Age 8

Units of anteroposterior dysplasia = prognathic - orthognathic: 0

FIG. 3.

ramus height, considered in relation to face height at the profile, is remarkably deficient. When this occurs, overall mandibular length does not contribute as materially to the anteroposterior dimension as it does normally, since in effect it becomes partially a vertical dimension. It is probable that this case would show a Class I jaw relationship if there were sufficient development in the ramus of the mandible.

In Fig. 4 we see that for all practical purposes the two halves of the cranial base area cancel one another out, and that there is more than adequate length in the mandible. The obvious basis for malrelation of the jaws is in the maxilla, with a first permanent molar too far forward on its base, even when one considers the fact that the base itelf is substantially larger than the standard.

Fig. 5 differs in reality very little from Fig. 4 except that the tendency for a forward positioning of the maxillary first permanent molar is even more marked.

Fig. 6 illustrates a condition where the Class II relationship may prevail due to mandibular insufficiency when all other factors mitigate against it. It also illustrates how this method of assessmment works when applied to a child small in all facial dimensions. The score mounts up consistently in the prognathic column, since each dimension is smaller than that of the standard, but in the fifth line, mandibular length, the same tendency to be small causes the difference to be entered in the orthognathic column. Unfortunately for this child the mandible is not merely 15 mm. smaller than the standard which would lead to satisfactory facial proportions, but it goes beyond that so that a Class II relationship is produced.

ASSESSMENT OF ANTEROPOSTERIOR DYSPLASIA

Female

Dimension	Standard	Patient's	Difference Orthognathic	Difference Prognathic
Glenoid fossa to sella	17	21	4	
Sella to ptm.	17	15		2
Maxillary length	52	60	8	
Ptm. - $\underline{6}$	16	22	6	
Mandibular length	101	109		8
		Totals:	18	10

H.G. ♀ Age 16

Units of anteroposterior dysplasia = prognathic-orthognathic: -8

FIG. 4.

ASSESSMENT OF ANTEROPOSTERIOR DYSPLASIA

Female

Dimension	Standard	Patient's	Difference Orthognathic	Difference Prognathic
Glenoid fossa to sella	17	23	6	
Sella to ptm.	17	22	5	
Maxillary length	52	51		1
Ptm. - $\underline{6}$	16	14		2
Mandibular length	101	106		5
		Totals:	11	8

C.F. ♀ Age 15

Units of anteroposterior dysplasia = prognathic-orthognathic: -3

FIG. 5.

ASSESSMENT OF ANTEROPOSTERIOR DYSPLASIA

Female

Dimension	Standard	Patient's	Difference Orthognathic	Difference Prognathic
Glenoid fossa to sella	17	9		8
Sella to ptm.	17	15		2
Maxillary length	52	48		4
Ptm. - 6	16	15		1
Mandibular length	101	80	21	
		Totals:	21	15

G. McA. ♀ Age 9

Units of anteroposterior dysplasia = prognathic - orthognathic: -6

FIG. 6.

ASSESSMENT OF ANTEROPOSTERIOR DYSPLASIA

Male

Dimension	Standard	Patient's	Difference Orthognathic	Difference Prognathic
Glenoid fossa to sella	18	19	1	
Sella to ptm.	18	14		4
Maxillary length	52	57	5	
Ptm. - 6	15	14		1
Mandibular length	103	110		7
		Totals:	6	12

L. C. ♂ Age 15

Units of anteroposterior dysplasia = prognathic - orthognathic: + 6

FIG. 7.

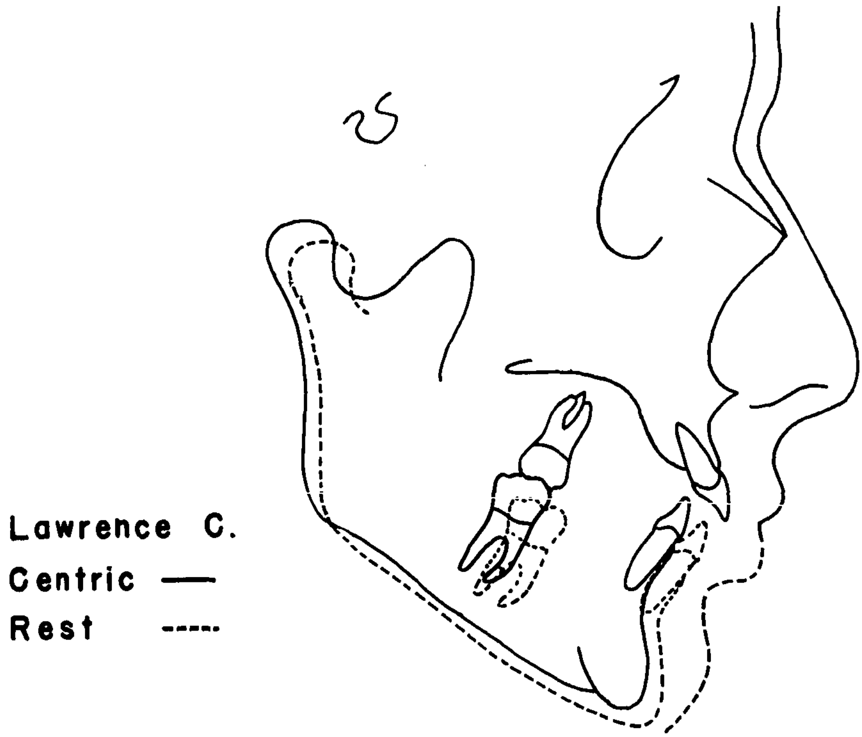

FIG. 8.

Fig 7, a male, is an apparent contradiction which seemingly invalidates the method of assessment. There is nothing in the chart to indicate why this boy should have a Class II, division 1 malocclusion; in fact, the net score of plus 6 would seem to call for a Class III jaw relationship. The true basis of this Class II, division 1 dental arch relationship is shown in Fig. 8. When the jaws are in rest position, the jaws and teeth occupy positions consistent with the one which is to be expected from an assessment of A-P dysplasia. When the teeth are together, however, the Class II, division 1, relationship is as assumed. Class II and Class III relationships, based on mandibular displacement rather than disproportion between facial structures, are not uncommon. We have found that when this method of assessment is applied to cases of mandibular displacement falling into either Class II or Class III the score is usually inconsistent with one which is to be expected from models in centric occlusion. Such an atypical score is an indication for carrying out more detailed analysis of the case through head-films, making a comparison of jaw position in centric and rest position in an effort to discover the nature and amount of mandibular displacement. The assessment of anteroposterior dysplasia serves this very valuable function because it is not based upon the relative position of facial parts in either centric or rest, but instead takes each part independently and assesses them with respect to their relative size.

SIGNIFICANCE OF NET SCORES

It would seem logical to assume from the foregoing that one might simply calculate a net score of units of anteroposterior dysplasia to discover the severity of the anomaly and to estimate the prognosis for treatment. This is not entirely true, for experience has taught us that the five dimensions used cannot be considered equal in this respect. More specifically, one may expect better results when the dyplasia is localized under "maxillary length" or "Ptm-6" than when it is to be attributed to insufficiency of mandibular length or to excessive length in the cranial base. We have found it to be most helpful in localizing the dysplasia so that we pay more attention to departures from standard with respect to each of the five different dimensions than we do to the net score itself.

TERMINOLOGY

The terms "orthognathism" and "prognathism" were selected to categorize facial types, in preference to "Class II faces" and "Class III faces". This latter terminology we prefer to reserve for dental arch relationships alone, in spite of the fact that these dental arch relationships admittedly are based primarily upon malrelation of basal structures. The terminology of Simon is too specific to be used to divide faces into two categories, i.e., an orthognathic face may be either a maxillary protraction or a mandibular retraction. Once a face is classified as orthognathic or prognathic, Simon's terminology is convenient for the very sort of analysis cited above as an example, and deserves wider use than it is given at the present time.

"Protrusion" and "retrusion" were avoided because of the specialized connotation which has been given the former term by clinical orthodontists in recent years. Since the assessment of anteroposterior dysplasia deals only with the size of the craniofacial bones, and not with the inclination of anterior teeth, we have deliberately left the term "protrusion" to those who have directed attention to the relationship between axial inclination of anterior teeth and the facial profile.

"Prognathism" and "orthognathism", when used by others, may apply either to the maxilla or the mandible or both. As it is used here it applies mainly to the mandible in relation to the maxilla, and prognathism of the maxilla, accompanied by a mandible of average length would arbitrarily be called "orthognathism" in the first assessment of anteroposterior dysplasia. Its true nature, of course, would be ascertained by further analysis with a rating in each of the five dimensions considered in the system.

THE DOWNS ANALYSIS AND A-P DYSPLASIA

The method has been rountinely used at the University of California for the assessment of patients, olong with the method called the Downs[9] analysis. It should be pointed out here that the two procedures serve different purposes and that one cannot be substituted for the other. The Down analysis has impressed us at California as the most workable scheme for evaluating facial patterns with respect to a normal range of variation, and it can also be used advantageously to appraise the change that has taken place during orthodontic treatment. Although the assessment of anteroposterior dysplasia has the added advantage of localizing dysplasia, perhaps thereby showing why the Downs analysis gives an unfavorable prognosis, at the same time it is of little value for "before and after" studies in orthodontic treatment. This is because only one of the dimensions involved (Ptm-6) may be altered through orthodontic treatment.

AGE DIFFERENCES

The reader may well question the propriety of applying a standard based on 11.5 years indiscriminately to patients of all ages coming to the orthodontist. Actually it is found that the amount of variation from individual to individual outstrips so markedly the variation which one finds due to age alone, that, practically speaking, the method may be used to good advantage regardles of age unless one seeks to apply it to children in the deciduous dentition. With the very young, the method errs in an orthognathic direction. We are in the process of correcting this deficiency by working out standards for the deciduous dentition age groups in both sexes, as indeed we intend to do for all ages and have completed for adult males. Interestingly enough, it has been found that essentially the same net scores are found in adult males with standards based on adult standards as those found from standards based on 11.5 years. In actual use, however, adult standards should be used for adult individuals if one is to obtain a reliable localization of dysplasia, which is more important than the determination of a net score.

Since the standard based on 11.5 years is satisfactory for the majority of orthodontic patients, the procedure is being routinely used in the Division of Orthodontics at the University of California. In addition to providing satisfactory standards for both sexes in all age groups, we also hope to expand the method's usefulness through an intensive study of clinical results of orthodontic cases falling into the various localizations of the chart. We have already come to believe that it is necessary to distinguish between different types of Class II, division 1's despite outward similarity and we think the distinction has clinical importance. Work is also under way on methods for the expansion of the assessment of craniofacial dysplasia into the vertical and lateral dimensions.

It should be pointed out that craniofacial dysplasia is by no means the only type of dysplasia encountered by the orthodontist. Dental dysplasia of congenital origin is found in peg laterals, missing teeth, and other teeth anomalous in form. It must be admitted that all too often we see evidence of acquired dental dysplasia in the form of dental restorations which fail grossly to imitate satisfactory anatomical form. In discussions of extraction in orthodontic procedure, it is commonly said that a disproportion exists between tooth structure and base bone. If this is actually so, then there is in these cases a dysplastic relation between dental structures and denture base.

SUMMARY

A method is presented whereby discrepancies in size of facial bones occurring in the anteroposterior plan of space may be assessed quantitatively in terms of millimeters. The work relies upon material published elsewhere as a justification of such a rationale, and makes no attempt to bring forth reasons for adopting the point of view that anteroposterior dysplasia exists. The method of assessment presented makes possible a net score of anteroposterior dysplasia which is approximately zero where

such dysplasia is either non-existent or compensated for by variation in different parts, and which is negative in the type of face where relative mandibular insufficiency exists, and positive in cases of mandibular prognathism. It permits the localization of this dysplasia in one or more of five different areas, an application which is probably more valuable than the derivation of a net score. Intelligent interpretation of the results of these scores makes it possible not only to measure the amount of anteroposterior dysplasia which exists in the face, but also indicates the necessity of looking elsewhere for existing dysplasia. Thus the true seat of dysplastic craniofacial relationship may be in the vertical dimension, or it may be attributable to mandibular displacement as described by Thompson.[8] Work is under way to refine the standards by providing them for a greater variety of age groups, and for vertical and lateral dimensions.

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