Dent.
THESIS
M.S.

CLEVELAND MUSEUM OF NATURAL HISTORY LIBRARY

THE OUTCOME OF ORTHODONTIC TREATMENT AS A FUNCTION OF CRANIOFACIAL ARCHITECTURE: A CEPHALOMETRIC INVESTIGATION OF THE BEGG TECHNIQUE

by

DANIEL BRODKOWITZ

Submitted in partial fulfillment of the requirements

for the Degree of Master of Science

Department of Orthodontics

School of Dentistry

CASE WESTERN RESERVE UNIVERSITY

June 1973

CASE WESTERN RESERVE UNIVERSITY

GRADUATE STUDIES

We hereby approve the thesis of

DANIEL BRODKOWITZ

candidate for the MASTER OF SCIENCE

degree.

Signed: Lyle E. Austin (Chairman)

Carl Wisotzky DDS, PhD

Ronald Weiser

B. Douglas Culbertson

Date May 25, 1973

73-40

THE OUTCOME OF ORTHODONTIC TREATMENT AS A FUNCTION OF CRANIOFACIAL ARCHITECTURE: A CEPHALOMETRIC INVESTIGATION OF THE BEGG TECHNIQUE

Abstract

by

DANIEL BRODKOWITZ

The purpose of this investigation was to evaluate the possibility of predicting the outcome of standard Begg orthodontic therapy.

The sample consisted of 60 individuals, 30 males and 30 females, each having a Class II, division I malocclusion and requiring the extraction of the four first bicuspids.

Stepwise multiple linear regression was used to examine the predictive significance of 29 characteristics of the pretreatment craniofacial skeleton as well as to examine 4 variables from other sources. All of these predictor variables were used simultaneously in an attempt to forecast treatment changes. Only those factors which contributed significant unduplicated information towards the estimation of the measures of treatment outcome entered the prediction equation. The 14 measures of treatment outcome were chosen based on their presumed clinical significance and were obtained from the last cephalogram taken. The time at which the final cephalogram was taken varied from just after the removal of bands to postretention.

As a result of this investigation, the following conclusions were drawn:

1. The changes seen in the present sample appear to be similar to those reported by other investigators for the Begg technique.

2. The dental changes accompanying the Begg technique are of a larger magnitude than the changes related to the skeletal framework, in Class II, division I malocclusions.

3. Stepwise multiple linear regression analysis proved of little value in predicting treatment outcome on an individual basis in the present study.

4. A number of possible explanations were advanced concerning the inability to obtain clinically useful prediction equations:

   a. Perhaps an attempt should have been made to find equations which reduce the variability around the absolute value of a Begg treatment goal. This may have proved clinically significant and may have provided some insight into the biological compatibility of the craniofacial architecture and some popular treatment objectives.

   b. Perhaps the skeletal architecture in most cases may not limit the orthodontist's ability to achieve his treatment goals.

   c. Perhaps the bony architecture may act as an inhibiting force. However, the extraction of teeth may enable the orthodontist to compensate and still achieve an acceptable result.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to the following individuals:

Dr. Lysle E. Johnston, Associate Professor and Chairman of the Department of Orthodontics, School of Dentistry, Case Western Reserve University, for his invaluable aid in the preparation of this thesis.

Dr. Benjamin Eichorn, Department of Mathematics, Case Western Reserve University, for implementing the Chaemaera program.

Dr. Milton Rabine, Assistant Professor, School of Dentistry, Department of Orthodontics, Case Western Reserve University, for his generosity in supplying the sample used in this study.

Dr. B. Holly Broadbent, Jr., Associate Professor of Dentofacial Morphology, School of Dentistry, Case Western Reserve University, for allowing me the use of the Bolton Study facilities.

To other members of my committee, Drs. Douglas Amberman, Ronald Neuger, and Joel Wisotzky, I wish to express my appreciation for their evaluation and constructive criticism of this thesis.

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	vii
INTRODUCTION	1
REVIEW OF THE LITERATURE	2
METHODS AND MATERIALS	15
FINDINGS	33
DISCUSSION	41
SUMMARY AND CONCLUSIONS	52
APPENDIX I	54
LITERATURE CITED	55

LIST OF TABLES

Table		Page
I.	Position of Lower and Upper Incisors as Determined by the ANB Angle (After Holdaway, 1956)	7
II.	Mandibular Characteristics and their Potential Effect on Growth (Ricketts, 1961)	12
III.	Angular Measurements on Initial Cephalogram	17
IV.	Linear Measurements on Initial Cephalogram	21
V.	Descriptive Statistics: Independent Variables	34
VI.	Descriptive Statistics: Dependent Variables; Treatment Change	35
VII.	Multiple Regression Equations, R, R^2, and S.E.Y.	36
VIII.	Standard Deviation of Y; Size-Size Standard Error of Estimate and Simple Coefficient of Correlation: Standard Error of Estimate and Multiple Correlation Coefficient	39
IX.	Coefficients of Prediction Efficiency	40
X.	Mandibular Position: A Comparison Between the Present Sample and that of Harris *et al.* (1972)	42
XI.	Changes Involving Growth and Treatment, as Opposed to Changes Involving Growth	44
XII.	Changes Accompanying the Begg Technique	46

LIST OF FIGURES

Figure Page

1. Angular Measures on Initial Cephalogram. 19

2. Angular Measures on Initial Cephalogram Continued. 20

3. Linear Measures on Initial Cephalogram 24

4. Linear Measures on Initial Cephalogram Continued 25

5. Linear Measures on Initial Cephalogram Continued 26

6. Linear Measure of the Upper and Lower Lip in Relation to Ricketts E Line 27

INTRODUCTION

The pretreatment cephalogram contains a great deal of information. Cephalometric analyses are based, presumably, on the assumption that much of this information is clinically useful. For example, in both the Begg and Tweed techniques, the pretreatment cephalogram is used to aid in choosing between extraction and non-extraction. Once this determination is made, however, a major question arises: how does the magnitude of the various angular and linear measures of a cephalometric analysis affect the orthodontist's ability to achieve his treatment objective?

It is rather ironic that so very little work has been done along this line, considering its potential value. Accordingly, it will be the purpose of the present study to evaluate the extent to which factors or combinations of factors within the architecture of the pretreatment face interact with treatment to influence the final result.

REVIEW OF THE LITERATURE

Introduction

The cephalometric method was introduced to the orthodontic profession over forty years ago, yet as will be seen, there is considerable ignorance as to the practical treatment significance of a given measure, or more importantly, a group of measures.

Indeed, the concept of an unchanging, orderly pattern of growth fostered by Broadbent (1937) and Brodie (1941), in conjunction with the report of Brodie et al. (1938) in which they stated that orthodontic changes are limited to the alveolar process, did little to encourage investigation into the clinical meaning of various cephalometric measures.

However, the work of Björk (1947), Lande (1952), Nanda (1955) and others have caused a re-evaluation of these rather static concepts. It is now recognized that the pattern of craniofacial growth does change with time and that the effects of orthodontic treatment may not be limited solely to the alveolar process.

It then follows that a knowledge of factors which might limit treatment changes would be clinically significant. Indeed, a number of investigators have attempted to determine possible influences of certain components of the craniofacial complex upon the attainment of various treatment objectives. As will be seen, their conclusions are not of one mind.

Significance of Cephalometric Analyses

Many cephalometric analyses have been proposed and most provide essentially the same information with differences in method and form. The analysis introduced by Downs (1948) was the first and sufficiently representative to be used as an example. His analysis consisted of ten measures, five describing various skeletal relationships and five, various relationships of the denture. The normal range for each was determined by an evaluation of 20 individuals, age 12 years to 17 years, equally divided as to sex and possessing excellent occlusion. With respect to his findings, Downs stated (p. 823, 828-829):

> Within these ranges one can expect to treat a malocclusion to a well-balanced face provided one maintains a balanced relationship of the denture to the skeletal pattern. Excessive deviations of any of these relationships may be considered as unfavorable variations which reduce the prospects of obtaining a harmoniously balanced face, in direct ratio to the amount of deviation.
>
> . . . . . .
>
> Many of our difficulties in treatment can be directly attributed to excessive disharmony of the skeletal pattern. A recognition of such limitations forewarns the orthodontist of what he may expect if he undertakes treatment.

It is interesting to note that the rather small sample size of twenty individuals, as a group, were considerably older than the age at which most children begin orthodontic therapy.

Basically, Downs developed a method for describing what exists, nothing more. By expressing the significance of his analysis in rather vague generalities, it is extremely difficult to relate these

measures to treatment outcome. For example, were one able to say that, given these measures, the probable reduction in angle A point-Nasion-B point would be, say, four degrees, then such an analysis would have ponderable clinical significance. Unfortunately, some interpreted Downs' norms as almost a scala naturae to be climbed by all. The frustration suffered by many still colors the specialty's attitude toward cephalometrics: like the weather, it is talked about, but rarely dealt with.

Treatment Analyses

Treatment analyses, as opposed to cephalometric analyses, in general, not only describe the craniofacial complex, but also, based on this description, determine various treatment objectives.

Tweed's Diagnostic Triangle (1954)

Perhaps the simplest and most widely employed treatment analysis is the Tweed diagnostic triangle. The triangle itself is composed of three intersecting planes:

1. The Frankfort plane is established by connecting a point 4.5 mm. above the geometric center of the ear rod with the lowest point midway between the left and right borders of the orbits.

2. The mandibular plane is drawn along the lower border of the mandible connecting menton and a point midway between the left and right borders of the mandible in the region of the gonial angle.

3. The third plane is constructed by extending a line through the long axis of the lower central incisor downward to the mandibular plane and upward to the Frankfort plane.

The intersection of these planes form the following angles:

1. The Frankfort mandibular plane angle (FMA)
2. The mandibular incisor plane angle (IMPA)
3. The Frankfort mandibular incisor angle (FMIA)

The FMIA is generally considered to be the most important angle, with a minimum requirement of 65° and an ideal value of 68°. The position of the lower incisor in relation to the mandibular plane is varied (depending on the value of FMA) so as to achieve the desired FMIA. According to Tweed, FMIA's in the range of 65° to 68° would result in good facial esthetics and a stable occlusion. His findings were based on a sample size of 95 individuals, who exhibited pleasing facial esthetics. Some had been treated orthodontically, most had not; no examination was made of the occlusion.

From the methods employed, it is impossible to verify the statement that FMIA's in this range would result in a stable occlusion, since the occlusion was never examined. In addition, his evaluation of esthetics is a subjective judgement, and the criteria used for one population would not necessarily be the same for a different population.

Holdaway's Analysis

Holdaway's analysis (1956) is concerned with apical base orientation. The relationship between A point and B point as measured by angle, A point-Nasion-B point (ANB), is the most significant factor. Based not only on his own clinical experience, but also on the analysis of seventy cases treated by other orthodontists, Holdaway concluded that a successfully treated case would have an ANB of 0-4°, preferably

in the range of 0-2°. He stated that this range would be difficult to obtain in the following types of patients and conditions (pp. 185-186):

1. Nearly all girls 13 years of age or over and boys past 16 years of age.
2. Children younger than this who obviously have had a growth and maturation rate earlier than normal. [sic]
3. ANB angles greater than 9°, regardless of type of mandible.
4. SN-GoGN[1] plane angles in excess of 40°, where associated with ANB angles greater than 5°.

Holdaway also described exactly where the upper and lower incisors should be located as a function of the posttreatment ANB angle. This information can be found in Table I.

This synthesis agreed with Graber's (1952) opinion that the greater the apical base difference, the more the maxillary incisors must be tipped lingually and the more the mandibular incisors must be tipped labially.

Holdaway, therefore, has attempted to predict the posttreatment value of angle ANB based on growth potential and certain cephalometric measures of the pretreatment face.

Steiner's Analysis

Steiner (1959) introduced an analysis based on a number of factors, the two most important being angle ANB and the measure

---

[1]A measure of the inclination of the lower border of the mandible. The angle is formed by the intersection of the Sella-Nasion plane with the mandibular plane defined by gonion and gnathion.

TABLE I

POSITION OF LOWER AND UPPER INCISORS AS DETERMINED BY THE ANB ANGLE (AFTER HOLDAWAY, 1956)

ANB Angle (Degrees)	1 to NB (mm)	1 to NA Angle (Degrees)
Up to 4	3.0	22
5	3.5	21
6	4.0	20
7	4.5	18
8	5.0	17
9	5.5	15
10	6.0	13
11	7.0	11
12	8.0	8

pogonion to the line Nasion-B point. Using these factors and an appreciation of his own clinical ability, Steiner arrived at "acceptable compromises" for the placement of the upper and lower incisors. This approach represented an attempt to individualize the treatment with respect to the craniofacial architecture exhibited by the patient.

Therefore Steiner, as Holdaway (1956), endeavored to predict future change based on growth potential, pretreatment cephalometric measures and a knowledge of his orthodontic prowess.

Tweed's Growth Trends (1963)

Tweed stressed the need for classifying the "Growth Trend" of the individual, based on the assumptions that the type of growth is a prime factor in determining the prognosis and that the growth pattern identified during the mixed dentition would prevail and treatment could then be planned accordingly. The trend is determined by the change in angle ANB over an approximate 18-month observation period. Growth is subsequently categorized into three types and a variety of subdivisions.

Ruekema (1971), in an unpublished thesis, examined the validity of Tweed's growth trend classification theory in a longitudinal study of 84 children. Based on contingency tests, he concluded that (pp. 41-42):

> The Tweed Growth Trend Classification Theory is statistically unreliable to such an extent that it is of questionable value as a diagnostic aid in the treatment planning of mixed dentition cases.

In reviewing the various treatment analyses, it appears that certain cephalometric dimensions might be more clinically useful than others.

The Significance of Individual Measures

For purposes of discussion, the mandibular plane angle, probably the one pretreatment measure which has received the most attention, will be examined as representative of the numerous measures derived from the initial cephalogram.

Tweed (1946) was perhaps the first investigator to attribute clinical significance to the value of the Frankfort-mandibular plane angle. Based upon many years of clinical experience, he concluded that this angle was extremely important to the success or failure or the case in that it indicated the growth pattern of the individual: the higher the angle, the more vertical the pattern and vice versa. His conclusions may be summarized:

1. Frankfort-mandibular plane angle range of 16° to 28°--the prognosis varies from excellent (16°) to good (28°).
2. Frankfort-mandibular plane angle range 28° to 32°--the prognosis varies from good (28°) to fair (32°).
3. Frankfort-mandibular plane angle range 32° to 35°--the prognosis is fair at 32° and unfavorable at 35°.
4. Frankfort-mandibular plane angle range 35° and upward--the prognosis is not favorable at 35° and at extremes such as 45° to 55° the case is virtually doomed to failure.

However, Björk (1947) in a roentgenographic study of adolescent growth changes in a cross-section sample of Swedish males (322 at age 12 and 281 at age 21) concluded that one of the growth changes which takes place is a reduction in the mandibular plane

angle. He later (1951) confirmed this finding in a longitudinal study in which 151 males were followed over a similar span.

Lande's (1952) study of 34 males confirmed Bjork's earlier findings concerning the reduction of the inclination of the lower border of the mandible with age. Included in his sample were 10 individuals with Class II denture relationships who also exhibited the same general tendency.

If then, a high FMA is an expression of vertical growth, it does not necessarily follow that the pattern will continue. Therefore, the difficulties encountered by Tweed might have been more related to the growth that had already taken place rather than a continuation of the vertical pattern. However, the exact nature of the resultant clinical problems is not discussed.

Clinical problems associated with high FMA's were, however, discussed by Graber (1952). Based on his experience, he stated (p. 612), "A steep mandibular plane is a severe limitation on holding any changes in the occlusal plane (accomplished by Class II therapy) or in maintaining any correction of a steep overbite." Graber did not support this contention with any clinical data.

Downs (1952) was also of the opinion that a high mandibular plane complicates treatment and prognosis, but an angular reading in and of itself cannot indicate the nature of the difficulty which will be encountered. This argument, like that of Graber, was an empirical evaluation.

It seems to be a general opinion that a high mandibular plane

angle makes treatment more difficult, but "why" remains a mystery. It is perhaps a soluable mystery, however, given contemporary technology.

Possible Treatment Limitations Imposed by the Bony Architecture

Mandibular Form

It is a popular belief that when Class II malocclusions are being corrected, forward growth of the mandible is of greater benefit than vertical growth. Accordingly, Ricketts (1961) presented ten characteristics of form which he felt could be used to determine the amount and direction of future mandibular growth. His scheme was based on 1,000 orthodontic cases, of which nearly 60% were female and about 60% were Class II malocclusions. Ricketts' synthesis of his observations are presented in Table II. It is perhaps not surprising that the validation of such a specific and potentially important formulation was attempted.

Johnston (1968), while not specifically evaluating the Ricketts' synthesis, did conclude that this type of prediction scheme would probably be incapable of predetermining the individual pattern of growth.

Balbach (1969), however, examined the predictive significance of Ricketts' study, covering the age range of approximately 7 years to 11 years, using a sample of 41 males. He concluded that no statistical support could be found for the hypothesis that an individual mandibular trait or the summation of a number of morphological characteristics could be used to accurately predict the future location of the mandible.

TABLE II

MANDIBULAR CHARACTERISTICS AND THEIR POTENTIAL EFFECT ON GROWTH (RICKETTS, 1961)

Mandibular Characteristic	Growth Behavior
1. Mandibular plane angle	
Low	Forward
High	Vertical
2. Gonial Angle	
Acute	Forward
Obtuse	Vertical
3. Width of Ramus	
Wide	Forward
Narrow	Vertical
4. Thickness of condyle	
Wide	Forward
Narrow	Vertical
5. Width of Symphysis	
Wide	Forward
Narrow	Vertical
6. Inclination of Condyle	
Forward	Forward
Backward	Vertical
7. Corpus Length	
Long	Forward
Short	Vertical
8. Coronoid Height	
Low	Forward
High	Vertical
9. Occlusal Plane	
Parallel	Forward
Divergent	Vertical
10. Ante-gonial Notching	
Normal	. .
Notched	Vertical

Certainly this challenges the validity of Ricketts' concepts. In order for a measure or group of measures to be considered clinically significant, it must relay information concerning the probable future treatment.

Multivariate Analysis as an Approach to Cephalometric Prediction

Coben (1955) was one of the first investigators to suggest the need for a multivariate approach to determine the clinical significance of a given variable. He (1955) was of the opinion that (p. 432), ". . .it is not sufficient to study any single variant alone, for the significance of each characteristic lies in its integration in the total facial morphology." However, this begs the question: what are the significant variables?

Brader (1965) stated that (p. 807):

> It has never been possible to establish clearly the consistent relations between the individual measurements, per se, or between the significant ones and purposeful clinical implication.

Johnston (1968) examined the possibility of predicting craniofacial growth over various 5-year time spans on a sample consisting of ninety individuals. The scheme of prediction was based on the belief that it was highly improbable that any one cephalometric measure could contain enough information to be of clinical significance. He therefore selected a statistical tool which allowed the evaluation of the predictive significance of multiple variables, stepwise multiple linear regression analysis. He concluded the results were of minimal clinical significance.

Summary

Although Johnston (1968) could not predict growth changes to a degree which would be clinically useful, he did postulate that if treatment were taken into account beforehand, a "clinically useful" prediction of the posttreatment face might be obtained. It was his belief that there were at least 3 components involved in the prediction of the posttreatment face:

1. The degree of stability
2. The degree of change due to growth
3. The degree of change due to treatment

If the extent of change due to treatment were large enough, a valid forecast might be possible without a knowledge of the relatively small individual growth changes.

Although assuasive, the last of these conjectures has never been examined specifically. Accordingly, the present thesis will examine the clinical significance of the cephalometric method in estimating the limitations imposed by the craniofacial architecture on the outcome of a given treatment modality, in this instance, the Begg light wire differential force technique. In other words, can the methods which have been employed to predict relatively insignificant growth changes be used to forecast efficiently the presumably richer repertoire of changes that can be wrought by treatment?

METHODS AND MATERIALS

Source

The cephalograms analyzed in this investigation were obtained from the files of Dr. Milton Rabine, who has been practicing the Begg technique for approximately 13 years.

Sample

A sample of 60 subjects, 30 males and 30 females, were selected. Each individual satisfied the following requirements:

1. The denture relationship was a Class II, division I malocclusion. The minimum requirement for the molar classification was an approximation of the mesial surface of the upper first molar with the mesial surface of the lower first molar.

2. The four first bicuspids were extracted.

3. Each individual had a pretreatment lateral cephalogram and a lateral cephalogram taken following the removal of bands. In many instances, there was more than one posttreatment lateral cephalogram; the last cephalogram of the series was used.

4. The cephalograms were of good quality and the landmarks were readily discernible.

The mean age at which the initial cephalogram was taken was 12.2 years with a standard deviation of 1.6 years. The mean age at which the final cephalogram was taken was 15.9 years with a standard deviation of 1.3 years. The mean time-period between removal of bands and the final cephalogram was 1.5 years, with a standard deviation of 1.3 years.

Technical Details

The lateral cephalograms were taken with a Wehmer cephalostat (vertical counter balance, B.F. Wehmer, Park Ridge, Illinois) and a General Electric X-ray head (11ce-2-2, General Electric, Milwaukee, Wisconsin), with a source-film distance of sixty inches. The tracings were made in pencil (2H) on .003" frosted acetate. The angular measurements were read to the nearest 5-minute interval with a conventional drafting machine (Vemco-Model 3300, V. and E. Manufacturing Company, Pasadena, California). The linear measurements were read to the nearest tenth of a millimeter with dial vernier calipers (Helios Dial Calipers, DCA Corporation, Washington, D.C.).

Measurements

On the initial cephalogram a total of 29 measurements were made, 12 angular (Table III, Figures 1 and 2) and 17 linear (Table IV, Figures 3, 4, and 5); on the final cephalogram 14 measurements were made, 7 angular and 7 linear (Figure 6). In Appendix I the various anatomic landmarks and cephalometric planes are defined.

Angular Measures on Final Cephalogram

The angular measures were:

1. Sella-Nasion-A point (SNA)
2. Sella-Nasion-B point (SNB)
3. A point-Nasion-B point (ANB)
4. Mandibular Plane Angle (SN-MP)
5. Occlusal Plane Angle (SN-Occ)
6. Incisor Mandibular Plane Angle (IMPA)
7. Interincisal Angle ($\underline{1}$-$\overline{1}$)

TABLE III

ANGULAR MEASUREMENTS ON INITIAL CEPHALOGRAM

Measurement	Definition
1. Articulare-Sella-Nasion angle (/Ar-S-N)	Angle formed by the intersection of lines inscribed from articulare to sella and from nasion to sella.
2. Gonial angle (/Go)	Angle formed by the intersection of the mandibular plane and a line from articulare which passes through the most posterior point on the posterior border of the ramus.
3. Palatal plane angle (/SN-Pal)	Angle of palatal plane relative to sella-nasion plane.
4. Incisor-mandibular plane angle (/IMPA)	Angle formed by the intersection of the mandibular plane and a line approximating the long axis of the mandibular central incisor.
5. Sella-Nasion-A point angle (/SNA)	Angle formed by the intersection of the sella-nasion plane and a line connecting nasion and A point.
6. Sella-Nasion-B point angle (/SNB)	Angle formed by the intersection of the sella-nasion plane and a line connecting nasion and B point.
7. A point-Nasion-B point angle (/ANB)	Angle formed by the lines NA and NB at Nasion.
8. Sella-Nasion-Pogonion angle (/SNP)	Angle formed by the intersection of the sella-nasion plane and a line connecting nasion and pogonion.
9. Maxillary Central Incisor angle (/ I-SN)	Angle formed by the intersection of the sella-nasion plane and a line approximating the long axis of the maxillary central incisor.

TABLE III continued

Measurement	Definition
10. Occlusal plane angle (/SN-Occ)	Angle of Down's occlusal plane with respect to sella-nasion plane.
11. Mandibular plane angle (/SN-MP)	Angle of mandibular plane in relation to sella-nasion plane.
12. Angle of Convexity (/Con)	Angle formed by the intersection of the lines nasion-A point and pogonion-A point.

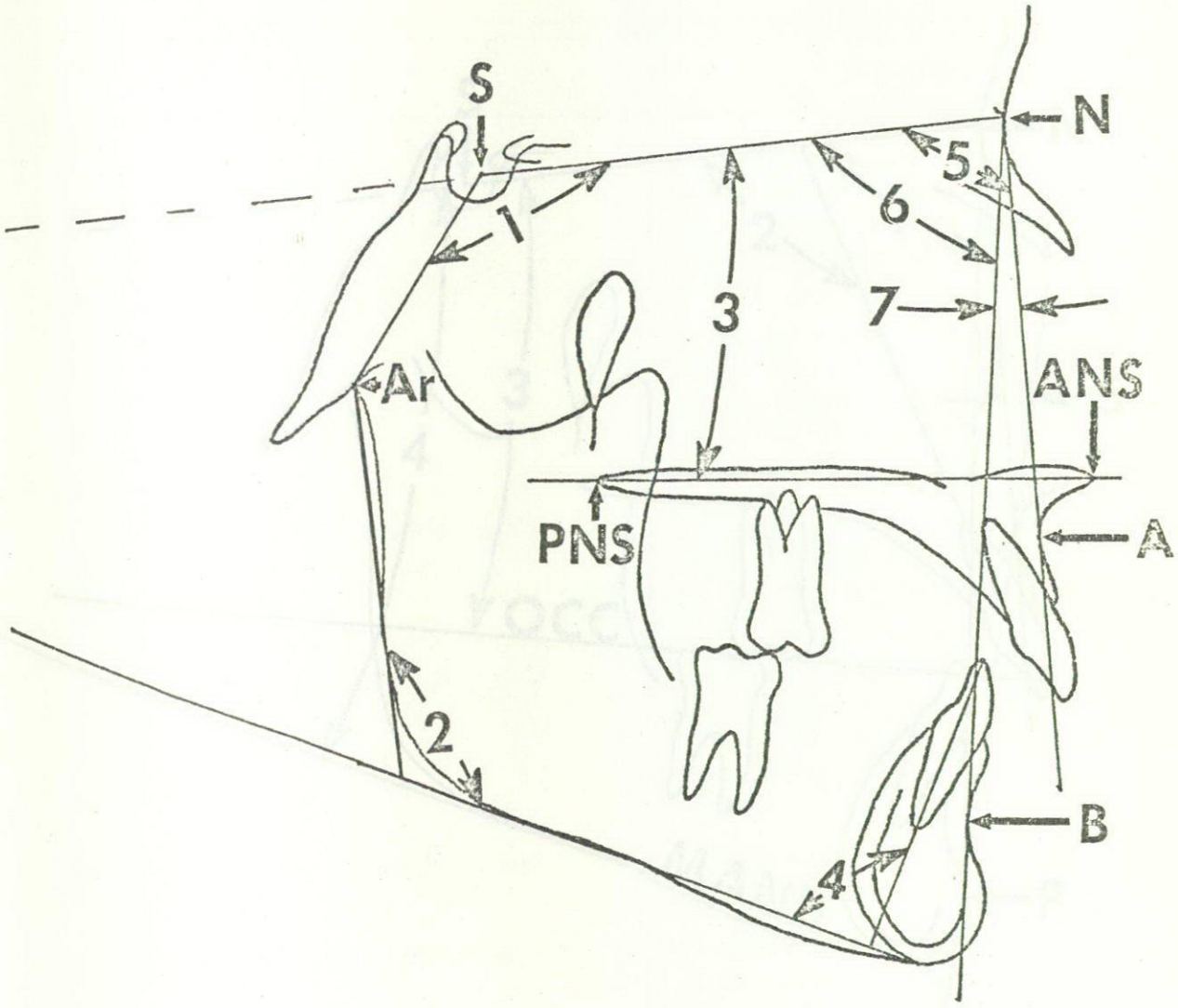


Figure 1--Angular Measures on Initial Cephalogram.

1. Ar-S-N
2. Go
3. SN-Pal
4. IMPA
5. SNA
6. SNB
7. ANB

(Diagram modified after Bolton representative skeletal norm, female age 12, number B-1208-11, 1971)

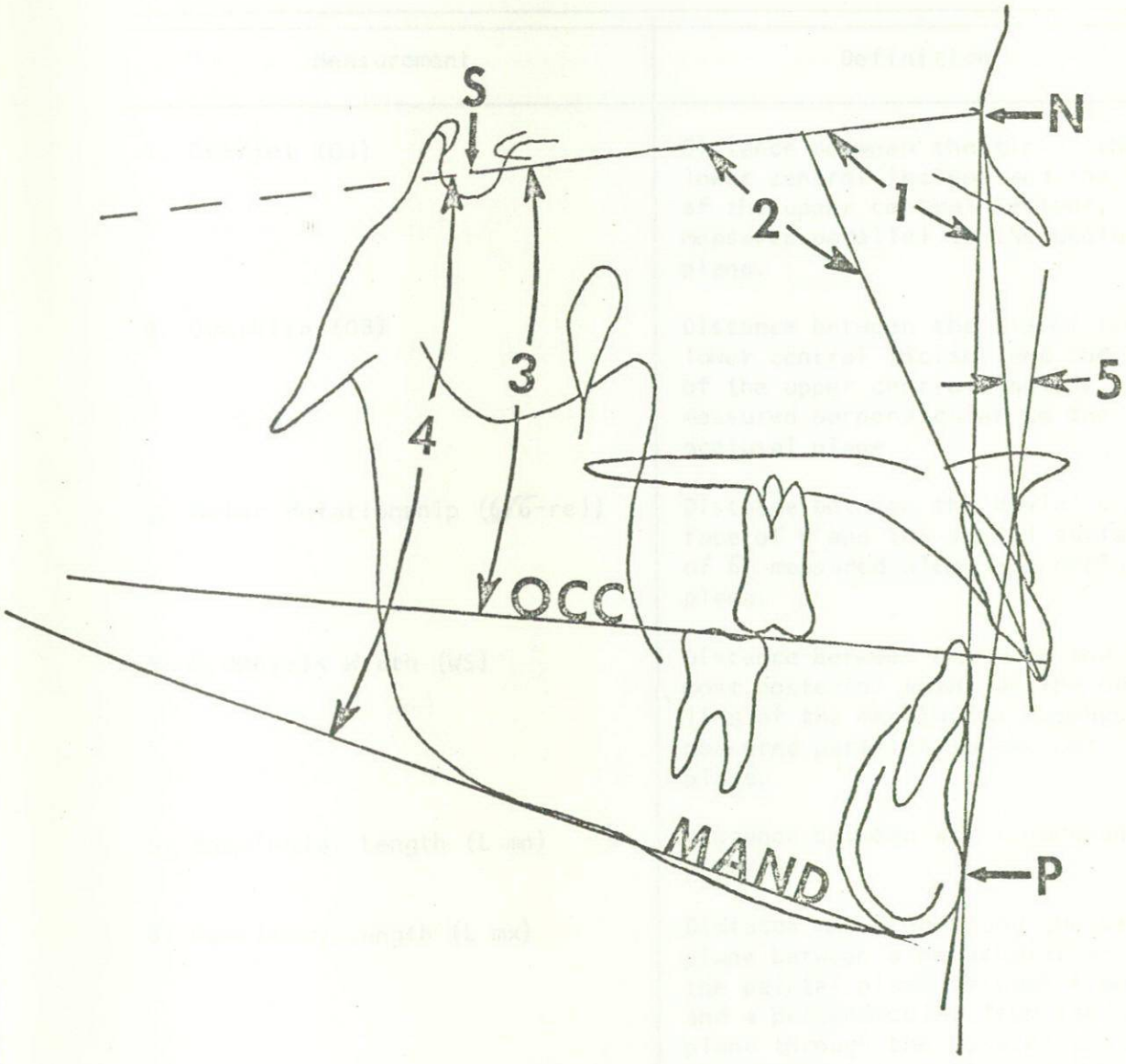


Figure 2--Angular Measures on Initial Cephalogram Continued

1. SNP
2. I-SN
3. SN-Occ
4. SN-MP
5. Con

(Diagram modified after Bolton representative skeletal norm, female, age 12, number B-1208-11, 1971.)

TABLE IV

LINEAR MEASUREMENTS ON INITIAL CEPHALOGRAM

Measurement	Definition
1. Overjet (OJ)	Distance between the tip of the lower central incisor and the tip of the upper central incisor, measured parallel to the occlusal plane.
2. Overbite (OB)	Distance between the tip of the lower central incisor and the tip of the upper central incisor, measured perpendicular to the occlusal plane.
3. Molar relationship ($\underline{6}/\overline{6}$-rel)	Distance between the mesial surface of $\underline{6}$ and the mesial surface of $\overline{6}$, measured along the occlusal plane.
4. Symphysis Width (WS)	Distance between pogonion and the most posterior point on the outline of the mandibular symphysis, measured parallel to the occlusal plane.
5. Mandibular Length (L mn)	Distance between articulare and pogonion.
6. Maxillary Length (L mx)	Distance measured along the palatal plane between a perpendicular from the palatal plane through A point and a perpendicular from the palatal plane through the base of the pterygo-maxillary fissure.
7. Maxillo-mandibular ratio (L mx/L mn)	Ratio of maxillary length to mandibular length.
8. Upper face height (Hu)	Distance between nasion and ANS measured parallel to the nasion-pogonion plane.

TABLE IV continued

Measurement	Definition
9. Lower face height (HL)	Distance between ANS and menton, measured parallel to the nasion-pogonion plane.
10. Total face height (H)	Distance between nasion and menton measured parallel to the nasion-pogonion plane.
11. Sella-Nasion Length (L SN)	Distance between sella and nasion.
12. Articulare-Sella Length (L Ar-S)	Distance between articulare and sella.
13. Ramus Length (Lr)	Distance between articulare and the mandibular plane measured along a line which intersects articulare and the most posterior point on the posterior border of the ramus.
14. Ramus Width (Wr)	A line was constructed parallel to the line connecting articulare and the mandibular plane, passing through the most posterior point on the anterior border of the ramus. At this point, a perpendicular was drawn which intersected the line connecting articulare and mandibular plane. The distance between the two lines was defined as ramus width.
15. Modified Holdaway's Ratio (Hold)	Instead of using (NB to T)/NB to Pogonion, the denominator of the ratio was subtracted from the numerator. Accordingly a Holdaway value of 1 would be equivalent to zero in this study, and so forth. This modification was employed because in a few instances the linear distance between NB and pogonion was zero.

TABLE IV continued

Measurement	Definition
16. A point to B point (A/B)	Distance measured along the occlusal plane between a line perpendicular to the occlusal plane raised through A point and a similar perpendicular raised through B point. If A point was anterior to B point, the measurement was given a plus value; if A point was posterior to B, the measurement was negative.
17. Lower incisor to AP ($\overline{1}$-AP)	Distance between the tip of the lower central incisor and the AP plane, measured parallel to the occlusal plane. If the tip of the lower incisor was anterior to the AP plane, the measurement was assigned a plus value.

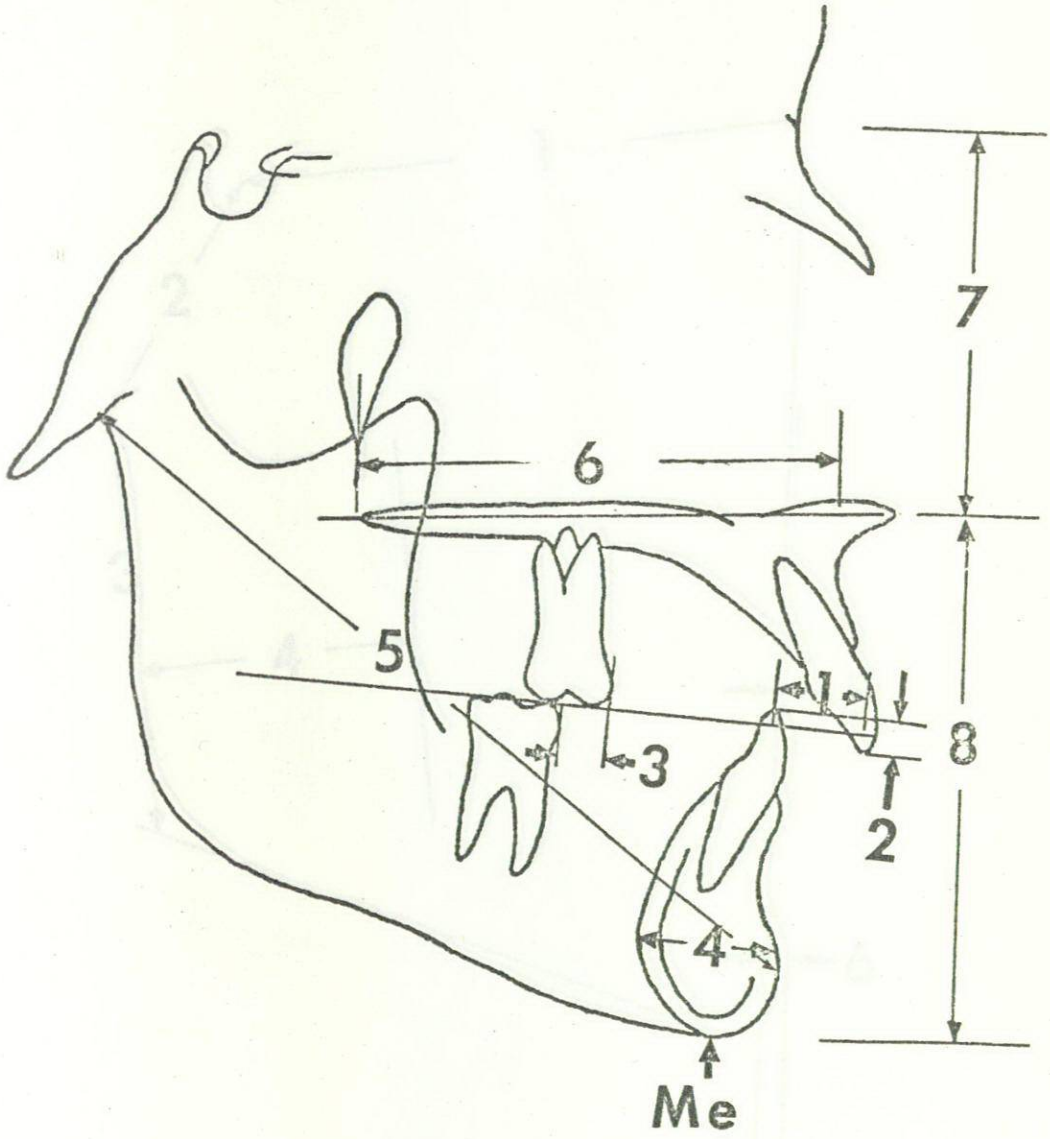


Figure 3--Linear Measures on Initial Cephalogram

1. OJ	3. $\frac{6}{\overline{6}}$	5. Lmn	7. Hu
2. OB	4. $\overline{WS}$	6. Lmx	8. Hl

(Diagram modified after Bolton representative skeletal norm, female, age 12, number B-1208-11, 1971)

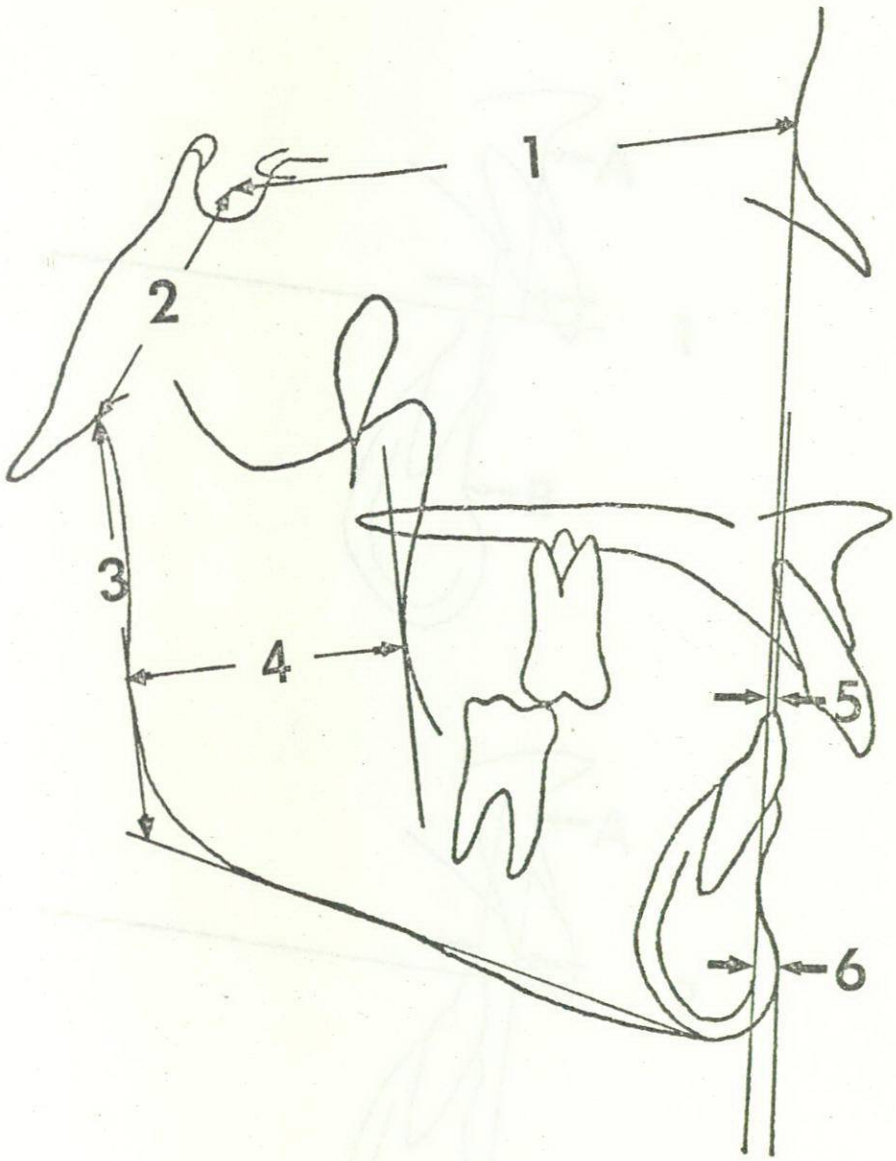


Figure 4--Linear Measurements on Initial Cephalogram Continued

1. LSN
2. LAr-S
3. Lr
4. Wr

Subtract 6 from 5 to obtain the modification of Holdaway's ratio

(Diagram modified from Bolton representative skeletal norm, female, age 12, number B-1208-11, 1971)

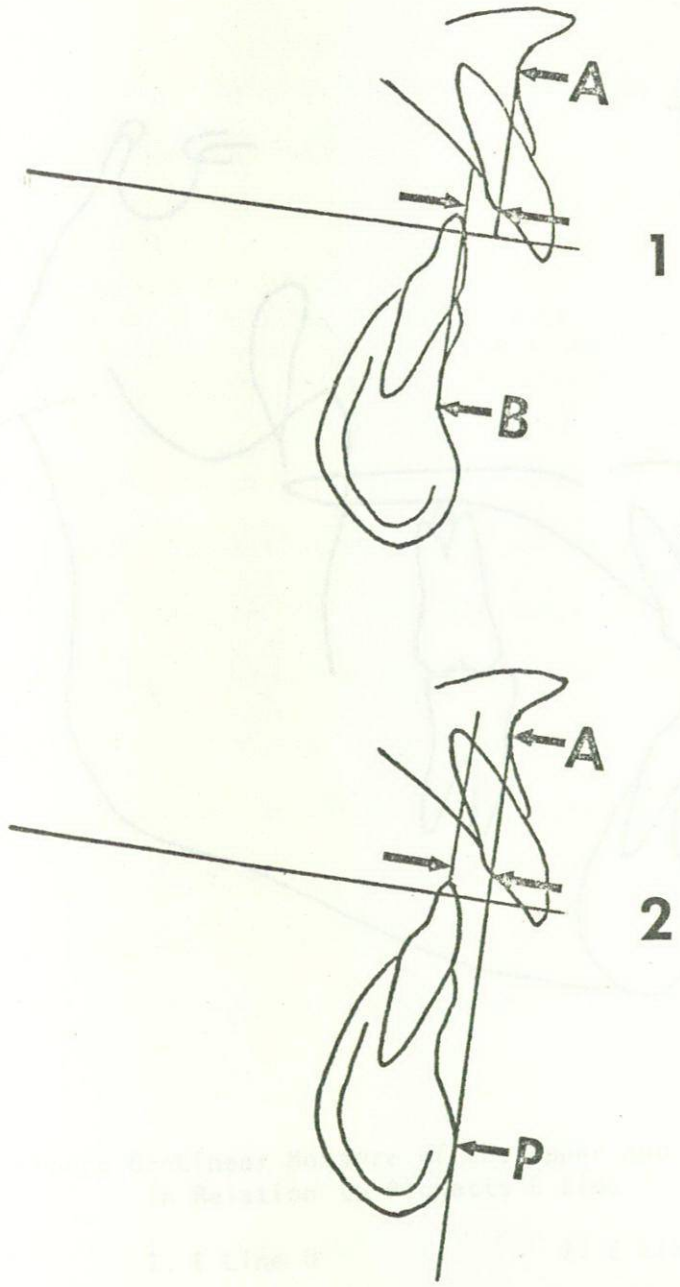


Figure 5--Linear Measurements on Initial Cephalogram Continued

1. A/B
2. $\overline{I}$-AP

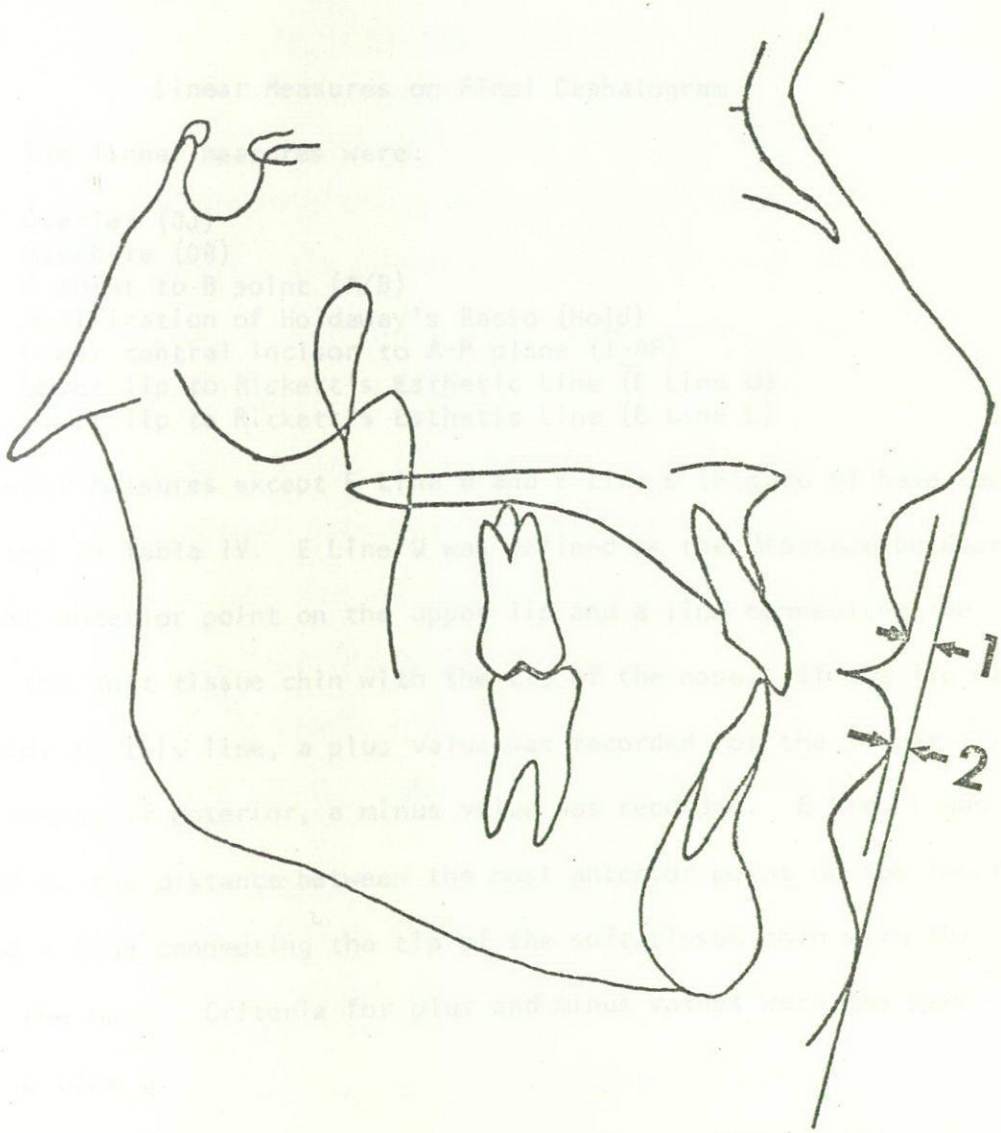


Figure 6--Linear Measure of the Upper and Lower Lip in Relation to Ricketts E Line

1. E Line U 2. E Line L

(Diagram modified from Bolton representative skeletal norm, female, age 12, number B-1208-11, 1971)

All the angular measures have already been presented (Table III), except $\underline{1}$-$\overline{1}$. This angle is formed by the intersection of a line through the long axis of the upper incisor and a line through the long axis of the lower incisor.

Linear Measures on Final Cephalogram

The linear measures were:

1. Overjet (OJ)
2. Overbite (OB)
3. A point to B point (A/B)
4. Modification of Holdaway's Ratio (Hold)
5. Lower central incisor to A-P plane ($\underline{1}$-AP)
6. Upper lip to Rickett's Esthetic Line (E Line U)
7. Lower lip to Rickett's Esthetic Line (E Line L)

All linear measures except E Line U and E Line L (Figure 6) have been presented in Table IV. E Line U was defined as the distance between the most anterior point on the upper lip and a line connecting the tip of the soft tissue chin with the tip of the nose. If the lip was posterior to this line, a plus value was recorded for the linear measurement; if anterior, a minus value was recorded. E Line L was defined as the distance between the most anterior point on the lower lip and a line connecting the tip of the soft tissue chin with the tip of the nose. Criteria for plus and minus values were the same as for E Line U.

Rationale for the Measurements Used

On the initial cephalogram an attempt was made to describe accurately the pretreatment craniofacial complex. Therefore, reliability of the landmarks was an important consideration. For example,

the Sella-Nasion plane was used instead of the Frankfort plane. The choice of measurements on the final cephalogram was based on their presumed clinical significance.

Multivariate Analysis

Based on Johnston's (1968) thesis that the increased variability introduced by treatment might allow a clinically useful forecast of the posttreatment face and the belief that no one variable could contain enough information to be of predictive significance, a multivariate approach to prediction was chosen.

In the present study, 33 variables were considered as possible sources of information concerning the treatment outcome. In addition to the dimensions described on the initial cephalogram the following predictor variables were employed:

1. sex (male = 1; female = 0)
2. age at which initial cephalogram was taken measured in months (age)
3. length of time between pretreatment cephalogram and posttreatment cephalogram measured in months (LT)
4. length of time between removal of bands and final cephalogram measured in months (LTB).

The specific type of multivariate analysis used was stepwise multiple linear regression.

Stepwise Multiple Linear Regression (Draper and Smith, 1966)

The equation for a regression has the general form:

$$\hat{Y}_i = a + b_1 \cdot X_{j1} + b_2 \cdot X_{j2} + \ldots + b_k \cdot X_{jk}$$

where,

$\hat{Y}_i$ is the predicted value of the ith dependent variable.

a is a constant for each equation and is analogous to the Y intercept in a simple regression equation.

$b_1, b_2 \ldots b_k$ are regression coefficients. These coefficients express the proportion of the independent variable (predictor variable) that must be added to or subtracted from the quantitative estimation of Y_i.

X_j is the significant independent variable which contributes unduplicated information towards the estimation of Y_i.

i is a subscript denoting the ith dependent variable, where i = 1, 2,. . .14.

j is a subscript denoting the independent variable, where j = 1, 2,. . .33.

k is the total number of significant independent variables employed in a given regression equation.

In evaluating the usefulness of the regression equation the following statistics were examined:

1. The coefficient of multiple correlation (R) which expresses the degree of linear correlation between the actual value of the dependent variable (Y_i) and the predicted value ($\hat{Y}_i$).

2. The coefficient of multiple determination (R^2) which shows the proportion of the total variability of Y which is "explained" by the regression equation, where
$$R^2 = \frac{\text{Explained variability of Y}}{\text{Total variability of Y}}$$

3. The standard error of estimate (S.E.Y), which is the standard deviation of the difference between the actual and predicted value of Y.

4. A coefficient of prediction efficiency (E) which represents the percentage reduction in error as a result of using the regression equation.

A general form for the equation is:

$$E = \frac{\text{(Error without regression)} - \text{(Error with regression)}}{\text{(Error without regression)}} \cdot 100$$

It will be used specifically in the following forms:

1. $E = \frac{\text{(Standard Deviation Y)} - \text{(S.E.Y.)}}{\text{(Standard Deviation Y)}} \cdot 100$

2. $E = \frac{\text{(Standard Deviation Y)} - \text{(S.E. size-size)}}{\text{(Standard Deviation Y)}}$

3. $E = \frac{\text{(S.E. size-size)} - \text{(S.E.Y.)}}{\text{(Standard Deviation Y)}}$

S.E. size-size is the standard deviation of the difference between the actual and predicted value of Y, based on a simple regression between the size of the original variable and the size of the future variable. A simple linear correlation (r size-size) indicates the extent of the association.

The stepwise regression procedure provides a judgement on the contribution made by each independent variable towards an estimation of Y_i. All the variables in the equation are re-examined at every stage of the regression, and any variable which does not provide significant information is removed from the equation. Thus, all the remaining variables contain unduplicated information concerning the prediction of the dependent variable.

In summary, 33 predictor variables were used simultaneously in order to yield a prediction equation for each of the 14 dependent variables.

Computations

The data were transferred to computer cards, and processed by

a Univac computer (owned and operated by Chi Corporation, Cleveland, Ohio) according to a multiple linear correlation and regression program known as Chimaera (Ladner, 1969). The F level chosen for inclusion or deletion of an independent variable was 4.0, approximately a 95% level of confidence.

FINDINGS

Means and Standard Deviations

Means and standard deviations are presented in Tables V and VI. The characteristics of the sample are statistically described in Table V and the effects of treatment are shown in Table VI. Of particular interest in Table VI are the mean treatment changes and the standard deviations of these changes.

Stepwise Multiple Linear Regression Equations

The equations for the predicted values of the dependent variables are presented in Table VII. For the dependent variable $\overline{I}$-I none of the independent variables provided significant information with respect to its future outcome. Therefore, no equation was generated. In a number of cases, for example, /$\hat{SNA}$, /$\hat{SNB}$, /$\hat{ANB}$, /$\hat{SN\text{-}MP}$, and $\hat{Hold}$, the first steps of the equation involved the original value of the same variable. Also of interest, are the multiple correlation coefficients, (R), the coefficients of multiple determination (R^2), and the standard errors of estimate (S.E.Y.) for all the equations.

Evaluation of Certain Equations

The statistical evaluation of the equations in which the dependent variable (Y) was also measured as an independent variable (X)

TABLE V

DESCRIPTIVE STATISTICS: INDEPENDENT VARIABLES

Variable	Mean	S.D.	Variable	Mean	S.D.
1. ∠ SN-Occ	15.74	3.70	18. OB	4.36	2.22
2. ∠ SN-MP	35.44	4.16	19. OJ	8.23	3.30
3. ∠ SNA	80.95	3.46	20. T-AP	1.91	2.29
4. ∠ SNB	75.21	2.82	21. A/B	4.80	2.76
5. ∠ ANB	5.74	1.90	22. Hold	4.22	3.14
6. ∠ IMPA	97.70	14.36	23. Lmx	51.18	3.31
7. ∠ SNP	76.13	2.98	24. Lmn	100.38	5.68
8. ∠ $\overline{1}$-SN	105.44	14.73	25. Wr	30.35	3.08
9. ∠ Ar-S-N	124.65	5.48	26. Lr	42.00	3.70
10. ∠ Go	126.38	5.02	27. LAr-S	34.35	2.98
11. ∠ Con	10.57	5.02	28. LS-N	71.69	3.38
12. ∠ SN-Pal	8.35	2.91	29. Lmx/Lmn	0.51	0.03
13. $\underline{6}/\overline{6}$	1.64	1.40	30. Sex	0.50	0.50
14. Ws	14.18	2.31	31. Age	146.23	19.65
15. Hu	51.70	3.16	32. LT	44.25	15.13
16. Hl	63.84	5.13	33. LTB	18.50	15.18
17. H	115.71	6.29			

TABLE VI

DESCRIPTIVE STATISTICS: DEPENDENT VARIABLES; TREATMENT CHANGE

Variable	Mean	S.D.	Mean Treatment Change	S.D. Treatment Change
1. ∠ SN-Occ	19.92	4.36	4.25	4.21
2. ∠ SN-MP	34.47	4.86	-1.17	3.14
3. ∠ SNA	79.35	3.41	-1.58	1.52
4. ∠ SNB	75.43	3.04	0.23	1.86
5. ∠ ANB	3.93	2.10	-1.79	1.43
6. ∠ IMPA	95.51	5.25	-2.21	5.67
7. OJ	3.00	0.72	-5.26	3.32
8. OB	2.81	1.21	-1.53	1.96
9. A/B	0.33	2.14	-4.46	2.61
10. Hold	1.78	3.13	-2.47	2.25
11. $\overline{I}$-AP	0.93	1.73	-1.00	2.10
12. $\overline{I}$-$\underline{I}$	134.79	13.55	. .	. .
13. E Line U	4.35	1.91	. .	. .
14. E Line L	2.70	2.02	. .	. .

Mean treatment change was subject to error due to the conversion of degrees to the decimal system and rounding errors. Therefore, mean treatment change is approximately equal to the initial mean minus the final mean.

TABLE VII

MULTIPLE REGRESSION EQUATIONS, R, R^2, and S.E.Y

Y = a	$+[(b_1)\cdot(X_1)]$	$+[(b_2)\cdot(X_2)]$	$+[(b_3)+(X_3)]$	$+[(b_4)\cdot(X_4)]$
1. ∠ SN-Occ	70.26	-.48 ∠SNP	-.10 LT	-.18 ∠Ar-S-N	-2.84 Sex
2. ∠ SN-MP	46.88	.88 ∠SN-MP	.10 LT	-.07 ∠IMPA	.30 ∠Con
3. ∠ SNA	4.75	.92 ∠SNA	.03 LTB	.08 ∠Ar-S-N	. .
4. ∠ SNB	-36.15	1.03 ∠SNB	.05 LT	.14 ∠Ar-S-N	.11 ∠Go
5. ∠ ANB	6.32	.79 ∠ANB	.02 Age	-.14 LSN	-.25 $\underline{6}/\overline{6}$
6. ∠ IMPA	159.66	-.95 ∠SN-MP	.80 Hold	.74 ∠SNP	43.51 Lmx/Lmn
7. OJ	7.63	.02 LTB	-.05 ∠Go	.05 ∠SN-Occ	. .
8. OB	.18	.25 OB	.04 LT	. .	. .
9. T-AP	-10.55	.31 Hold	.08 ∠Go	. .	. .
10. Hold	15.18	.90 Hold	.38 OJ	-.28 LSN	. .
11. A/B	19.22	.52 A/B	-.16 ∠Go	-.27 OJ	.15 ∠SN-Pal
12. E Line U	4.22	-.16 ∠Con	.04 LT	. .	. .
13. E Line L	4.14	-.27 Hold	-.15 ∠Con	.03 LT	. .

TABLE VII continued

+ $[(b_5)\cdot(X_5)]$	+ $[(b_6)+(X_6)]$	+ $[(b_7)+(X_7)]$	R	R^2	S.E.Y	
+.73 OJ	.47 /SN-Occ	.29 Hold	.802	.643	2.771°	1.
-.15 /Ar-S-N	-33.70 Lmx/Lmn	. .	.902	.814	2.215°	2.
. .	. .	. .	.917	.841	1.395°	3.
.88 Sex	. .	. .	.880	.774	1.509°	4.
. .	. .	. .	.808	.653	1.284°	5.
. .	. .	. .	.678	.460	3.997°	6.
. .	. .	. .	.500	.250	.640 mm	7.
. .	. .	. .	.664	.440	.919 mm	8.
. .	. .	. .	.645	.416	1.347 mm	9.
. .	. .	. .	.870	.757	1.583 mm	10.
. .	. .	. .	.684	.468	1.618 mm	11.
. .	. .	. .	.469	.220	1.720 mm	12.
. .	. .	. .	.653	.426	1.567 mm	13.

is presented in Tables VIII and IX.

Table VIII represents a comparison of the standard deviation of the difference between the actual and predicted value of Y by using two methods, one based on the assumption that the size of the original variable determines the size of the future variable (size-size), and the other a multivariate approach (stepwise multiple linear regression).

The percentage reduction in error, accompanied by the use of a size-size method as opposed to the multivariate method is shown in Table IX.

TABLE VIII

STANDARD DEVIATION OF Y; SIZE-SIZE STANDARD ERROR OF ESTIMATE AND SIMPLE COEFFICIENT OF CORRELATION: STANDARD ERROR OF ESTIMATE AND MULTIPLE CORRELATION COEFFICIENT

Variable	S.D.Y	S.E. (size-size)	S.E.Y	r (size-size)	R
1. ∠SN-MP	4.86	2.94	2.22	.800	.902
2. ∠SN-Occ	4.36	3.90	2.77	.444	.802
3. ∠SNA	3.41	1.48	1.40	.903	.917
4. ∠SNB	3.04	1.83	1.51	.802	.880
5. ∠ANB	2.10	1.43	1.28	.739	.808
6. ∠IMPA	5.25	5.16	4.00	.184	.678
7. OB	1.21	1.06	0.92	.497	.664
8. OJ	0.72	0.72	0.64	.056	.500
9. $\overline{1}$-AP	1.73	1.51	1.35	.488	.645
10. Hold	3.13	2.11	1.58	.743	.870
11. A/B	2.14	1.93	1.62	.451	.684

TABLE IX

COEFFICIENTS OF PREDICTION EFFICIENCY

Variable	S.E.Y vs. S.D.Y	S.E. (size-size) vs. S.D.Y	S.E.Y vs. S.E. (size-size)
1. ∠SN-MP	54.4%	39.4%	24.8%
2. ∠SN-Occ	36.4%	10.4%	29.0%
3. ∠SNA	59.0%	56.7%	5.5%
4. ∠SNB	50.3%	39.7%	17.6%
5. ∠ANB	39.0%	32.1%	10.2%
6. ∠IMPA	23.9%	0.0	22.6%
7. OB	23.9	12.4%	13.1%
8. OJ	11.1%	0.0	11.0%
9. $\overline{I}$-AP	22.2%	12.7%	10.9%
10. Hold	49.4%	32.5%	25.0%
11. A/B	24.5%	10.0%	16.1%
12. E Line U	10.1%	. .	. .
13. E Line L	22.2%	. .	. .
14. $\underline{I}$ to $\overline{I}$	. .	. .	. .

DISCUSSION

Before the results, *per se*, can be discussed, some attention must be paid to the sample used.

Propriety of the Sample

A number of investigators have examined Class II, division 1 malocclusions. Fisk (1955) reviewed the results of some of these studies and concluded that there is a good deal of disagreement concerning the characteristics of this abnormality. There was however one characteristic which was reported fairly consistently: the mandible seemed to be posteriorly positioned in relation to the cranium.

Accordingly, angular measures--SNA, SNB, and ANB--which describe the location of the maxilla and mandible, may be compared to similar measures employed by Harris *et al.* (1972) to describe and discriminate Class II, division 1 malocclusions. It can be seen in Table X that the present value of these angles compare well, although a statistically significant difference was found with respect to ANB. Thus it appears that the sample used in the present study may be comparable to a general group of patients that exhibit Class II, division 1 malocclusions.

The results of the present study will now be discussed, beginning with the changes that were seen, associated with Begg therapy.

TABLE X

MANDIBULAR POSITION: A COMPARISON BETWEEN THE PRESENT SAMPLE AND THAT OF HARRIS ET AL. (1972)

Present Sample			Harris et al.		
Measure	Mean	S.D.	Mean	S.D.	t[a]
∠SNA	80.95	3.46	80.88	3.59	. .
∠SNB	75.21	2.82	74.42	2.95	. .
∠ANB	5.74	1.90	6.46*	1.92	-2.09*

[a] *P<.05; **P<.01

Changes Accompanying the Begg Technique

Two questions must be examined concerning these changes:

1. What has caused these changes?
2. Are these changes characteristic of Begg therapy?

Source of Change

Firstly, it may be assumed for the sake of discussion, that the changes seen here can be attributed to growth or a combination of both growth and treatment.

Lande (1952) described growth changes in a variety of linear and angular measures of the bony profile. Table XI summarizes those measures used both by Lande and the present investigation along with descriptive statistics obtained from the two studies.

Also seen in Table XI are descriptive statistics regarding overbite and overjet changes which had taken place between the ages of 12 to 20 years, in a group of 44 Swedish males, as reported by Björk (1953).

Certainly it appears that overjet and overbite changes are mainly the result of treatment intervention. Also, the standard deviations of change for overjet and overbite seem to be almost as large as the ranges described by Björk. Therefore it appears that treatment is primarily responsible for dental changes. It also appears that treatment may be primarily responsible for reduction of /SNA and possible inhibition of the foreward movement of B point. The change in /SN-MP may be due to growth, however the standard

TABLE XI

CHANGES INVOLVING GROWTH AND TREATMENT, AS OPPOSED TO CHANGES INVOLVING GROWTH

Treatment[a]			Growth				t[d]
Variable	Mean Change	S.D. of Change	Variable	Mean Change	S.D. of Change	Range	
/SNA	-1.58	1.52	/SNA[b]	1.2**	1.2	. .	-5.53**
/SNB	.23	1.86	/SNB	1.9**	1.2*	. .	-3.87**
/SN-MP	-1.17	3.14	/SN-Go-Gn	-2.2	1.9**	. .	. .
OJ	-5.26	3.32	OJ[c]	-0.9	. .	3 to -3.5	. .
OB	-1.53	1.96	OB	-1.0	. .	2 to -4.5	. .

[a]from present study, includes presumably, growth.
[b]after Lande (1952)
[c]after Björk (1953), no standard deviations of change were reported and neither a "t" or "F" test was attempted.
[d]*P<.05; **P<

deviation of change is larger (F ratio = 2.73) than would be expected if growth were the only influence.

Previously-Reported Changes Accompanying Begg Therapy

The results of this study may be compared to readily available findings of other investigators with regard to changes associated with the Begg technique in Table XII.

It seems the changes with respect to the angles SNA, SNB and ANB approximate the changes reported by Payne (1966). However for the reduction of overbite, compared to the findings of Mittler (1967), there appears to be a significant difference. One of the criteria used by Mittler, for the selection of his sample was an overbite of 4 mm. or more. The mean overbite in the present study is 4.36 mm. with a standard deviation of 2.22 mm. Therefore, the pretreatment overbite in Mittler's study was greater than the initial overbite in the present study. Perhaps in the Begg technique, the amount of change in overbite is dependent on the amount initially present.

Williams (1968) and Begg and Kesling (1971) have claimed that the angle of the occlusal plane and the angle of the mandibular plane tend to be changed by Begg treatment. Both angles are increased initially and then tend to return. However, the cant of the occlusal plane changed more and reverted less than the cant of the mandibular plane. They also believed that greater flattening of both planes would occur if posttreatment growth were favorable. The findings in the present study seem to support the contention that the occlusal plane changes more and reverts less than the mandibular plane (Table VI).

TABLE XII

CHANGES ACCOMPANYING THE BEGG TECHNIQUE

Variable	Present Study		Other Studies		t[c]	F[c]
	Mean Change	S.D. of Change	Mean Change	S.D. of Change		
∠ SNA	-1.58	1.52	-1.7[a]	1.60	. .	. .
∠ SNB	.23	1.86	-0.1	1.06**	. .	3.06**
∠ ANB	-1.79	1.43	-1.7	1.20	. .	. .
OB	-1.53	1.96	-1.73*[b]	1.68	.568*	. .

[a]after Payne (1966)
[b]after Mittler (1967)
[c]*P<.05; **P<.01

In general, it appears that the changes found in the present study are fairly consistent with the findings of other investigators. It should be noted that the changes, as estimated here and elsewhere, are not random variables in the usual sense; instead they are chosen by the clinician with reference to the general treatment goals to which he, or his sub-specialty, subscribes. In other words, can the remaining variability be reduced?

Error

The final extent to which variability can be reduced is limited by error. It is generally assumed that error is a random variable and thus cannot be predicted. For the prediction of treatment changes, there are a number of potential sources of error such as the accuracy of the cephalometric technique, patient cooperation and the individual's response to treatment. There is no prior information available upon which to estimate patient cooperation or response to treatment. However, Hatton and Grainger (1958), Richardson (1966), Baumrind and Frantz (1971) and others, have investigated the error inherent in the cephalometric technique.

Baumrind and Frantz (1971) examined the magnitude of error for certain cephalometric measures, by analyzing the tracings drawn by 5 individuals on 20 films. It was their conclusion that some measures appear to be more reliable than others, but all cephalometric measures are subject to error. For example, the standard deviation of the error in measuring angle ANB was estimated at .62°.

Assuming Baumrind and Frantz' findings are valid, .62° would

represent the minimum value to which the standard error of estimate for the prediction of /ANB would be reduced. Thus the regression equations in the present study, at best cannot account for all of the remaining variability. Whether these equations can reduce the remaining variability to an extent that is clinically meaningful is another question.

Evaluation of the Regression Equations

The equations basically may be divided into two categories:

1. Equations related to the skeletal framework.
2. Equations related to the denture.

Skeletal Equations

The prediction equation for /SNA is fairly representative of the various equations which are related to the skeletal framework and will be used as an example for this discussion.

As may be seen in Table IX, the efficiency of the stepwise multiple linear regression equation for the prediction of /SNA is quite high. However, the efficiency is almost as high for a simple regression between the original size and final size. Consequently, the stepwise multiple linear regression has improved the prediction by only a very small amount. Two other findings are of interest concerning /SNA. Firstly, the simple correlation for size-size appears to be extremely high (Table VIII) and secondly, the magnitude of treatment change is fairly small. Perhaps an estimate of the mean change added to the initial size of /SNA, will

result in a prediction which is almost as accurate as that obtained by use of a regression equation. However as Johnston (1968) stated, if one uses a mean change to forecast the outcome, this in actuality is not an individual prediction. Philosophically, the use of a mean change is inimical to the concept of an individual prediction.

In summary, it seems that the use of regression equations to predict changes for the skeletal framework appear not to be clinically meaningful. Perhaps, equations related to dental changes are more significant.

Equations Related to the Denture

The prediction equation for overjet is also representative of the various equations which are related to changes within the denture and will be used as an example for this discussion.

The variability of overjet may be so reduced by treatment that, practically speaking, there is no need for a prediction equation (Tables V and VIII). In other words, highly stereotyped results are obtained. The standard deviation of overjet has so little variability that further reduction is unlikely considering the technical error involved.

It appears then that there is little need to predict dental changes, and for skeletal changes an estimate of the mean change may be used. However, this approach to skeletal change is not appropriate on an individual basis. There are exceptions to the general categories discussed, but these equations attempted to predict dependent variables which are not goals of the Begg technique. It the orthodontist is not

concerned with achieving a desired change for a certain measure, one cannot really assess the influence of the craniofacial architecture on the final result.

It also should be mentioned that there is no equation for the prediction of the interincisal angle. No independent variables could be found which contribute significant information. Three possible explanations may be advanced:

1. The pretreatment value of $\underline{1}$ to $\overline{1}$ was never determined. As with other dimensions this variable might have been a significant factor relative to the future value of $\underline{1}$ to $\overline{1}$.

2. Neither the pretreatment face nor the orthodontist have any influence on the posttreatment value of $\underline{1}$ to $\overline{1}$.

3. The pretreatment face exerts no influence on the post-treatment value of this characteristic; its value is basically dependent on the orthodontist.

It was believed, given the mechanics of the Begg technique, the original value of $\underline{1}$ to $\overline{1}$ would be of little consequence in determining the future value of any dependent variable, including itself. The third possibility appears most likely. This would seem to agree with Steiner's (1959) belief that the inclination of the upper and lower incisor may be changed at the discretion of the orthodontist and lend credence to the practice of planning "acceptable compromises" based on the pretreatment appical base relationships.

Johnston (1968) believed that the variability introduced by carefully planned treatment would perhaps result in clinically useful prediction equations. This argument was based on the assumption that treatment would increase variability and thus more efficient regression

equations might be obtained. From the findings of the present study it appears that treatment may increase change (Table VI) but change is not necessarily related to an increase in the final variability. It seems that large changes occur within the denture yet the standard deviation of the dependent variable is decreased. However, perhaps in the present study the hypothesis was not entirely appropriate. In that, instead of attempting to find equations which reduce the variability around a mean value for a dependent variable, it may have been more meaningful to attempt to find equations which reduce the variability around the absolute value of the treatment goal. This procedure might have proved clinically significant and might have shed some light on the biological compatibility of the craniofacial architecture and some popular treatment objectives. There are at least two other possible explanations for the results of this study:

1. The skeletal architecture in most cases may not limit the orthodontist's ability to achieve his treatment goals.

2. The bony framework may act as an inhibiting force. However, the extraction of teeth may enable the orthodontist to compensate and still achieve an acceptable result.

SUMMARY AND CONCLUSIONS

The purpose of this investigation was to evaluate the possibility of predicting the outcome of standard Begg orthodontic therapy.

The sample consisted of 60 individuals, 30 males and 30 females, each having a Class II, division I malocclusion and requiring the extraction of the four first bicuspids.

Stepwise multiple linear regression was used to examine the predictive significance of 29 characteristics of the pretreatment craniofacial skeleton as well as to examine 4 variables from other sources. All of these predictor variables were used simultaneously in an attempt to forecast treatment changes. Only those factors which contributed significant unduplicated information towards the estimation of the measures of treatment outcome entered the prediction equation. The 14 measures of treatment outcome were chosen based on their presumed clinical significance and were obtained from the last cephalogram taken. The time at which the final cephalogram was taken varied from just after the removal of bands to postretention.

As a result of this investigation, the following conclusions were drawn:

1. The changes seen in the present sample appear to be similar to those reported by other investigators for the Begg technique.

2. The dental changes accompanying the Begg technique are of a larger magnitude than the changes related to the skeletal framework, in Class II, division I malocclusions.

3. Stepwise multiple linear regression analysis proved of little value in predicting treatment outcome on an individual basis in the present study.

4. A number of possible explanations were advanced concerning the inability to obtain clinically useful prediction equations:

   a. Perhaps an attempt should have been made to find equations which reduce the variability around the absolute value of a Begg treatment goal. This may have proved clinically significant and may have provided some insight into the biological compatibility of the craniofacial architecture and some popular treatment objectives.

   b. Perhaps the skeletal architecture in most cases may not limit the orthodontist's ability to achieve his treatment goals.

   c. Perhaps the bony architecture may act as an inhibiting force. However, the extraction of teeth may enable the orthodontist to compensate and still achieve an acceptable result.

APPENDIX I

A. Definition of Cephalometric Landmarks-(Norma Lateralis) Modified After Thurow (1971)

1. N--The most forward point on the naso-frontal suture.

2. S--The center of sella turica, as estimated by inspection.

3. ANS--The tip of the anterior nasal spine.

4. PNS--The tip of the posterior nasal spine of the palatine bone.

5. Ar--The intersection of the posterior border of the ramus with the base of the occipital bone.

6. A point--The deepest concavity below ANS and above the crown of the upper central incisor on the anterior border of the maxilla.

7. B point--The deepest concavity on the labial surface of the bony symphysis.

8. P--The most anterior point on the labial outline of the bony symphysis.

9. Me--The most inferior point on the outline of the bony symphysis.

B. Definition of Anatomic Planes Not Adequately Characterized by Cephalometric Landmarks

1. Mandibular Plane--A line connecting Me and the lowest point on the lower border of the mandible posterior to the antegonial notch.

2. Occlusal Plane--A line which bisects the overbite of the first molars and the upper and lower incisors.

3. Palatal Plane--A line which connects ANS and PNS.

LITERATURE CITED

Balbach, D. R. 1969. The cephalometric relationship between the morphology of the mandible and its future occlusal position. Angle Orthod., 39: 29-41.

Baumrind, S. and Frantz, R. C. 1971. The reliability of head film measurements. 2. Conventional angular and linear measures. Am. J. Orthod., 60: 505-517.

Begg, P. and Kesling, P. 1971. Begg Orthodontic Theory and Technique. Philadelphia, W. B. Saunders Company. pp. XII+676.

Bjork, A. 1947. The face in profile. Svensk Tandl.-Tidskrift, 40: (Suppl. 5B), Lund.

Bjork, A. 1951. The significance of growth changes in facial pattern and their relationship to changes in occlusion. D. Rec., 71: 197-208.

Bjork, A. 1953. Variability and age changes in overjet and overbite. Am. J. Orthod., 39: 779-801.

Brader, A. C. 1965. Differential orthodontic diagnosis and treatment planning. Am. J. Orthod., 51: 806-815.

Broadbent, B. H. 1937. The face of the normal child. Angle Orthod., 7: 183-208.

Brodie, A., Downs, W., Goldstein, A., and Myer, E. 1938. Cephalometric appraisal of orthodontic results. Angle Orthod., 8: 261-351.

Brodie, A. 1941. The growth pattern of the human head from the third month to the eighth year of life. Am. J. Anat., 68: 209-262.

Coben, S. E. 1955. Integration of facial skeletal variants. Am. J. Orthod., 41: 407-434.

Downs, W. B. 1948. Variations in facial relationships: their significance in treatment and prognosis. Am. J. Orthod., 34: 812-840.

Downs, W. B. 1952. The role of cephalometrics in orthodontic case analysis and diagnosis. Am. J. Orthod., 38: 162-182.

Draper, N. R. and Smith, H. 1966. Applied Regression Analysis. New York, John Wiley and Sons, Inc. pp. IX+407.

Fisk, G. V., Culpert, M. R., Grainger, R. M., Hemrend, B. and Moyers, R. 1955. The morphology and physiology of distoclusion. Am. J. Orthod., 39: 3-12.

Graber, T. M. 1952. New horizons in case analysis--clinical cephalometrics. Am. J. Orthod., 38: 603-624.

Harris, J. E., Kowalski, C. J. and Walker, G. F. 1972. Discrimination between normal and Class II individuals using Steiner's analysis. Angle Orthod., 42: 212-220.

Hatton, M. E. and Grainger, R. M. 1958. Reliability of measurements for cephalograms at the Burlington Orthodontic Research Center. J. D. Res., 37: 853-859.

Holdaway, R. A. 1956. Changes in relationship of points A and B during orthodontic treatment. Am. J. Orthod., 42: 176-193.

Johnston, L. E. 1968. A statistical evaluation of cephalometric prediction. Angle Orthod., 38: 285-304.

Ladner, R. L. 1969. Chimaera. Cleveland, Ohio, Chi Corp.

Lande, M. J. 1952. Growth behavior of the human bony facial profile as revealed by cephalometric roentgenology. Angle Orthod., 22: 78-90.

Mittler, W. A. 1967. A cephalometric evaluation of anterior overbite reduction with the Begg technique. Unpublished M.S. thesis, Western Reserve University, Cleveland, Ohio.

Nanda, R. S. 1955. The rates of growth of several facial components measured from serial roentgenograms. Am. J. Orthod., 41: 658-673.

Payne, C. J. 1966. Changes in apical base relations and the vertical position of the maxillary central incisor incident to treatment with the Begg light wire differential force technique. Unpublished M.S. thesis, University of Tennessee.

Richardson, A. 1966. An investigation into the reproducibility of some points, planes and lines used in cephalometric analysis. Am. J. Orthod., 52: 637-651.

Ricketts, R. M. 1961. Cephalometric analysis and synthesis. Angle Orthod., 31: 141-156.

Ruekema, K. R. 1971. An evaluation of the reliability of the facial growth trend classification theory of Dr. Charles H. Tweed. Unpublished M.S. thesis, St. Louis University.

Steiner, C. C. 1959. Cephalometrics in clinical practice. Angle Orthod., 29: 8-29.

Thurow, R. C. 1970. Atlas of Orthodontic Principles. St. Louis, Missouri, C. V. Mosby Company. pp. XI+231.

Tweed, C. H. 1946. The Frankfort-mandibular plane angle in orthodontic diagnosis, classification, treatment planning and prognosis. Am. J. Orthod. Oral Surg. (Sect. Orthod.), 32: 175-230.

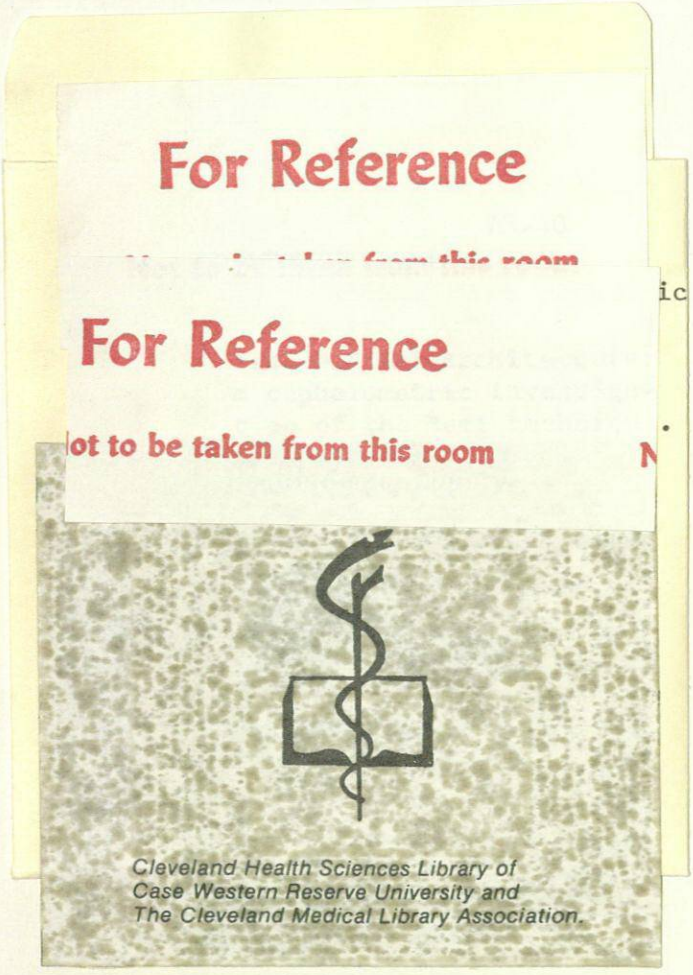
Tweed, C. H. 1954. The Frankfort-mandibular incisor angle (FMIA) in orthodontic diagnosis, treatment planning and prognosis. Angle Orthod., 24(3): 121-169.

Tweed, C. H. 1963. Treatment planning and therapy in the mixed dentition. Am. J. Orthod., 49: 881-906.

Williams, R. 1968. The cant of the occlusal and mandibular planes with and without pure Begg treatment. J. Pract. Orthod., 2: 496-505.

GENERAL BOOK BINDING CO.
73 2850S 104 5 TI 6193
QUALITY CONTROL MARK

CLEVELAND HEALTH SCIENCES LIBRARY
HEALTH CENTER LIBRARY



CWRU LIBRARY SYSTEMS
3 9156 00545109 6