CASE WESTERN RESERVE UNIVERSITY

GRADUATE STUDIES

We hereby approve the thesis of

CHOU BING WU

candidate for the Master of Science in Dentistry degree.

Signed: Donald N. Enlow
(Chairman)

Howard S. Kosowski, DDS, MS

Arthur E. Loges, DDS

Date April 27, 1984

A MORPHOMETRIC APPROACH TO CLASS II TREATMENT

by

CHOU BING WU

Submitted in partial fulfillment of the requirements

for the Degree of Master of Science in Dentistry

Department of Orthodontics

CASE WESTERN RESERVE UNIVERSITY

May 1984

A MORPHOMETRIC APPROACH TO
CLASS II TREATMENT

Abstract

by

CHOU BING WU

The morphological responses of a part or parts in treated Class II individuals were a major interest in this study. Enlow's counterpart analysis was utilized to identify the particular combinations of anatomic characteristics in the craniofacial complex. Three measurements were used as the basis of grouping: middle cranial fossa (MCF) alignment, vertical relationship of posterior nasomaxillary complex (PM vertical), and mandibular ramus alignment. The horizontal expression of three measurements were added to evaluate the treatment effects. These were ramus/MCF skeletal dimension, maxillary/mandibular bony arch measured at A and B points, and maxillary/mandibular bony arch measured at SPr and IPr points. All individuals were morphologically categorized into five groups, each with unique distinguishing features.

This study involved 157 subjects divided into two different treatment categories:

1. Class II individuals treated with Tweed mechanics.
2. Class II individuals treated with Begg mechanics.

The findings led to the following conclusions:

1. The ramus alignment showed a constancy of clockwise rotation in all groups (incidence of 95%) before and after treatment, which added its aggregate mandibular retrusive effect to the Class II individuals.

2. In Group I and Group II, MCF alignment and PM vertical compensated each other. However, less of a tendency for a mandibular protrusive effect existed before and after treatment in Group II than was found in Group I.

3. Only Group I possessed a relatively "short" PM vertical (short face). A great tendency toward a mandibular protrusive effect existed before treatment, and even more so, following treatment for the majority of individuals in this group.

4. Group III exhibited a strong Class II tendency but the horizontal skeletal compensatory effect existed as was found in Group I.

5. Group IV and Group V showed variability in the horizontal contributory effects before treatment, however, orthodontic treatment offered an improved craniofacial balance for both groups.

6. The measurements of ramus/MCF skeletal dimension displayed a unique characteristic in this study. There was an interesting transformation from "wide" ramus before treatment to "narrow" ramus after treatment, coinciding with changes of expressions of mandibular bony arch at A and B points and at SPr and IPr points from what used to be a mandibular retrusive effect before treatment to what then was a protrusive effect after treatment.

7. The synergic mandibular protrusive effect was provided by the existence of "wide" ramus and "long" mandibular arch measured at A and B points and SPr and IPr points.

8. A morphometric approach to Class II treatment was discovered and described. Three diagnostic horizontal measurements (1) ramus/MCF skeletal dimension, (2) maxillary/ mandibular bony arch measured at A and B points, and (3) maxillary/mandibular bony arch measured

at SPr and IPr points, are reliable to predict the treatment prognosis.

9. Statistically, there is no significant difference with respect to the treatment effects of the two different systems of mechanics studied.

ACKNOWLEDGEMENTS

The author wishes to extend his sincere appreciation to the following indiciduals and groups:

Dr. Donald H. Enlow, Chairman of the Department of Orthodontics and Assistant Dean for Graduate Studies and Research, Case Western Reserve University, for his boundless knowledge and expertise in the field of facial growth and for being my chief advisor in this thesis.

Dr. Rolf G. Behrents, Clinical Director of Orthodontics, for his friendship and assistance in "most" phases of this thesis.

Dr. Arthur E. Phelps, Clinical Professor, for his helpful suggestions and clinical judgement.

Dr. Howard Kossoff, for his help with the completion of this thesis.

Dr. B. Holly Broadbent, Jr., for allowing the use of the Bolton Study facilities.

Drs. Herbert Adelstein, Richard Gift, Howard Kossoff, Arthur Phelps, and David Haas, for graciously providing cephalometric radiographs utilized in this study.

I would like to thank the entire faculty of the Department of Orthodontics for theur undying friendship and guidance.

Mrs. Linda Nicholl, for her clerical expertise and generous adaptation to rigorous time schedules in the typing of this thesis.

Marsha Dunner, for her assistance in the past two years.

And finally, to my classmates, Drs. Charles Canepa, Elias Katsavrias, Eric Ornella, and Scott Pinkard, their friendship I shall never forget.

DEDICATED

TO

My parents,
who have made my education possible.

To my brothers and sisters,
who have given me their love and support.

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGEMENTS	v
DEDICATION	vii
LIST OF TABLES	ix
LIST OF ILLUSTRATIONS	x
INTRODUCTION	1
REVIEW OF THE LITERATURE	2
STATEMENT OF THESIS	14
METHODS AND MATERIALS	15
RESULTS	70
DISCUSSION	113
SUMMARY AND CONCLUSIONS	121
LITERATURE CITED	123
APPENDIX	127

LIST OF TABLES

		Page
I.	Definitions of Anatomic Landmarks	23
II.	Definition of Cephalometric Planes	25
III.	Determination of Sign Convention	26
IV.	Determination of the PM Vertical Dimension	28
V.	Morphological Expression of Forward Alignment of Ramus	72
VI.	Morphologic Expression of Grouping of Class II Individuals	73
VII.	Morphological Expression Group I	83
VIII.	Morphological Expression Group II	89
IX.	Morphological Expression Group III	94
X.	Morphological Expression Group IV	100
XI.	Morphological Expression Group V	104
XII.	Morphological Expression of Effective Changes of Three Variables	107
XIII.	Treatment Effect of Maxillary/Mandibular Skeletal Arch Measured at A and B Points	111
XIV.	Treatment Effect of Maxillary/Mandibular Skeletal Arch Measured at SPr and IPr Points	112

LIST OF ILLUSTRATIONS

Figure		Page
1.	Points and planes used in the counterpart analysis . . .	31
2.	Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A and B points	33
3.	Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at SPr and IPr	35
4.	Middle cranial fossa (MCF) and posterior maxillary (PM) relative alignment	37
5.	Ramus alignment	39
6.	Ramus/MCF horizontal dimensions (skeletal)	41
7.	Ramus/MCF horizontal dimensions (dental)	43
8.	Molar positions (composite)	45
9.	Maxillary/mandibular arches, skeletal dimensions, A point compared with B point	47
10.	Maxillary/mandibular arches, dental dimensions, A point compared with B point	49
11.	Maxillary/mandibular arches, skeletal dimensions, SPr compared with IPr	51
12.	Maxillary/mandibular arches, dental dimensions, SPr compared with IPr	53
13.	PM as compared with ramus/MCF vertical dimensions . . .	55
14.	Corpus-occlusal alignment	57
15.	Gonial angle alignment	59
16.	Curve of Spee	61
17.	Palatal plane alignment	63

LIST OF ILLUSTRATIONS continued

Figure	Page
18. Inferior maxillary plane	65
19. Maxillary nerve/palatal plane alignment	67
20. Vertical anterior maxillary plane	69

INTRODUCTION

The morphological assessment of the effects treatment upon Class II individuals is considered to be important with regards to the overall composite craniofacial expression. Individuals with seemingly similar Class II molar relationships reveal different craniofacial configurations. Recognition of the intrinsic inter-related facial characteristics within a given person before treatment can be of great assistance in the diagnosis and treatment planning. The investigation of changes following treatment is intended to help understand the adjustment and adaptive mechanism in a specific field and contribution of this mechanism to overall facial morphologic balance. This can inform us of the prognosis of the treatment effects.

Enlow's counterpart analysis is utilized as a tool for this investigation. Most conventional methods are intended to determine "what" a particular craniofacial growth pattern is as compared with population standards. This analysis explains "how" a growth pattern has occurred in a particular individual, and it accounts for the principal regional developmental activities among the various growth fields throughout the craniofacial complex.

REVIEW OF THE LITERATURE

Clinical management of Class II malocclusion is a constant challenge in orthodontics. Of many pathogenetic factors which have been claimed to be associated with this kind of molar relationship, the following are in common for Class II: anteroposterior skeletal discrepancy, vertical skeletal dysplasia, the muscle pattern, and the arch space available for alignment of the teeth (Moyers, 1972). Recently, relevant studies have been carried out from simplified denture classification to far more sophisticated craniofacial evaluation. Limiting factors leading to compromised treatment results were realized (Steiner, 1960; Jacobson, 1973). However, modern treatment goals still aim at establishing optimal occlusal adjustment within the framework of facial esthetics, oral function, and post-retention stability. Currently, a major concern is how to construct an overall composite three dimensional craniofacial configuration to a morphologic fit, i.e., match of "equivalents", and growth balance (Enlow, 1969).

Sassouni (1970) has advocated the measurement of proportionality in the individual by means of archial analysis. He divided Class II problems into 128 dentofacial situations: 64 different situations in each of two categories: deep-bite and open-bite. Recognizing the importance of excesssive or deficient

vertical development in the determination of skeletal dysplasia, Sassouni et al. (1964) stated that vertical facial disproportions were the problems of origin in anteroposterior disharmonies. The basic differences of: (1) the position of condyles, (2) the position of maxillary molars, and (3) the height of the ramus, led to the divergent expressions of mandibular and occlusal plane and denture relation.

Moyers et al. (1980), presenting an arborization, assessed 677 North American white children with Class II malocclusion having similar dental and skeletal configurations. They described different facial types of Class II malocclusion with six horizontal and five vertical characteristics. They concluded that midface prognathism made up only 20% of the population sample, whereas over 50% displayed mandibular retrusion with little or no maxillary protrusion.

McNamara (1981) studied 277 individuals with Class II malocclusion between the age 8 and 10 years for the determination of the relative frequency of appropriateness as defined by quantitative assessment of the four horizontal components (maxillary skeletal position, maxillary dental position, mandibular skeletal position, and mandibular dental position) and one vertical component of Class II malocclusions. He further noted that mandibular skeletal retrusion was the most common single characteristic of the Class II sample.

Enlow (1971) presented the counterpart analysis to evaluate and to account for the individual combination of anatomical and developmental characteristics that have produced the craniofacial composite pattern in any given person. Certain specific types of regional counterpart relationships revealed the distinct craniofacial patterns characterizing Class I, II and III tendencies. This explains essentially "how" a growth pattern has occurred in a particular individual, and it accounts for the contributions of the various growth fields throughout the craniofacial complex.

Utilizing the same procedure, investigations have been done on Class II (Whitney, 1983) and Class III (Pfister, 1983) untreated sample populations--both serially, using cross-sectional frequency distribution for anatomic relationships at different age levels--and by comparing the individuals progressively to themselves. Three of the measurements: middle cranial fossa (MCF) alignment, vertical relationship of posterior nasomaxillary complex (PM vertical), and the mandibular ramus alignment, were utilized as the basis for the groupings. Four other measurements, bony maxillary and mandibular arches, ramus/MCF horizontal dimension relationship, gonial angle alignment, and the Curve of Spee, added anatomical specificity by addressing individual combinations within the groups formed. These seven anatomical relationships were found to offer the best geometrical expression of the facial

pattern, and a most relevent morphologic classification of a given malocclusion. Categorizing his 20 Class II untreated individuals into eight recognizable groups, Whitney pointed out that many of the maxillary protrusive effects may worsen with age if left untreated; by comparing the existing facial disharmonies he noted that, "Class II individuals got more Class II with time."

At this point it seems clear that trends toward more precise classification systems have been established progressively contrary to most conventional analytic methods intended to determine "what" a particular craniofacial pattern is as compared with population standards, these newer techniques shed light on evaluating a given person to be more individualized according to his own morphologic requirements. It is known as well that specificity of treatment for a given individual pattern of facial growth is a demand to a more efficient treatment delivery (Ackerman and Proffit, 1969, 1970; Sassouni, 1970; Moyers, 1980; McNamara, 1981; Enlow, 1983).

Coben (1971) divided the biologic process of Class II correction into three basic treatment principles: (1) growth correction, (2) resorption and remodeling of the subnasal maxillary alveolar process, and (3) intra-alveolar tooth movement. The correction of every Class II malocclusion is the result of one, two or a combination of all three treatment principles. He concluded that the response to Class II treatment depends largely upon the growth pattern of the face (1966).

Enlow (1969) pointed out that continued growth can (1) sustain a balanced or an imbalanced condition, (2) improve an unbalanced situation, or (3) aggravate the original status of balance or imbalance. With growth, variant patterns could substantially affect the treatment response by complementing or nullifying treatment efforts.

Schudy (1964, 1965) divided factors controlling the forward and downward displacement of the mandible with growth into vertical and horizontal components. The vertical growth factor of the mandible is produced by (1) increased height from nasion to ANS, (2) descending of the maxillary molars and (3) elevation of the mandibular molars. In the face of vertical growth exceeding growth of the condyle and ramus, efforts should be made to retard eruption of the maxillary and mandibular molars to reduce the vertical growth component so that mandibular growth can be directed forward properly.

Herzberg (1973), studying treated Class II cases that experienced post-treatment relapse, stressed the importance of "good forward growth" on stability. Lack of good forward growth of the mandible during the post-treatment period will contribute to relapse. The results would be disastrous if no post-treatment growth or vertical growth of the mandible occurs, leading to an opening of the FMA angle, backward and downward movement of B point and extrusion of molars. Where post-treatment growth is

favorable, even though the FMA angle is opened and angle ANB is not reduced sufficiently, the case will not relapse.

Another integral part of craniofacial growth is the development of the dentition. The arrangement of intra-arch and interarch dental relations is very dynamic during the process of transformation of mixed dentition into permanent dentition through the following transitional adjustment mechanisms: (1) forward growth of the maxilla, (2) maxillary leeway space, (3) forward growth of the mandible, and (4) mandibular leeway space. It appears that potential skeletal growth contributes most to the adjustment of the occlusal relationships.

At the arrival of second molars, the dentition is considered rather complete. However, growth activities still continue into a new stage during puberty. "Catch up" growth of the mandible makes it possible for the facial profile to look less retruded than it used to be. Spatial adjustment of the mandible owing to the descent of the growing nasomaxillary complex is made through the dimensional changes of the specific mandibular components at differing speeds. The height increase of the ramus will compensate for the post-eruption vertical movement of teeth, the vertical growth of the alveolar processes, and for the entire descent of the middle face. Increase in vertical and horizontal dimension with simultaneous displacement of the whole jaw downward and forward swings the mandibular symphysis forward so that the

chin becomes prominent. Thus the growth processes of the mandible and their directional expression play an important role in the outcome of the facial appearance. Studies centered on this bone have revealed patterns of remodeling (Enlow, 1975, 1982), realignment of the adjacent fields, growth direction of the condyle, and adaptation of the ramus, all of which were under the influence of genetic, epigenetic, and environmental factors and contributed to the formation of the final product.

Significant information about growth rotation of the mandible as derivable from a single cephalogram was described by Bjork (1969). He noted an obvious relationship between the type of rotation of the mandible and the direction of condylar growth. The principle was to recognize seven specific structural features that develop as a result of remodeling in a particular type of mandibular growth rotation. A potential horizontal grower was represented by a person with a condyle growing in a forward and upward direction, with the final growth expression being a counterclockwise rotation. On the other hand, a potential vertical grower with upward and backward condylar configuration would have a clockwise expression.

In spite of the fact that growth potential continues to affect the facial appearance as a whole, a low correlation between facial growth and the dentition was observed (Bjork, 1953). It appeared that there was a low correlation between overjet and maxillary growth, overjet and mandibular growth, and overjet and

the difference between maxillary growth and mandibular growth. This study also implied that once the anterior limits of the denture position were defined, no matter what the magnitude of the potential, that the anteroposterior dental discrepancy remained rather constant irrespective of the mesial migration of the denture and the uprighting of the lower anterior teeth. Schudy (1973) states:

> The maxilla and the mandible are functionally locked together by the interlocking of the cusps of the teeth, much like two wheels that are locked together with cogs. Yet these two bony bases grow forward at different rates without changing the interlocking of the teeth and without causing trauma to the tissues surrounding the roots of the teeth.

Cross (1977) made an effort to study only growth changes in response to treatment with no regard to changes in dentition. He superimposed tracings of sella turcica and of the anterior cranial base and measured quantitatively the amount and direction of movement of points ANS and pogonion. He concluded that there was no evidence of growth guidance nor correction resulting from treatment. Therefore, treatment efforts should be directed toward correction of the malocclusion rather than attempting to correct facial growth.

In an effort to distinguish the pattern concept from the growth concept in relation to the studies of human craniofacial development, a "craniofacial constant" was developed. This was defined by Moyers et al. (1979) as:

1. measures displaying no systematic change with age for the majority of individuals,

2. measures of relative invariance by which pattern can be recognized and segregated from growth, and

3. growth is change and is best identified by studying those measures of size and shape that vary most sensitively through time over developmental stages.

With these in mind, by precision handling of the treatment mechanics, clinical intervention may create a new, steady developmental pattern by producing differential growth. Moyers, applying this concept to his Class II study, further suggested that persons of the same craniofacial pattern grow alike, and may respond consistently to the same treatment.

Mandibular retrusion is a common characteristic of Class II malocclusion. In designing an ideal treatment regime, therefore, an approach which would alter the amount and the direction of mandibular growth appears to be indicated. The guidelines for detection of the relative position of the mandible to that of maxilla and of the cranial base are bewildering due to the differences in cephalometric measures chosen for different systems of analysis. Encouragingly, Enlow (1975) has set up boundary conditions to establish the perimeter of the nasomaxillary growth fields. As for the boundary or limitation of the lower jaw, its final length is still somewhat a mystery (Moyers et al., 1970; Petrovic et al., 1981). Fortunately, there exists a constructed measurement, Wits appraisal, which uses the occlusal plane to

appraise the anteroposterior jaw disharmony, and is considered a better diagnostic aid in the assessment of severity or degree of horizontal jaw discrepancy (Jacobson, 1975, 1976; Demish, 1978).

Evaluation of the soft tissue profile in addition to the information of the skeletal analysis can assist in reaching one of the primary orthodontic treatment objectives, which is optimal facial esthetics. Subtelny (1961) inferred that soft tissue alterations incident to treatment would focus around lip contour, whereas soft tissue alterations incident to growth would incorporate a greater aspect of the soft tissue profile--the nose and chin as well as the lips. Methods to evaluate soft tissue profile are purely subjective. These include the integumental analysis of Burstone (1958), the esthetic plane of Ricketts (1960), and the profile line (Z angle) of Merrifield (1966), soft tissue facial angle (H angle) of Holdaway (1983).

The amount and direction of tooth movement along the denture base can be observed and readily controlled, while alteration in certain other components may frequently be obscure or only rarely detectable through clinical judgement. Phelps (1978) stated that correction of Class II's effected through the preparation of the lower arch by means of leveling with Class III elastic mechanics and uprighting the lower posterior teeth (anchorage preparation) prior to the application of Class II elastic mechanics, offers better oral function and enhances further protraction

of the lower face--a point which reiterates a similar view stated earlier by Herzberg (1973). Correction of Class II molar relation can also be assisted by means of a headgear attached to the upper arch anteriorly or posteriorly. The distal component of the headgear force either holds the upper molars in the initial position or drives them distally which, concomitantly with the forward thrust resulting from growth of the lower jaw, improves the molar relation from a Class II to a Class I (Baumrind, 1978). Therefore, before initiating the treatment, it is necessary and important to develop a working strategy, which can be implemented throughout the entire procedure. This makes it possible for clinical manipulation to be better managed and guided without losing sight of the objectives.

Schudy (1973) advocated that the optimal way to open the bite is to elevate occlusally the lower posterior teeth within physiologic limits instead of intruding the lower anterior teeth. There is clinical evidence demonstrating the strong tendency for lower anterior teeth, once depressed, to return to their original position. There is a lesser tendency for the upper anterior teeth, once intruded, to relapse. Moreover, an improved smile often results when the upper anterior teeth are depressed (Subtelny, 1970; Merrifield and Cross, 1970).

In contrast, open-bite cases are more difficult to manage because determination of the etiology may be difficult and unpredictable. The primary objective, then, is to correct these

causative factors which may include habits such as thumb-sucking, tongue-thrusting, lip biting, etc.

Another important aspect in orthodontics is the maintenance of the treatment result following appliance removal. This is a matter of stability, retention, and relapse. Reidel (1969) listed 10 theorems that were general considerations for handling the phenomena of retention and relapse. Moyers (1972), in his commentaries on Reidel's theorems, added one more factor: that one could not remove the tooth from its total functioning environment. He further stressed two important factors causing relapse:

1. failure to place the teeth in occlusion in harmony with the reflex position of the mandible during the unconscious swallow (primitive reflex function), and
2. untoward intrusion resulting from new vectors of growth after orthodontic therapy was finished.

The diverse causes of relapse can serve as a warning to current and future generations of orthodontists.

Increased knowledge about craniofacial growth, clarification of classification of specific anatomic patterns as they relate to different individual's needs, and careful mechanotherapy can all contribute to the achievement of favorable treatment objectives.

STATEMENT OF THESIS

The objective of this investigation is to uncover any correlations between treated Class II malocclusions of varying morphologic categories and the treatment effects of different appliance systems. Enlow's counterpart analysis is utilized to identify the particular combinations of anatomic characteristics in the craniofacial complex. Three measurements are used as the basis of groupings: middle cranial fossa (MCF) alignment, vertical relationship of posterior nasomaxillary complex (PM vertical), and mandibular ramus alignment. Once the malocclusion is objectively classified, an evaluation of anatomic effects of the treatment for each category will be made. Changes that take place during the treatment of Class II malocclusion when treated with Tweed or Begg mechanics will also be examined.

METHODS AND MATERIALS

The lateral cephalograms of the 157 treated Class II individuals (73 males and 84 females) utilized in this study were obtained from the records of four private orthodontic practices, and were divided into two categories:

1. Category 1: treatment consisted of fixed appliances in conjunction with high pull J-hook extra-oral headgear therapy (Tweed mechanics).

2. Category 2: treatment consisted of fixed appliances only (Begg mechanics).

These cases were selected according to the following criteria:

1. At the start of treatment the subject was in the age range of approximately 11 to 14 years.

2. ANB was greater than 4.5 degrees.

3. Angle Class II molar relationship, bilaterally or unilaterally (presence of at least end-on molar and cuspid relationships as determined from a headfilm).

4. Initial and post-treatment cephalograms were available.

All cases were treated to a successful result concerning correction of molar relationship, overbite, and overjet as shown by lateral cephalograms taken at the end of treatment.

Sample

Category I

A sample of 73 treated cases of Class II malocclusion was

used. All were treated with the Tweed technique.

The average age in this group at the time of the initial cephalograms was 12 years, 6 months and the range was 11 years, 6 months to 13 years, 6 months.

The average age at the end of treatment was 15 years, 6 months and the range was 14 years, 5 months to 16 years, 7 months.

There were 30 males and 43 females in this group.

Category II

A sample of 84 treated cases of Class II malocclusion was used. The Begg appliance was utilized for each case in this category.

The average age in this group at the time of the initial cephalograms was 12 years, 6 months and the range was 10 years, 11 months to 14 years, 1 month.

The average age at the end of treatment was 15 years, 1 month and the range was 13 years, 5 months to 16 years, 9 months.

There were 43 males and 41 females in this group.

Technical Details

Tracings were done, as necessary for representation of landmarks and points, on 0.003" acetate with a Pental (0.3 mm, 2H) lead drawing pencil. A total of 27 points were entered in the same sequence for each cephalogram. The points are as follows:

1. Me
2. B
3. IPr
4. in the incisal edge of the mandibular central incisors
5. SPr
6. A
7. ANS
8. the most posterior occlusal point of the last fully erupted maxillary and mandibular molars
9. the distal surface of the mandibular first molar
10. the distal surface of the maxillary first molar
11. the most anterior maxillary-mandibular first premolar occlusal contact
12. the cementoenamel junction of the last fully erupted maxillary molar
13. ARa
14. Go
15. PRa
16. Ar
17. O
18. PNS
19. the inferior most point of the pterygomaxillary fissures
20. foramen rotundum in the pterygomaxillary fissure
21. SE

22. the posterior boundary of the cribiform plate
23. Or
24. the anterior boundary of the cribiform plate
25. the most anterior point of the endocranial surface of the frontal bone
26. Sella
27. Nasion

All linear measurements were executed geometrically by a computer from X-Y coordinates of anatomic landmarks previously located on acetate paper.

Digitization of cephalometric landmarks was done in the following manner. The acetate paper was secured to a digitizing pod (summagraphics). A movable stylus was then placed over each individual landmark and its X-Y coordinates taken. Storage of information and execution of calculations was accomplished via normal methods, and utilized calculation programs developed previously (Behrents, 1984). Data reduction was accomplished via the SPSS (Statistical Program for the Statistical Sciences).

Measurements

All points necessary for the counterpart analysis (Enlow, 1971) were located and plotted by the investigator. Nineteen anatomic variables were evaluated for each tracing. The results of the part-counterpart comparisons were recorded as a mandibular retrusive (+) effect, a neutral (0) effect, or a mandibular pro-

trusive (-) effect. If the extent of mandibular retrusive or protrusive effects was 2.5 mm or less in either direction, it was given a single (+) or (-) value (except for the palatal plane determination). If the extent of mandibular retrusive or protrusive effect was between 2.5 mm and 5.0 mm in either direction, it was given a double (++) or (--) value (except for the palatal plane determination). If the effect exceeded 5.0 mm, it was given the more extreme (+++) or (---) value (except for the palatal alignment determination). When the extent of palatal plane rotational alignment in either direction was greater than 5.0 mm, the symbol (++) or (--) was recorded. If palatal plane was less than 5.0 mm, the symbol (+) or (-) was recorded.

An explanation of how each measurement was made accompanies the appropriate figures.

The 19 variables examined were as follows:

1. Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A and B points.
2. Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at SPr and IPr.
3. Middle cranial fossa (MCF) and posterior maxillary (PM) relative alignment.
4. Ramus alignment.
5. Ramus/MCF horizontal dimensions (skeletal).
6. Ramus/MCF horizontal dimensions (dental).
7. Molar positions (composite).
8. Maxillary/mandibular arches, skeletal dimensions, A point compared with B point.

9. Maxillary/mandibular arches, dental dimensions, A point compared with B point.
10. Maxillary/mandibular arches, skeletal dimensions, SPr compared with IPr.
11. Maxillary/mandibular arches, dental dimensions, SPr compared with IPr.
12. PM as compared with ramus/MCF vertical dimensions.
13. Corpus-occlusal alignment.
14. Gonial angle alignment.
15. Curve of Spee.
16. Palatal plane alignment.
17. Inferior maxillary plane.
18. Maxillary nerve/palatal plane alignment.
19. Vertical anterior maxillary plane.

Tests for proportions were utilized in this study. In order to test measurement reliability, 16 cases were randomly selected to retrace and evaluate for error using the paired t-test. No significant difference was found.

Sign Conventions

The merit of counterpart analysis has been described previously (Enlow, 1971), in that its measures as represented by "+" and "-" signs can contribute to an understanding of the different expressions in facial configurations. For example, in horizontal expression, "+" means mandibular retrusion (or retrognathism), "0" means neutral effect, "-" means mandibular protru-

sion (or prognathism); in vertical expression, "+" means long face, "0" means neutral effect, "-" means short face. These signs also apply to the interpretation of the open bite and deep bite tendency (Trouten, 1983).

Mathematically, however, it will be of great help if these signs have their general rules to follow whenever calculation is operated. Therefore, a universal sign convention for measurements of counterpart analysis in expressions of rotational, horizontal dimensions is constructed as follows.

Rotation

A sign is determined simply by comparing the direction and extent of rotational alignment of solid lines with dashed lines (Table III). Solid lines represent the individual's own anatomic positions, while the dashed lines represent neutral positions.

1. Ar (Articulare) registered measurements--measurements using Ar as a registration point. A positive (+) sign indicates clockwise rotation, while a negative (-) sign indicates counterclockwise rotation. Examples: Middle cranial fossa (MCF) and posterior maxillary (PM) relative alignment; ramus alignment; ramus/MCF horizontal dimension (dental); PM as compared with ramus/MCF vertical dimensions; ramus rotation in corpusocclusal alignment.

2. Non-Ar registered measurements: measurements not using Ar as a registration point. A positive (+) sign indicates counterclockwise rotation, while a negative (-) sign indicates clockwise rotation. Examples: occlusal rotation in corpus-occlusal alignment; gonial angle alignment.

3. Measurements related to one (anatomic) point. Determination of positive (+) or negative (-) sign is the

same as #1. Examples: Curve of Spee; palatal plane alignment; inferior maxillary plane.

Horizontal dimension

Determination of positive (+) or negative (-) signs is based on the difference between upper measurements and lower measurements. A positive (+) sign indicates a mandibular retrusive effect, while a negative (-) sign indicates a mandibular protrusive effect. Examples: aggregate cranial floor/maxilla and ramus/ corpus horisontal dimensions at A and B points; aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at SPr and IPr; Ramus/MCF horizontal dimensions (skeletal); ramus/MCF horizontal dimensions (dental); molar positions (composite); maxillary/mandibular arches, skeletal dimensions, A point compared with B point; maxillary/mandibular arches, dental dimensions, A point compared with B point; maxillary/ mandibular arches, skeletal dimensions, SPr compared with IPr; maxillary/mandibular arches, dental dimensions, SPr compared with IPr.

TABLE I

DEFINITIONS OF ANATOMIC LANDMARKS

Points	Definition
A	A point, the deepest middle point on the labial premaxillary surface between the anterior nasal spine and superior prosthion.
ANS	Anterior nasal spine, the tip of the spinous process of the maxilla forming the most anterior projection of the bony floor of the nasal cavity.
Ar	Bjork's Articulare, the point of intersection of the external inferior surface of the basicranium and the posterior margin of the condylar neck.
ARa	Anterior ramus, the point of intersection of the anterior margin of the ramus with the functional occlusal plane.
B	B point, the deepest middle point on the anterior surface of the symphysial outline of the mandible between infradentale (inferior prosthion) and pogonion.
Go	Construction gonion, intersection of lines tangent to the posterior border of the ramus and inferior border of the mandible.
IPr	Inferior prosthion, the point of contact of the alveolar process between the mandibular central incisors.
Me	Menton, the most inferior point on the symphysis of the mandible.
O	Occipital point, the inferior most point on the endocranial surface of the occipital fossa.
PNS	Posterior nasal spine, the tip of the spinous process formed by the most posterior projection of the junction of the palatine bones in the midline of the roof of the oral cavity.

TABLE I continued

Points	Definition
PRa	Posterior ramus, the point of intersection of the posterior surface of the ramus with the functional occlusal plane.
SE	Sphenoethmoidal junction, intersection of the averaged image of the right and left shadows of the great wings of the sphenoid with the floor of the alveolar cranial fossa.

TABLE II

DEFINITION OF CEPHALOMETRIC PLANES

Line	Description
Ar to Go	A line from Ar to constructed Go used to determine the alignment of the ramus.
ARa	Anterior ramus plane, a line from the intersection of FOP and the anterior border of the ramus drawn parallel to PRa up to Ref.
FOP	Functional occlusal plane, a line from the most posterior occlusal contact point to the last fully erupted maxillary and mandibular molars to the most anterior maxillary-mandibular first premolar occlusal contact.
MCF	Middle cranial fossa plant, represented by a line from SE to Ar.
NOA	Neutral occlusal axis, a line perpendicular to PM through the most posterior occlusal contact point of the last fully erupted maxillary and mandibular molars.
NRa	Neutral ramus, a line from Ar to a point midway between Ar and neutral PM line at the level of gonion.
PM	PM vertical, a line from SE through the averaged inferior most point of the pterygomaxillary fissures.
PRa	Posterior ramus plane, from Ar to the posterior margin of the ramus where it intersects FOP.
Ref	Reference line, a line parallel to FOP from Ar anteriorly.

TABLE III

DETERMINATION OF SIGN CONVENTION

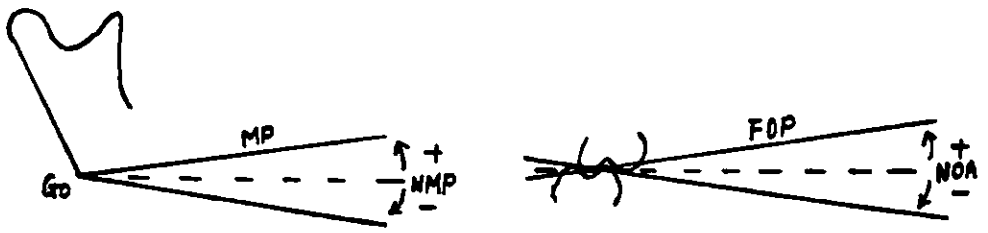
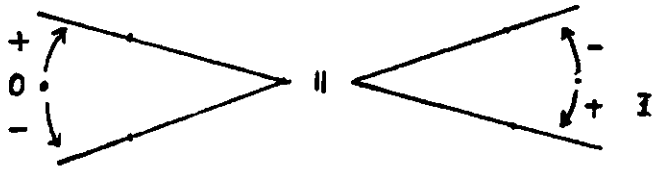
Rotation
(1) Ar Articulare) registered measurements: measurements using Ar as a registration point.  Sign = "+" -- clockwise rotation "0" -- neutral effect "-" -- counterclockwise rotation
(2) Non-Ar registered measurements: measurements not using Ar as a registration point.  Sign = "+" -- counterclockwise rotation "0" -- neutral effect "-" -- clockwise rotation

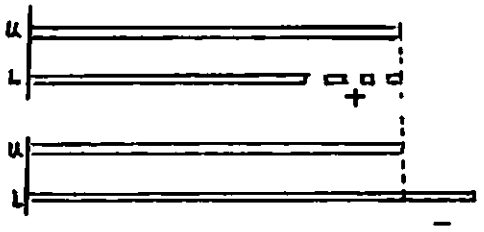
TABLE III continued

Rotation
(3) Measurements relate to one (anatomic) point



Sign = "+" -- counterclockwise rotation
"0" -- neutral effect
"-" -- clockwise rotation

Horizontal Dimension



Sign = upper measurement-lower measurement
"+" -- mandibular retrusion
"0" -- neutral effect
"-" -- mandibular protrusion

TABLE IV

DETERMINATION OF THE PM VERTICAL DIMENSION

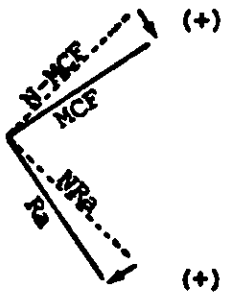
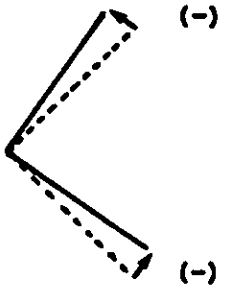
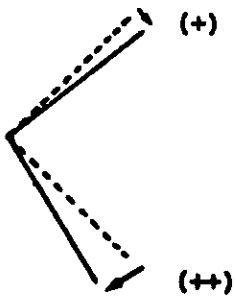
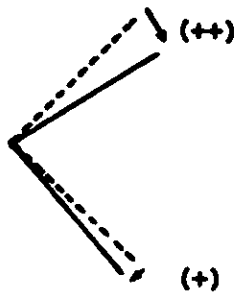
	Description	Effect
	Forward rotation of MCF and backward rotation of ramus are equal in extent.	Neutral (0) effect.
	Backward rotation of MCF and forward rotation of ramus are equal in extent and direction.	Neutral (0) effect.
	Backward rotation is greater than forward rotation of MCF	Long (+) PM vertical. Extent determined by the difference between the two values.
	Forward rotation of MCF is greater than backward rotation of ramus.	Short (-) PM vertical. Extent determined by the difference between the two values.

TABLE IV continued

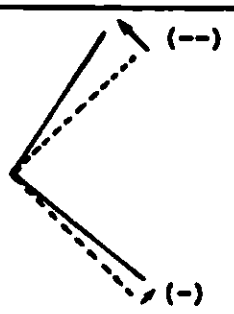
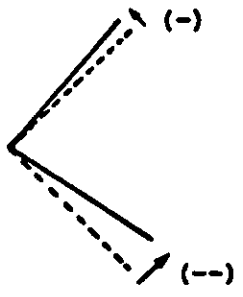
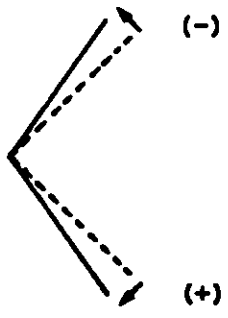
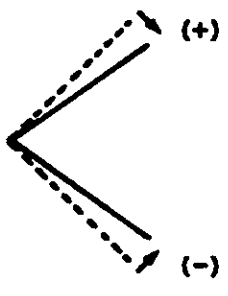
	Description	Effect
	Backward rotation of MCF is greater than forward rotation of ramus.	Long (+) PM vertical. Extent determined by the difference between the two values.
	Forward rotation of ramus is greater than backward rotation of MCF.	Short (-) PM vertical. Extent determined by the difference between the two values.
	Backward rotations of MCF and ramus are equal in extent.	Long (+) PM vertical. Extent determined by adding the two values.
	Forward rotations of MCF and ramus are equal in extent.	Short (-) PM vertical. Extent determined by adding the two values.

Figure 1. All the points and planes used in the counterpart analysis are demonstrated in this diagram. The solid lines represent the subject's own relationships while the dashed lines represent neutral positions. This diagram includes additions to the original construct and procedure presented by Enlow (1971).

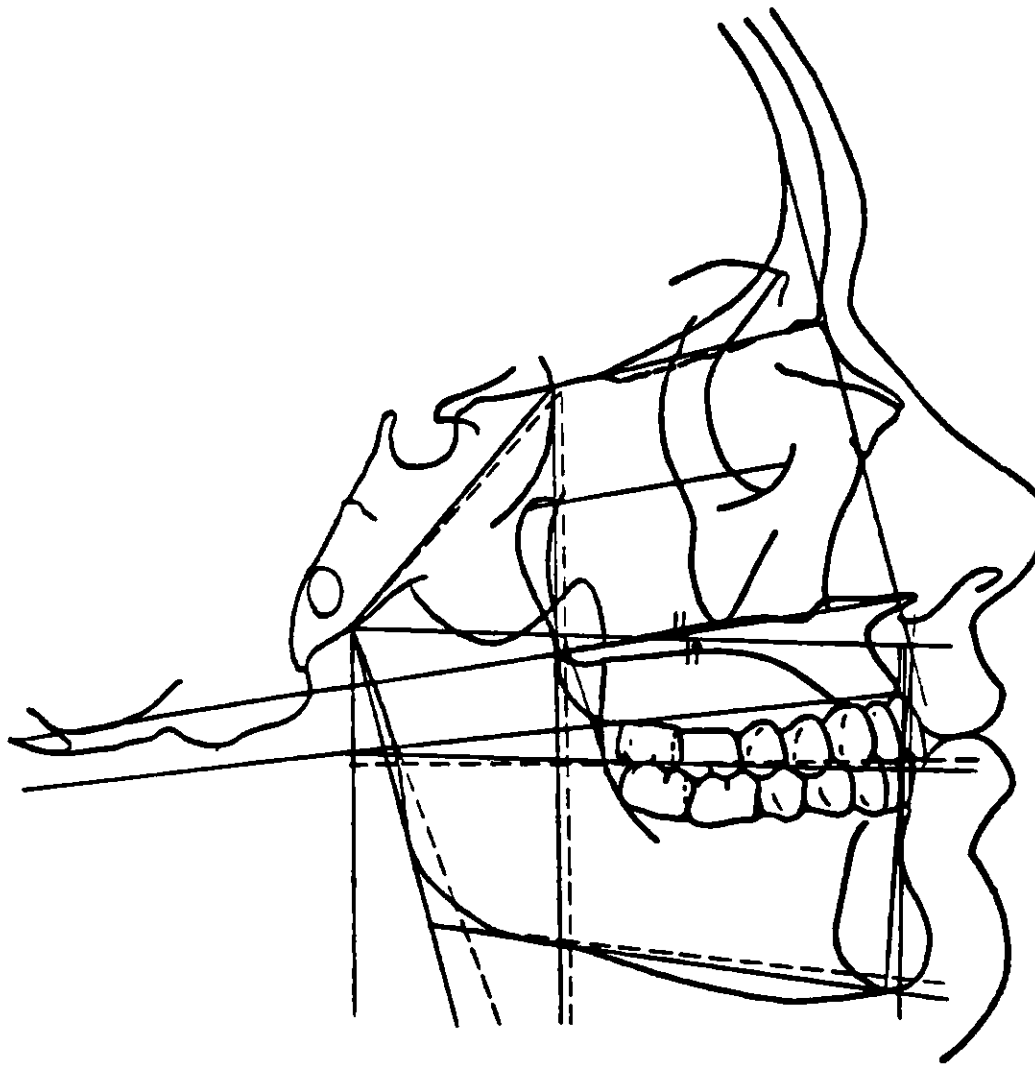


Figure 2. Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A and B points. This diagram demonstrates the comparison of lengths from Ar to A point and Ar to B point. The measurements are made in millimeters along REF. The lines from A point to REF and B point to REF are drawn perpendicular to REF.

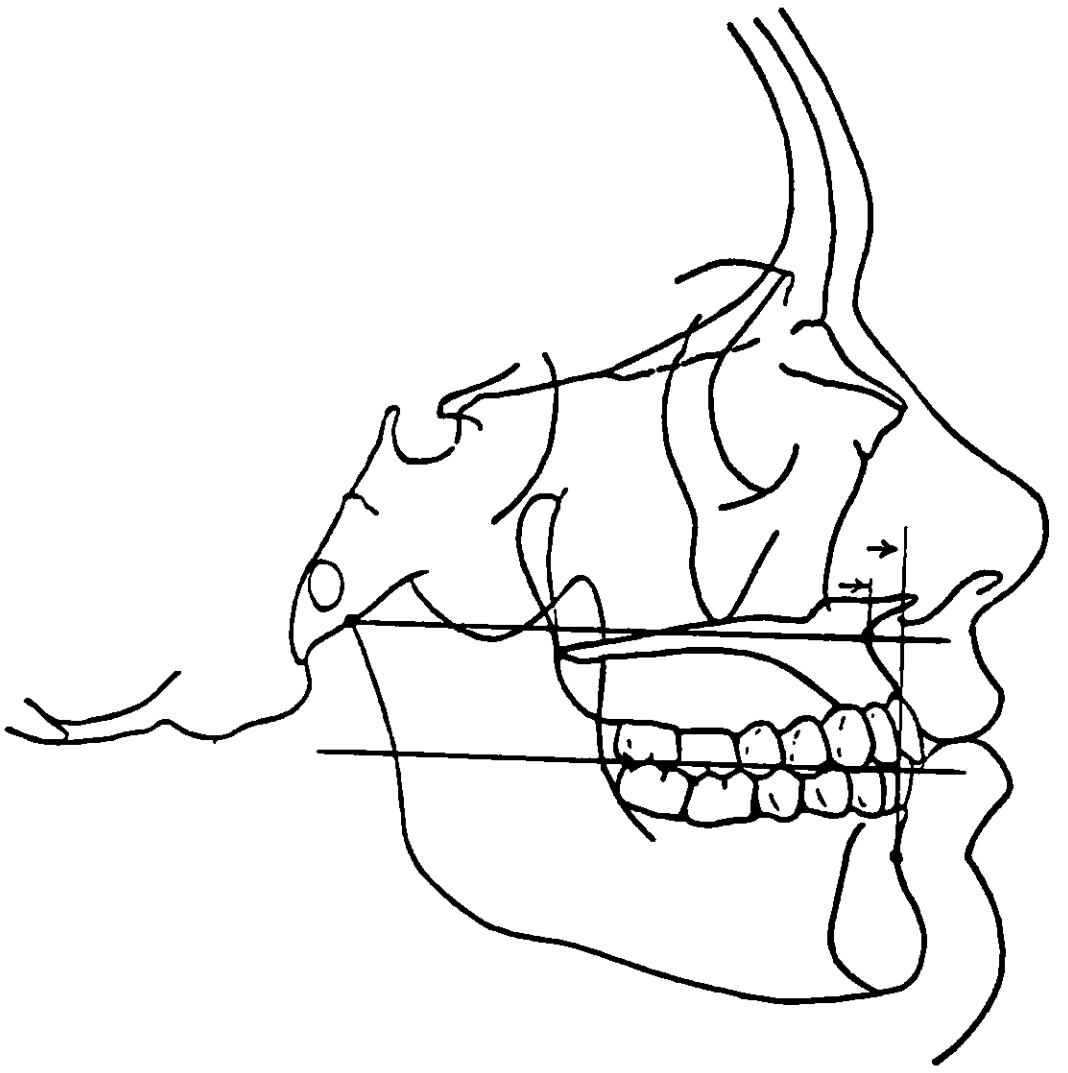


Figure 3. Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at SPr and IPr. This diagram demonstrates the comparison of lengths from Ar to SPr and Ar to IPr. The measurements are made in millimeters along REF. The lines from SPr to REF and IPr to REF are drawn perpendicular to REF.

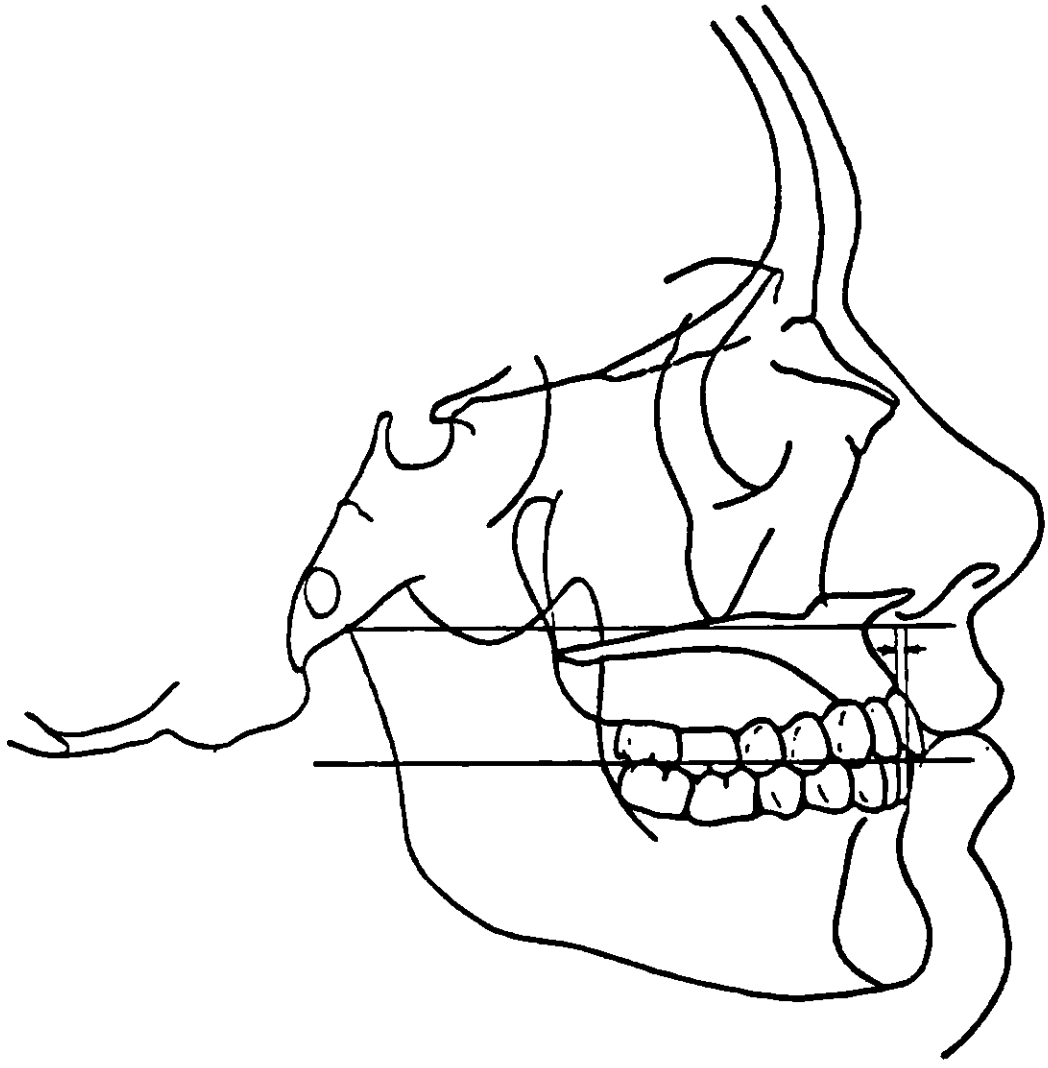


Figure 4. Middle cranial fossa (MCF) and posterior maxillary (PM) relative alignment. This diagram compares the neutral MCF/PM alignment (dashed line), which has an internal angle of 40.3° to the patient's MCF/PM alignment. The neutral MCF/PM alignment is drawn using a pre-constructed template which has a 40.3° internal angle. The template is used by: (1) measuring the length of the MCF, and (2) transfering this length to the corresponding line on the template (with the vertex representing SE). (3) Place the tracing of the subject over the template superimposing on Ar and orienting the PM vertical of the patient and the neutral PM parallel to each other. (4) Draw the neutral MCF/PM alignment with a dashed line on the tracing. The distance between the neutral PM and the subject's PM vertical can now be measured along REF in millimeters. When the PM vertical lies behind the neutral PM it is recorded as a negative number. When it is in front of the neutral PM it is a positive number. This measurement determines the effects of anterior/ posterior directions of middle cranial fossa alignment on corresponding retrusive/protrusive placement of the maxilla and mandible.

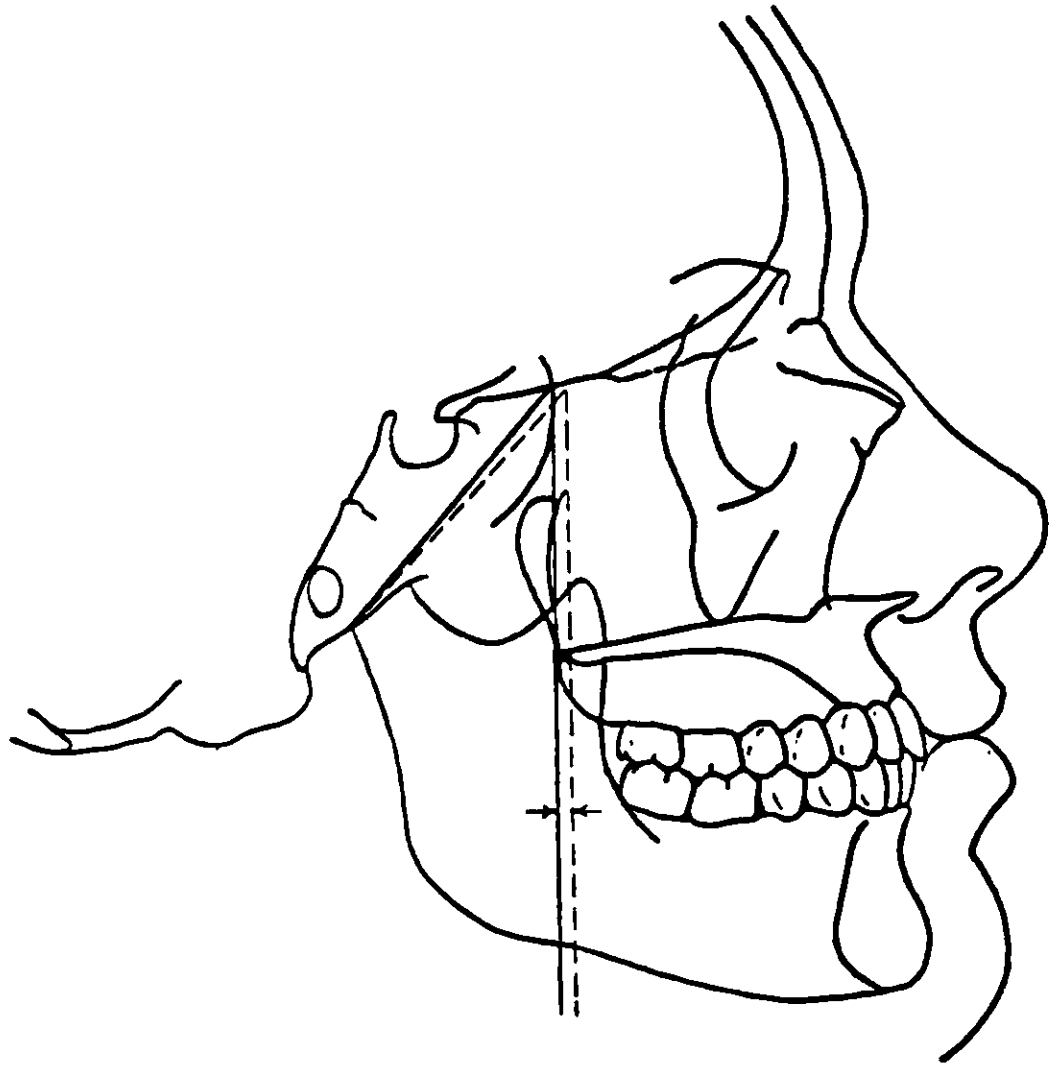


Figure 5. Ramus alignment. This diagram demonstrates the alignment of the subject's ramus plane and its relationship to the neutral ramus plane. A line from Ar to Go represents the individual's ramus plane. The neutral ramus plane is represented by a line from Ar to the midpoint between Ar and the neutral PM vertical at the level of Go. The comparison of their alignment effects on retrusive/protrusive placement of the mandible is made along FOP. The distance between Ar-Go and NRa is measured in millimeters along FOP. If Ar-Go is behind NRa, the distance is recorded as a positive number. If it is in front of NRa it is recorded as a negative number.

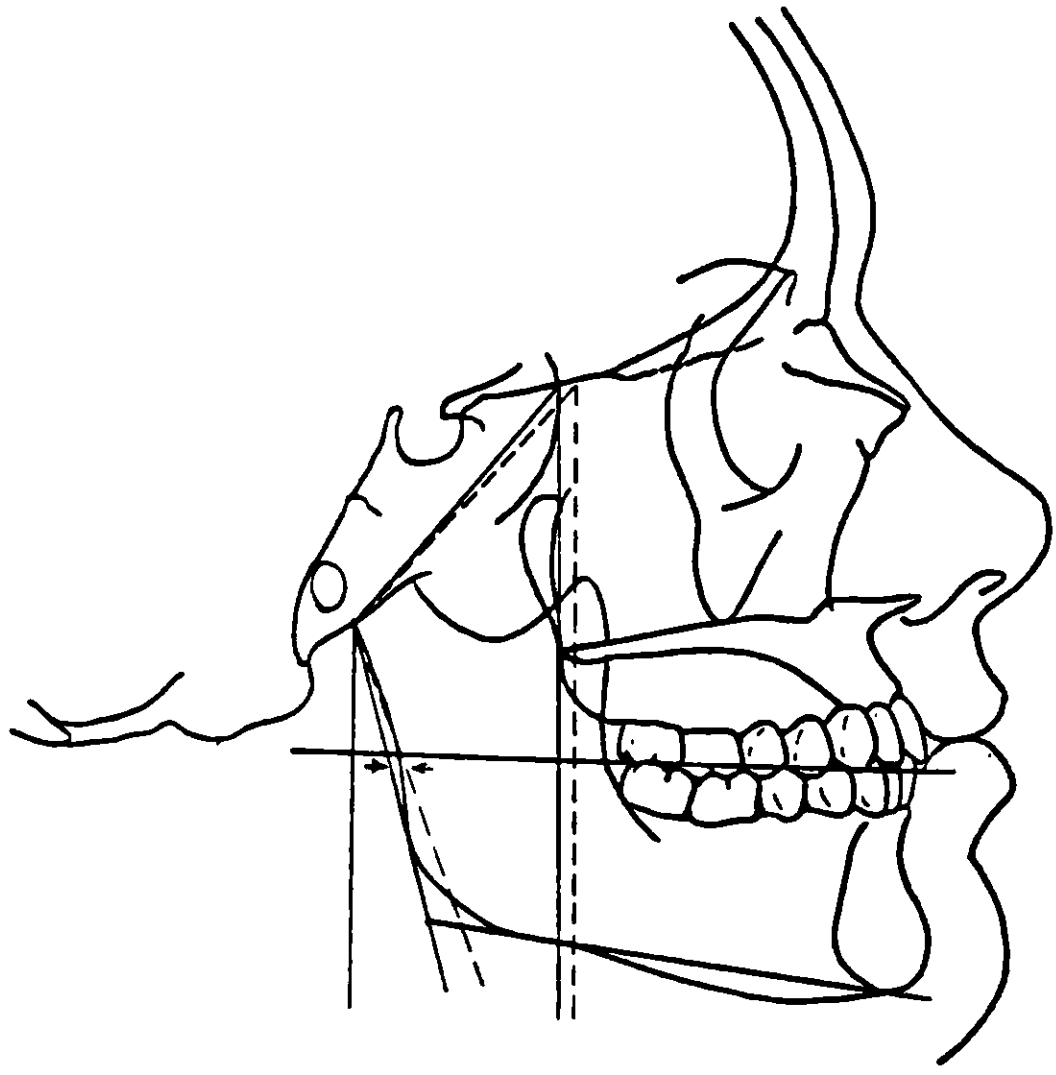


Figure 6. Ramus/MCF horizontal dimensions (skeletal). This diagram demonstrates the comparison of the horizontal dimensions of the middle cranial fossa (Ar to PM neutral) with the width of the ramus (Ar to ARa), and resultant effect on retrusive/protrusive placement of the maxilla and mandible. This measurement is made along REF in millimeters. The line PRa is drawn from Ar to FOP where it intersects the posterior border of the ramus. A line parallel to PRa is drawn from the anterior border of the ramus where it intersects FOP up to REF. The line indicates ARa. The distance from AR to ARa and Ar to PM neutral are now measured along REF.

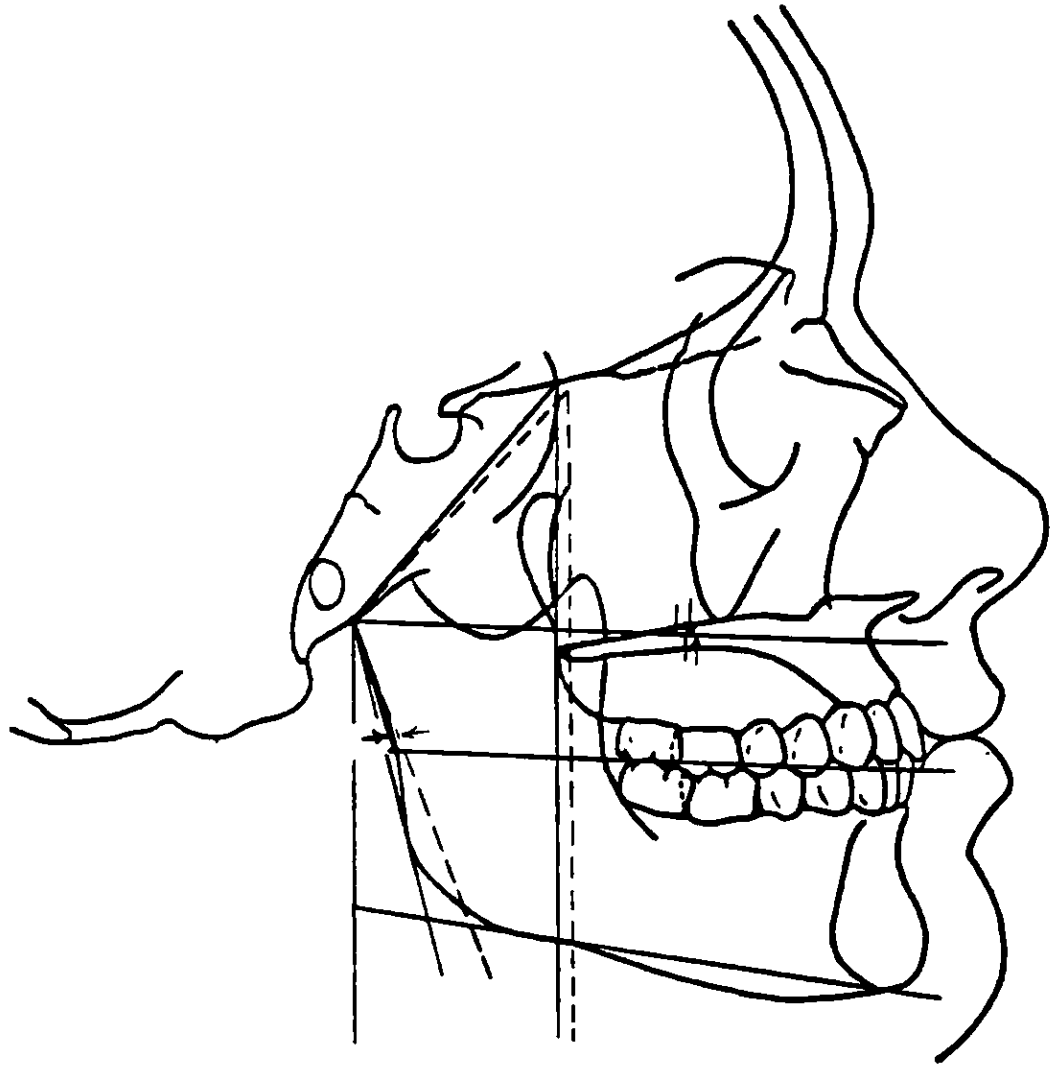


Figure 7. Ramus/MCF horizontal dimension (dental). The neutral positions of the molars are demonstrated with this measurement. The distal surfaces of the maxillary and mandibular first molars are indicated on REF by short vertical lines. The maxillary molar is corrected to its neutral position by adding or subtracting the distance between PM and neutral PM. When the MCF/PM rotation is forward (PM is in front of neutral PM) the correction is made by subtracting the PM-PM neutral difference from the Ar to maxillary molar length along REF. The mandibular molar is corrected to its neutral by adding or subtracting the distance from NRa to PRa along FOP. If PRa is behind NRa then the correction is made by adding the distance between them to the length from Ar to the mandibular molar along REF. Arrows on REF demonstrate these neutral positions. The maxillary and mandibular molar neutral positions can now be measured in millimeters from Ar along REF.

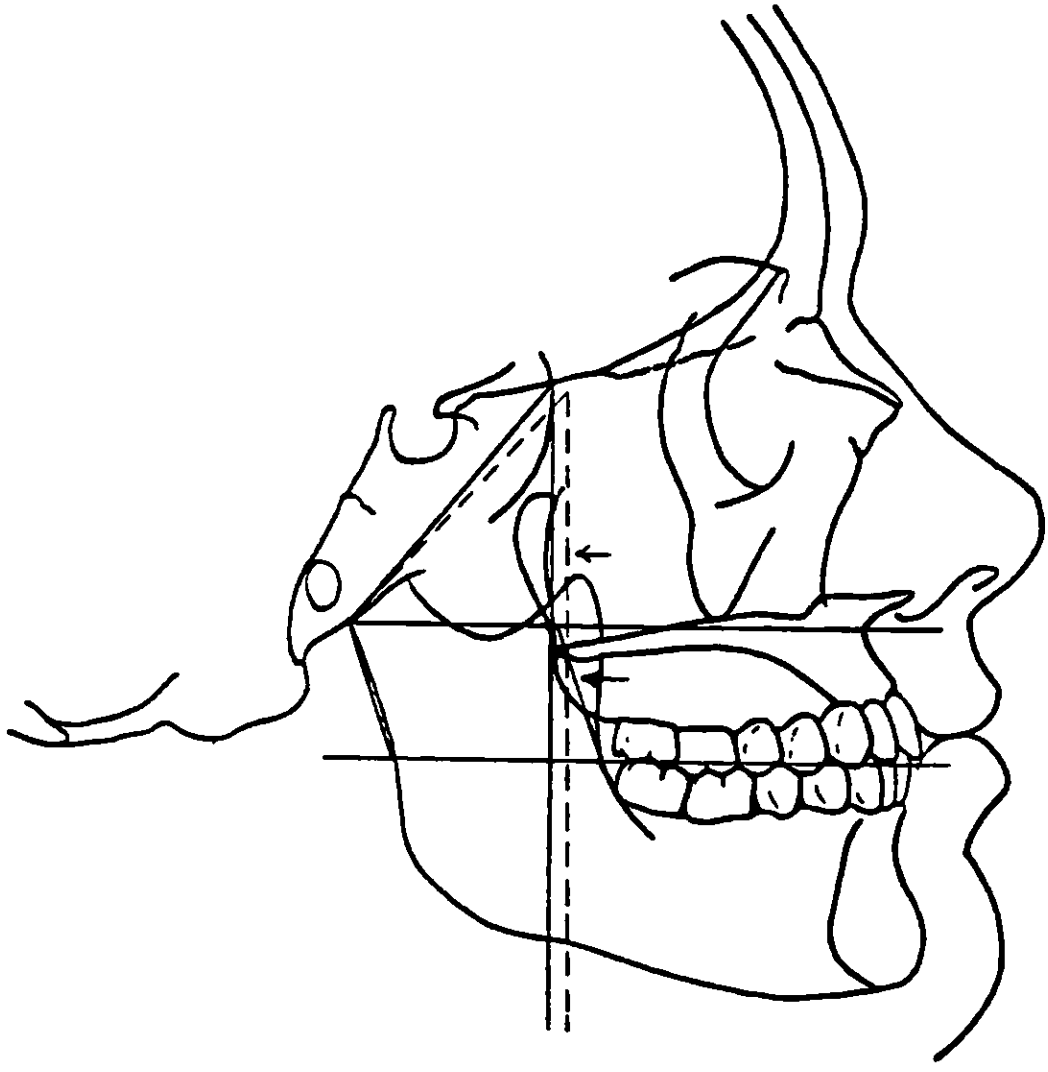


Figure 8. Molar positions (composite). Short vertical lines along REF indicate the distal surfaces of the maxillary and mandibular first molars. The measurement is made in millimeters along REF from Ar to the short vertical lines.

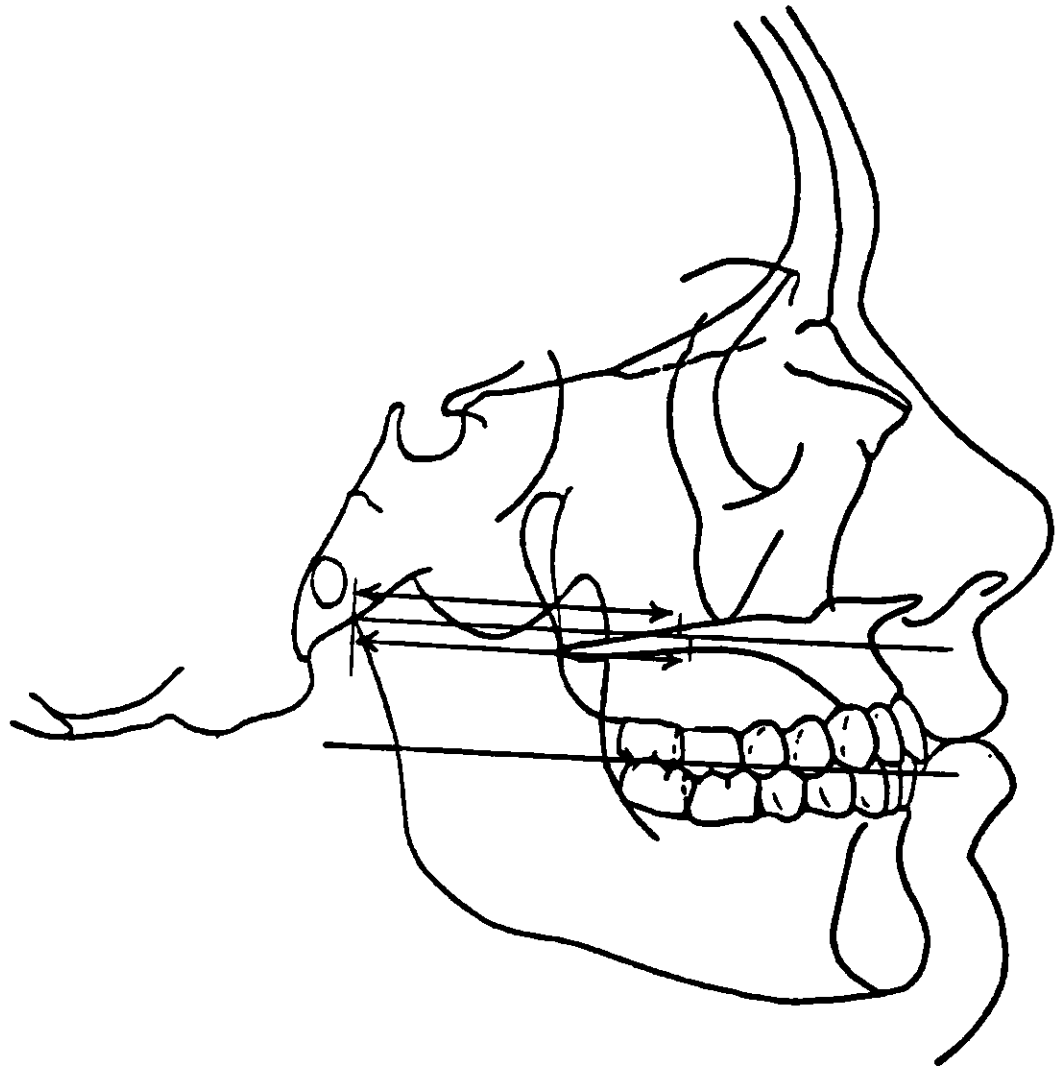


Figure 9. Maxillary/mandibular arches, skeletal dimensions, A point compared with B point. This diagram compares the length of the maxillary skeletal arch with the length of the mandibular skeletal arch. The maxillary skeletal arch is measured in millimeters from PM (solid line) along REF to A point. The mandibular skeletal arch is measured in millimeters from ARa where it intersects REF to B point along REF.

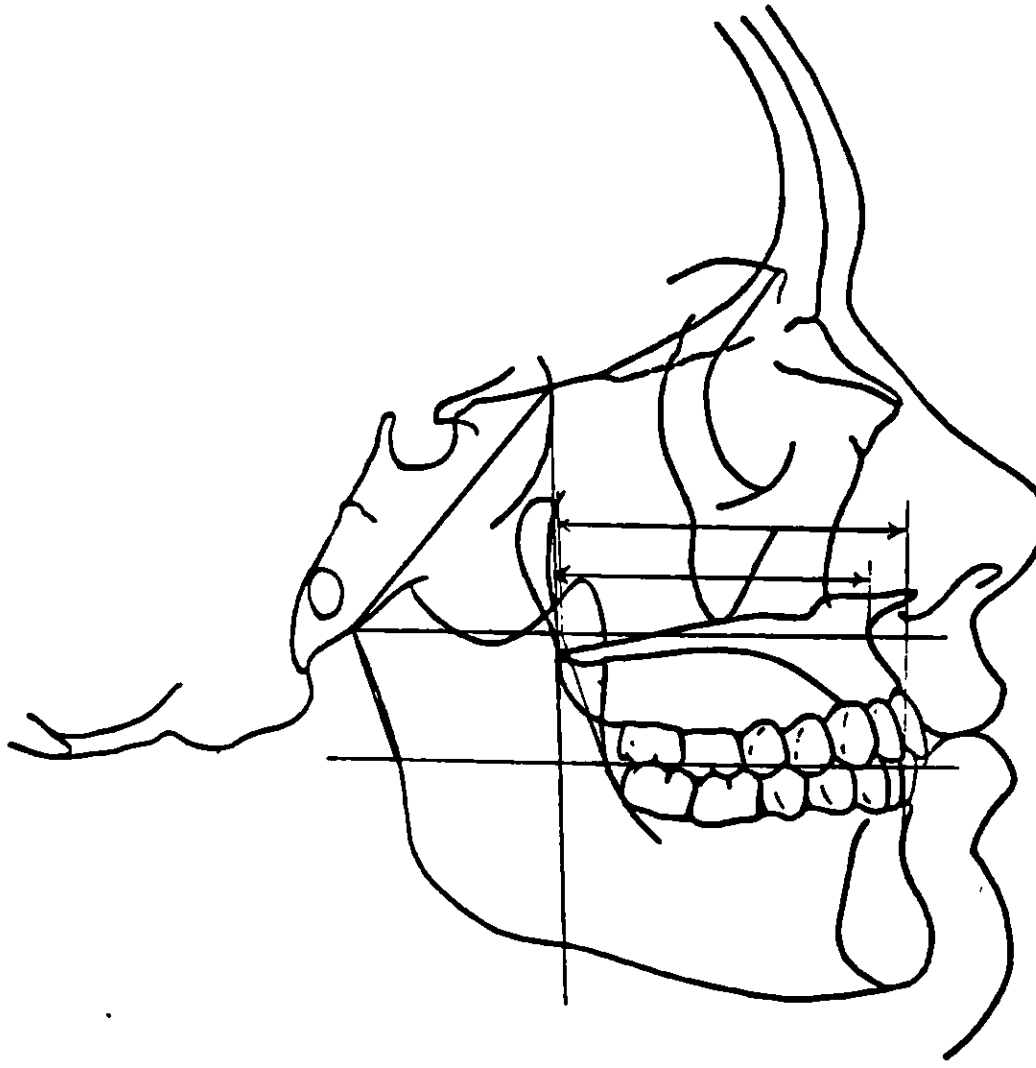


Figure 10. Maxillary/mandibular arches, dental dimensions, A point compared with B point. This is similar to the previous measurement except that the distances are measured to the distal surfaces of the first molars.

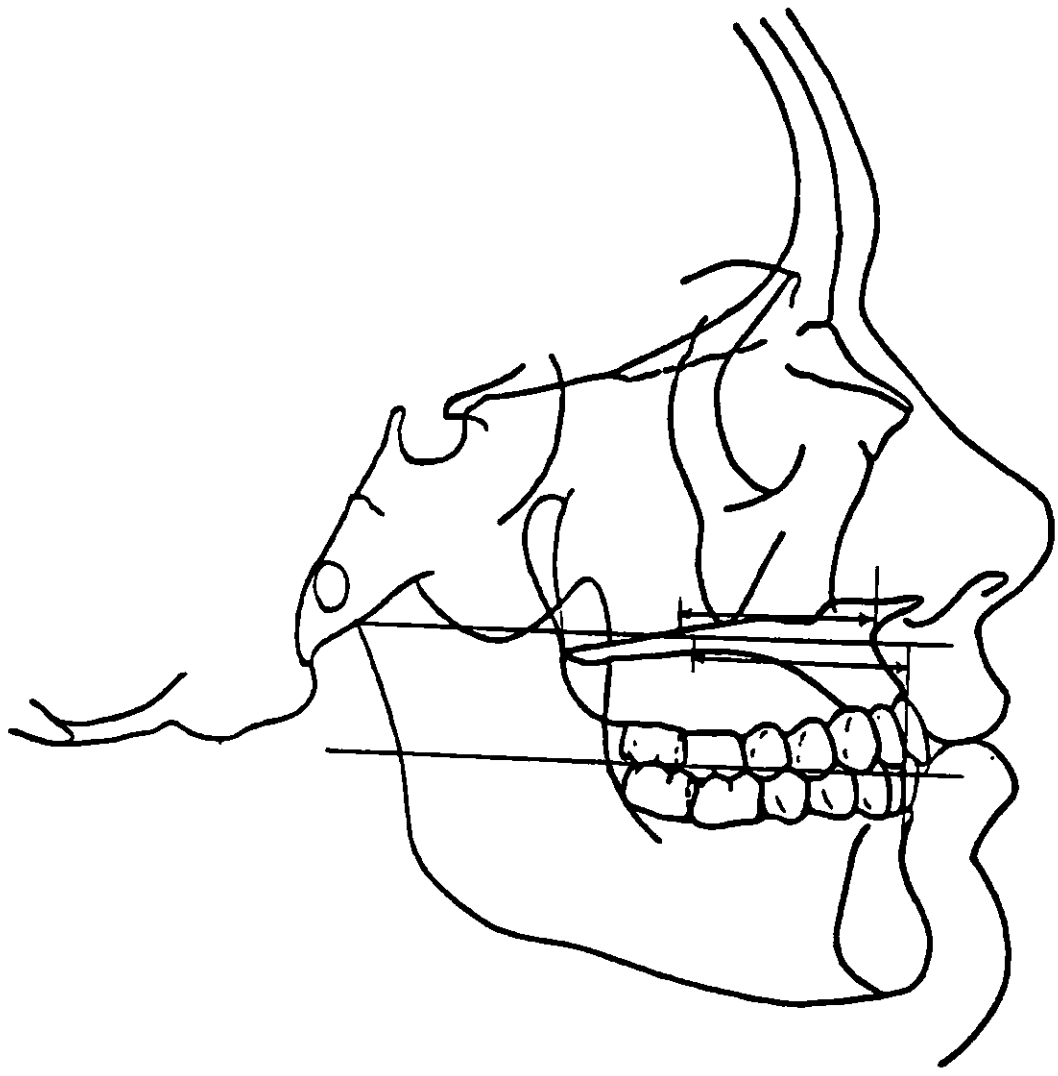


Figure 11. Maxillary/mandibular arches, skeletal dimensions, SPr compared with IPr. This comparison is identical to Figure 11 except that PM is measured to SPr and ARa is measured to IPr.

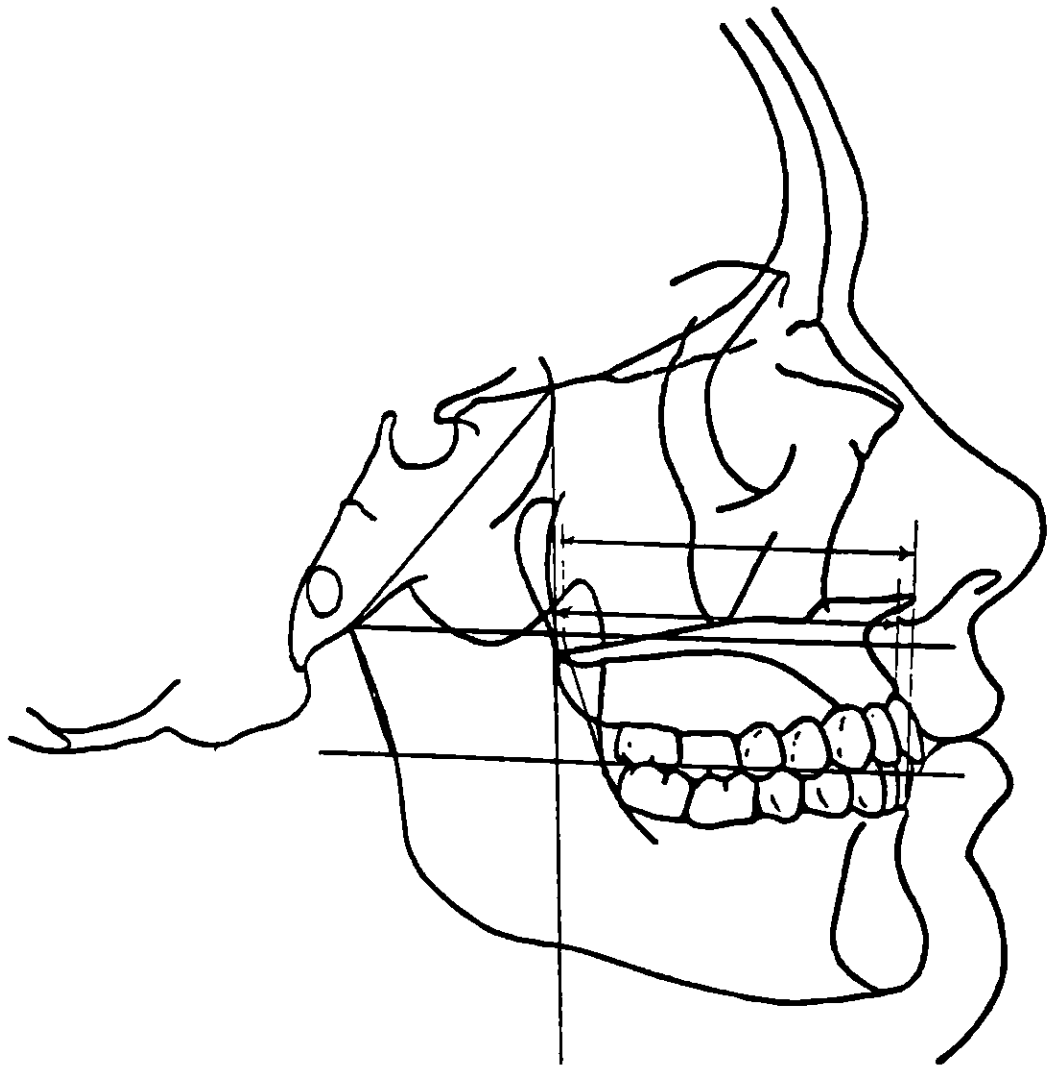


Figure 12. Maxillary/mandibular arches, dental dimensions, SPr compared with IPr. This measurement is identical to that in Figure 12 except that the distal of the maxillary first molar is measured to SPr and the distal of the mandibular first molar is measured to IPr.

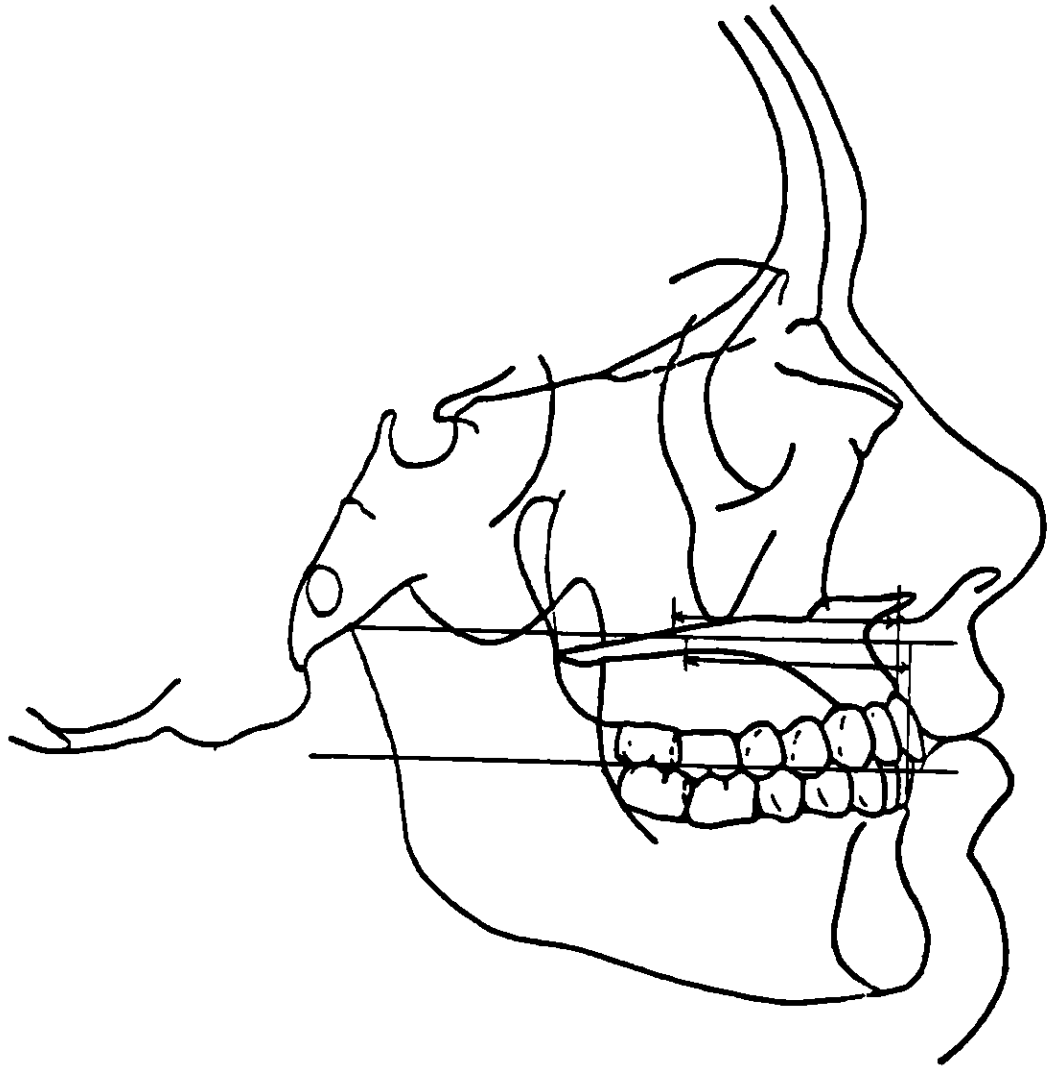


Figure 13. PM as compared with ramus/MCF vertical dimensions. The individual's relative posterior vertical nasomaxillary height is determined by this measurement. When the MCF rotates forward or backward, and the ramus rotates the same amount in the corresponding direction, no vertical disproportion in PM dimension has occurred relative to the composite vertical dimension of the middle cranial fossa and the ramus. The MCF rotation is determined by measuring the difference between PM and neutral PM along FOP. If PM is ahead of neutral PM, the MCF has a downward and forward rotation and is recorded as a positive value. If the PM is behind the neutral PM, the MCF has an upward and backward rotation and is recorded as a negative value. The ramus rotation is determined by measuring the difference between PRa and NRa along FOP. If PRa is ahead of NRa then the ramus has a forward rotation and is recorded as a negative value. If PRa is behind NRa then the ramus has a backwards rotation and is recorded as a positive value. Positive rotations of the MCF and the ramus will cause a "long" PM to occur. Negative rotations will cause a "short" PM to occur. (Ethnic variations and populations tendencies were not considered in this study.) A schematic explanation is provided in Table IV.

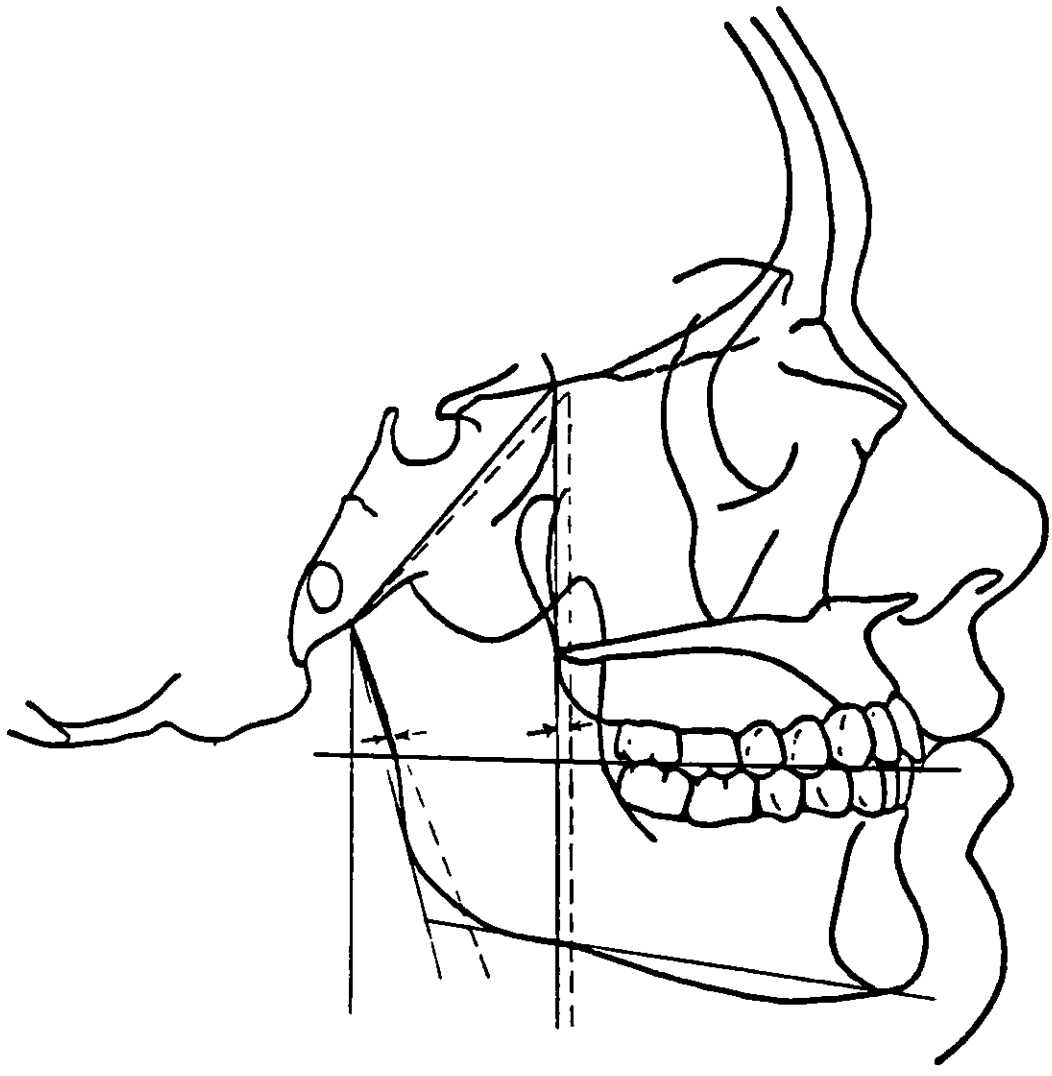


Figure 14. Corpus-occlusal alignment. This diagram demonstrates the extent of occlusal rotation as compared to the extent of ramus rotation. NOA acts as a reference line to determine the amount and direction of the occlusal rotation. NRa acts as a reference line to determine the amount of ramus rotation. Two arcs are drawn in this diagram. The radius of both arcs are equal in length. The length of the radius is determined by measuring the distance from the last occlusal contact point of the last fully erupted maxillary and mandibular molar to the point where the perpendicular from B point to REF crosses FOP along FOP. One arc is drawn from Ar, as the vertex, crossing the lines Ar to Go and NRa. The other arc is made from the last molar contact point, as the vertex crossing NOA and FOP. The distance between Ar to Go and NRa is measured at the points of intersection with the arc. If Ar to Go is behind NRa it is a positive number, if in front it is a negative number. The distance between FOP and NOA is measured at the point of intersection with the arc. If FOP is above NOA it is a positive number, if below it is a negative number. If FOP and Ar to Go have rotated equally in the same direction, the occlusal/corpus rotation is neutral. Any differential between them which involves an upward rotation of the corpus/occlusal plane relative to the ramus rotation results in a maxillary protrusive effect, and a downward corpus/occlusal rotation relative to the ramus rotation produces a mandibular protrusive effect.

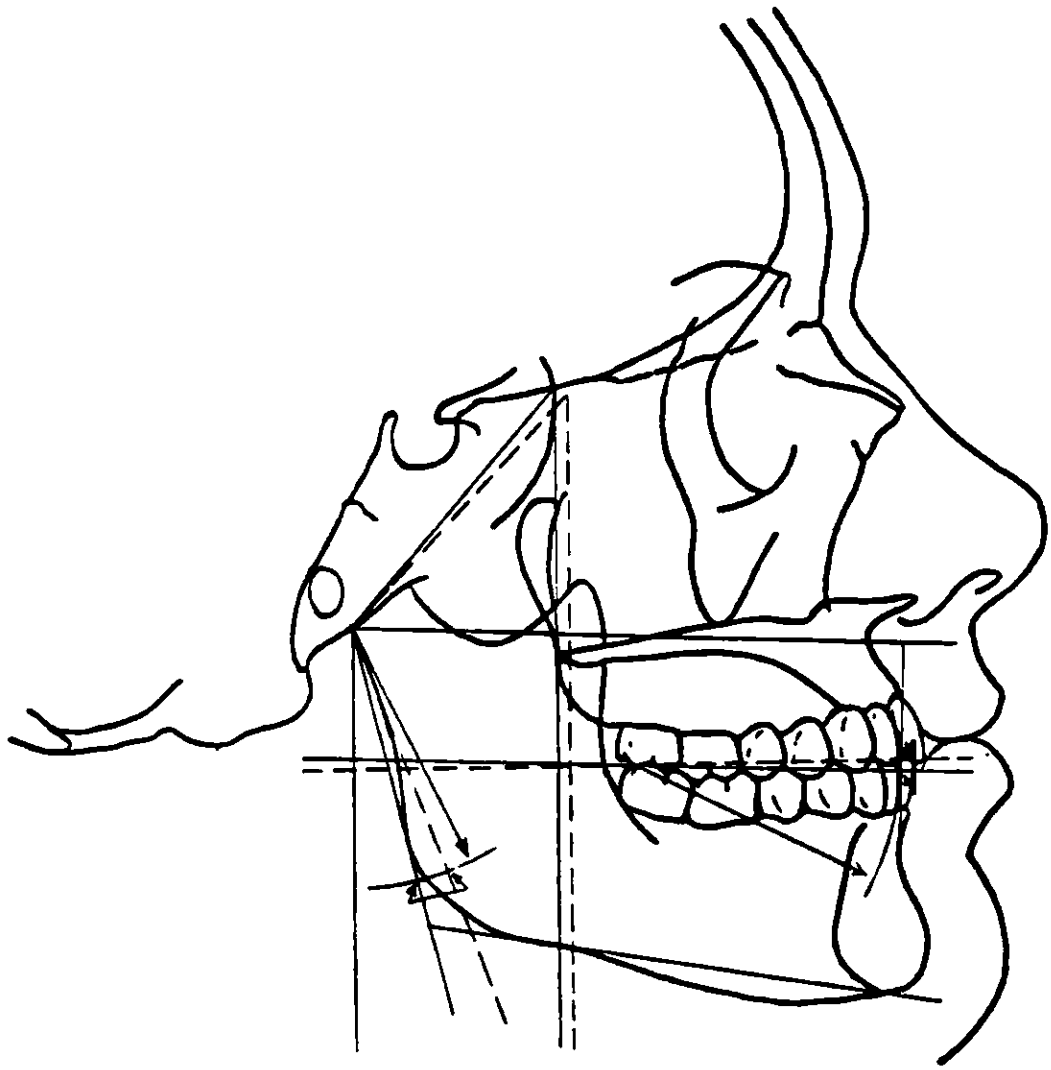


Figure 15. Gonial angle alignment. The mean gonial angle as presented in the Michigan Standard (Riolo et al., 1975) is used as a neutral value, as indicated by a dashed line. The individual's mandibular plane is indicated by the line Me to Go. The measurement here is of two angles made in degrees. The neutral gonial angle and Ar to Go to Me.

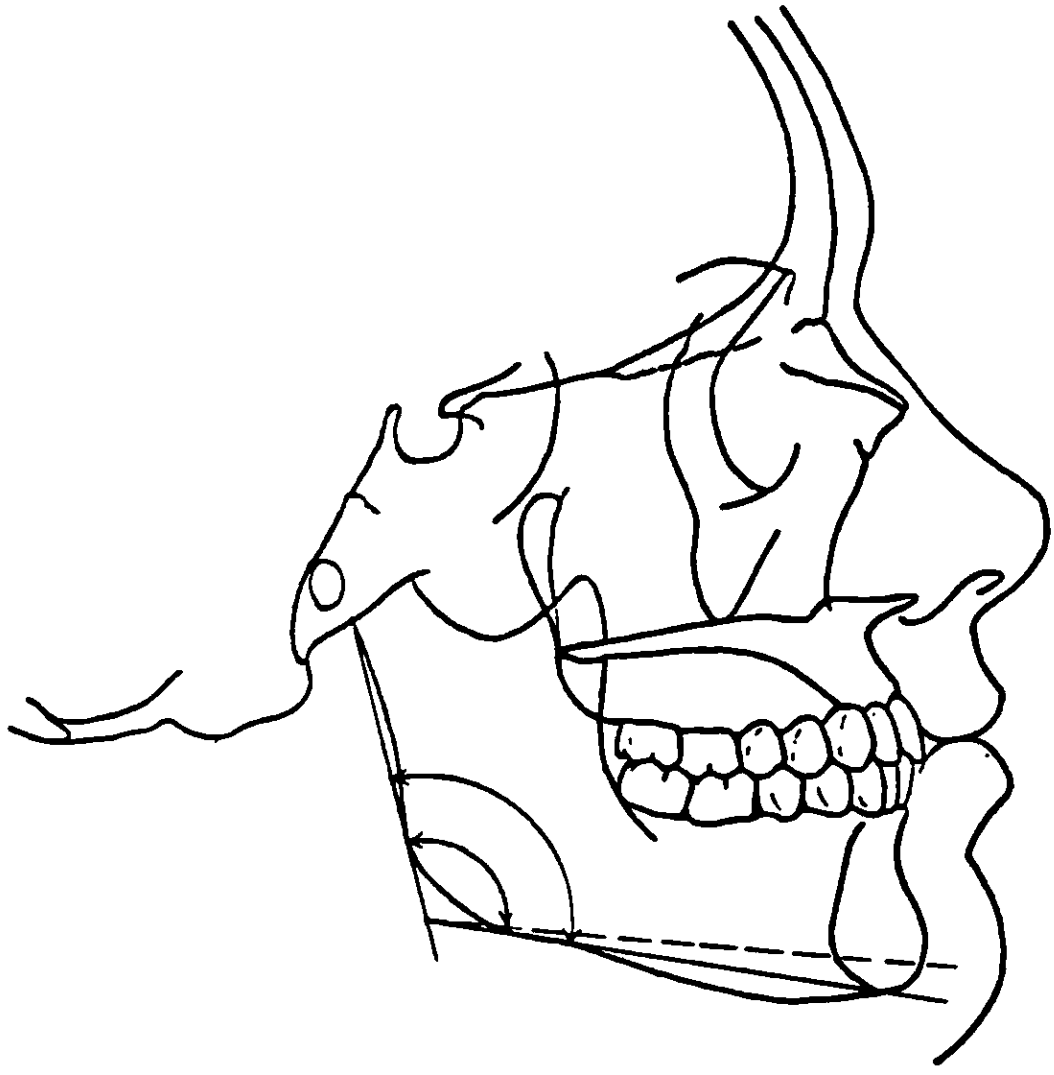


Figure 16. Curve of Spee. This is demonstrated by measuring the distance between the incisal edge of the mandibular central incisors and FOP. If the central incisors are above FOP it is a positive number, if below FOP it is a negative number.

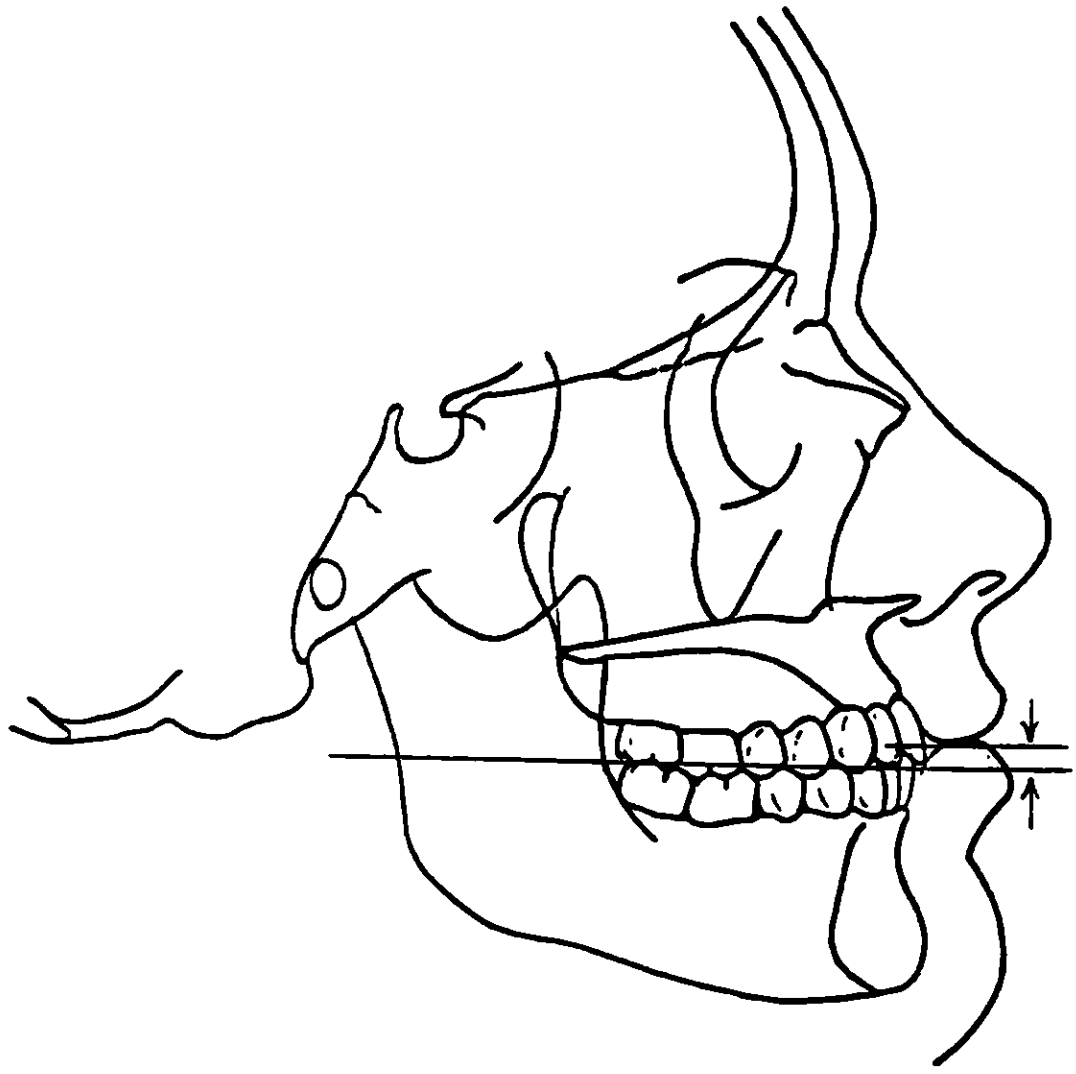


Figure 17. Palatal plane alignment. This diagram demonstrates the alignment between the palatal plane and the occipital fossa. The palatal plane is represented by a line from ANS through PNS. The distance between the plane and occipital point is measured. If the palatal plane is above 0 it is a positive number. If it is below 0 it is a negative number. Positive and negative values represent clockwise and counterclockwise rotations, respectively.

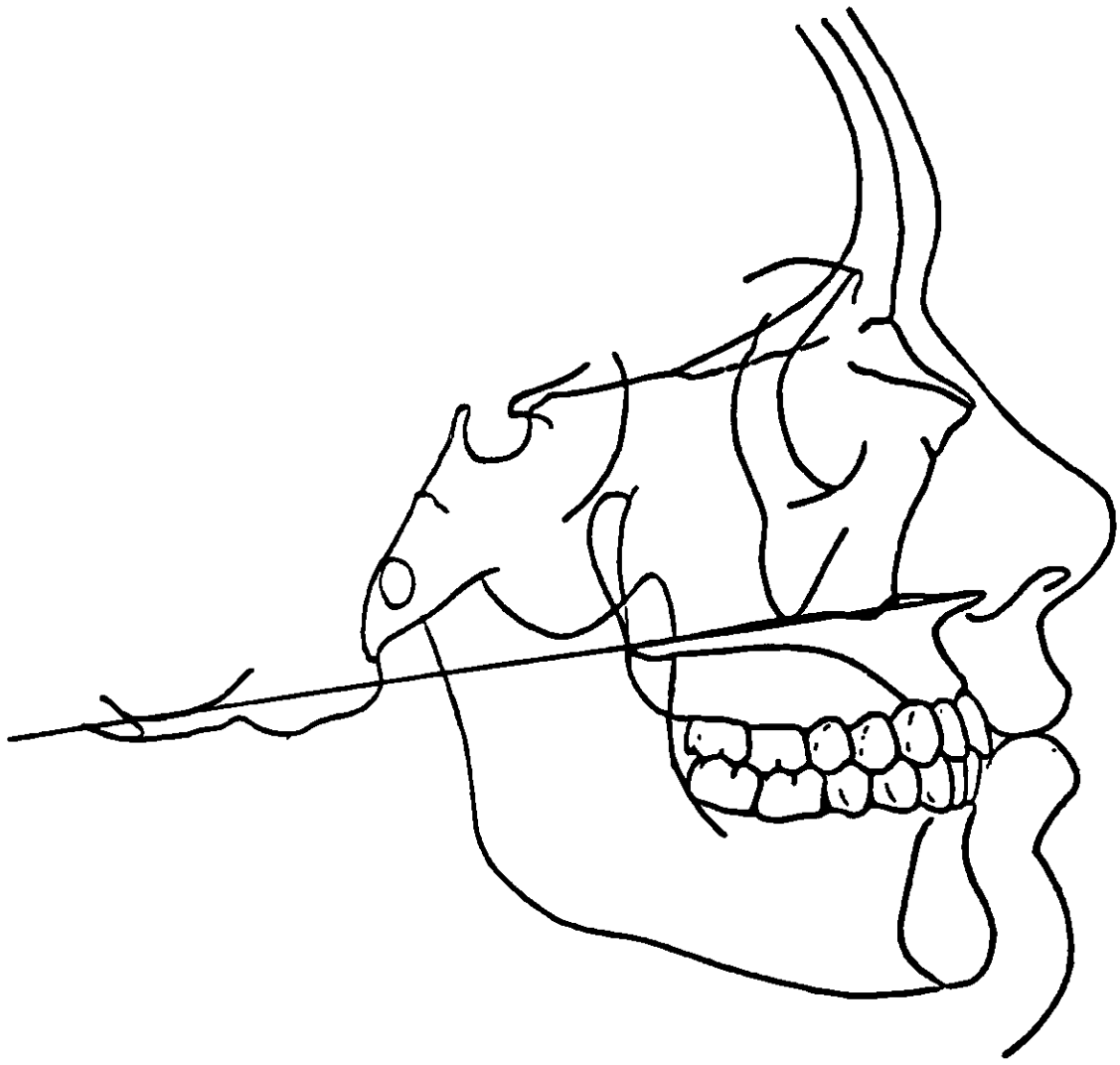


Figure 18. Inferior maxillary plane. This diagram demonstrates the alignments relationship between the inferior boundry of the nasomaxillary complex and the occipital fossa, theoretically representing the position establishing the inferior boundry for the nasomaxillary growth field. The line from SPr through the cementoenamel junction of the last fully erupted maxillary molar represents the inferior maxillary plane. The distance between this plane and occipital point is then measured. If IMP is above 0 it is a positive number, if IMP is below 0 it is a negative number. Positive and negative values represent clockwise and counterclockwise rotations, respectively, of IMP in relation to 0.

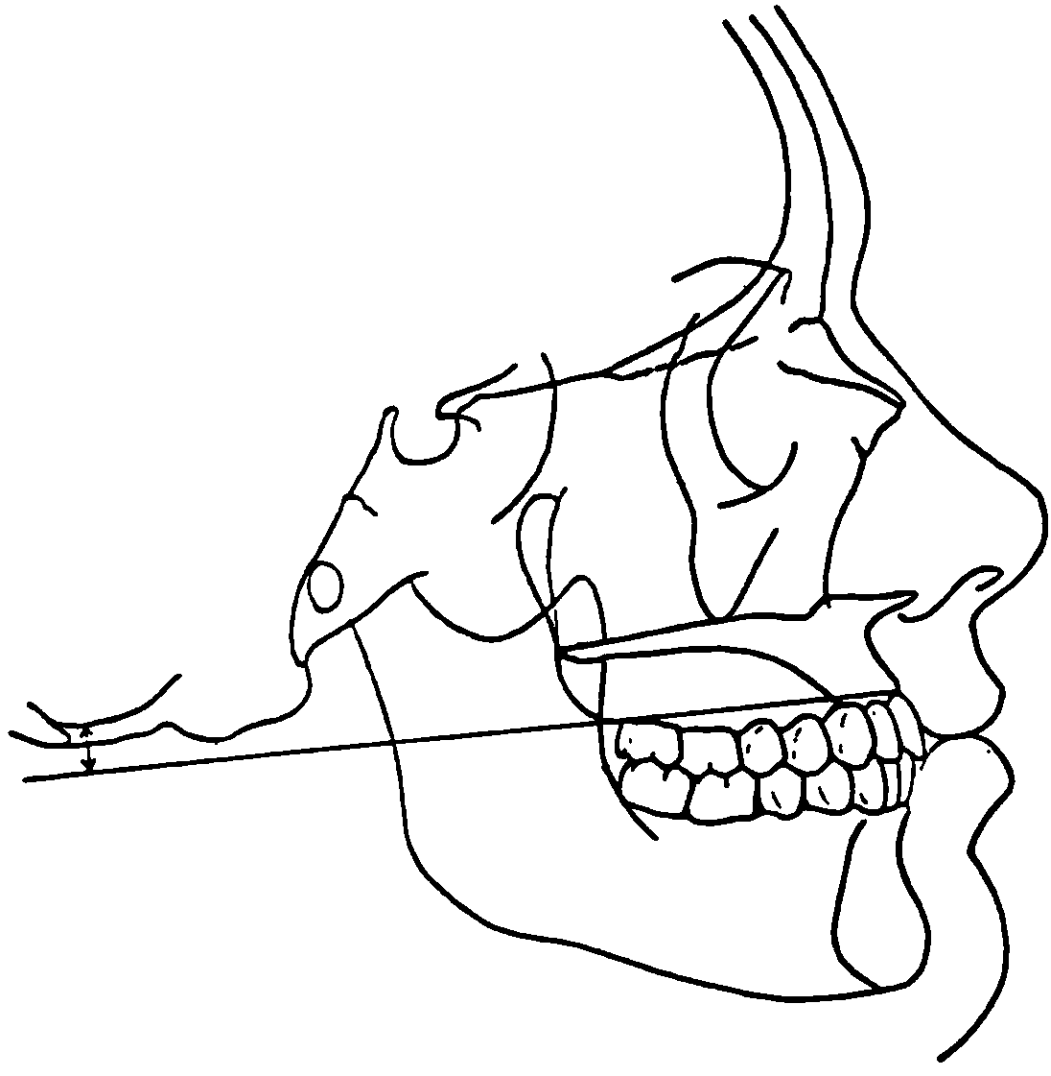


Figure 19. Maxillary nerve/palatal plane alignment. This diagram demonstrates the alignment relationship between the maxillary nerve and the palatal plane. The plane of the maxillary nerve is represented by a line from foramen rotundum in the pterygomaxillary fissure to a point 3 mm above orbitale (representing the course of the nerve prior to its downturn into the orbital floor). The palatal plane is determined as illustrated in Figure 17. An angular intersection is made between these two planes. If the angle is zero, the planes are in a neutral position. If the vertex of the angle is behind the subject, the angle is positive and indicates a clockwise rotational alignment of the palate. If the vertex is in front of the patient, the angle is negative and indicates a counterclockwise rotational alignment of the palate relative to the maxillary nerve.

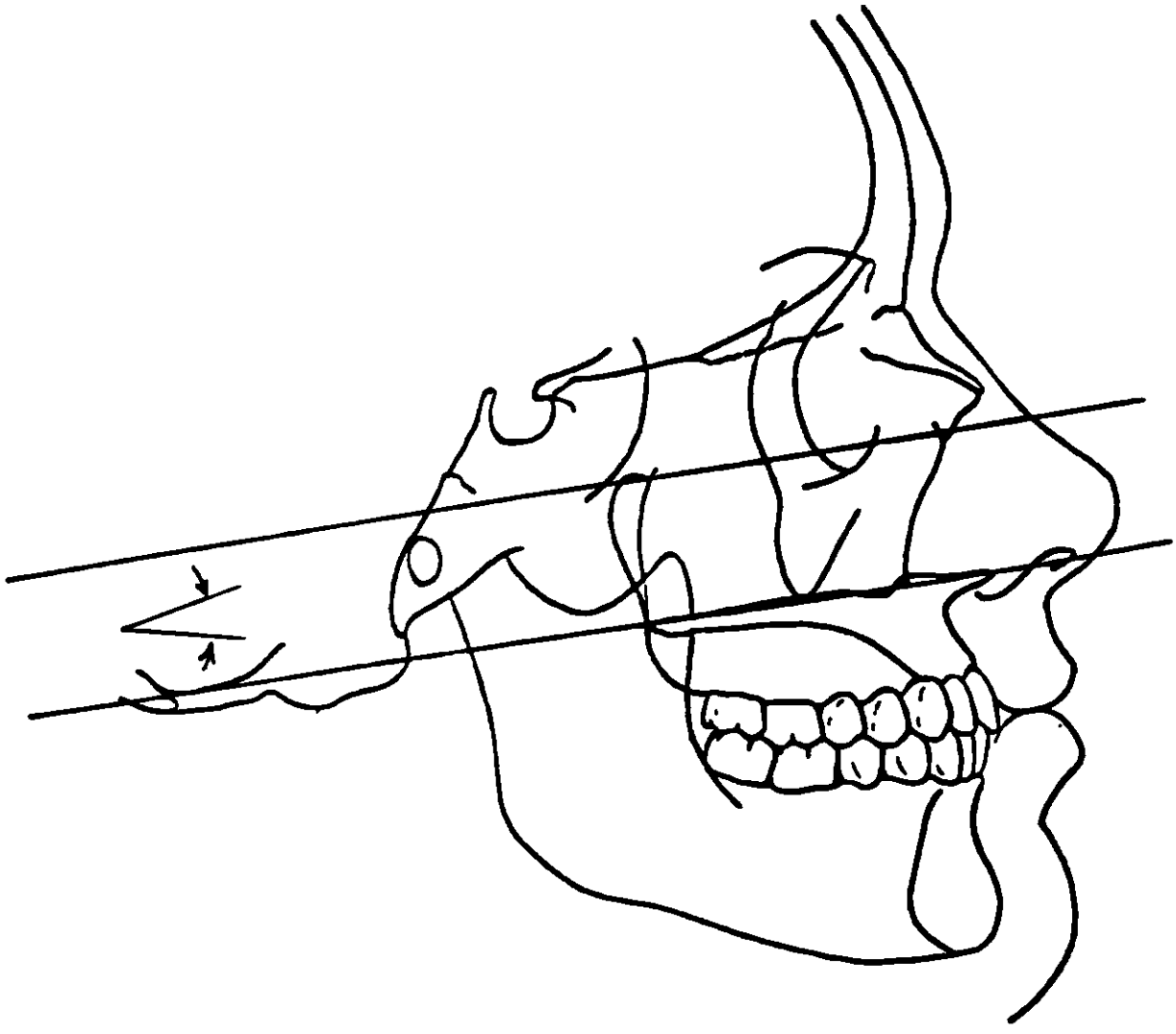
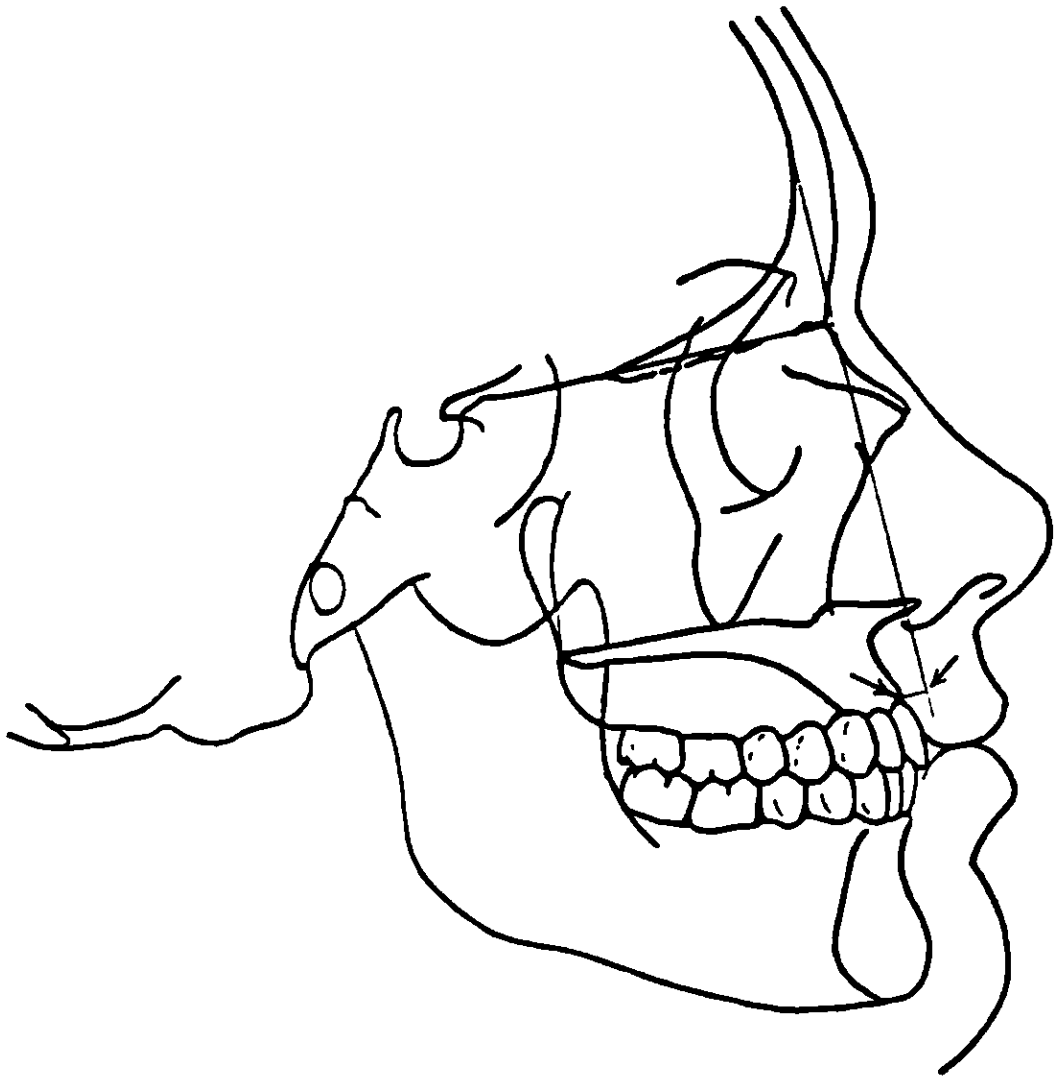


Figure 20. Vertical anterior maxillary plane. This diagram demonstrates the anterior boundary of growth of the nasomaxillary complex. A line from the most anterior point of the endocranial surface of the frontal bone (representing the frontal lobe of the cerebrum) is drawn perpendicular to a line from the posterior boundry of the cribiform plate to the anterior boundry of the cribiform plate. The distance from SPr to the perpendicular is measured in millimeters. If SPr is in front of the perpendicular it is a + value, if SPr is behind the perpendicular it is a - value. A + value can normally be expected until full naso-maxillary growth is attained.



RESULTS

Recognition of an individual's craniofacial configuration utilizing counterpart analysis is an improved approach to analysis of Class II malocclusions. In a previous study (Whitney, 1983) three measurements were used as the basis for the grouping of his Class II sample, namely middle cranial fossa (MCF) alignment, vertical relationship of posterior nasomaxillary complex (PM vertical), and the mandibular ramus alignment. Data in this study of pre-treatment and post-treatment analyzed results were examined first to survey the consistency of the given signs of these three measurements.

Both MCF alignment and PM vertical demonstrated a moderate change throughout treatment period. In 77 out of 157 cases, PM vertical remained constant and 88 out of 157 cases of MCF alignment stayed about the same. A higher incidence of ramus alignment consistency was observed, inasmuch as 103 of 157 cases remained unchanged. It also appeared that most of the data (Tables VII to XI) fell into the "+" category, i.e., a clockwise rotation of ramus (mandibular retrusive effect). Only 8 cases showed a "-" sign in pre-treatment and/or post-treatment results. Therefore, it is recommended that a "+" sign (backward alignment of ramus) be considered as virtually a constant.

Data was collected for 8 cases that displayed a "-" sign. In Table V, 7 Tweed treated (TT) cases showed a high incidence of mandibular protrusive effect post-treatment. One Begg treated (BT) case that previously showed a mandibular protrusive effect was back to the mandibular retrusive effect.

The results of applying the counterpart analysis to the Class II treated sample population led to the recognition of five groups within this general malocclusion type, as summarized in Table VI.

Groups I, II and III showed constancy of expression (a mandibular protrusive or retrusive effect) before and after treatment. Group IV and Group V displayed variability of expression of MCF alignment and PM vertical before and after treatment. Group I demonstrated a relatively "short" PM vertical which had a reciprocal effect to offset a mandibular retrusive effect of MCF alignment and ramus alignment. Group II exhibited a backward rotation of MCF alignment which compensated for a mandibular retrusive effect of PM vertical and ramus alignment. Group III, Group IV and Group V showed a strong Class II tendency. Only Group I had a relative "short" PM vertical, whereas the other four groups all had a relatively "long" PM vertical which was expressed as a mandibular retrusive effect.

The synergic and reciprocal relationship between MCF alignment and PM vertical formed the fundamental criteria for

TABLE V

MORPHOLOGICAL EXPRESSION OF FORWARD ALIGNMENT OF RAMUS

Variable	Individual															
	092		102		122		124		130		140		149		054*	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ramus Alignment	0	-	-	--	-	-	+	-	0	-	0	-	+	-	-	+

*: BT case
Others: TT cases

TABLE VI

MORPHOLOGIC EXPRESSION OF GROUPING
OF CLASS II INDIVIDUALS

Variable	Group				
	I	II	III	IV*	V*
MCF	+	-	+	+	+
PM	-	+	+	+	+
Ramus	+	+	+	+	+

+ = mandibular retrusive effect.
- = mandibular protrusive effect.
* = see explanation in text.

grouping. In addition, the following anatomical measures were found to be informative in terms of assessment of:

1. treatment effect: aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A and B points, aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at SPr and IPr, molar positions (composite), Curve of Spee measurement;

2. regional adaptive change: ramus/MCF horizontal dimensions (skeletal), maxillary/mandibular arches, skeletal dimensions, A point compared with B point, and maxillary/mandibular arches, skeletal dimensions, SPr compared with IPr.

Group I

The craniofacial complex of this group had a constant expression before and after treatment which was characterized by a forward rotation of the middle cranial fossa and a backward rotation of the ramus. Clockwise rotation of both MCF alignment and ramus alignment displayed mandibular retrusive features and could be compensated for by a "short" PM vertical which had a mandibular protrusive expression (Tables VI and VII). This group consisted of 22 BT and 24 TT cases.

Maxillary/mandibular Arches, Skeletal Dimensions, A Point Compared with B Point (8)

Prior to treatment, three Begg treated (BT) cases exhibited a mandibular retrusive effect. After treatment only one BT case remained unchanged. On the other hand, pre-treatment records showed 19 out of 22BT cases had a mandibular protrusive effect,

and at the end of treatment, 21 out of 22 BT cases showed the same effect.

In Tweed treated (TT) cases, four before treatment cases had a mandibular retrusive effect, and this number decreased to 0 at the end of treatment. Twenty out of 24 TT cases prior to treatment that had a mandibular protrusive effect increased to 24 TT cases after treatment.

A great tendency toward mandibular protrusive effect was seen in Group I. A continual increase of mandibular protrusive effect was apparent by the end of treatment; a relatively "long" mandibular arch existed before treatment and, even more so, following treatment for a majority of the cases.

Maxillary/Mandibular Arches, Skeletal Dimensions, SPr Compared with IPr Point (10)

Prior to treatment, 14 out of 22 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 21 cases. In TT cases, it was 17 out of 24 cases at the start of treatment and later became 23 cases. Again, there existed a strong trend for a mandibular protrusive effect in this group.

Significant finding (at the level of $\alpha = .01$) was observed that between these two measurements Tweed mechanics could have more influence on maxillary/mandibular arches, skeletal dimensions measured at SPr and IPr points (alveolar bone) (10) than measured at A and B points (basal bone) (8).

Group II

The craniofacial morphology in this group that displayed constant expressions before and after treatment was characterized by a composite of regional mandibular retrusive effects with reciprocal expressions. These anatomical expressions consisted of a backward rotation of the ramus and a "long" PM vertical and a compensatory upward rotation of the middle cranial fossa. This group included 16 BT cases and nine TT cases (Tables VI and VIII).

Maxillary/Mandibular Arches, Skeletal Dimensions, A Point Compared with B Point (8)

At the beginning of treatment, nine out of 16 BT cases had a mandibular protrusive effect and this effect increased to 11 cases after treatment. In TT cases, it was 7 out of 9 cases that had the mandibular protrusive effect prior to treatment, and remained the same following treatment.

Maxillary/Mandibular Arches, Skeletal Dimensions, SPr Point Compared with IPr Point (10)

Prior to treatment, 2 out of 16 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 9 cases. In TT cases, it was 2 out of 9 cases at the start of treatment and later became 6 cases. Less tendency of mandibular protrusive effect before and after treatment was noted in this group than in the preceding group.

Group III

This group exhibited a forward rotation of the cranial floor, a "long" PM vertical and a backward rotation of the ramus before and after treatment. All features contributed to underlying Class II mandibular retrusive tendencies. This group included 27 BT cases and 21 TT cases (Tables VI and IX).

Maxillary/Mandibular Arches, Skeletal Dimensions, A Point Compared with B Point (8)

Prior to treatment, 20 out of 27 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 26 cases. In TT cases, it was 13 out of 21 cases at the start of treatment and later became 16 cases.

Maxillary/Mandibular Arches, Skeletal Dimensions, SPr Point Compared with IPr Point (10)

Prior to treatment, 19 out of 27 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 26 cases. In TT cases, it was 11 out of 21 cases at the start of treatment and later became 15 cases.

At the end of treatment a strong, overall tendency of mandibular protrusive compensating effect was found in this group.

Group IV

A lack of constancy for measurements of MCF alignment or

PM vertical occurred before and after treatment for individuals in Group IV and Group V. Group IV (Tables VI and X) had an aggravated effect in pre-treatment record and a reciprocal effect in post-treatment record. Following treatment, one part of the measurement changed from a clockwise rotation (mandibular retrusive effect) to a counterclockwise rotation (mandibular protrusive effect) which could offer a compensatory affect to its counterpart. This group included 11 BT cases and 9 TT cases.

Maxillary/Mandibular Arches, Skeletal Dimensions, A Point Compared with B Point (8)

Prior to treatment, 7 out of 11 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 10 cases. In TT cases, it was 3 out of 9 cases at the start of treatment and later became 7 cases.

Maxillary/Mandibular Arches, Skeletal Dimensions, SPr Point Compared with IPr Point (10)

Prior to treatment, 5 out of 11 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 10 cases. In TT cases, it was 2 out of 9 cases at the start of treatment and later became 8 cases.

At the end of treatment, expressional changes in either MCF alignment or PM vertical were expressed as a compensatory effect to offset a Class II tendancy. For both treatment tech-

niques, the treatment effect in this group showed an improved situation as reflected by a greater mandibular protrusive effect in post-treatment cases than in pre-treatment cases.

Group V

Group V (Tables VI and XI) revealed the opposite situation of Group IV. A reciprocal effect was noted at the start of treatment, but an aggravated effect was shown at the end of treatment. This group included 8 BT cases and 10 TT cases.

Maxillary/Mandibular Arches, Skeletal Dimensions, A Point Compared with B Point (8)

Prior to treatment, 5 out of 8 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 6 cases. In TT cases, it was 8 out of 10 cases at the start of treatment and 10 cases after treatment.

Maxillary/Mandibular Arches, Skeletal Dimensions, SPr Point Compared with IPr Point (10)

Prior to treatment, 2 out of 8 BT cases demonstrated a mandibular protrusive effect and after treatment this increased to 6 cases. In TT cases, it was 4 out of 10 cases at the start of treatment and later became all 10 cases. The high incidence of mandibular protrusiveness expressed by relatively "long" mandibular arches following treatment revealed a compensatory effect for this tendency.

Unique Feature of Relative Width of Ramus

The measurement of ramus/MCF skeletal horizontal dimension (5) showed a unique feature in this study. The "wide" ramus relative to middle cranial fossa possessed a mandibular protrusive effect that could offset a mandibular retrusive effect of another part or parts. Among 75 out of 157 cases that had a "wide" ramus, 50 cases demonstrated a protrusive contribution from both of these measures: maxillary/mandibular basal and alveolar skeletal arches (8 and 10). The other 25 cases showed a protrusive effect in the ramus alignment only (Table XII).

In Table XII, 18 out of 20 cases that had "wide" ramus before treatment became a relatively "narrow" ramus after treatment. Only two cases remained unchanged. However, these 20 cases showed in post-treatment records that what used to be a "short" mandibular basal and alveolar arch before treatment became what was then a "long" mandibular arch after treatment.

Existence of Relatively "Wide" Ramus (15) and/or Relatively "Long" Mandibular Arch at A and B Points (8) (Basal Bone Level) or at SPr and IPr Points (10) (Alveolar Bone Level)

Groups III, IV and V demonstrated more of a Class II tendency than Group I and II. The compensatory mechanisms in Group III, IV and V (Tables IX, X and XI) of the horizontal expressions (of "wide" ramus and "long" mandibular arch at basal

level and alveolar level) as they contribute to overall facial configuration were evaluated.

Twenty-nine cases possessed a mandibular protrusive effect (Tables IX, X and XI) for two out of three measurements (5, 8 and 10) before treatment. Nineteen cases showed improvement after treatment in the comparison of cumulative maxillary length with cumulative mandibular length (Figure 2). Eight cases maintained the same situation after treatment as before treatment. Only 2 cases failed to show the compensatory effect contributing to the overall facial expression.

Nineteen cases exhibited a mandibular protrusive effect of all three measurements (5, 8 and 10) before treatment. Eleven cases showed improvement after treatment while 7 cases remained unchanged; only one case worsened when a comparison of cumulative maxillary length with cumulative mandibular length (Figure 2) was made.

It was interesting to note that even though these patients displayed a Class II malocclusion, that the measures 8 and 10 revealed a pre-treatment protrusive effect in the mandible which persisted during and after treatment and seemed to prove beneficial to the final treatment result by substantially offsetting the overall composite Class II mandibular retrusive tendency.

Two Different Mechanotherapies

Statistics showed that there was not sufficient evidence

to reject the null hypothesis that Tweed and Begg treatment throughout the 5 groups showed equal effectiveness as evaluated by measurements of maxillary/mandibular bony arches at A and B points (basal bone) and maxillary/mandibular bony arches at SPr and IPr points (alveolar bone) (Tables XIII and XIV). Binomial testing was utilized to analyze data in this study.

TABLE VII

MORPHOLOGICAL EXPRESSION GROUP I

Variable	Individual															
	006		007		008		012		024		030		035		039	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	++	++	++	-	0	++	+	+	-	++	+	+	-	++	-
Ar-SPr Ar-IPr	++	+++	+++	++	+	+	++	++	+++	+	++	+	++	+	+	0
MCF Alignment	+	+	++	++	+	+	++	++	+++	++	+++	++	+++	+++	++	++
Ramus Alignment	0	+	++	++	+	0	++	+	++	++	++	++	++	++	0	0
Ramus/MCF Sk	+	+	+	-	+	++	--	0	--	--	+	0	--	--	0	++
Molar (composite)	+	+	+	-	0	-	0	-	++	-	+	-	0	--	+	-
Mx/Md A-B Sk	+	+	--	--	---	---	-	--	--	--	---	---	-	---	0	---
Mx/Md SPr-IPr Sk	+	--	-	--	---	---	0	--	+	--	---	---	+	---	--	---
PM Vertical	-	-	--	-	0	-	--	---	--	--	--	-	--	--	--	-
Gonial Angle Alignment*	-	-	+	+	+	+	-	-	+	+	-	-	-	-	-	-
Curve of Spee	++	++	++	++	++	+	+	0	++	+	++	+	++	+	++	++

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP I

Variable	Individual															
	040		041		045		052		059		060		061		065	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	0	-	+	-	-	--	-	0	+	0	++	+	+++	+	0	--
Ar-SPr Ar-IPr	++	+	++	+	0	-	++	+	++	+	++	++	++	+	+	0
MCF Alignment	++	++	+	++	++	++	+	+	++	++	++	++	++	++	++	++
Ramus Alignment	+	+	+	++	+	++	+	+	++	++	+	+	++	++	0	+
Ramus/MCF Sk	0	++	-	0	-	0	+	++	--	-	-	+	--	+	--	--
Molar (composite)	++	-	+	-	+	-	+	-	+	--	+	_	+	-	+	-
Mx/Md A-B Sk	---	---	0	--	--	---	--	---	--	---	+	--	++	---	-	--
Mx/Md SPr-IPr Sk	---	---	++	--	--	---	-	--	-	---	++	--	++	---	+	--
PM Vertical	---	---	-	-	--	--	-	-	0	--	--	--	0	-	--	--
Gonial Angle Alignment*	0	+	-	-	-	-	0	+	+	+	-	-	+	+	-	0
Curve of Spee	+++	+	++	+	+++	++	++	+	0	+	++	+	+	-	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP I

Variable	Individual															
	068		071		074		077		080		082		085		090	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	++	0	-	++	+	+	-	+	+	0	-	+	-	0	-
Ar-SPr Ar-IPr	+++	++	++	++	+++	++	+++	0	++	++	++	+	++	0	++	0
MCF Alignment	++	++	++	+	+	+	++	++	++	++	+++	+++	++	+++	++	++
Ramus Alignment	++	++	++	++	+	++	+	++	++	++	++	++	+	++	+	+
Ramus/MCF Sk	--	-	0	0	++	+	++	++	-	0	--	+	-	0	0	+
Molar (composite)	+	0	0	-	+	+	+	--	0	-	++	-	+	-	+	-
Mx/Md A-B Sk	0	-	---	---	0	-	---	---	--	---	---	---	-	---	---	---
Mx/Md SPr-IPr Sk	+	-	--	-	0	-	--	---	-	---	--	---	+	---	---	---
PM Vertical	--	-	-	-	-	-	--	--	-	--	---	---	--	--	--	--
Gonial Angle Alignment*	-	-	+	+	-	-	+	+	-	-	+	0	-	-	+	+
Curve of Spee	+	0	++	++	+	+	+++	0	++	+	+++	0	+	++	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP I

Variable	Individual															
	092		095		098		104		106		107		110		115	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	-	-	0	0	0	0	++	-	++	++	+	--	0	-	0	0
Ar-SPr Ar-IPr	+	0	+	+	+	+	++	+	+++	++	++	0	+	-	++	+
MCF Alignment	+++	+++	++	+++	+++	+++	++	++	+++	+++	++	+++	++	++	++	++
Ramus Alignment	0	-	++	++	++	++	+	0	++	++	++	+++	++	+++	+	+
Ramus/MCF Sk	+	0	-	--	-	-	--	-	--	+	--	--	--	-	--	-
Molar (composite)	0	-	-	-	0	--	-	-	0	-	+	-	0	-	-	-
Mx/Md A-B Sk	---	--	--	--	---	---	+	---	--	---	---	---	--	---	--	-
Mx/Md SPr-IPr Sk	---	--	--	--	---	---	+	--	0	---	--	---	0	---	+	+
PM Vertical	--	--	-	--	--	--	--	-	--	--	--	-	--	-	-	-
Gonial Angle Alignment*	+	+	+	+	-	-	+	+	-	-	-	-	+	+	-	-
Curve of Spee	+++	0	++	+	+	+	0	+	+++	+	++	+	++	+	++	++

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP I

Variable	Individual															
	116		120		121		126		127		128		130		134	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	0	--	+	-	+	-	-	0	0	+	+	-	0	-	0	--
Ar-SPr Ar-IPr	+	-	+++	+	++	+	++	+	++	+	++	0	++	+	++	0
MCF Alignment	++	++	++	+	++	++	++	+	+	+	+	+	++	++	++	++
Ramus Alignment	+	++	+	0	+	0	0	0	+	0	++	++	0	-	+	+
Ramus/MCF Sk	0	+	--	+	--	--	0	+	-	++	0	0	++	+	--	-
Molar (composite)	-	-	0	-	+	-	0	-	+	-	0	-	-	-	-	—
Mx/Md A-B Sk	—	---	+	--	+	--	---	---	--	--	-	--	--	---	--	---
Mx/Md SPr-IPr Sk	—	---	+++	-	++	-	--	--	++	--	0	--	--	--	0	--
PM Vertical	-	--	-	-	--	--	-	-	-	-	0	-	-	-	--	--
Gonial Angle Alignment*	-	-	+	-	+	+	+	+	-	-	-	-	-	-	-	-
Curve of Spee	+		++	++	++	+	++	+	+++	+	++	+	++	+	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP I

Variable	Individual											
	136		137		139		143		144		156	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	+	-	-	0	-	+++	+	++	+	0	+
Ar-SPr Ar-IPr	++	++	0	0	+	0	++	++	++	+	+	+
MCF Alignment	++	++	++	++	+	+	+	++	++	+	++	++
Ramus Alignment	++	++	++	+	+	+	0	0	++	+	+	++
Ramus/MCF Sk	-	+	-	0	+	+++	+	++	++	++	-	+
Molar (composite)	0	-	0	-	+	-	+	0	0	0	0	-
Mx/Md A-B Sk	-	--	---	---	--	---	++	-	--	---	-	--
Mx/Md SPr-IPr Sk	-	--	---	---	-	---	++	-	--	---	0	--
PM Vertical	-	-	--	--	0	-	-	-	-	-	-	-
Gonial Angle Alignment*	-	-	+	+	+	+	+	+	+	-	-	-
Curve of Spee	++	-	++	+	++	+	++	0	+	+	+	0

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

TABLE VIII

MORPHOLOGICAL EXPRESSION GROUP II

Variable	Individual									
	003		004		005		009		017	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	+	+	+	0	-	--	+	0	-
Ar-SPr Ar-IPr	+++	+	-	+	+	-	0	+	+++	0
MCF Alignment	-	-	--	---	--	--	--	-	--	---
Ramus Alignment	+	+	++	++	++	++	++	++	0	0
Ramus/MCF Sk	-	+	+	++	+	-	+	+	+++	+++
Molar (composite)	+	-	-	-	+	--	0	-	+	-
Mx/Md A-B Sk	+++	++	++	++	+++	++	--	--	-	--
Mx/Md SPr-IPr Sk	+++	+++	++	++	+++	+++	+	+	+++	-
PM Vertical	+	+++	+++	++	+++	+++	+++	++	+++	+++
Gonial Angle Alignment*	-	-	-	-	0	0	+	-	+	+
Curve of Spee	++	-	++	0	++	+	+++	+++	++	0

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP II

Variable	Individual									
	018		025		048		050		063	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	-	-	--	++	++	0	-	+	+
Ar-SPr Ar-IPr	++	+	++	0	++	++	++	-	++	+
MCF Alignment	-	-	0	---	--	-	--	--	-	--
Ramus Alignment	+	+	++	+	+	+	0	+	0	0
Ramus/MCF Sk	++	++	-	++	+	+	++	++	+	0
Molar (composite)	+	-	0	--	+	0	++	+	++	-
Mx/Md A-B Sk	+	---	--	-	++	+++	-	-	-	++
Mx/Md SPr-IPr Sk	++	--	0	+	+++	+++	+	0	+	++
PM Vertical	+	+	+	+++	++	++	++	++	++	+++
Gonial Angle Alignment*	+	+	-	-	0	0	-	-	-	-
Curve of Spee	++	0	+++	-	++	+	++	+	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP II

Variable	Individual									
	064		067		073		078		083	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	-	--	+	--	0	--	+	-	-	--
Ar-SPr Ar-IPr	++	0	++	0	++	0	+	0	+	-
MCF Alignment	--	-	-	-	-	-	-	-	-	-
Ramus Alignment	+	++	++	++	++	++	++	++	+	+
Ramus/MCF Sk	0	++	+	++	-	0	++	++	-	+
Molar (composite)	-	--	++	-	+	-	0	-	++	-
Mx/Md A-B Sk	++	---	-	---	0	---	--	---	0	---
Mx/Md SPr-IPr Sk	+++	--	+	---	++	--	--	--	+	---
PM Vertical	++	+	++	++	++	++	+++	+++	++	++
Gonial Angle Alignment*	-	-	0	0	-	-	-	-	-	-
Curve of Spee	+	+	+++	++	+	+	+++	0	+	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP II

Variable	Individual									
	084		088		111		113		118	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	-	+	0	0	--	+	++	0	-
Ar-SPr Ar-IPr	+++	0	++	+	++	+	++	+	++	+
MCF Alignment	-	-	0	-	--	--	-	-	0	--
Ramus Alignment	++	++	+	0	++	+	++	++	++	++
Ramus/MCF Sk	++	++	0	++	++	++	+	++	++	++
Molar (composite)	++	-	-	-	+	-	+	+	+	-
Mx/Md A-B Sk	+	---	0	--	-	--	0	+	--	-
Mx/Md SPr-IPr Sk	++	---	++	-	+	-	++	+	0	+
PM Vertical	++	++	0	+	++	++	++	++	++	+++
Gonial Angle Alignment*	-	-	+	0	+	+	-	-	-	-
Curve of Spee	++	++	+	+	0	0	++	+	++	0

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP II

Variable	Individual									
	129		131		152		154		157	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	0	---	--	0	0	+++	-	--	--
Ar-SPr Ar-IPr	++	+	0	-	++	+	+++	0	0	0
MCF Alignment	0	--	0	-	--	--	--	--	-	--
Ramus Alignment	+	0	+	+	++	++	+	0	+	++
Ramus/MCF Sk	+	++	+	+	0	++	+++	+++	+	+++
Molar (composite)	0	-	0	-	-	--	+	-	+	-
Mx/Md A-B Sk	++	++	---	---	0	-	++	--	---	---
Mx/Md SPr-IPr Sk	++	++	--	--	++	-	++	--	--	---
PM Vertical	+	++	+	+	++	+++	++	++	+	++
Gonial Angle Alignment*	-	+	0	-	-	-	+	0	-	-
Curve of Spee	+	+	+	++	++	-	++	+	+++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

TABLE IX

MORPHOLOGICAL EXPRESSION GROUP III

Variable	Individual															
	013		014		015		016		020		021		022		023	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	-	++	+	--	--	+	+	++	0	--	-	+	+	+	+
Ar-SPr Ar-IPr	+++	+	+++	++	+	0	+	++	++	+	0	0	+	+	++	++
MCF Alignment	+	++	++	+	0	+	0	+	+	0	+	+	0	+	+	++
Ramus Alignment	++	++	+++	+++	+	++	+	+	+++	++	++	++	++	++	+	+++
Ramus/MCF Sk	0	++	+	0	-	0	-	-	-	+	+	-	++	++	-	0
Molar (composite)	+	-	+	-	+	-	+	-	0	-	-	-	-	+	0	+
Mx/Md A-B Sk	-	---	--	0	--	---	+	0	0	--	---	---	---	---	--	--
Mx/Md SPr-IPr Sk	++	---	0	+	-	---	++	+	0	--	---	--	---	--	0	---
PM Vertical	+	0	++	++	+	++	+	0	+	+	+	+	+	+	0	+
Gonial Angle Alignment*	-	-	-	-	+	+	-	-	+	+	+	-	-	-	-	-
Curve of Spee	+	+	+++	0	++	++	++	+	0	-	+	+	+	+	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP III

Variable	Individual															
	027		028		029		031		033		042		049		053	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	-	--	+++	++	-	--	++	++	++	++	++	-	+++	+	++	+
Ar-SPr Ar-IPr	+	-	++	++	+	0	++	++	++	+	++	-	+++	++	++	++
MCF Alignment	+	+	+	0	+	+	++	++	+	0	0	0	+	0	++	0
Ramus Alignment	++	++	++	+	++	+++	++	++	++	++	+	++	++	++	+++	++
Ramus/MCF Sk	-	0	-	+	--	0	0	0	++	++	+	++	++	++	-	0
Molar (composite)	0	-	0	+	0	--	-	-	+	--	+	-	+	-	+	-
Mx/Md A-B Sk	--	---	+	--	--	---	--	--	-	-	+	---	+	--	-	--
Mx/Md SPr-IPr Sk	-	---	+	--	-	---	--	-	-	--	0	---	+	-	-	--
PM Vertical	+	++	+	+	+	++	0	0	0	++	++	++	0	+	+	++
Gonial Angle Alignment*	-	-	+	+	+	+	-	-	-	-	+	-	-	-	+	+
Curve of Spee	++	+	++	+	++	++	+	0	++	+	++	++	++	+	+	0

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP III

Variable	Individual															
	054		055		056		057		058		066		069		070	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	+++	++	++	0	+	-	++	+	0	--	++	+	++	+	0	--
Ar-SPr Ar-IPr	+++	++	++	0	+++	-	+++	+	++	+	++	++	+++	+	++	0
MCF Alignment	0	+	++	+	+	+	++	+	+	0	++	+	+	+	++	+
Ramus Alignment	-	+	+++	++	++	++	++	++	++	++	++	+++	++	++	0	+
Ramus/MCF Sk	++	++	-	++	-	0	--	0	+	0	-	--	-	+	++	+++
Molar (composite)	++	0	0	0	++	--	+	-	+	-	+	-	++	0	+	-
Mx/Md A-B Sk	++	--	0	---	--	---	++	--	--	---	--	-	+	--	---	---
Mx/Md SPr-IPr Sk	++	--	0	---	0	---	++	-	-	--	-	-	++	--	--	---
PM Vertical	++	0	+++	++	+	0	0	+	++	++	0	++	0	++	0	+
Gonial Angle Alignment*	+	-	-	-	+	+	-	-	-	-	+	-	0	-	-	-
Curve of Spee	++	+	++	0	+	+	+	+	++	++	++	++	+	0	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP III

Variable	Individual															
	075		079		081		089		097		101		102		108	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	-	-	0	--	++	0	+++	0	+	+	++	0	++	+	+++	++
Ar-SPr Ar-IPr	+	0	++	+	+++	+	+++	0	++	+	+++	+	++	+	+++	++
MCF Alignment	+	0	+	0	+	0	+	+	++	++	++	++	0	0	++	+
Ramus Alignment	+	++	++	++	++	+++	0	+	+++	+++	++	++	-	--	++	++
Ramus/MCF Sk	+	++	--	-	--	--	+	++	--	--	---	--	0	-	--	-
Molar (composite)	0	-	0	--	+	-	+	--	-	-	+	-	0	-	0	-
Mx/Md A-B Sk	---	---	0	---	++	+	+++	---	--	--	+++	-	++	+++	+++	+
Mx/Md SPr-IPr Sk	--	---	++	0	+++	+	+++	---	-	--	+++	+	+++	+++	++	+
PM Vertical	0	++	+	++	++	++	0	+	+	+	+	0	++	++	0	+
Gonial Angle Alignment*	+	-	++	+	-	-	-	-	-	-	-	-	-	-	+	-
Curve of Spee	++	0	++	+	+++	+	++	++	++	+	+	+	++	0	0	0

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP III

Variable	Individual															
	109		112		114		117		122		132		133		138	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	+++	+	-	--	+	0	++	0	-	-	++	-	0	0	++	-
Ar-SPr Ar-IPr	+++	+	++	0	++	+	++	+	+	+	+++	+	+	+	+++	0
MCF Alignment	++	+	0	0	++	++	+	0	0	+	+	+	++	++	+	0
Ramus Alignment	+++	++	+	+	++	+++	++	+	-	-	++	++	++	++	++	++
Ramus/MCF Sk	+	++	++	++	---	--	--	0	++	++	++	++	-	-	++	++
Molar (composite)	0	-	0	-	0	-	-	-	-	-	+	-	0	-	0	-
Mx/Md A-B Sk	++	--	--	---	--	-	+++	+	--	---	--	---	--	-	---	---
Mx/Md SPr-IPr Sk	+	--	-	--	0	-	+++	++	--	--	-	---	-	0	--	---
PM Vertical	+	+	0	+	+	+	+	+	++	++	+	0	+	0	+	++
Gonial Angle Alignment*	-	-	0	-	+	+	-	-	+	0	+	+	-	-	+	+
Curve of Spee	++	+	++	+	+	+	++	+	+	+	++	0	+	+	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP III

Variable	Individual															
	140		142		145		146		147		149		151		155	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	-	---	++	++	++	+	++	-	++	0	+	-	+	0	-	-
Ar-SPr Ar-IPr	++	0	++	+	++	+	+++	+	++	0	++	0	++	-	++	+
MCF Alignment	+	+	0	0	++	++	+	+	+	0	+	++	+++	++	+	+
Ramus Alignment	0	-	++	+++	++	++	+++	+++	+++	++	+	-	+++	+++	+++	++
Ramus/MCF Sk	++	+++	0	0	---	---	++	+++	0	+	-	+	--	-	-	+
Molar (composite)	+	-	0	-	0	-	++	-	0	-	+	-	+	0	0	-
Mx/Md A-B Sk	---	---	+	+	+++	+	--	---	0	-	+	--	---	---	--	--
Mx/Md SPr-IPr Sk	--	---	+	0	++	+	--	---	+	-	++	--	---	---	+	-
PM Vertical	0	+	+++	++	+	0	++	++	++	++	0	+	0	+	++	+++
Gonial Angle Alignment*	+	+	0	-	+	-	-	-	-	-	+	0	-	-	-	-
Curve of Spee	+++	++	+	0	-	-	++	+	++	0	++	0	++	+	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

TABLE X

MORPHOLOGICAL EXPRESSION GROUP IV

Variable	Individual									
	001		002		010		019		036	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	0	+	+++	++	+	--	++	++	0	-
Ar-SPr Ar-IPr	++	+	+++	++	++	+	+	+	++	+
MCF Alignment	+	++	+	-	++	-	0	-	+	-
Ramus Alignment	0	+	++	++	++	0	++	++	++	++
Ramus/MCF Sk	++	+	++	++	-	++	+	-	+++	+++
Molar (composite)	0	-	+	-	+	0	+	-	+	-
Mx/Md A-B Sk	--	---	-	--	0	---	+	-	---	---
Mx/Md SPr-IPr Sk	-	---	-	--	+	-	-	-	---	---
PM Vertical	+	--	+	++	+	++	++	++	+	+
Gonial Angle Alignment*	-	-	-	-	-	-	-	-	-	-
Curve of Spee	++	+	+++	+	+	++	-	0	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP IV

Variable	Individual									
	037		038		043		047		062	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	+	+	+	0	+	+	-	-	++	++
Ar-SPr Ar-IPr	++	++	+++	++	+++	++	+	0	+++	++
MCF Alignment	+	-	0	-	+	--	+	-	+	+
Ramus Alignment	+	++	+	+	++	++	0	0	+	++
Ramus/MCF Sk	+	++	++	+++	+	+++	+	+++	+	++
Molar (composite)	0	-	+	-	-	-	0	-	++	-
Mx/Md A-B Sk	-	0	-	--	-	--	---	---	+	-
Mx/Md SPr-IPr Sk	0	+	++	-	++	-	--	--	+++	-
PM Vertical	0	++	+	++	++	++	0	+	+	-
Gonial Angle Alignment*	-	-	-	0	0	0	-	-	-	-
Curve of Spee	++	+	++	+	++	+	++	+	+++	+++

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP IV

Variable	Individual									
	076		093		096		099		100	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	+++	++	+	-	+	-	0	-	-	--
Ar-SPr Ar-IPr	+++	++	++	0	+++	-	++	0	+	-
MCF Alignment	+	++	+	-	++	++	+	0	++	++
Ramus Alignment	++	++	+++	++	+++	++	++	++	+	+
Ramus/MCF Sk	+	++	-	-	--	-	++	+++	0	+
Molar (composite)	++	-	-	-	+	--	-	-	0	-
Mx/Md A-B Sk	+	--	0	-	++	---	---	---	---	---
Mx/Md SPr-IPr Sk	++	--	+	-	+++	---	--	---	---	---
PM Vertical	+	_	++	+++	+	-	+	0	+	-
Gonial Angle Alignment*	+	+	-	-	-	-	+	-	+	+
Curve of Spee	++	+	++	0	+++	+	+	+	+	++

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP IV

Variable	Individual									
	103		119		125		135		141	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	++	+	++	++	++	+++	+	++	--
Ar-SPr Ar-IPr	++	+	+++	+	+++	+	+++	+	++	0
MCF Alignment	+	-	+	_	++	0	++	++	++	++
Ramus Alignment	+	+	++	++	++	+	+++	++	++	++
Ramus/MCF Sk	-	-	++	++	--	0	--	+	--	+
Molar (composite)	0	-	+	--	+	-	+	-	+	-
Mx/Md A-B Sk	++	++	--	0	0	-	+	---	+++	---
Mx/Md SPr-IPr Sk	++	+++	+	-	+	--	+	---	+++	---
PM Vertical	+	++	+++	++	0	0	+	-	0	-
Gonial Angle Alignment*	+	-	0	0	-	-	-	-	-	-
Curve of Spee	++	+	+++	0	++	+	++	0	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

TABLE XI

MORPHOLOGICAL EXPRESSION GROUP V

Variable	Individual											
	011		026		032		034		044		046	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	++	++	+	++	0	-	++	++	--	-	0	+
Ar-SPr Ar-IPr	++	++	++	++	+	+	++	++	0	-	++	+
MCF Alignment	+	++	+	0	-	0	+	+	0	+	+	0
Ramus Alignment	+	+++	++	+	++	++	+	++	+	+	+	++
Ramus/MCF Sk	-	0	0	+	+	+	-	0	0	++	-	+
Molar (composite)	++	0	+	0	+	---	++	-	+	-	0	-
Mx/Md A-B Sk	-	--	-	+	0	--	+	+	--	----	---	--
Mx/Md SPr-IPr Sk	0	---	+	+	+	--	++	+	-	----	0	--
PM Vertical	-	+	-	+	++	+	-	+	0	+	-	+
Gonial Angle Alignment*	+	+	0	-	-	-	+	+	-	-	+	+
Curve of Spee	++	0	+++	0	0	-	+++	+	++	0	++	0

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP V

Variable	Individual											
	051		072		086		087		091		094	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	+++	+	0	+	++	+	++	-	++	0	+	0
Ar-SPr Ar-IPr	+++	+	++	+	+++	+	++	+	+++	+	++	0
MCF Alignment	-	0	+++	++	-	0	+	+	++	0	+++	+++
Ramus Alignment	++	++	++	++	+++	+++	++	++	++	+	+++	+++
Ramus/MCF Sk	0	++	--	--	-	++	0	0	-	+	--	--
Molar (composite)	+	-	0	-	+	-	-	--	-	-	0	-
Mx/Md A-B Sk	+++	--	---	--	++	---	-	---	++	--	---	---
Mx/Md SPr-IPr Sk	+++	--	-	-	+++	---	+	---	+++	-	--	---
PM Vertical	++	+	--	0	+++	+++	-	+	-	+	-	0
Gonial Angle Alignment*	-	-	0	-	-	-	-	-	-	-	-	-
Curve of Spee	++	+	++	+	+++	++	++	++	++	+	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

MORPHOLOGICAL EXPRESSION GROUP V

Variable	Individual											
	105		123		124		148		150		153	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ar-A Ar-B	+	+	0	-	+	-	+	+	-	-	-	--
Ar-SPr Ar-IPr	++	+	++	+	++	+	+++	+	+	+	++	-
MCP Alignment	++	++	++	+	++	++	+	0	+	+	++	++
Ramus Alignment	++	++	++	++	+	-	++	+++	+	+	+	++
Ramus/MCP Sk	--	-	-	0	--	+	-	++	--	0	+	+
Molar (composite)	0	-	+	-	++	-	++	-	-	0	+	--
Mx/Md A-B Sk	--	-	---	--	-	--	--	--	-	--	---	---
Mx/Md SPr-IPr Sk	-	-	--	-	+	--	+	--	+	-	--	---
PM Vertical	--	-	--	0	--	+	-	++	-	0	--	0
Gonial Angle Alignment*	+	0	-	-	-	-	-	-	-	-	+	-
Curve of Spee	++	0	++	-	++	+	++	+	++	0	++	+

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

* All mandibular retrusive effects are indicated by a (+), and all mandibular protrusive effects are indicated by a (-).

TABLE XII

MORPHOLOGIC EXPRESSION OF EFFECTIVE CHANGES
OF THREE VARIABLES

Variable	Individual									
	003		010		028		041		057	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ramus/MCF Sk	-	+	-	++	-	+	-	0	--	0
Mx/Md A-B Sk	+++	++	0	---	+	--	0	--	++	--
Mx/Md SPr-IPr Sk	+++	+++	+	-	+	--	++	--	++	-

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

MORPHOLOGIC EXPRESSION OF EFFECTIVE CHANGES
OF THREE VARIABLES

Variable	Individual									
	060		061		068		069		073	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ramus/MCF Sk	-	+	-	+	--	-	-	+	-	0
Mx/Md A-B Sk	+	--	++	---	0	-	+	--	0	---
Mx/Md SPr-IPr Sk	++	--	++	---	+	-	++	--	++	--

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

MORPHOLOGIC EXPRESSION OF EFFECTIVE CHANGES
OF THREE VARIABLES

Variable	Individual									
	101		104		108		117		120	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ramus/MCF Sk	---	--	--	-	--	-	--	0	--	+
Mx/Md A-B Sk	+++	-	+	---	+++	+	+++	+	+	--
Mx/Md SPr-IPr Sk	+++	+	+	--	+++	+	+++	++	+++	-

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

MORPHOLOGIC EXPRESSION OF EFFECTIVE CHANGES
OF THREE VARIABLES

Variable	Individual									
	121		125		135		141		149	
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx
Ramus/MCF Sk	--	--	--	0	--	+	--	+	-	+
Mx/Md A-B Sk	+	--	0	-	+	---	+++	---	+	--
Mx/Md SPr-IPr Sk	++	-	+	--	+	---	+++	---	++	--

Mandibular retrusive effects are indicated by a (+), and mandibular protrusive effects are indicated by a (-). Effects that measure between 0 and 2.5 mm are represented by a (+) or (-). Effects that measure between 2.5 and 5.0 mm are represented by a (++) or (--). Effects that exceed 5.0 mm are represented by a (+++) or (---). A neutral effect is indicated by a (0).

TABLE XIII

TREATMENT EFFECT OF MAXILLARY/ MANDIBULAR SKELETAL ARCH MEASURED AT A AND B POINTS

	Mechanics			
	Begg		Tweed	
Group	C*	NC**	C	NC
I	5	17	5	19
II	6	10	3	6
III	10	17	7	14
IV	2	9	3	6
V	2	6	3	7

C* = Change; NC** = No Change.

Change requires a difference of at least 2 sign increments, e.g., +++ to + or + to --.

TABLE XIV

TREATMENT EFFECTS OF MAXILLARY/ MANDIBULAR SKELETAL ARCH MEASURED AT SPr AND IPr POINTS

	Mechanics			
	Begg		Tweed	
Group	C*	NC**	C	NC
I	10	12	12	12
II	7	9	4	5
III	16	11	8	13
IV	5	6	4	5
V	4	4	5	5

C* = Change; NC** = No Change.

Change requires a difference of at least 2 sign increments, e.g., +++ to + or + to --.

DISCUSSION

The purpose of this study was to relate morphologic categories of facial combinations of treated Class II malocclusion to the treatment effects of Begg or Tweed mechanotherapies. Counterpart analysis was used because it explains essentially "how" a growth pattern happens in a particular individual, and it accounts for the principal regional developmental activities among the various growth fields throughout the craniofacial complex. In contrast, most conventional methods are intended to determine "what" a particular craniofacial pattern is as compared with population standards. The construction of the neutral plane (Figures 4, 5 and 14) was thought to be a unique design that made counterpart analysis move with growth. A morphometric approach to treatment changes with growth of a part or parts was thus evaluated.

In this Class II treated sample, 101 out of 157 cases displayed a clockwise rotation (a mandibular protrusive effect) of the gonial angle alignment. A high incidence (up to 95%) of ramus alignment demonstrated a clockwise alignment (a mandibular retrusive effect). The reciprocal effect of the ramus alignment and gonial angle alignment showed the adjustment and adaptation mechanism of the pattern of remodeling and relocation of mandible in most Class II individuals.

The variability of the MCF alignment and PM vertical in this study exposed the complexity of the growth process. As Enlow (1967) stated:

> Actual growth and the displacement that is a consequence of growth frequently follow divergent courses, thereby confusing and greatly complicating understanding of the overall growth processes.

Although 19 measures were initially evaluated, only six were ultimately used. Rotational expression of MCF alignment, PM vertical, and ramus alignment demonstrated not only a vertical influence on the face but also horizontal effects. Therefore, vertical facial disproportions as revealed by these three measures could also reflect the problems of anteroposterior disharmonies, a view supported by Sassouni (1964). The three measures ramus/MCF horizontal skeletal dimensions (5), maxillary/mandibular bony arches measured at A and B points (8), and maxillary/mandibular bony arches measured at SPr and IPr points (10) were informative in assessing horizontal discrepancies.

The concept of synergic and reciprocal anatomical relationship can be adapted to interpret findings among the five groups of this study. Enlow (1971) remarked:

> If the effects between any two groups of parts and counterparts are reciprocal, the composite anatomical result is thereby partly or wholly offsetting and compensatory. This is a morphologically advantageous situation since a protrusive effect produced by either the alignment or the dimensions of one such part-counterpart relationship is, at least in part, cancelled by an opposite protrusive effect in some other craniofacial region. If the two different part-counterpart groups have a common protrusive

> effect, however, the relationship is synergic and their respective effects are cumulative within that individual. Such synergic relationships may be either advantageous or disadvantageous in a given person. Regional relationships that produce a cumulative, synergic maxillary protrusion effect in a Class II individual augment and worsen the over-all extent of his composite maxillary prognathism. Conversely, regional relationships having synergic mandibular protrusive effects in a Class II individual are advantageous because they contribute a degree of regional compensation within the craniofacial framework and thereby reduce the aggregate extent of maxillary protrusion.

The alignment of the ramus showed a constancy of clockwise rotation in all groups, which aggravated the retrusive effect in the Class II individuals. In group I and Group II, MCF alignment and PM vertical compensated each other. In contrast, Group III, Group IV and Group V had a disadvantageous synergic result producing a retrusive effect.

In comparing Group I and Group II, the former possessed a relatively "short" PM vertical (short midface), while the latter possessed a relatively "long" midface. A great tendency toward a mandibular protrusive effect existed before treatment, and even moreso following treatment for the majority of individuals in Group I. However, in Group II, less of a tendency for a mandibular protrusive effect existed before and after treatment than was found in Group I. It seemed that backward rotation of MCF alignment compensated partly for a mandibular retrusive effect of a relatively "long" midface. Adding this result to the constant backward alignment of ramus, all contributed to a Class II tendency. One other point that needs to be noted was that there were

seven treated individuals in Group II who showed no horizontal treatment effect in the mandibular skeletal arch. Thus the final morphological equilibrium would depend on another part or parts that would have a mandibular protrusive effect. Unfortunately, gonial angle alignment showed great variability in this group. For this group, it appears that treatment procedures should be applied very cautiously and the shorter the duration of Class II elastic mechanics in edgewise mechanics, the better the treatment result will be (Hersberg, 1973).

Group III exhibited a strong Class II tendency. All rotational alignments led to a mandibular retrusive effect. However, study revealed that a high incidence of horizontal skeletal compensatory mechanism existed as was observed in Group I. It seems that nature always makes an effort to establish equilibrium for craniofacial configuration. Treated individuals had more change to reach their own morphologic "fit".

Group IV was categorized from a pre-treatment disadvantageous synergic effect of expression of MCF alignment and PM vertical to a post-treatment reciprocal (compensatory) effect. Group V, to the contrary, was categorized from a pre-treatment reciprocal effect to a post-treatment aggravating effect. Orthodontic treatment offered an improved mandibular protrusive effect that offset the Class II tendency.

The measurement of ramus/MCF skeletal dimension (5) had its unique feature in this study. The "wide" ramus relative to the width of MCF possessed a mandibular protrusive effect, and vice versa, a "narrow" ramus coincided with a mandibular retrusive effect. Table XII showed an interesting transformation of "wide" ramus before treatment to "narrow" ramus after treatment, and meantime, measurements of mandibular bony arch at A and B points (8) and at SPr and IPr points (10) also changed from what used to be a mandibular retrusive effect before treatment to what then became a protrusive effect after treatment. The remodeling and relocation of the ramus made room for the lengthening of the relatively "short" mandibular bony arch to a relatively "long" one. The whole effect contributed to the improvement of overall composite facial configuration when measures of 1 (Figure 2) and 2 (Figure 3) were checked.

The regional synergic effect that demonstrated a desirable mandibular protrusive effect among all groups maintained its relationship throughout treatment. This favorable synergic effect was provided by the existence of "wide" ramus and "long" mandibular arch measured at A and B points and SPr and IPr points..

The above two features can be used as a basis for prediction for Class II individuals ready for orthodontic treatment. A morphometric approach (using three measures: ramus/MCF skeletal dimension, maxillary/mandibular bony arches at A and B points and

at SPr and IPr points) to evaluate Class II individuals prior to treatment is a guide to the treatment effect with respect to craniofacial configuration.

A pre-treatment record of a Class II individual may demonstrate a Group I characteristic of forward MCF alignment, backward ramus alignment, and "short" PM vertical. Following treatment, the expressions of these three rotational effects may remain constant as in Group I. Treatment prognosis according to this study may be expected to reveal an improved facial morphologic "fit" and better growth balance. Following treatment, some patients falling into Group I may be transformed so as to fit within Group V, i.e., they show a strong Class II tendency. Treatment prognosis can be determined by the expressions of horizontal contributory effect of 3 diagnostic measurements: relative ramus width (5), relative mandibular arch length at basal level (8), and relative mandibular arch length at alveolar level (10).

A given Class II individual, prior to treatment, who falls into the Group II criteria of backward MCF alignment, backward ramus alignment, and "long" PM vertical may remain in Group II following treatment. Facial expression of Group II features may also be transformed to Group V demonstrating a strong Class II tendency. Less tendency for a mandibular protrusive effect existed before and after treatment in Group II than was found in Group I. Therefore, it is wise before treatment to assess the

three horizontal contributory expressions which demonstrate a mandibular protrusive effect.

A pre-treatment record of Group III features that exhibit a forward MCF alignment, a backward ramus alignment, and a "long" PM vertical, may or may not have the same features following treatment. If the same pattern of Group III features exists throughout treatment, a given individual will demonstrate a morphologic "fit" of craniofacial configuration. The expression of Group III features may be changed to a reciprocal effect characterized by Group IV features. To predict the treatment prognosis the three horizontal diagnostic measurements can be used.

Moyers (1979) advocated the "craniofacial constant" to distinguish "pattern" concept from growth concept. He stated:

> "pattern is invariance of relationships--a set of constraints operating to preserve the integration of parts under conditions and throughtime. Craniofacial pattern can be described and quantified by the identification of craniofacial constants, measures that are relatively invariant.

What Cross' statement of no evidence of growth guidance nor correction (1977) following treatment was based on the "pattern" viewpoint.

Enlow (1969) remarked the concept of incremental "balance" on the basis of three concepts of (1) architectural equivalence, (2) effective dimensions, and (3) aggregate balance. He described "the concept of balance applies to increments of growth as well as to effective anatomic dimensions among the structural equivalents."

The ideas of "craniofacial constant" of Moyers and "growth balance" of Enlow are similar to the concept of chemical equilibrium. Where growth activity exists, there is a dynamic condition that will accomplish the state of balance within craniofacial configuration. If an individual received orthodontic interception, his own pattern still remained constant, the post-treatment record can be a reflection of treatment effect and growth. This study pointed out that the schematic conversion of pre-treatment "wide" ramus to post-treatment "long" mandibular arch (Table XII) was one that showed the process of adjustment and adaptation mechanism through remodeling and relocation of mandibular growth activity. A desirable regional synergic mandibular protrusive effect (displayed by the existence of relative "wide" ramus and/or relative "long" mandibular arch measured at A and B points and at SPr and IPr points) in Class II individual prior to treatment could provide a better treatment result to the morphological "fit".

McNamara's analysis and Sassouni's analysis represented their own "idea" to "normal" face in different perspectives. They might be a "predictive" type of analysis that biology does not follow the mathematic linear instruction. Three horizontal measurements based on biologic response are more reliable to predict the treatment prognosis.

SUMMARY AND CONCLUSIONS

The objective of the present study was to uncover any correlations between treated Class II malocclusions of varying morphologic categories and the treatment effects of two different appliance systems. Enlow's counterpart analysis was utilized to identify the particular combinations of anatomic characteristics in the craniofacial complex. Three measurements were used as the basis of grouping: middle cranial fossa (MCF) alignment, vertical relationship of posterior nasomaxillary complex (PM vertical), and mandibular ramus alignment. Horizontal expressions were assessed by of three measurements: ramus/MCF skeletal dimension, maxillary/mandibular bony arch measured at A and B points, and maxillary/mandibular bony arch measured at SPr and IPr points. An evaluation of anatomic effects of the treatment for each category was made.

This study involved 157 subjects divided into two different categories:

1. Class II individuals treated with Tweed mechanics.
2. Class II individuals treated with Begg mechanics.

The findings led to the following conclusions:

1. The ramus alignment showed a constancy of clockwise rotation in all groups (incidence of 95%) before and after treatment, which added its aggregate mandibular retrusive effect to the Class II individuals.

2. In Group I and Group II, MCF alignment and PM vertical compensated each other. However, less of a tendency for a mandibular protrusive effect existed before and after treatment in Group II than was found in Group I.

3. Only Group I possessed a relative "short" PM vertical (short face). A great tendency toward a mandibular protrusive effect existed before treatment, and even more so, following treatment for the majority of individuals in this group.

4. Group III exhibited a strong Class II tendency but the horizontal skeletal compensatory effect existed as was found in Group I.

5. Group IV and Group V showed variability in the horizontal contributory effects before treatment; however, orthodontic treatment offered an improved craniofacial balance for both groups.

6. The measurements of ramus/MCF skeletal dimension had its unique feature in this study. There was an interesting transformation from "wide" ramus before treatment to "narrow" ramus after treatment, coinciding with changes of expressions of mandibular bony arch at A and B points and at SPr and IPr points from what used to be a mandibular retrusive effect before treatment to what then was a protrusive effect after treatment.

7. The synergic mandibular protrusive effect was provided by the existence of "wide" ramus and "long" mandibular arch measured at A and B points and SPr and IPr points.

8. A morphometric approach to Class II treatment was discovered and described. Three horizontal measurements (1) ramus/MCF skeletal dimension, (2) maxillary/mandibular bony arch measured at A and B points, and (3) maxillary/mandibular bony arch measured at SPr and IPr points, are reliable to predict the treatment prognosis.

9. Statistically, there is no significant difference with respect to the effects of Tweed and Begg mechanics.

LITERATURE CITED

Ackerman, J. and W. Profit: The characteristics of malocclusion. Am. J. Orthod., 56: 443-454, 1969.

Ackerman, J. and W. Profit: Treatment response as an aid in diagnosis and treatment planning. Am. J. Orthod., 57: 490-496, 1970.

Baumrind, S., R. Molthen, E.E. West, and D.M. Miller: Mandibular plane changes during maxillary retraction. Am. J. Orthod., 74: 32-40, 1978.

Behrents, R.: A treatise on the continuum of growth in the aging craniofacial skeleton. Unpublished Ph.D. Dissertation, University of Michigan, 1984.

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

Bjork, A.: Prediction of mandibular growth rotation. Am. J. Orthod., 55: 585-599, 1969.

Burstone, C.J.: Integumental profile. Am. J. Orthod., 44: 1-25, 1958.

Coben, S.E.: Growth and Class II treatment. Am. J. Orthod., 52: 5-26, 1966.

Coben, S.E.: The biology of Class II treatment. Am. J. Orthod., 59: 470-487, 1971.

Cross, J.J.: Facial growth: Before, during, and following orthodontic treatment. Am. J. Orthod., 71: 68-78, 1977.

Demisch, A.: Comparison of three cephalometric measurements of sagittal jaw relationship: angle ANB, 'Wits' appraisal and AB/occlusal angle. Eur. Orthod. Soc. Trans., 53: 269-281, 1977.

Enlow, D.H.: Morphogenic interpretation of cephalometric data. J. Dent. Res., 46: 1209, 1967.

Enlow, D.H., R.E. Moyers, W.S. Hunter, and J.A. McNamara, Jr.: A procedure for the analysis of intrinsic facial form and growth. Am. J. Orthod., 56: 6-23, 1969.

Enlow, D.H.: Handbook of Facial Growth. W.B. Saunders, Co., Philadelphia, 1982.

Enlow, D.H., and M. Azuma: Functional growth boundaries in the human and mammalian face. In: Morphogenesis and Malformations of the Face and Brain. Ed. by J. Langman. White Plains, N.Y., National Foundation, 1975.

Enlow, D.H.: Handbook of Facial Growth. W.B. Saunders, Co., Philadelphia, 1975.

Enlow, D.H., T. Kuroda, and A. Lewis: The morphological and morphogenic basis for craniofacial form and pattern. Angle Orthod., 41: 161-188, 1971.

Enlow, D.H., T. Kuroda, and A. Lewis: Intrinsic craniofacial compensations. Angle Orthod., 41: 271-185, 1971.

Enlow, D.H.: Interview: On craniofacial growth. J. Clin. Orthod., 17: 669-679, 1983.

Herzberg, R.: A cephalometric study of Class II relapse. Am. J. Orthod., 43: 112-118, 1973.

Holdway, R.A.: A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. Am. J. Orthod., 84: 1-28, 1983.

Jacobson, A.: Orthodontics--mechaincal or biologic objectives? Am. J. Orthod., 64: 1-16, 1973.

Jacobson, A.: The "Wits" appraisal of jaw disharmony. Am. J. Orthod., 67: 125-138, 1975.

Jacobson, A.: Application of the "Wits" appraisal. Am. J. Orthod., 70: 179-189, 1976.

Merrifield, L.: The profile line as an aid in critically evaluating facial esthetics. Am. J. Orthod., 52: 804-822, 1966.

Merrifield, L. and J. Cross: Directional forces. Am. J. Orthod., 57: 435-464, 1970.

Moyers, R.E., J. Elgoyhen, M. Riolo, J. McNamara, and T. Kuroda: Experimental production of Class III in rhesus monkeys. Eur. Orthod. Soc. Trans., 46: 61, 1970.

Moyers, R.E.: A Handbook of Orthodontics. 3rd Ed. Chicago, Year Book Medical Publishers, 1972.

Moyers, R.E., F.L. Bookstein, and K.E. Guire: The concept of pattern in craniofacial growth. Am. J. Orthod., 76: 136-148, 1979.

Moyers, R.E., M. Riolo, K. Guire, R. Wainright, and F. Bookstein: Differential diagnosis of Class II malocclusions. Part I: Facial types associated with Class II malocclusions. Am. J. Orthod., 78: 477-494, 1980.

McNamara, J.A.: Components of Class II malocclusion in children 8-10 years of age. Angle Orthod., 51: 177-202, 1981.

Petrovic, A.G., J.J. Stutsmann, and N. Gasson: The final length of the mandible: Is it genetically predetermined? In: Craniofacial Biology. Ed. by D.S. Carlson. University of Michigan, Center for Human Growth and Development, 1981.

Pfister, C.: A morphometric analysis of the mandibular prognathic individual. Unpublished Masters thesis, Case Western Reserve University, Cleveland, Ohio, 1983.

Phelps, A.E.: A comparison of lower face changes. Angle Orthod., 48: 283-290, 1978.

Reidel, R.A.: Retention. In: Current Orthodontic Concepts and Techniques. Ed. by T.M. Graber. W.B. Saunders Co., Philadelphia, 1969.

Ricketts, R.M.: The influence of orthodontic treatment on facial growth and development. Angle Orthod., 30: 103-131, 1960.

Riolo, et al.: An Atlas of Craniofacial Growth Cephalometric Standards from the University School Growth Study, Center for Human Growth and Development, The University of Michigan, 74, 1974.

Sassouni, V. and S. Nanda: Analysis of dentofacial vertical proportions. Am. J. Orthod., 50: 801-823, 1964.

Sassouni, V.: The Class II syndrome: Differential diagnosis and treatment. Am. J. Orthod., 40: 334-341, 1970.

Schudy, F.F.: Vertical growth vs anteroposterior growth as related to function and treatment. Angle Orthod., 34: 75, 1964.

Schudy, F.F.: The rotation of the mandible resulting from growth: Its implications in orthodontic treatment. Angle Orthod., 35: 36, 1965.

Schudy, F.F.: Sound biologic concepts in orthodontics. Am. J. Orthod., 63: 376-397, 1973.

Steiner, C.C.: The use of cephalometrics as an aid to planning and assessing orthodontic treatment. Am. J. Orthod., 46: 721-735, 1960.

Subtelny, J.D.: The soft tissue profile, growth and treatment changes. Angle Orthod., 31: 105-122, 1961.

Subtelny, J.D.: Cephalometric diagnosis, growth, and treatment: Something old, something new? Am. J. Orthod., 57: 262-286, 1970.

Trouten, J.D., D. Enlow, M. Rabine, and A. Phelps: Factors involved in the morphologic determinants of open bite and deep bite. Angle Orthod., 53: 192-211, 1983.

Whitney, J.: A longitudinal morphometric analysis and classification of the Class II individual. Unpublished Masters Thesis, Case Western Reserve University, Cleveland, Ohio, 1983.

APPENDIX I

FILE NUMBERS OF CASES USED IN THIS STUDY ARE FROM THE OFFICE OF DR. KOSSOFF

Case #	Patient #	Case #	Patient #	Case #	Patient #
001	9406	029	6006	057	8602
002	9042	030	5070	058	9140
003	1504	031	7089	059	1172
004	9304	032	9125	060	1458
005	9077	033	1473	061	5030
006	9045	034	6049	062	9116
007	9490	035	6043	063	8073
008	1283	036	9171	064	9184
009	9438	037	1434	065	9456
010	9344	038	1296	066	9259
011	9408	039	5045	067	6071
012	1418	040	1468	068	7061
013	9265	041	9397	069	9232
014	9295	042	1647	070	5088
015	6013	043	9031	071	7082
016	9201	044	9041	072	9135
017	9468	045	9040	073	6035
018	8082	046	1480	074	9529
019	9166	047	9178	075	7094
020	9440	048	9449	076	8026
021	9483	049	8086	077	1478
022	1169	050	9161	078	7090
023	1072	051	9441	079	5033
024	1162	052	7063	080	1343
025	2071	053	8101	081	5034
026	7072	054	9279	082	1529
027	9064	055	9143	083	9271
028	7002	056	7022	084	9060

APPENDIX II

FILE NUMBERS OF CASES USED IN THIS STUDY ARE FROM THE OFFICE OF DR. ADELSTEIN

Case #	Patient #	Case #	Patient #	Case #	Patient #
085	2215	096	2302	107	2569
086	2676	097	2378	108	2816
087	1833	098	2008	110	1553
088	2385	099	2266	112	2467
089	2798	100	2710	113	2329
090	1945	101	2992	114	2621
091	1779	102	2565	115	2767
092	1736	103	2639	116	3261
093	2527	104	2880	119	1480
094	2381	105	2393		
095	2813	106	2620		

APPENDIX III

FILE NUMBERS OF CASES USED IN THIS STUDY ARE FROM THE OFFICE OF DR. GIFT

Case #	Patient #
117	0037
118	0055
120	0126
121	0119
122	0104
123	0006
124	0179
125	0303
126	008
127	0102

APPENDIX IV

FILE NUMBERS OF CASES USED IN THIS STUDY ARE FROM THE OFFICE OF DR. PHELPS

Case #	Patient #	Case #	Patient #	Case #	Patient #
109	651	137	829	148	721
111	846	138	743	149	761
128	772	139	795	150	783
129	946	140	732	151	879
130	765	141	808	152	751
131	787	142	893	153	777
132	664	143	842	154	637
133	759	144	880	155	820
134	756	145	074	156	757
135	718	146	881	157	396
136	832	147	766		