Orthodontic Influence Upon Anterior Facial Height*

H. Weinberg, D.M.D., M.D.S.
J. H. Kronman, D.D.S., Ph.D.**
Boston, Massachusetts

Introduction

A survey of previous studies indicated that the etiologic factors in deep overbite cases have not been well defined. Nor has it been established which incisor teeth, maxillary or mandibular, are responsible for overbite correction. Little unanimity of opinion has been expressed in either of these respects.

The objective of this study was to investigate anterior facial height and its individual components and, if possible, to establish the following:

1. Variations in the components of anterior facial height in patients with normal occlusion, as well as in patients with malocclusion and deep overbite.
2. The effect of orthodontic therapy upon these proportional relationships.
3. Which incisor teeth, maxillary or mandibular, undergo major orthodontic repositioning in correction of overbite.

Review of Literature

Brodie[7] conducted a longitudinal cephalometric study of twenty-one males from age 3 months to 8 years. The nasal floor, in its growth downward from the brain case, descended along parallel lines. In a later study Brodie[9] studied growth changes from 8 to 17 years. He summarized his findings as follows:

"1. There is a strong tendency for the nasal floor to remain stable throughout the growth range.

2. The occlusal plane is stable in about one half the cases but its behavior in the others leads to a decrease in the angle between it and the N-S plane.

3. The mandibular border similarly shows no appreciable change in over half of the cases."

Meredith, Knott, and Hixon[20] measured the relation between nasal and subnasal components of facial height. They found that nasal height, as a percentage of subnasal height, increased between the ages of 4 to 12 years. This was not in agreement with Brodie[7] who stated that percentage contributions of the facial parts to total height remained the same, regardless of age.

Hellman[15] studied the growth of the head from infancy to adulthood. He found that the proportions of the lower to upper facial height remained approximately constant.

In his study of occlusal development, Broadbent[5] stated:

"After the pattern of the face is established at the completion of the deciduous dentition, it is significant that, contrary to popular belief, there is no marked change in the proportions of the face thereafter. It consists of a more or less proportional increase in size."

Moore[22] questioned the validity of "constancy of the facial growth pattern" when applied to the individual. He proposed that variation rather than con-

* Thesis submitted in partial fulfillment of the requirements for the Master of Dental Science degree, Tufts University, 1964.

** Associate Professor, Department of Orthodontics, Tufts University School of Dental Medicine.

stancy was the rule.

In contrast to Moore's[22] theory, Wylie[32] and Brodie[8] reaffirmed the concept that facial growth was characterized by strictly proportional increases in growth rates.

According to Scott[26] growth in facial height is determined by:

"1. The growth of the cartilage of the nasal septum and its extent are approximately indicated by the height of the nasal cavity (between cranial base plane and the palatal plane), bearing in mind that the palate also descends by bone deposition and resorption.

2. The vertical component of growth of the cartilages of the mandibular condyles. The extent of this is shown by the height of the mandibular ramus.

3. The growth of the alveolar bone of both jaws. The extent of the vertical growth of the upper alveolar process is indicated by the distance between the palatal plane and the occlusal plane."

In a study of serial cephalometric roentgenograms, Tirk[30] divided the face into nasal, oral, facial and cranial regions. Although these areas grew at different incremental rates, constant proportionality of one area to another was maintained.

Williams,[31] after comparing individuals before and after the onset of puberty in order to determine craniofacial proportionality, concluded that "on the whole, it would seem that the vertical proportions are quite variable and would indicate the need for further study."

In a study of cephalo-facio-dental relationship, Sassouni[25] reported a high correlation between facial patterns and anterior vertical proportions.

Herzberg and Holic[16] measured 326 dry skulls which had all degrees of dental abrasion. They found that the degree of dental attrition did not affect the proportions of facial height.

Proportionality of the upper or lower to total facial height has been reported by many investigators. Wylie[33] reported that lower facial height represented 56.8% of total facial height. Mayne[18] reported a figure of 43.95% for upper to total facial height. Other investigators have confirmed these figures within narrow limits (Coben,[10] Lippitz,[17] Behm,[1] Goldsman[14]).

In a study of overbite Diamond[11] concluded that the primary factor in increased vertical height was growth in ramus length. Wylie[34] was not able to confirm this hypothesis.

Björk[2] reported that persons with deep overbite showed a reduction in total facial height when measured from nasion to gnathion. Wylie[33] found that the vertical dimension in orthodontic patients was less than in normal controls.

In their cephalometric study of overbite, Prakash and Margolis[23] reported: "Excessive overbite appears to be associated with infraclusion of the mandibular molars and supraclusion of the maxillary incisors, together with some infraclusion of the maxillary molars. The lower incisors were not in supraclusion in cases exhibiting excessive overbite."

Studies of changes in overbite without orthodontic therapy have yielded varying results. Björk[3] reported that overbite decreased. Fleming[12] found increased overbite from 9-12 years, which then decreased in later years. Fröhlich[13] reported increased overbite and overjet in the transition from the deciduous to the permanent dentition. Brodie, Downs, Goldstein, and Myer[6] reported that after orthodontic treatment of overbite cases behavior of incisors and molars in the cases shown varied too greatly to permit a definite statement.

Material and Methods

The material utilized in this study consisted of cephalometric records of thirty children with normal occlusion and pre- and posttreatment records of

thirty children with malocclusion.

The normal occlusion group was obtained from Dr. C. F. A. Moorrees of Forsyth Dental Clinic. The sample consisted of eleven males and nineteen females between the ages of 11.0 and 12.8, with a mean age of 11.6. All subjects were analyzed by means of orientated lateral cephalograms.

The criteria for selection of the normal group were:

1. Normal mesiodistal dental arch relationship.
2. Overbite within an acceptable range.
3. Good proximal relationships, or less than 3 mm crowding.
4. Interproximal spacing nonexistent or minimal.

The malocclusion group, both pre- and posttreatment, was obtained from the files of the Graduate Orthodontic Department, Tufts University School of Dental Medicine, and from the files of members of the teaching staff. All treatment was with the edgewise arch mechanism.

The criteria for selection of the malocclusion group were:

1. Malocclusion of major severity with no regard for classification.
2. A deep overbite, 5 mm or more when measured on a tangent from the tip of the maxillary incisor to a tangent from the tip of the mandibular incisor.
3. Case successfully treated; that is, molars in Class I relationship; overbite and overjet within normal limits and an esthetically pleasing face.

The malocclusion group consisted of ten boys and twenty girls. The ages of the group before treatment were between 8.4 and 13.9, with a mean of 10.7. The posttreatment group ranged from age 11.0 to 15.10, with a mean of 13.7. No attempt was made to differentiate these groups according to sex.

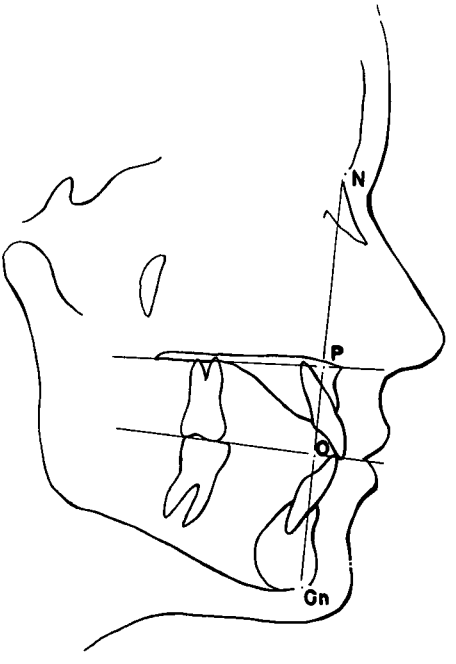

Fig. 1 Components of anterior facial height.

The following landmarks were utilized in the analysis (Fig. 1): nasion (N), anterior nasal spine (ANS), posterior nasal spine (PNS), gnathion (Gn), palatal plane (PP), occlusal plane (OP), and anterior skeletal plane (ASP), a line drawn from nasion to gnathion.

The palatal plane and the occlusal plane served to divide the face into several component parts in the vertical plane. The anterior vertical face height and its component parts discussed in this study are as follows:

1. N-Gn — Total facial height,
2. P-Gn — Lower facial height,
3. P-O — Maxillary components of lower facial height, and
4. O-Gn — Mandibular components of lower facial height.

The roentgenograms were obtained by standardized cephalometric pro-

TABLE I

ANTERIOR FACIAL HEIGHT

	N-Gn		N-P		P-O		O-Gn	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.
Normal	108.7	±4.3	49.1	±2.3	23.2	±1.7	36.4	±2.4
Pretreatment	113.7	±6.5	52.3	±3.5	23.6	±2.6	37.8	±2.6
Posttreatment	122.0	±6.0	55.9	±3.2	26.1	±2.7	40.0	±3.0

All measurement in mm.
M = mean
S.D. = standard deviation

TABLE II

PERCENTAGE VALUES OF ANTERIOR FACIAL HEIGHT

	Lower as a percent of N-Gn		Max. as a percent of N-Gn		Mand. as a percent of N-Gn		Mand. as a percent of P-Gn	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.
Normal	54..86	±1.97	21.43	±1.42	33.48	±1.27	61.11	±1.66
Pretreatment	53.96	±2.20	20.72	±1.61	33.27	±1.37	61.94	±2.40
Posttreatment	54.08	±2.26	21.35	±1.76	32.76	±1.36	60.58	±2.16

cedures (Broadbent,[4] Margolis[19]). Linear measurements to the nearest 0.5 mm were taken with a clear plastic millimeter ruler. Measurements were made along the anterior skeletal plane to the points of intersection with the palatal and occlusal planes. The material was then subjected to analysis involving the various components of anterior facial height and the ratios of these components to each other and to total facial height.

The following facial proportions were calculated:

1. $\frac{\text{Lower facial height}}{\text{Total facial height}} \times 100$
2. $\frac{\text{Maxillary components of lower facial height}}{\text{Total facial height}} \times 100$
3. $\frac{\text{Mandibular component of lower facial height}}{\text{Total facial height}} \times 100$
4. $\frac{\text{Mandibular component of lower facial height}}{\text{Lower facial height}} \times 100$

The arithmetic mean, range, and standard deviation were calculated for each component of facial height. The "t" test was employed to determine any significant statistical differences between the normal and pretreatment group and between the pre- and posttreatment group. In comparing these groups, two different "t" test formulae were used. This was necessary because the comparison of the normal with the pretreatment group represented two different samples, whereas a single sample group was used in comparing pre- and posttreatment.

Findings

The linear and proportional values of anterior facial height components obtained in this study are tabulated in Tables I and II.

A statistical analysis employing the

TABLE III

STATISTICAL ANALYSIS

	Comparison of normal and pretreatment F-Value	Comparison of pre- and posttreatment F-Value
Lower as a percent of total facial height	2.67	0.1
Maxillary as a percent of total facial height	3.57	8.44*
Mandibular as a percent of total facial height	0.47	6.26**
Mandibular as a percent of lower facial height	2.84	8.29*

* Significant at the 1% level
** Significant at the 5% level

"t" test was performed for the purpose of determining whether there existed any significant differences between groups relative to the mean values of the components of anterior facial height. The 5% level of significance was selected as the division between statistically valid and nonsignificant differences. The F values were calculated (Table III).

The normal and pretreatment malocclusion groups displayed no significant differences in the components of anterior facial height.

A comparison of the pre- and posttreatment groups revealed no significant changes in the lower part of the faces (P-Gn). The F value was < 1.

In comparing the dental components of the lower face to total facial height, however, significant differences were found between the means of the pre- and posttreatment groups. Statistical analysis of the maxillary components of total facial height yielded an F value of 8.44. The comparison of the mandibular component of total facial height gave an F value of 6.26. The F value obtained from comparing the mandibular components of lower facial height was 8.29.

In Figures II and III are presented graphic representations of the changes in the means of the pre- and posttreatment groups when compared with normal values.

Discussion

A survey of the literature revealed disagreement as to the cause of overbite in malocclusion and the factors responsible for its correction. In one of the first cephalometric appraisals of

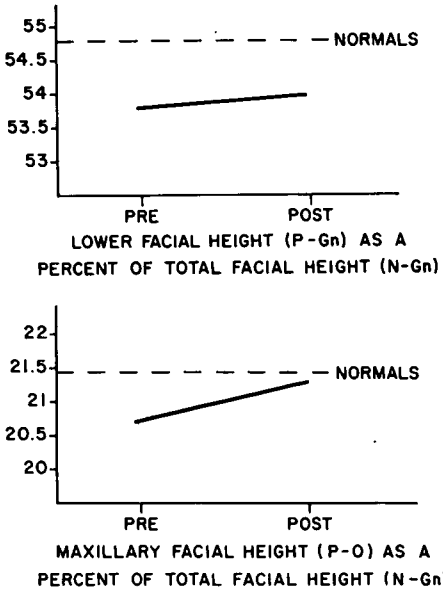

Fig. 2 Comparison of pre- and posttreatment means with normal values.

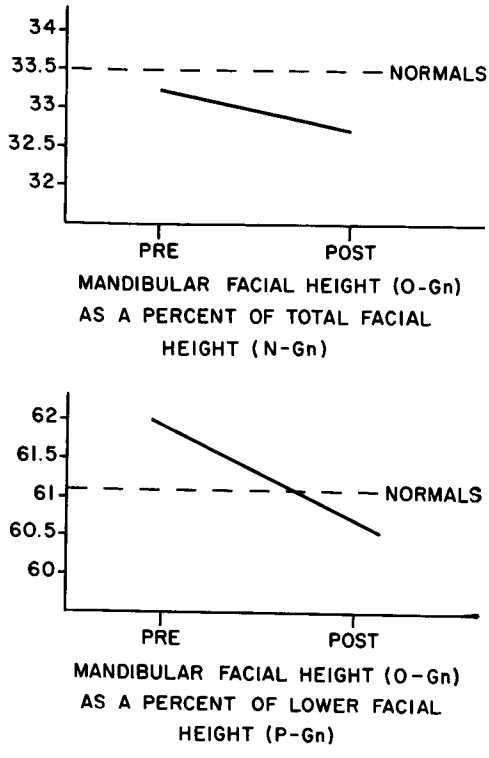

Fig. 3 Comparison of pre- and posttreatment means with normal values.

orthodontic treatment, Brodie, Downs, Goldstein, and Myer[6] tried to ascertain the site of correction when overbite was corrected orthodontically, i.e., in the incisors or in the molars. They concluded that the variation was too great to make a definite statement. Since that time investigators have studied the problem further and have come to varying conclusions regarding the mechanism of overbite correction as well as concomitant changes in anterior facial height.

This study was designed for the purpose of gaining additional insight into the problem and, if possible, to theorize about the mechanisms involved in maintaining proportionality of the components of anterior facial height. Thirty malocclusions were selected, all of which displayed a deep overbite before orthodontic therapy and a normal overbite after treatment. The cases were studied and compared with a group of patients having normal occlusion and a satisfactory overbite.

Only anterior facial height was studied. Linear measurements were taken along the anterior skeletal plane from nasion to points P, O, and Gn. The subjects were of different ages and sizes and, therefore, had different linear dimensions for total facial height (N-Gn). In order to compare any changes in the components of facial height and to negate the role of enlargement of the image on the film, proportions were calculated.

The percentage of the lower face to total facial height was found to be smaller in the pretreatment group than in the normal group, the percentage being 53.96 in the former and 54.86 in the latter. This small difference, however, was found to be nonsignificant at the 5% level ($F = 2.67$).

The pre- and posttreatment records of the malocclusion subjects were then compared. The percentage of the lower face to total facial height increased slightly in the direction of normal to 54.08 in the posttreatment records. Statistical analysis of the lower facial height of the treated group compared with the pretreatment group yielded an F value < 1 which demonstrated that there was no significant change in the proportion of the lower face to total facial height after satisfactory orthodontic correction of a deep overbite.

These findings tended to substantiate those of Wylie[33] and of Thompson and Brodie.[29] Wylie,[33] studying overbite and vertical dimension of the face, concluded that a normal freeway space cannot be encroached upon in correcting a deep overbite. He believed that elevation of the buccal teeth in such cases would be opposed by the musculature, with the eventual return of the overbite. Thompson and Brodie[29]

studied rest position of the mandible and showed that the proportions of any face, as far as vertical height was concerned, were constant throughout life.

In the group of treated malocclusions, overbite correction did not cause an elongation of the lower face in relation to total facial height. The morphogenetic pattern of the muscles of mastication of the individual was thought to be the determining factor in the relationship between mandible and maxilla in the vertical plane. A limited amount of vertical space was available in the dental area for correction of overbite which can best be accomplished by depression of the mandibular incisors. Examination of the dental components of facial height lends credence to this hypothesis.

In the normal and pretreatment groups the percentage values for the maxillary components of facial height were 21.43 and 20.72 respectively. This was found to be a nonsignificant difference at the 5% level. The pre- and posttreatment percentage means, however, were 20.72 and 21.35 respectively. Statistical analysis yielded an F value of 8.44, significant at the 1% level. The maxillary component increased in relation to total facial height after overbite reduction. Clinically, this suggests a slight elongation of the maxillary incisors due, possibly, to the use of Class II elastics.

The mandibular components of total facial height were 33.48% in the normal and 33.27% in the pretreatment group. This difference was found to be nonsignificant at the 5% level.

A partial explanation of the manner in which overbite correction took place may be deduced by studying the pre- and posttreatment mean percentage values of the mandibular components of total facial height which were 33.27 and 32.76 respectively. This difference yielded an F value of 6.26, significant at the 5% level. The significant difference in the means of these groups suggested that depression of the mandibular incisors had occurred.

The mandibular component in relation to lower facial height also was compared in the three groups. No significant difference was found between the normal group and the pretreatment group. The means were 61.11% of the normal group and 61.94% for the pretreatment group. The comparison of the mean value of the mandibular component of lower facial height before and after treatment yielded an F value of 8.29 which was significant at the 1% level. The drop in percentage from 61.94 in the pretreatment group to 60.58 in the posttreatment group again indicated that the mandibular incisors were intruded in overbite correction. This was in agreement with the findings of Stoner, Lindquist, Vorhies, Hanes, Hapak, and Haynes[28] who found an average mandibular incisor depression of 2.0 mm during overbite correction.

Ricketts[24] reported that treatment of overbite in patients not expressing vertical growth was accomplished by depression of incisors.

A comparison of the mean values of the normal and pretreatment groups demonstrated no significant differences in the various components of facial height. Consequently, any discrepancies which existed between the normal group and the malocclusion group did not lie in the vertical plane of the anterior face to any significant extent. This finding agreed with the findings of Shotts[27] who studied discrepancies in the vertical plane of normal and of Class II, Division 1 malocclusion. Björk,[2] however, studied vertical dimension in persons with deep overbite and normal occlusion and found a smaller total facial height in the former.

The length and position of the muscles of mastication in relation to the mandible may be the determining fac-

tor in maintaining the proportion of lower to total facial height. The length of the muscles may also dictate whether the overbite can be corrected by depression of anterior teeth or by elongation of buccal segments. If the patient has a large freeway space, it may be possible to encroach upon this and elongate the buccal segments in order to secure overbite correction. If, however, there is little freeway space, the correction must be made by the intrusion of incisors, since the length of the muscles will not allow elongation of the buccal segments.

Wylie[33] found that 20% of orthodontic patients had sufficient freeway space in order to allow elongation of buccal segments. "In the remaining 80%, any therapeutic measures other than depression of incisors may be expected to be opposed by the musculature with the prognosis doubtful."

It has been stated that muscles could not be induced to grow beyond their predetermined limit (Mershon[21]). In order to reduce the overbite, mandibular incisors had to be depressed.

These findings were confirmed in this study, but there is still need for further research in this area in order to evaluate how normal occlusion in the vertical plane may be achieved.

Conclusions and Summary

1. A study of anterior facial height was designed to compare thirty children with normal occlusion and thirty children having malocclusion and deep overbite.

2. Total facial height was measured along the anterior skeletal plane from nasion to gnathion and was subdivided into component parts by the palatal and occlusal planes. Proportions of the components relative to total and lower facial height were calculated.

3. No significant differences in proportions were found in the vertical plane between the normal and the pre-treatment groups.

4. Orthodontic correction of the deep overbite did not alter significantly the proportion of the lower face to total facial height. The masticatory muscles were thought to be the determining factor in maintaining this proportion, since these muscles would act to maintain their optimal resting length.

5. Overbite correction altered significantly the dental components of facial height.

6. Depression of the mandibular incisors accounted for the reduction of the overbite in the treated malocclusions.

136 Harrison Avenue

References

1. Behm, R. W. A radiographic cephalometric evaluation of skeletal facial height in children with Class II, Division 1 malocclusion. M.S.D. Thesis, *Northwestern University*. 1958.
2. Björk, A. *The Face in Profile*. Berlingsks Bok Tryckeriet, Lund. 1947.
3. ———— Variability and age changes in overjet and overbite, *Am. J. Ortho.*, 39: 778-801, 1953.
4. Broadbent, B. H. A new x-ray technique. *Angle Ortho.*, 1: 45-66. 1931.
5. ———— Odontogenetic development of occlusion. *Angle Ortho.*, 11: 223-241. 1941.
6. Brodie, A. G., Downs, Goldstein, and Myer. Cephalometric appraisal of orthodontic results. *Angle Ortho.*, 8: 261-351. 1938.
7. Brodie, A. G. The growth pattern of the head from 3rd month to 8th year of life. *Am. J. Anat.*, 68: 209-262, 1941.
8. ———— Appraisal of present concepts in orthodontics. *Angle Ortho.*, 20: 24-38. 1950.
9. ———— Late growth changes in the human face. *Angle Ortho.*, 23: 146-151, 1953.
10. Coben. S. E. The integration of facial skeletal variants. *Am. J. Ortho.*, 41: 407-434. 1955.
11. Diamond, M. The development of dental height. *Am. J. Ortho.*, 30: 380-605, 1944.
12. Fleming, H.B. An investigation of the vertical overbite during eruption of the permanent dentition. *Angle Ortho.*, 31: 53-62, 1961.

13. Fröhlich, F. J. Changes in untreated Class II type malocclusion. *Angle Ortho.*, 32: 167-179, 1962.
14. Goldsman, S. The variation in skeletal and dental patterns in excellent adult facial types. *Angle Ortho.*, 29: 63-92, 1958.
15. Hellman, M. An introduction to growth of the human face from infancy to adulthood. *Internat. J. Ortho.*, 18: 777-798, 1932.
16. Herzberg, F., and Holic, R. An anthropologic study of face height. *Am. J. Ortho. and Oral Surg.*, 29: 90-100, 1943.
17. Lippitz, H. A. A cephalometric radiographic evaluation of face height in adult males with excellent occlusion of the teeth. M. S. Thesis, *Northwestern University*, 1955.
18. Mayne, W. A study of the skeletal pattern of the human face. M.S.D. Thesis, *Northwestern University*, 1946.
19. Margolis, H. Standardized x-ray cephalometrics. *Am. J. Ortho. and Oral Surg.*, 26: 725-740, 1940.
20. Meredith, H. V., Knott, V. B., and Hixon, F. H. Relation of nasal and subnasal components of facial heights in childhood. *Am. J. Ortho.*, 44: 284-294, 1958.
21. Mershon, J. V. Possibilities and limitations in treatment of closed bites. *Internat. J. Ortho. and Oral Surg.*, 23: 581-589, 1937.
22. Moore, A. W. Observations on facial growth and its clinical significance. *Am. J. Ortho.*, 45: 399- 423, 1959.
23. Prakash, P., and Margolis, H. Dentocraniofacial relations in varying degrees of overbite. *Am. J. Ortho.*, 38: 657-673, 1952.
24. Ricketts, R. M. Facial and denture changes during orthodontic treatment, analyzed from the temporomandibular joint. *Am. J. Ortho.*, 41: 163-167, 1955.
25. Sassouni, V. A roentgenographic cephalometric analysis of cephalofacio-dental relationships. *Am. J. Ortho.*, 41: 735-764, 1955.
26. Scott, J. H. The analysis of facial growth: I. The anteroposterior and vertical dimension. *Am. J. Ortho.*, 44: 507-512, 1958.
II. The horizontal and vertical dimension. *Am. J. Ortho.*, 44: 585-589, 1958.
27. Shotts, A. C. A study of correlation of some vertical facial components in males possessing Class II, Division 1 malocclusion. M. S. Thesis, *University of Tennessee*, 1961.
28. Stoner, M. M., Lindquist, J. T., Vorhies, J. M., Hanes, R. A., Hapak, F. M., and Haynes, E. T. A cephalometric evaluation of fifty-seven consecutive cases treated by Dr. Charles H. Tweed. *Angle Ortho.*, 26: 68-98, 1956.
29. Thompson, J. R., and Brodie, A. G. Factors in the position of the mandible. *J.A.D.A.*, 29: 925-941, 1942.
30. Tirk, T. M. A study of the growth of the head by planimetric method. *Angle Ortho.*, 17: 76-94, 1948.
31. Williams, B. H. Craniofacial proportionality in a horizontal and vertical plane, a study in norma lateralis. *Angle Ortho.*, 23: 26-33, 1953.
32. Wylie, W. L. Statistical analysis of the constancy of certain facial dimensions. *J. D. Res.*, 23: 200-201, 1944.
33. ———— Overbite and vertical facial dimensions in terms of muscle balance. *Angle Ortho.*, 14: 13-17, 1944.
34. ———— The relationship between ramus height, dental height and the overbite. *Am. J. Ortho.*, 32: 57-67, 1946.