The Cephalometric Relationship between the Morphology of the Mandible and its Future Occlusal Position

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"Shape is a function of growth, and the connection between variations in shape and variations in growth is a question about which relatively little is known."[4]

The purpose of this study was to investigate the relationship of the morphology of the mandible to the amount and direction of mandibular growth, and to determine the predictive significance of any existing relationships.

REVIEW OF THE LITERATURE

A review of studies which relate mandibular morphology to malocclusions and to muscle action helps one to understand the rationale for the hypothesis that "the form of a grown mandible is thought to reflect its past behavior and its present tendencies."[34]

Numerous studies of facial patterns associated with Class I, II, and III malocclusions (Angle) have attempted to identify characteristics common to a particular malocclusion.[1,5,9,12,15,20,26,30,32] Although there are conflicting findings, there does appear to be some evidence that mandibular morphology varies with the type of malocclusion.[14]

The relationship between facial patterns and patterns of mandibular growth has also been studied. The findings of these studies indicate that patterns of mandibular growth tend to vary with facial type, i.e., Class II cases tend to grow more vertically, and Class I cases tend to grow more horizontally.[11] If mandibular morphology varies with the type of malocclusion and if there is a relationship between types of malocclusion and patterns of mandibular growth, then one may propose the hypothesis that mandibular morphology is related to patterns of mandibular growth.

Additional support for this hypothesis may be derived from a survey of the relationship of muscle forces to mandibular morphology and the relationship of patterns of muscle activity to malocclusions. Washburn has identified three elements of the mandible: 1) the mandible proper, 2) the alveolar bone, and 3) the muscle insertions.[38] It is his opinion that the form of the coronoid process and gonial angle is largely a result of the functional relation that each has with the muscles of mastication. Additional studies also have pointed to the relationship between mandibular form and the degree of development of the muscles of mastication.[21,36] Electromyographic studies seem to indicate different patterns of muscle activity in individuals with Class II and with normal occlusion.[27,31] It is conceivable then that the different patterns of muscle activity associated with Class II malocclusions would have different impacts upon the morphology of the mandible. Hopefully, an analysis of mandibular morphology would shed some light not only on the nature of the muscle forces but also on the influence of these forces on the pattern of future mandibular growth.

If one assumes that the studies just discussed indicate an existing relationship between mandibular morphology and the pattern of mandibular growth, then the measurement and statistical

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inspection f the resulting data would logically foı ow. Studies of the correlation betweeı. a facial characteristic and craniofacial growth have been reported in the literature.[3,19,23,24,25] The extent of linear correlation found by some investigators has led them to conclude that: "there was no correlation between the original facial type . . . and the (horizontal) growth change at gnathion from seven to seventeen years of age";[23] "the size of a child at age four or five years gives no clinically useful information regarding the rate at which he will grow during the ensuing years";[25] "the degree of prognathy in either jaw does not therefore provide any clue to the future prognathic development";[3] "the size at age six does not offer a base for predicting growth in the following three years."[19] On the other hand, others have found that "there is a significant relation between values of the gonial angle at nine years and the relative growth increments in mandibular length from nine to thirteen years."[24] All of the preceding findings are based upon the correlation between two variables. Unfortunately, the complexity of facial growth would make it unlikely that any one measurement would be highly descriptive of the individual facial pattern.[8] More recently investigators have applied multivariate analysis to these problems.[18,22] This statistical approach, i.e., stepwise regression, allows one to examine the relationship of a series of variables to a single criterion. In an extensive study using multivariate analysis, the relationship between a series of craniofacial characteristics and growth changes in the maxillomandibular relation was found to be of limited predictive value to the clinician.[22]

Since the mandible represents a key to the understanding of the development of malocclusion, the present study was designed to examine the relationship of mandibular morphology to changes in its usual occlusal position through time. The availability of the computer permitted an examination of these subtle interrelationships through the application of the multivariate approach.

Sample

This report has been based on lateral cephalometric radiographs taken from the files of the University of Michigan Growth Study. Each individual whose records satisfied the following requirements was included in this study:

1. The individual was a male.
2. Lateral cephalograms taken with the teeth in occlusion at years seven and eleven were available. The limits for each age group were 6.55-7.55 years and 10.55-11.55 years.
3. The quality of each film set was such as to allow accurate identification of the landmarks.
4. The individual had no history of orthodontic treatment.

A male sample was drawn to eliminate any variability in growth timing and in growth patterns due to sex differences. The age range was chosen because: 1) diagnosis of orthodontic problems is often first sought during this period, 2) advocates of early treatment are concerned about the growth changes during this period, and 3) the variability in growth increments and patterns caused by the pubertal growth spurt generally is avoided.[2,17]

Upon examination of the Growth Study files, forty-one individuals satisfied the requirements listed above; and hence their eighty-two lateral cephalometric radiographs comprised the sample.

Method

A combination of linear and angular measurements of mandibular morphology and position at age seven and eleven were made. From these measurements the changes in the occlusal position of the mandible could be determined, and the relationship between mandibular morphology at seven and the changes in the usual occlusal position of the mandible from seven to eleven could be studied.

Fifteen measures represented the morphology of the mandible.[33,34] These were:

1. Ramus width
2. Ramus height
3. Width of the condylar head
4. Width of the condylar neck
5. Body length at pogonion
6. Body length at B point
7. Antegonial notch
8. Molar height
9. Mandibular length
10. Width of the symphysis at B point
11. Width of the symphysis at pogonion
12. Mandibular plane angle
13. Gonial angle
14. Occlusal plane angle
15. Condyle—coronoid angle

Since longitudinal studies of craniofacial growth patterns have demonstrated clearly that an analysis of facial growth must include a measure of direction as well as amount, two measurements were made to represent the usual occlusal position of the mandible.[3,8,23,28,29] These were:

1) S-Gn length
and 2) XY-axis angle.

These seventeen measurements made on each cephalogram are represented in Figures 1 and 2. Each of the measurements was recorded for every individual at ages seven and eleven. For the two measurements of mandibular position an additional recording was made, namely, the change which occurred in the dimension from age seven to age eleven, i.e., S-Gn (age 11)—S-Gn (age 7)=S-Gn change; XY-axis angle (age 11)—XY-axis (age 7)=XY-axis angle change.

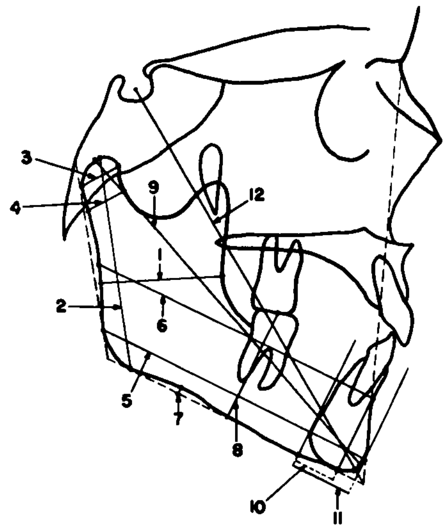

Fig. 1 Linear Measurements. 1—Ramus Width. 2—Ramus Height. 3—Condyle Head Width. 4—Condyle Neck Width. 5—Corpus Length (Pg). 6—Corpus Length (B). 7—Antegonial Notch. 8—Molar Height. 9—Mandibular Length. 10—Symphysis (B). 11—Symphysis. (Pg). 12—S-Gn.

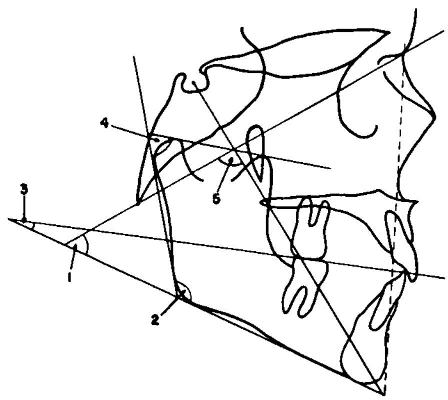

Fig. 2 Angular Measures. 1—Mandibular Plane Angle. 2—Gonial Angle. 3—Occlusal Plane Angle. 4—Condyle-Coronoid Angle. 5—XY-Axis Angle.

The sample means and standard deviations of the seventeen variables were calculated for each age.

A correlation matrix for the sample of all variables both measured and calculated was established, and from this matrix the following correlation coefficients (r) were extracted for closer examination:

1. The correlation coefficients for the relationship between the fifteen measures of mandibular morphology at age seven and S-Gn and XY-axis angle changes for the four year interval.
2. The correlation coefficients for the relationship between the measures of mandibular morphology at seven years and the size of S-Gn and XY-axis angle at eleven.
3. The correlation coefficients for the relationship of S-Gn to XY-axis angle at age seven with S-Gn, S-Gn changes, XY-axis angle, and XY-axis angle changes at eleven.

To evaluate the significance of the relationships expressed by these simple correlation coefficients the following statistical techniques were used:

1. All coefficients of correlation were analyzed for significance, and those coefficients significant at the one and five per cent levels were labeled.
2. The statistic, $1 - \sqrt{1 - r^2}$, was used to better evaluate the extent of the linear relationship between two variables in the sample. This statistic expresses the proportion of the standard deviation of one variable which is explained by the other.

Multiple regression equations were calculated for the relationship between the characteristics of mandibular morphology and position at seven and S-Gn length and XY-axis angle at eleven. Those measures of mandibular morphology and position at age seven which contributed information (significant at .05% F) and which provided new information about S-Gn and XY-axis angle at eleven were included in the equations.

The predictive significance of the multiple regression equations for this sample was examined using the following statistics:

1. The coefficient of multiple correlation (R) which determines the degree of linear relationship between actual values of S-Gn (and XY-axis angle) at eleven and the predicted values of S-Gn (and XY-axis angle) at eleven.
2. The standard error of estimate (S.E.Y) which is the size in mm or degrees of the standard deviation for the difference between observed and predicted values of S-Gn and XY-axis angle.
3. A coefficient of prediction efficiency (E) which estimates for this sample the relative advantage of using a given multiple regression equation as opposed to an alternate method of predicting S-Gn and XY-axis angle.

Variability Inherent in the Method

The purpose of the study was to predict the pattern of mandibular growth based on the morphology of the mandible; however, variability inherent in the method itself places certain limitations on the interpretation of the findings. For this reason the variability inherent in the method is now identified and evaluated.

Tracing and measuring error was examined by retracing and reanalyzing a total of thirty cephalograms. An analysis of variance was applied to the thirty pairs of tracings to estimate the standard deviation due to tracing error and the standard deviation between individuals. The estimated standard deviation due to error ranged from 76 per cent to 4 per cent of the estimates of standard deviation among individuals. The averages of the estimates of standard deviation due to tracing and measuring error were found to be .6

TABLE I

Means ($\bar{X}$), Standard Deviations (s), and Ranges of Change in Mandibular Position from 7 Years to 11 Years

Measure of Change in Mandibular Position for 4 year Interval		$\bar{X}$	s	Range
S-Gn Change	mm	11.0	2.4	6.6 to 18.4
XY-Axis Angle Change	degrees	—.9	1.5	—4.0 to +3.4

mm for linear measures and 1.3° for angular measures. Coefficients of reliability were also calculated for all variables. This coefficient represents the linear correlation between the measurements of the first and second cephalogram and is an indication of the reliability of the tracing and measuring procedures. The coefficient of alienation ($\sqrt{1 - r^2}$), a measure of the unreliability of the measure, was also calculated. The average of the coefficients of reliability was .92 with a range of .999 - .71. The average of the coefficients of alienation was .35 with a range of .03 - .70.

A second source of variability present in this method stemmed from the positioning of the patient in the cephalostat. Although this type of error was not quantitated in this study, an attempt was made to reduce the effects of this error by bisecting all bilateral images while tracing.

The measures (S-Gn and XY-axis angle) of the amount and direction of mandibular growth include a third source of variability. This is true since the occlusal position of the mandible was used as the maxillomandibular relationship from which the amount and direction of change in mandibular position was analyzed. Conceivably, the occlusal position of the mandible could be altered by occlusal interferences, loss of vertical support, and orthodontic forces applied to the teeth and supporting bone. Although the selection of the sample eliminated any changes due to orthodontic treatment, the changes in the occlusal position of the mandible still include factors other than mandibular growth. Thus, changes in the XY-axis angle and S-Gn length cannot be viewed as due *solely* to mandibular growth.

In conclusion, if the errors observed in this study are randomly dispersed, 1) they will have a negligible effect on measures of central tendency; 2) they will tend to increase measures of variability; and 3) they will tend to decrease measures of relationship. On the other hand, the errors made in the estimation of population value from sample findings may be in either direction. There can be no question then that the variability inherent in the method has a definite impact on the statistical approach, and this variability may in fact tend to obscure biologically significant relationships.

Findings

Means and Standard Deviations for All Variables

An attempt to predict future mandibular position is in part predicated on the assumption that there may be a change in mandibular position relative to the cranial base. The four year mean increment of change for S-Gn and XY-axis angle as well as the standard deviation and range of these changes are presented in Table 1. The findings indicate changes in XY-axis angle from seven to eleven range from —4.0° to +3.4°. The means and standard deviations for each variable measured at age seven and age eleven are presented in Table 2, and the growth trends in the various dimensions may be noted.

TABLE II

Means ($\overline{X}$) and Standard Deviations (s) for All Variables in the Sample at 7 Years and 11 Years

Measures of Mandibular Morphology and Position		7 Years $\overline{X}$	7 Years s	11 Years $\overline{X}$	11 Years s
Ramus Width	mm	30.4	2.0	32.5	1.9
Ramus Height		55.4	3.4	61.2	4.1
Condyle Head Width		11.2	.9	12.0	.8
Condyle Neck Width		10.1	.7	10.9	.8
Corpus Length (Pg)		73.2	2.8	81.0	3.2
Corpus Length (B)		80.0	3.8	85.3	3.7
Antegonial Notch		2.0	.9	1.6	.9
Molar Height		27.7	2.3	29.9	1.8
Mandibular Length		104.9	4.1	115.6	5.4
Symphysis (B)		11.1	2.0	10.1	1.6
Symphysis (Pg)		16.1	1.5	17.3	1.5
Mandibular Plane Angle	degrees	53.6	3.7	53.3	4.0
Gonial Angle		132.5	3.6	129.6	4.6
Occlusal Plane Angle		14.7	3.5	15.2	3.5
Condyle-Coronoid Angle		68.6	5.4	68.8	4.9
S-Gn	mm	112.9	4.9	124.0	6.1
XY-Axis Angle	degrees	93.9	2.7	92.9	2.9

TABLE III

Sample Correlation Coefficients of Mandibular Morphology at Age 7 with the usual Occlusal Position of the Mandible and with Change in this Position

Measures of Mandibular Morphology at Age 7	Measures of Mandibular Position and Change in Position at Age 11: S-Gn	X-Y Axis Angle	S-Gn Change	X-Y Axis Angle Change
Ramus Width	.16	.21	—.16	.24
Ramus Height	.43[b]	.10	.07	.17
Condyle Head Width	.42[b]	—.10	.16	.03
Condyle Neck Width	.38[a]	—.13	.09	—.06
Corpus Length (Pg)	.42[b]	—.13	—.09	—.01
Corpus Length (B)	.46[b]	—.13	—.02	.12
Antegonial Notch	.27	—.13	.01	.18
Molar Height	.27	—.04	.19	.00
Mandibular Length	.71[b]	—.09	.14	.12
Symphysis (B) Width	—.06	.19	—.06	.10
Symphysis (Pg) Width	.05	—.07	—.24	—.03
Mandibular Plane Angle	.30	—.74[b]	.18	.08
Gonial Angle	.18	—.35[a]	.21	—.05
Occlusal Plane Angle	.07	—.40[b]	.11	.08
Condyle-Coronoid Angle	.15	—.12	.31	—.36[a]

[a] 5% level of significance
[b] 1% level of significance

Simple Linear Correlation

In Table 3 the correlation coefficients are presented for the relationship of the fifteen measures of mandibular morphology at age seven with the change in S-Gn and XY-axis angle for the four year interval. It may be noted that there was only one mandibular measure in this sample where the correlation with XY-axis angle change was significant at the 5 per cent level. This variable, condyle-coronoid angle, accounted for only 7 per cent of the standard deviation of XY-axis angle change. There were no single measures of mandibular morphology in this sample where correlation with S-Gn change was significant at the 5 per cent level.

Included in Table 3 are the correlation coefficients which represent the relationship in this sample between the measures of mandibular morphology at age seven and the size of S-Gn and XY-axis angle at age eleven.

In Table 4 the sample correlation coefficients for S-Gn at age seven with S-Gn at age eleven and XY-axis angle at age seven with XY-axis angle at age eleven are presented. These values should be compared with the statistically significant correlations between the relationship of mandibular morphology at seven years with S-Gn and XY-axis angle at age eleven in Table 3. It may be seen that no single measure of mandibular morphology in this sample explained as much about the variability of S-Gn or XY-axis angle or predicted with greater precision the S-Gn or XY-axis angle at age eleven than did the measurement of the individual's S-Gn or XY-axis angle at age seven. Although there were high correlations between an individual's S-Gn and XY-axis angle at seven years with the same measures at eleven years, the correlations between these same measurements with their change from seven to eleven were not significant at the 5 per cent level.

The coefficient of prediction efficiency for the relationship of S-Gn and XY-axis angle at eleven with S-Gn and XY-axis angle at seven was calculated for comparison with the predictive efficiency of the multiple regression equations (Table 7).

Multiple Regression

In the previous section it was noted that certain measures of mandibular morphology at age seven bore a small but statistically significant relation with S-Gn and XY-axis angle at eleven. In the attempt to determine whether groups of variables considered simultaneously would yield a significant increase in the extent of linear relationship, multiple regression analyses were employed, and the results presented in Tables 5 and 6.

All measures of mandibular morphology at age seven were examined by the

TABLE IV

Sample Correlation Coefficients of the Usual Occlusal Position of the Mandible and Change in this Position at Age 11 with the Usual Occlusal Position at Age 7

Measures of Mandibular Position at Age 7	Measures of Mandibular Position and Change in Position at Age 11			
	S-Gn	XY-Axis	S-Gn Change	XY-Axis Angle Change
S-Gn	.91[b]	—.31[a]	.27	.05
XY-Axis Angle	—.36[a]	.82[b]	—.18	—.15

[a] 5% level of significance
[b] 1% level of significance

TABLE V

The Results of Multiple Regression Analyses for this Sample Considering All Measures of Mandibular Morphology at Age 7

Mand. Position and Changes at 11 Yrs.	Significant Measures of Mand. Morphology at 7 Yrs.	S.E.$\hat{Y}$	R	$1-\sqrt{1-R^2}$
S-Gn	Corpus Length Pg = X_1			
$\bar{Y}$ = 124.034 mm	Ramus Height = X_2	4.825m	.67	.26
s = 6.102 mm	Mandibular Plane Angle = X_3			
S-Gn Change	None Significant at			
$\bar{Y}$ = 11.020 mm	the 5% Level			
s = 2.393 mm				
XY-Axis Angle	Mandibular Plane Angle = X_1	1.994°	.73	.32
$\bar{Y}$ = 92.939°				
s = 2.901°				
XY-Axis Angle Change	Condyle-Coronoid Angle = X_1	1.432°	.36	.07
$\bar{Y}$ = —.941°				
s = 1.513°				

s = standard deviation of Y
S.E.Y = standard error of estimate of Y

TABLE VI

The Results of Multiple Regression Analyses for this Sample Considering All Measures of Mandibular Morphology and Position at Age 7

Mand. Position and Changes at 11 Yrs.	Significant Measures of Mand. Morphology and Position at 7 Yrs. (Predictor Variables)	S.E.$\hat{Y}$	R	$1-\sqrt{1-R^2}$
S-Gn	S-Gn = X_1			
$\bar{Y}$ = 124.034 mm	Corpus Length (Pg) = X_2	2.312	.93	.64
s = 6.102 mm	Condyle-Coronoid Angle = X_3			
S-Gn Change	None Significant at			
$\bar{Y}$ = 11.020 mm	the 5% Level			
s = 2.393 mm				
XY-Axis Angle	XY-Axis Angle = X_1			
$\bar{Y}$ = 92.939°	Condyle-Coronoid Angle = X_2	1.474	.87	.51
s = 2.901				
XY-Axis Angle Change	Condyle-Coronoid Angle = X_1	1.432	.36	.07
$\bar{Y}$ = —.941				
s = 1.513				

s = standard deviation of Y
S.E.Y = standard error of estimate of Y

TABLE VII

The Improvement in Standard Errors of Estimate for S-Gn and XY-Axis Angle at 11 Years When Alternate Methods of Prediction are Used

Alternate Methods of Predicting an Individual's S-Gn Length and XY-Axis Angle at 11 Years	Amount of Reduction in the Standard Deviation of S-Gn and XY-Axis Angle at 11 Years when Alternate Methods of Prediction are Employed	
S-Gn	Per Cent Reduction in S.E. of Estimate	Decrement of the S.E. of Estimate
A. Prediction based on the relationship between S-Gn at 7 years and S-Gn at 11 years, r = .91	58%	3.5 mm
B. Assume size of S-Gn at 11 years to be the length of S-Gn at 7 years plus an observed mean increment of change for the 4 year interval[a]	61%	3.7 mm
C. Prediction of S-Gn at 11 years based upon the most efficient multiple regression equation. Table 6	62%	3.8 mm
XY-Axis Angle		
D. Prediction based on the relationship between XY-Axis Angle at 7 years and XY-Axis Angle at 11 years, r = .82	43%	1.2°
E. Assume size of S-Gn at 11 years to be the length of XY-Axis Angle at 7 years plus an observed mean	48%	1.4°
F. Prediction of XY-Axis angle at 11 years based upon the most efficient multiple regression equation. Table 6	49%	1.4°

[a] 11.0 mm (Table I)
[b] .9° (Table I)

technique of multiple regression analysis. It was found that, at most, three variables were entered into the program at the predetermined 5 per cent level of F when at age eleven S-Gn was the dependent variable. Only one variable at age seven was found to yield similar information relative to XY-axis angle. Thus, it would seem reasonable to assume that those measures of mandibular morphology which were found to be statistically significant (Table 3) when compared individually with S-Gn and XY-axis angle, but were not included as variables in the multiple regression equation, failed to yield any new information.

The multiple regression (Table 5) derived only from measurements of mandibular morphology resulted in less prediction precision than did the regression equations utilizing only S-Gn and XY-axis angle, at age seven.

When S-Gn and XY-axis angle measurements were included with the variables previously analyzed, the prediction accuracy was markedly increased (Table 6).

To better understand the practical significance of the regression equations, the prediction efficiency of the multiple regression equations was compared with alternate methods of predicting the future size of S-Gn and XY-axis angle. The alternate methods are presented in Table 7. The percentage reduction in the standard error of prediction of an individual's S-Gn and XY-axis angle using the multiple regression equation was considerable when compared with

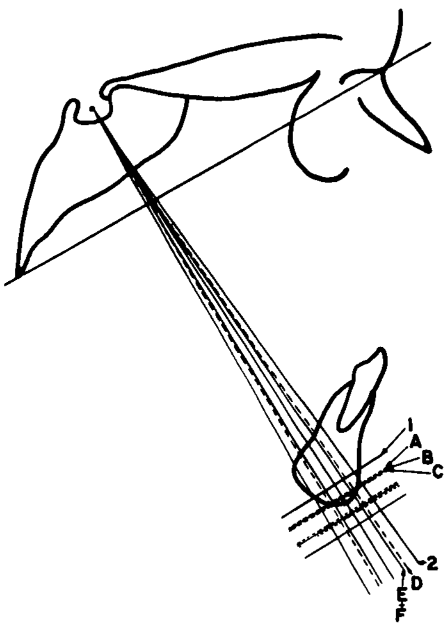

Fig. 3 Standard Error of Estimate with Alternate Methods of Prediction. 1—Standard Deviation of S-Gn at Age 11. 2—Standard Deviation of XY-Axis at Age 11. A, B, C, D, E, F—Standard Error of Estimate with Alternate Methods of Prediction (See Table 7).

the assumption that the S-Gn and XY-axis angle will be a given mean size at eleven. However, the use of the multiple regression equation provided only a small percentage reduction in the standard error of prediction of S-Gn or XY-axis angle when compared with the assumption that the size of S-Gn and XY-axis at eleven will be the size at age seven plus a mean increment of change. The reduction in the confidence intervals for the alternate methods of predicting the future size of S-Gn and XY-axis angle are also illustrated in Figure 3.

Discussion

An analysis of the findings provided no support for the hypothesis that a biologically significant relationship exists between the morphology of the mandible and changes through time in the usual occlusal position of the mandible.[33,34] The correlation coefficients of mandibular morphology with changes in the amount and direction of S-Gn (Table 3) provided no statistical support for the hypothesized relationship between individual mandibular characteristics and changes in the usual occlusal position of the mandible. In addition, the application of multiple regression analyses to this problem (Table 5) provided little statistical support for the view that increasing amounts of pertinent information concerning changes in the future occlusal position of the mandible may be obtained by examining many aspects of the morphology of the mandible.

Although no significant relationships between mandibular morphology and changes in the usual occlusal position of the mandible were demonstrated, other statistically significant relationships for this sample were present in the findings (Table 3). What then is the meaning of these relationships?

The statistically significant relationships between measurements of mandibular morphology at seven and the size of S-Gn and XY-axis angle at eleven (Table 3) seem to reflect the relative stability of the mandibular morphology. Without exception, in this sample the coefficients of correlation between mandibular morphology at seven and measures of the usual occlusal position of the mandible at seven were larger than the correlation coefficients for the same measures of mandibular morphology at seven with measures of the usual occlusal position of the mandible at eleven. Thus, it would seem that the significant correlations here discussed resulted from the interrelationship of skeletal parts at a particular age, and the significant correlation coefficients in this sample between mandibular morphology at seven and occlusal mandibular at eleven are a result of the stability of this interrelationship through time.

The high sample correlation between S-Gn at seven and S-Gn at eleven and between XY-axis angle at seven and XY-axis angle at eleven (Table 4) also demonstrates the part stability plays in the statistically significant relationships found in this study. Unfortunately, these relationships fail to provide any information about variations in direction or amount of growth as is indicated by the low correlation coefficients between S-Gn at seven and S-Gn change and between XY-axis angle at seven and XY-axis angle change (Table 4).

Having identified the nature of the significant correlations and regression equations found in this study, the predictive significance of these findings deserves further discussion. The future position of facial parts in an individual may be thought of as a summation of three theoretical components. In this study one theoretical component of the future occlusal position of the mandible which has eluded quantitation is the component of change in the occlusal position of the mandible due to growth. Although the component of change makes a significant contribution to the final position of the mandible, no relationships of predictive significance could be demonstrated between the initial morphology of the mandible and the changes which occur in the occlusal position of the mandible with time.

Another theoretical component of the future occlusal position of the mandible is based on the stability of facial relationships. In other words, the future occlusal position of a mandible is in part a function of its present position. It is the component of stability in craniofacial relationships which seemed to account for the limited success achieved in the prediction of the future occlusal position of the mandible. The component of stability partially explains the relative success claimed by certain investigators who construct a patient's future facial pattern by adding mean increments to the existing facial pattern.[33,34] The improvement in the standard error of estimate for this sample gained by using multiple regression equations or by adding mean increments of change to the existing dimensions are presented in Table 7 and Figure 3. Both of these methods of predicting the future occlusal position of the mandible are based mainly upon the component of stability.

A third theoretical component of the future occlusal position of the mandible may be due to the impact of orthodontic forces on the occlusal position of the mandible. Previously the component of stability was used to explain in part the relative success achieved by some clinicians in the prediction of a patient's future facial pattern. A part of their success may also be due to their ability to accurately predict the amount of change in the future craniofacial relationships produced by orthodontic treatment. Recently there has been renewed interest in the impact of orthodontic forces on the development of the facial skeleton[34] and on the vertical development of the alveolar process;[35] unfortunately, accurate quantitation of the changes produced in craniofacial relations by orthodontic treatment is lacking. If orthodontic forces cause permanent changes in craniofacial relations and if these changes are of the magnitude reported by some investigators, then the component of the future occlusal position of the mandible due to orthodontic treatment could well be the most important factor in the accurate prediction of future craniofacial relations.

Summary and Conclusions

The purpose of this investigation was 1) to analyze the relationship between mandibular morphology and the future occlusal position of the mandible and

2) to determine the predictive significance of any existing relationships.

The sample consisted of forty-one males, each represented by a series of two cephalograms taken at seven and eleven years.

The scheme of the cephalometric analysis consisted of linear and angular measures of mandibular morphology and of the occlusal position of the mandible at seven and eleven years. From these measurements the changes in the occlusal position of the mandible were determined, and the relationships between mandibular morphology and changes in the usual occlusal position of the mandible were studied.

The statistical approach of simple linear correlations and multiple regression was employed 1) to test the significance in this sample of various relationships of mandibular morphology at age seven with the occlusal position of the mandible at age eleven and 2) to evaluate the predictive significance of these relationships.

From the findings the following conclusions were drawn relative to this specific sample:

1. The addition of mean increments of change to the existing position of a mandible proved to be a simple and fairly efficient method of predicting the future position of the mandible. Although complex multiple regression equations were statistically more efficient, the difference in prediction efficiency was clinically negligible.
2. The extent of prediction efficiency noted in this study results from the degree of stability in craniofacial relationships through time and not from any new insight into individual changes in craniofacial relationships.
3. No statistical support is found for the hypothesis that individual mandibular characteristics provide information upon which to base an accurate prediction of changes in the occlusal position of the mandible.
4. There is no statistical support for the view that the summation of a number of morphological traits of the mandible will allow a more accurate prediction of changes which occur in the occlusal position of the mandible with time.

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