Components of Class II Malocclusion in Children 8-10 Years of Age

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A cross-sectional lateral cephalometric evaluation of the distribution of specific relationships in subjects with a Class II malocclusion. Broad variation was found, with retrusion and excessive height of the lower face among the most common findings.

Many treatment approaches are currently available to the orthodontist for alteration of the occlusal relationships of Class II malocclusions. These include a variety of extraoral traction appliances, arch expansion mechanisms, extraction procedures and functional jaw orthopedic appliances. It is common to find that only one or two of these modalities are applied to cases of Class II malocclusion in any given orthodontic practice, depending on the experience, personal preference and success rate of the operator. Each, however, differs in its effect on the skeletal structures of the craniofacial region, sometimes including the acceleration or limitation of the growth of the various regions involved.

The aim of all therapeutic regimens is to correct existing problems in the hard and soft tissues and to attain a normal relationship which remains after all appliances have been removed. Since specific therapeutic techniques affect craniofacial structures in different ways, the variety available should correspond to the variety of true etiologies.

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We believe that there is a spectrum of Class II malocclusions and that the choice of treatment should be a function of the individual problem, not of the clinician. To this end, we have examined a clinical population with Class II malocclusions to determine the nature and frequency of occurrence of the specific components that can contribute to a Class II occlusal relationship.

Review of the Literature

Much has been written in the orthodontic literature concerning the nature of Class II malocclusions. It has been pointed out by many investigators (e.g. Case, '21; Wylie, '47; Wylie and Johnson, '52; Fisk *et al.*, '56; Woodside, '68; Sassouni, '69, '70; Moyers *et al.*, '79) that a Class II molar relationship occurs in a variety of skeletal and dental configurations. Cross-sectional studies in the literature have usually compared Class II individuals to either a group of Class I or normal subjects or to existing cephalometric standards. Comparison of mean values is the most commonly employed analytical procedure in those studies.

One of the difficulties in comparing and contrasting cephalometric studies of Class II malocclusions from different populations is that the selection of cephalometric measurements varies from investigator to investigator. Another difficulty is that data are sometimes presented but not interpreted.

In this review of the literature, the measures of the craniofacial region have been divided into four sets based on different anteroposterior criteria: maxillary skeletal position, maxillary dental position, mandibular dental position and mandibular skeletal position. In addition, the vertical configuration of the Class II patient will be considered. These arbitrary divisions allow a comparison of various cross-sectional studies of patients possessing Angle Class II malocclusion.

Maxillary Skeletal Position (Table 1)

One prime component of a Class II molar relationship can be assumed to be an anterior positioning of maxillary structures relative to other craniofacial components. Drelich ('48), Altemus ('55) and Rothstein ('71) report this to be the case, while Elsasser and Wylie ('48) note that although maxillary protrusion occurs in males, the maxillae of females were found in a neutral position. Riedel ('52), Hunter ('67) and Hitchcock ('73) record that in their samples the maxilla was normally positioned in both sexes and Hitchcock ('73) states that only nine of 57 cases had an S-N-A

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TABLE 1. MAXILLARY SKELETAL POSITION

Retrusion	*Neutral*	*Protrusion*
Renfroe, '48	Elsasser and Wylie, '48 (females)	Drelich, '47
Henry, '57	Reidel, '52	Elsasser and Wylie, '48 (females)
Harris *et al.*, '72	Hunter, '67 Hitchcock, '73	Altemus, '55 Rothstein, '71

angle one standard deviation above 81°. In contrast, Renfroe ('48), Henry ('57), and Harris *et al.* ('73) indicate that, on the average, the maxilla was in a slightly retrusive position in both sexes, and Henry reports that the S-N-A angle of his Class II sample averaged 1.5° less than the Class I mean to which the Class II was compared. It should be noted that the angle S-N-A may also vary due to the position of Sella (Freeman '81). Renfroe ('48) stated that the maxillae of Class II, division 1 individuals were in a more retrusive position than those in comparable Class I or Class II, division 2 malocclusion samples.

Maxillary Dental Position (Table 2)

Another obvious component of the Class II malocclusion is the position of the maxillary dentition relative to the maxillary skeletal structures. Previous studies have usually associated protrusion of the upper anterior teeth with the majority of Class II cases. For example, Riedel ('52) notes that the maxillary incisor in his Class II, division 1 sample was twice as far anterior to the facial plane as that in patients having normal occlusions. Hitchcock ('73) reports maxillary dental protrusion relative to the A-Po line. In contrast, Henry ('57) notes that, relative to a line from nasion to point A, only 11 of 103 cases exhibited maxillary dentoalveolar protrusion. However, point A may be displaced by the incisor root and so mask some dental protrusion.

There also have been differences in the reported position of the upper first molar relative to maxillary skeletal structures. Altemus ('55) reports in his study that the posterior dentition was mesially located in the maxilla, while Baldridge ('41, '50) and Elsasser and Wylie ('48) noted no difference in maxillary molar position between groups of Class II and Class I individuals. Renfroe ('48) reported that the upper first molar in his Class II sample was located slightly posterior relative to the Class I group.

Mandibular Dental Position (Table 3)

Less attention has been paid to the position of the mandibular dentition relative to the structures of the man-

TABLE 2. MAXILLARY DENTOALVEOLAR POSITION

	Retrusion	*Neutral*	*Protrusion*
Incisors		Henry, '57	Drelich, '48 Renfroe, '48 Riedel, '52 Hunter, '67 Rothstein, '71 Harris *et al.*, '72 Hitchcock, '73
Molars	Renfroe, '48	Baldridge, '41, '50 Elsasser and Wylie, '48 Henry, '57	Altemus, '55

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TABLE 3. MANDIBULAR DENTAL POSITION

	Retrusion	Neutral	Protrusion
Incisors	Hunter, '67 Hitchcock, '73 Harris *et al.*, '73		
Molars	Craig, '51 Altemus, '55	Elman, '48 Gilmore, '50 (variable)	

dible. Generally, the investigators who did consider the position of the mandibular dentition report that, on the average, the lower incisors were related normally to basal structures. However, there was again some disagreement about the relative position of the lower first molar. Elman ('48) reported no difference in the position of the lower molar relative to Class I individuals; Craig ('51) and Altemus ('55) both reported that the lower molar in the Class II individual was located more posteriorly; and Gilmore ('50) found the position of the lower molar was quite variable.

Mandibular Skeletal Position (Table 4)

In previous studies much emphasis has been placed on the size and position of the mandible itself relative to other craniofacial structures. Adams ('48) and Rothstein ('71) state that the absolute length of the mandibles in Class II patients did not differ from those of Class I subjects; Altemus ('55) reported that the mandible was slightly longer in Class II patients than in Class I individuals; and Elsasser and Wylie ('48) note sexual dimorphism in Class II individuals. In their studies, the mean value for

TABLE 4. MANDIBULAR SKELETAL POSITION

Retrusion	Neutral	Protrusion
Drelich, '48	Adams, '48	
Elasser and Wylie, '48 (females)	Elasser and Wylie, '48 (males)	
Renfroe, '48	Altemus, '55	
Nelson and Higley, '48	Rothstein, '71	
Gilmore, '50		
Craig, '51		
Riedel, '52		
Blair, '54		
Henry, '57		
Hunter, '67		
Hitchcock, '73		
Harris *et al.*, '73		

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mandibular length in Class II males was within normal limits, while it was less than normal in Class II females.

However, most other investigators note a mandibular deficiency in Class II individuals for both sexes (Table 4). For example, Craig ('51) notes that the mandibular body is shorter in Class II subjects. Most did not differentiate between the absolute size and the position of the mandible, but Renfroe ('48) and Henry ('57) noted that while certain Class II patients could be characterized as being deficient in mandibular size, other Class II patients had mandibles that were well formed but were retruded due to a posterior position of the glenoid fossa. All concluded that the mandibles of Class II individuals were retrognathic relative to other craniofacial structures.

Vertical Development (Table 5)

Although many authors (e.g., Wylie and Johnson, '52; Harvold, '63; Schudy '64; Sassouni and Nanda, '64; Sassouni, '69, '70) have recognized the importance of excessive or deficient vertical development in the determination of occlusal relationships, few of the cephalometric studies of Class II malocclusion surveyed in this review specifically mention anterior or posterior facial height. Drelich ('48) notes that the Y-axis in Class II patients was directed more downward than in Class I individuals and that the ratio of anterior to posterior face height was greater in Class II individuals than in Class I individuals. Henry ('57) noted a larger mandibular plane angle in his Class II sample, Altemus ('55) an increased vertical dysplasia, and Hunter ('67) a slight increase in anterior face height.

Overview

The above review of the literature covers most of the major studies of the cephalometric characteristics found in association with Angle Class II malocclusion. It is obvious that there is no agreement regarding the relative importance of the five principal components of a Class II malocclusion. Most authors agree that mandibular skeletal retrusion, in either absolute size or relative position, is an important component along with maxillary dental protrusion. Excessive vertical development, particularly in anterior face height, can also be a significant factor.

Most studies indicate also that the lower incisors are usually placed normally relative to the skeletal structures of the mandible, and thus are not a factor in the occurrence of the distal occlusal relationship. The investigators disagree most about the position of maxillary skeletal structures relative to the cranium and cranial base, with some authors reporting maxillary skeletal protrusion, some maxillary skeletal retrusion, and others no difference in maxillary po-

TABLE 5. ANTERIOR FACIAL HEIGHT

Short	*Neutral*	*Long*
	Harris *et al.*, '73	Drelich, '48
		Henry, '57
		Hunter, '67

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sition in Class II samples compared with Class I individuals. This variety of findings can be explained, at least in part, by differences in the cephalometric measures chosen for analysis as well as by differing clinical populations and standards to which Class II samples were compared.

The mean values in these studies are not as important as the variability seen among individuals. Few studies have directly considered the frequency of occurrence of the various factors which can, at least theoretically, lead to a Class II malocclusion. The reports of Henry ('57), Hitchcock ('73) and Moyers *et al.* ('80) are the notable exceptions. Henry ('57) lists four categories into which most cases of Class II, division 1 malocclusion may be classified: (1) maxillary alveolar protrusion, (2) maxillary basal protrusion, (3) micromandible, and (4) mandibular retrusion. Moyers *et al.* ('80) present an arborization that allows the identification of various groups of factors which can determine a clustering of Class II malocclusions with similar skeletal and dental characteristics.

The purpose of the present study is to determine the relative frequency with which various identifiable components appear in the clinical entity called Class II malocclusion. A further intent is to evaluate the existing therapeutic approaches currently available (extraoral traction, intraoral traction, palatal expansion, extraction, functional jaw orthopedics) in terms of the relative frequency of appropriateness as defined by quantitative assessment of the components of Class II malocclusion.

Materials and Methods

Lateral cephalometric radiographs of 277 children, 153 male and 124 female, were evaluated in this study. Ages ranged from 8 years, 0 months to 10 years, 11 months, with an average of 9 years. This age range was selected because all treatment techniques to be considered can be used on children of this age. The radiographs were obtained from the records of 12 private orthodontic practices and from the University of Michigan Elementary and Secondary School Growth Study.

The criteria for inclusion of a subject in the study were the presence of at least end-on molar and cuspid relationships as determined from a headfilm. No skeletal criteria were used. Both Class II, division 1 and Class II, division 2 cases were included.

Each film was traced by one investigator and checked by a second to verify the accuracy of the anatomical outline determinations and landmark placement. The tracings were then digitized at the Center for Human Growth and Development (the precision of the digitizer is 0.1 mm) by placing the tracings on a backlighted digitizer board and translating the positions of the landmarks into an X-Y coordinate system.

For ease of analysis, measures of craniofacial structure were divided into four horizontal and one vertical component in a manner similar to that used in the review of the literature. In addition to traditional cephalometric measurements, three new horizontal measurements were used in the analysis; point A to Nasion Perpendicular, Maxillary Incisor to Point A and Pogonion to Nasion Perpendicular.

Anteroposterior Components

Maxillary Skeletal Position

The position of the maxilla relative to cranial base and cranial struc-

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tures was determined by two variables.

A. *Sella-Nasion-Point A Angle.* The S-N-A angle, as popularized by Riedel ('52) and Steiner ('53), was used to assess the relative anteroposterior position of the maxilla. The Steiner norm for this angle is 82°.

B. *Point A to the Nasion Perpendicular (mm).* This measurement is determined by first establishing the Frankfort horizontal plane using anatomical porion and orbitale (Ricketts, '60). A line is then drawn perpendicular to the Frankfort horizontal plane from nasion inferiorly (Fig. 1). In our opinion, point A should lie within 2 mm of this perpendicular plane in an individual with a normal, well-balanced face.

Studies of longitudinal growth of untreated individuals (Riolo *et al.*, '74; Broadbent *et al.*, '75) have revealed that the relationship of the maxillary complex to upper facial structures as shown by angles such as S-N-A and Ba-N-A stays relatively constant during growth. A typical measure can be expected to increase by only 1° or 1 mm during this interval. Thus, the anteroposterior position of the maxilla (as indicated by point A) does not change appreciably relative to the nasion perpendicular.

Maxillary Dentoalveolar Position

Two variables were used to measure the position of the upper incisor relative to the structures of the maxilla.

A. *Maxillary Incisor to A-Po Line.* This is the distance from the anteriormost point of the maxillary incisor to a line drawn from point A to pogonion. In a study of 83 patients who possessed clinically excellent, untreated occlusions, Christie ('77) states that the average value for this variable was in the range of 5 to 6 mm for both males and females.

B. *Maxillary Incisor to Point A (Fig. 2).* The horizontal distance of the maxillary incisor to Point A is determined by first measuring the distance from the anteriormost point on the incisor to the nasion perpendicular. The distance from point A to the nasion perpendicular is then subtracted from that value.

The advantage of this measure is its independence of the position of the mandible. In our opinion this measurement should be 4-5 mm in a balanced face.

Mandibular Dentoalveolar Position

The distance from the anteriormost point on the lower incisor to the A-Po line was used to determine the relative position of the lower incisor relative to basal structures. Christie ('77) reports that the average value for this measurement in his ideal occlusion sample is 2.3 mm.

Mandibular Skeletal Position

Four variables were considered in the evaluation of the anteroposterior position of the mandible relative to cranial base and cranial structures.

A. *Facial Angle.* The angle formed by the intersection of a line drawn from nasion to pogonion with the Frankfort horizontal plane. Ricketts ('60) states that ideally this value should be 86° at nine years of age.

B. *Pogonion to the Nasion Perpendicular (mm).* This is a direct measurement of the distance from pogonion to the nasion perpendicular (Fig. 3). In our opinion this distance should be −8 to −5 mm in the age group considered in this study.

C. *Sella-Nasion-Pogonion Angle.* No normal values are given.

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D. *Sella-Nasion-Point B.* This measurement is included only for completeness since the position of point B is greatly influenced by muscle function (e.g., mentalis, orbicularis oris). This measurement may, in fact, be an indication of the position of the lower dentition, rather than of the skeletal position of the mandible.

Vertical Components

Mandibular Plane Angle

This is the angle between the Frankfort plane and a line constructed through gonion and menton.

The Growth (Facial) Axis Angle

This measurement, invented by Ricketts ('60, '81), is determined by first constructing a line from basion to nasion (Fig. 4). The deviation from 90 degrees of the angle formed by the intersection of that line with a line drawn through the posterosuperior aspect of the pterygomaxillary fissure and gnathion can be used as an evaluation of vertical facial development. According to Ricketts, a perpendicular geometric relationship (zero deviation) is to be expected with a balanced face. Deficient vertical facial development is indicated by positive values, excessive vertical development by negative values.

Lower Face Height

This distance, modified from that presented by Harvold ('63) and Woodside and Linder-Aronson ('79), is measured from the anterior nasal spine to menton (Fig. 5). In a 9-year-old child with a balanced face, its value is approximately 60 mm, and should be expected to increase 1 mm per year until adult facial height is reached.

RESULTS

Maxillary Skeletal Position

A wide variation was observed in the measured position of the maxilla relative to cranial and cranial base structures. The average S-N-A angle was 80.4° (Fig. 6), only 1.6° less than the Steiner norm. More cases were found with the maxilla in a retrusive position than in a protrusive position, relative to the Steiner norm.

In terms of the relationship of point A to the nasion perpendicular (Figs. 1, 7), the position of the maxillary skeletal structures averaged 0.6 mm with a standard deviation of 3.1 mm. This measurement also indicated more cases of maxillary skeletal retrusion than protrusion.

Maxillary Dental Position

Analyses of the two measurements used in this portion of the study differ from one another in their implications. A measurement based in part on mandibular skeletal position (Fig. 8), tends to show protrusion of the upper incisors in most cases. For example, the average distance from the upper incisor to the A-Po line is 8.3 mm, which is significantly greater than the average of 5-6 mm for normal occlusion. Only 15% of the entire sample showed upper incisor protrusion of less than 6 mm when evaluated in this way.

But should maxillary dental position be evaluated in relation to the maxilla instead of the mandible, our sample group appears "normal." The average horizontal distance of the upper incisor to point A (Fig. 2) is 4.8 mm, well within average limits. The distribution of this measurement was symmetrical (Fig. 9); twenty-nine per-

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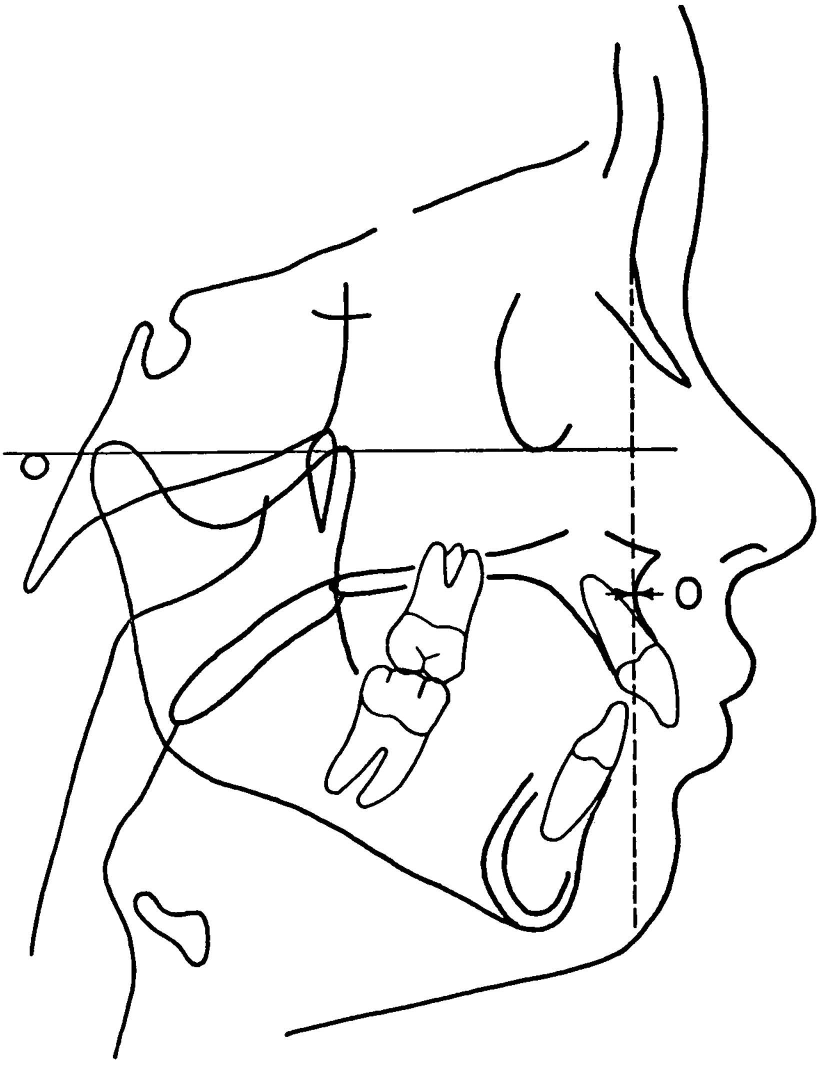

Fig. 1 Point A to nasion perpendicular. Frankfort horizontal plane is constructed using anatomic porion and orbitale. A perpendicular is then erected from Frankfort plane to nasion and extended downward past point A. The distance is measured from point A to the nasion perpendicular; in this illustration point A lies on the perpendicular, so the distance is zero.

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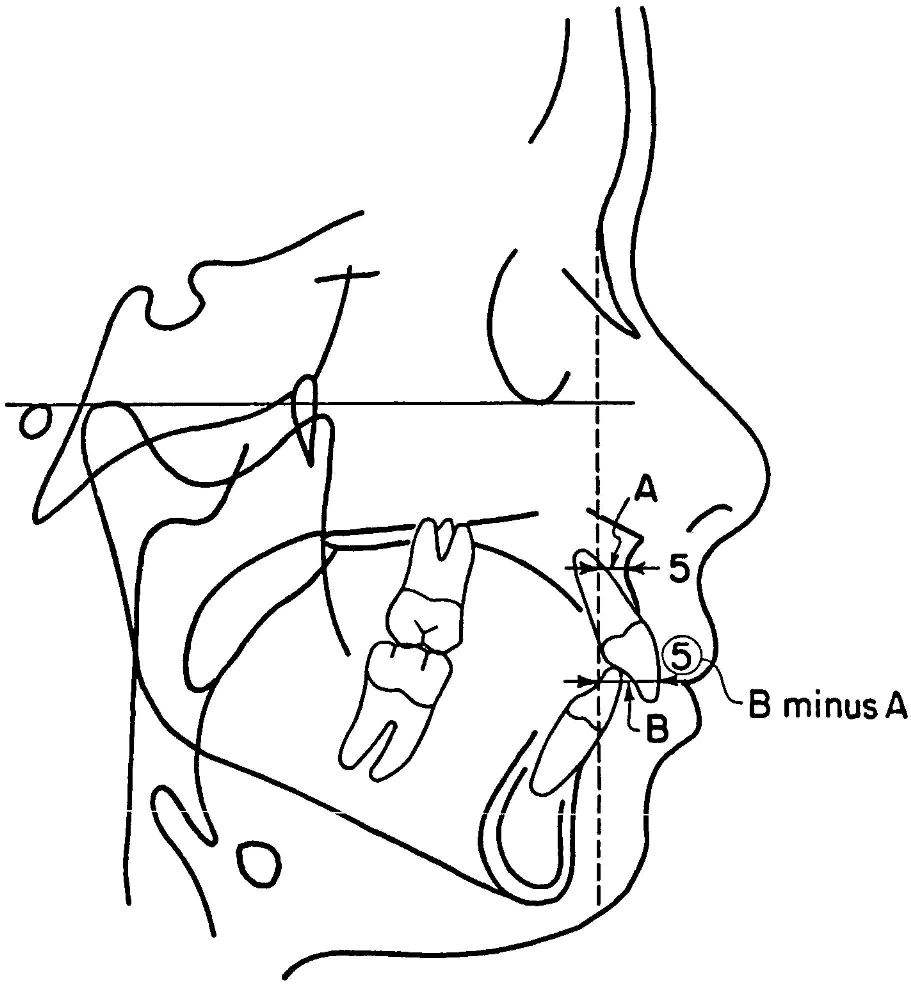

Fig. 2 Horizontal distance of the maxillary incisor to point A. A = distance from point A to the nasion perpendicular. B = distance from the anteriormost point on the incisor to the nasion perpendicular. The difference (5 mm in this illustration) is the horizontal distance of the incisor from point A.

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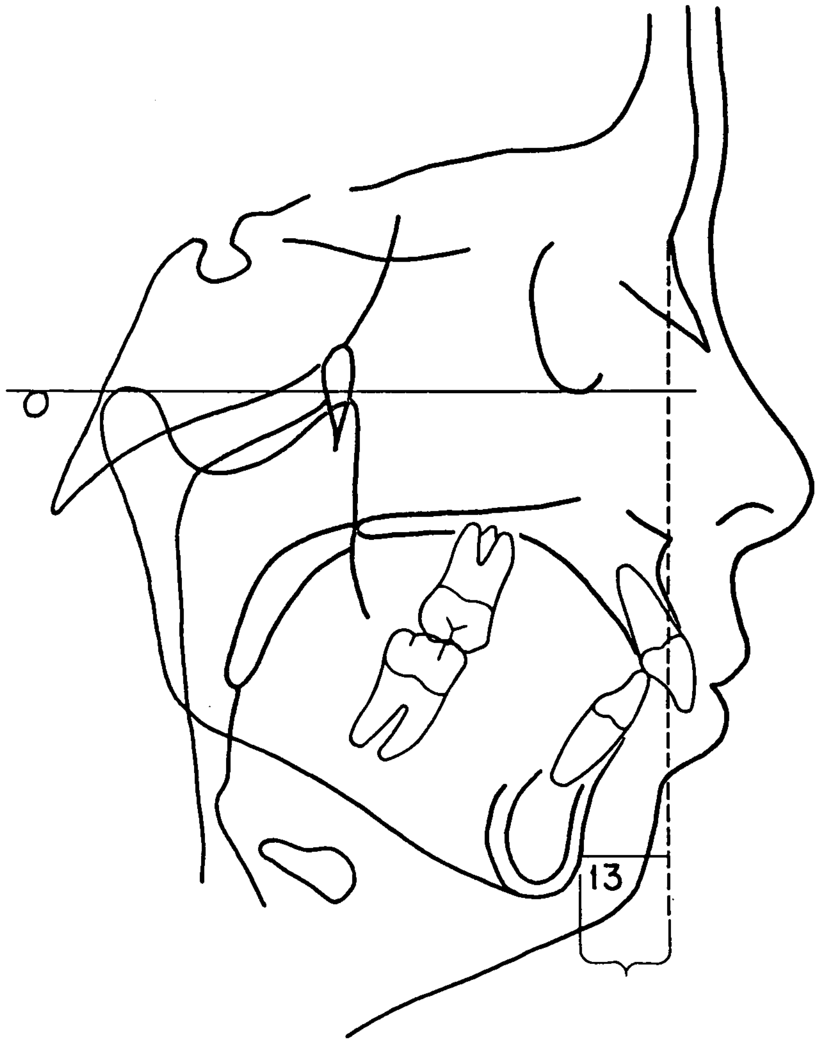

Fig. 3 Distance from pogonion to nasion perpendicular. In this Class II malocclusion the distance is 13 mm.

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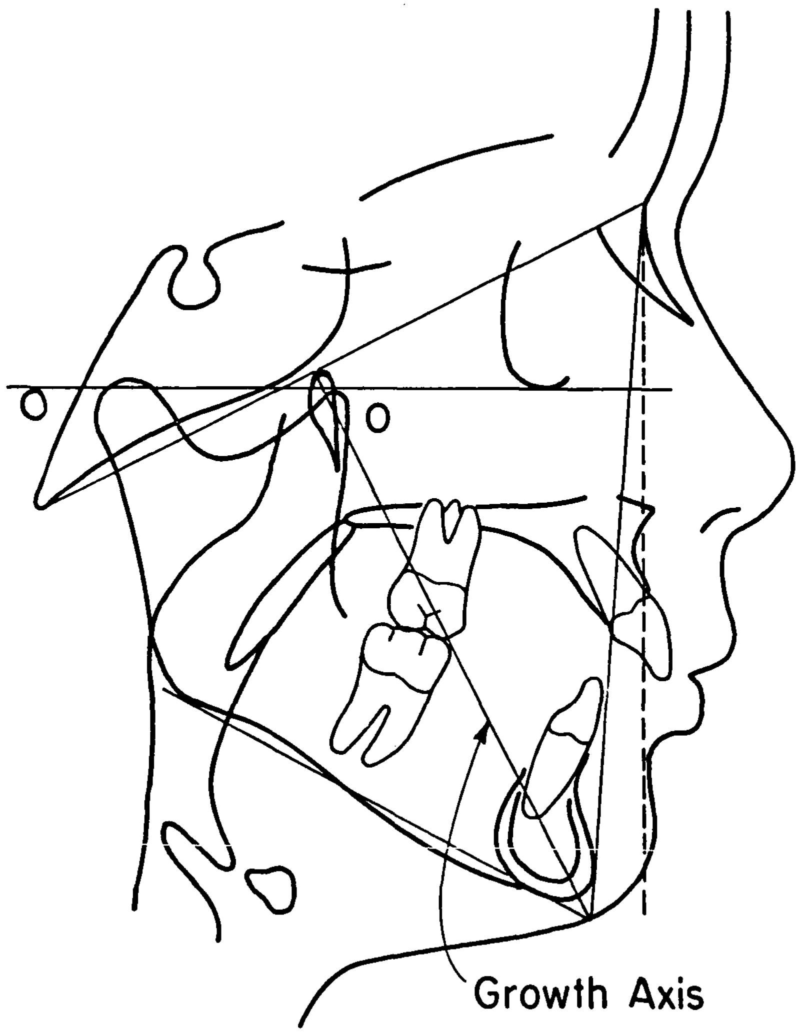

Fig. 4 Facial growth axis. The facial axis is constructed through gnathion and the postero-superior margin of the pterygomaxillary fissure (Ricketts '60 and '81). The angle of this axis is measured as the difference from a perpendicular to the basion-nasion line (Ba-N). The clinical norm is zero, as shown in this illustration.

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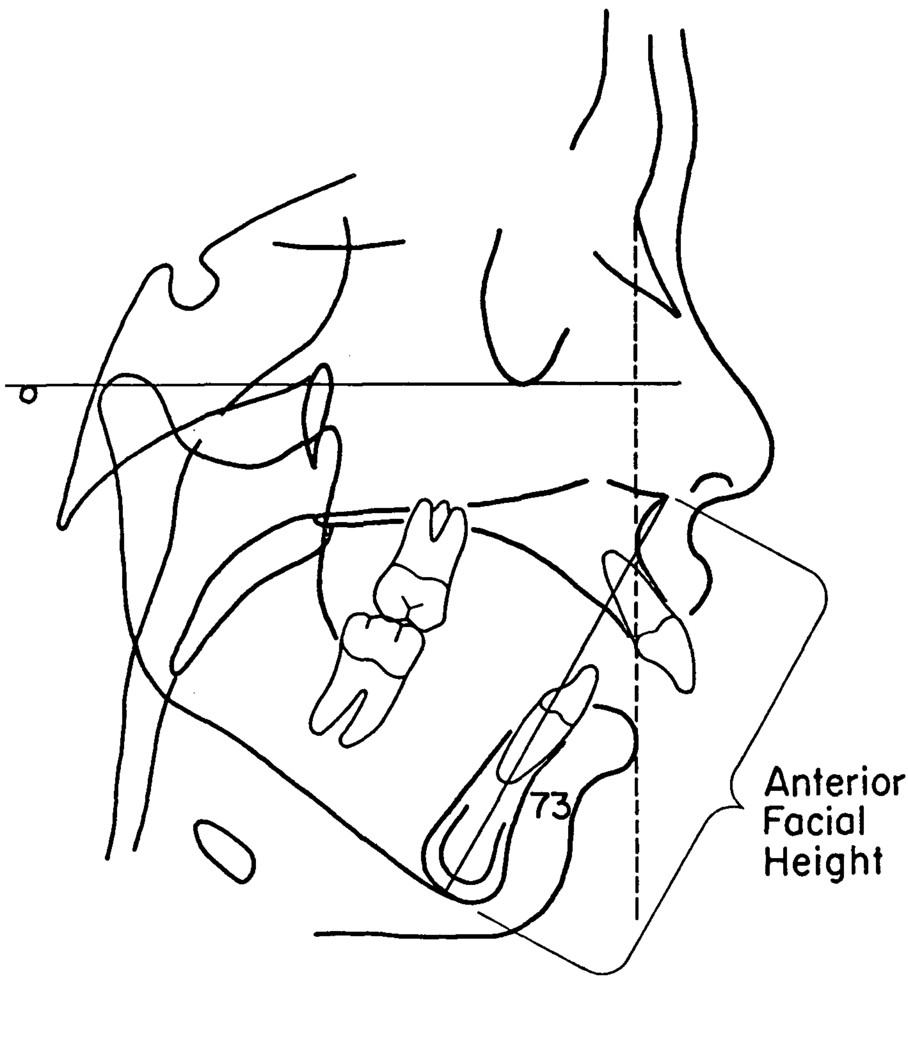

Fig. 5 Anterior facial height. This is a direct measurement from the anterior nasal spine to menton. In this illustration of a skeletal open bite, that distance is 73 mm.

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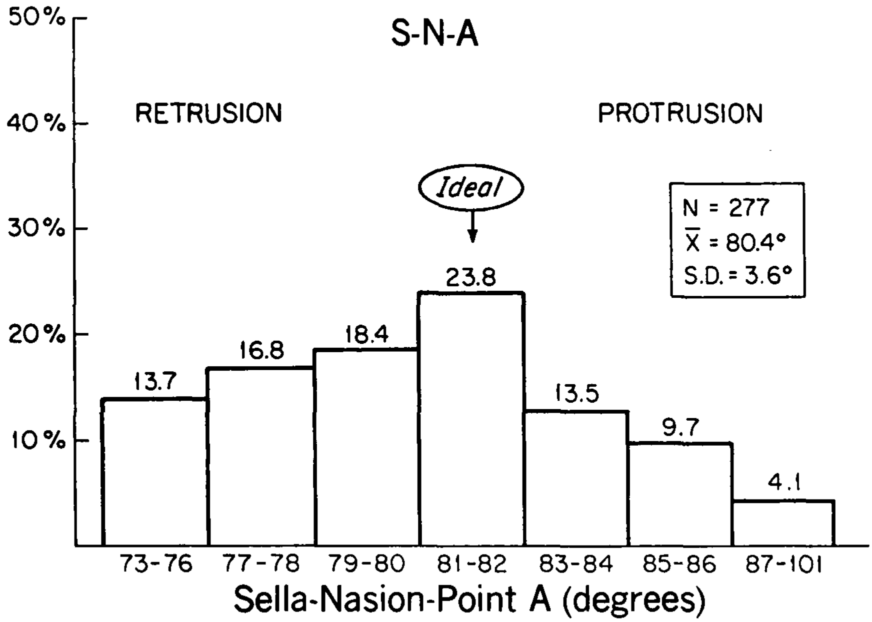

Fig. 6 Distribution of angle S-N-A (degrees) in Class II sample.

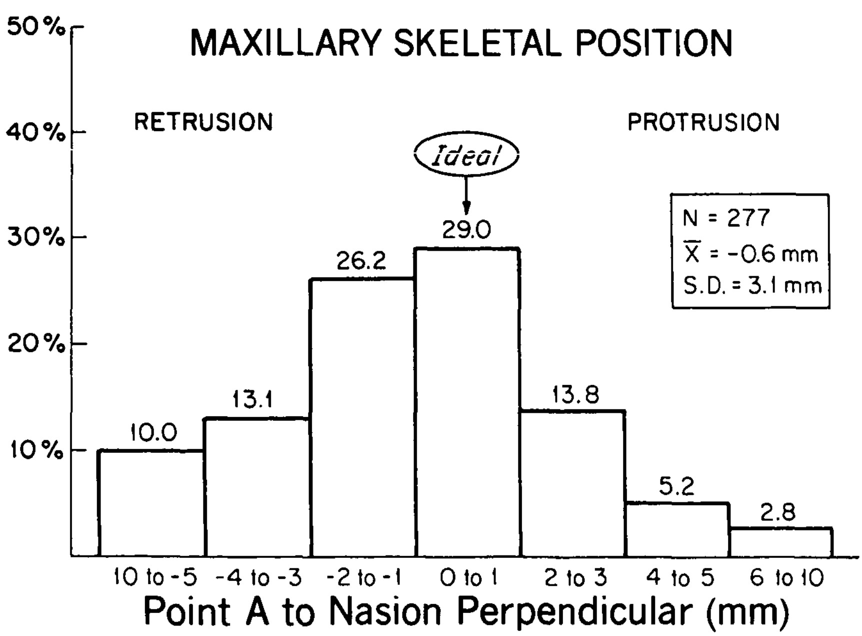

Fig. 7 Distribution of maxillary skeletal position in the Class II sample, as measured by the distance of Point A from the nasion perpendicular.

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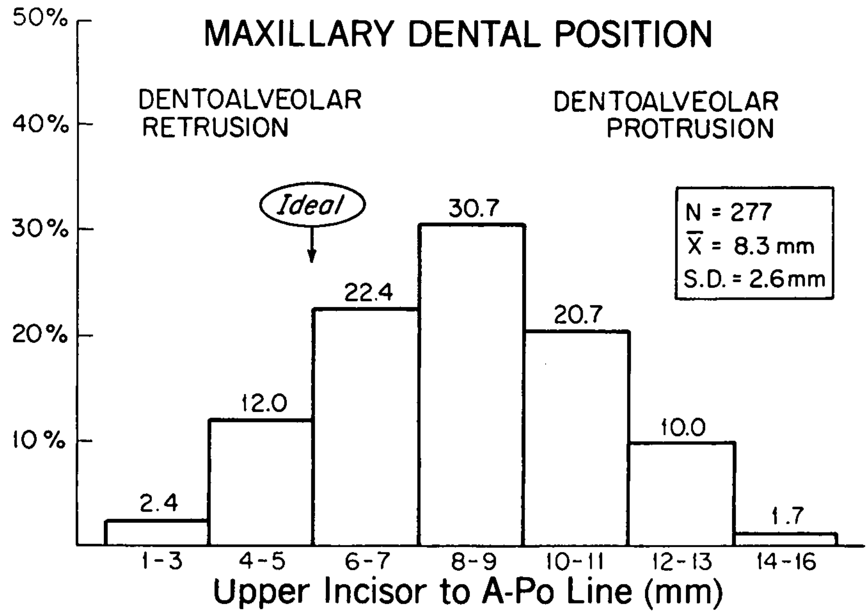

Fig. 8 Distribution of maxillary dental position in the Class II sample, as measured by the distance of the upper incisor from the A-Po line.

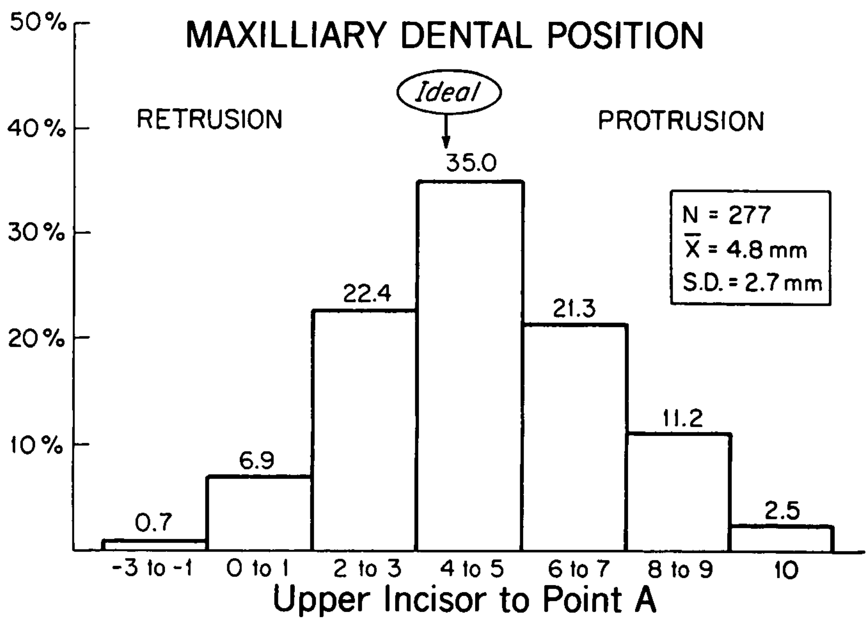

Fig. 9 Distribution of maxillary dental position in the Class II sample, as measured by the horizontal distance of the upper incisor from point A.

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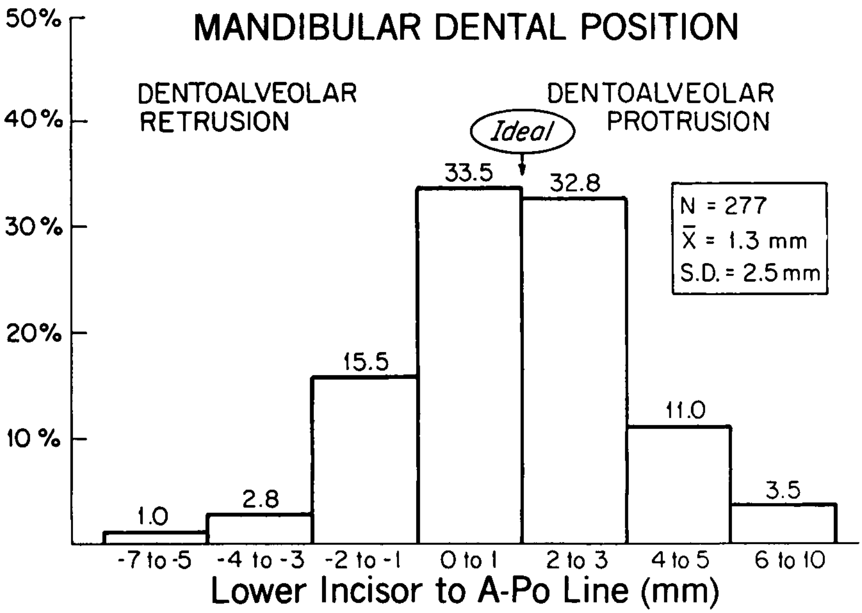

Fig. 10 Distribution of mandibular dental position in the Class II sample, as measured by the distance of the lower incisor from the A-Po line.

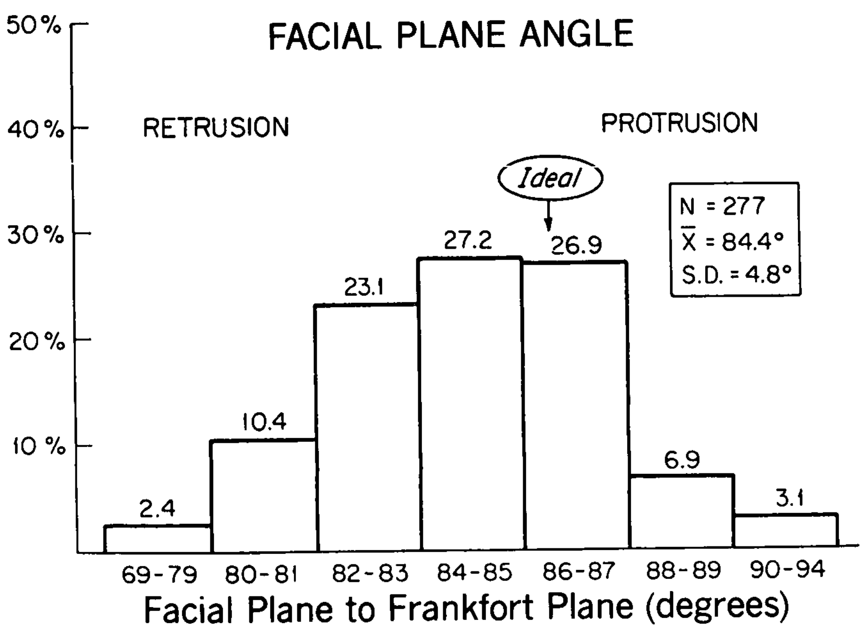

Fig. 11 Distribution of the facial plane angle (N-Po to Frankfort) in the Class II sample.

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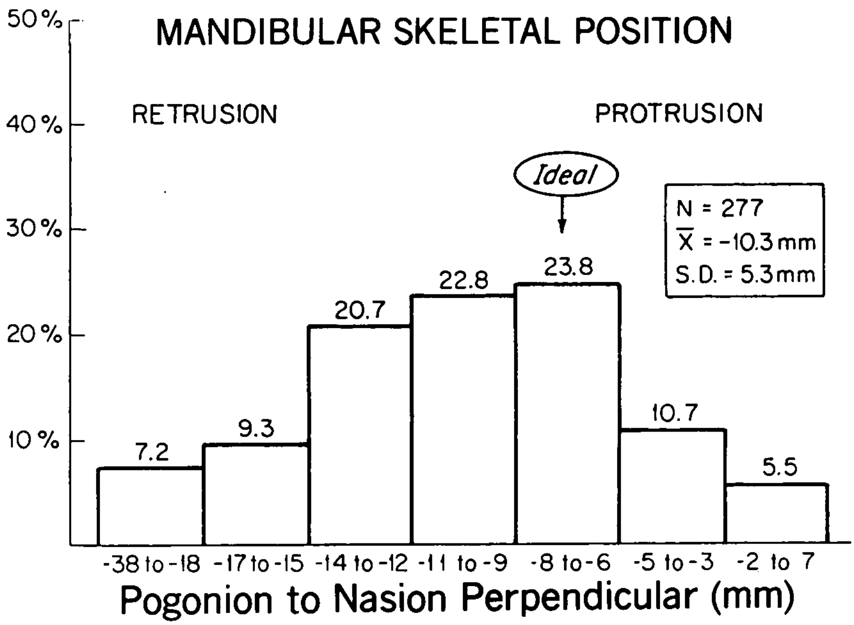

Fig. 12 Distribution of mandibular skeletal position in the Class II sample, as measured by the distance of Pogonion from the nasion perpendicular.

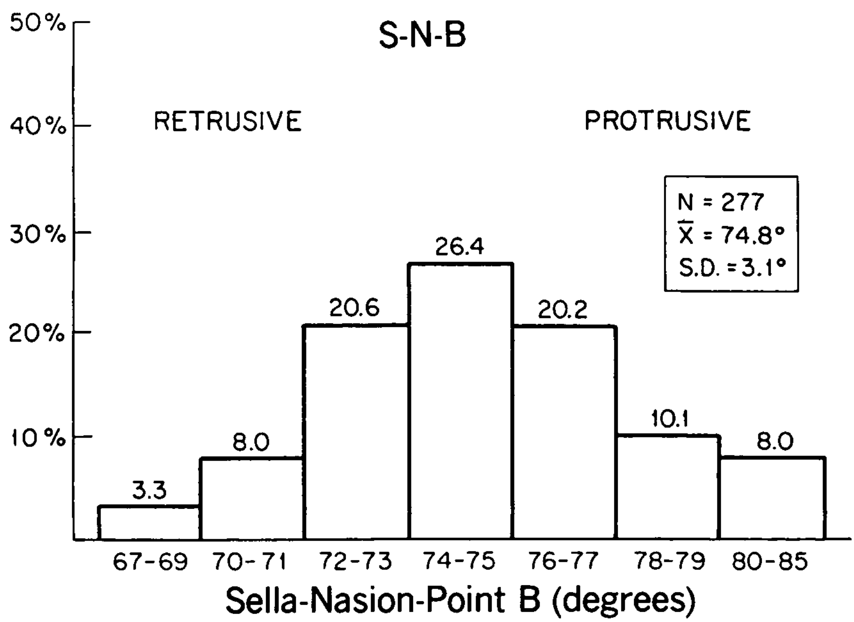

Fig. 13 Distribution of mandibular position in the Class II sample, as measured by the angle S-N-B.

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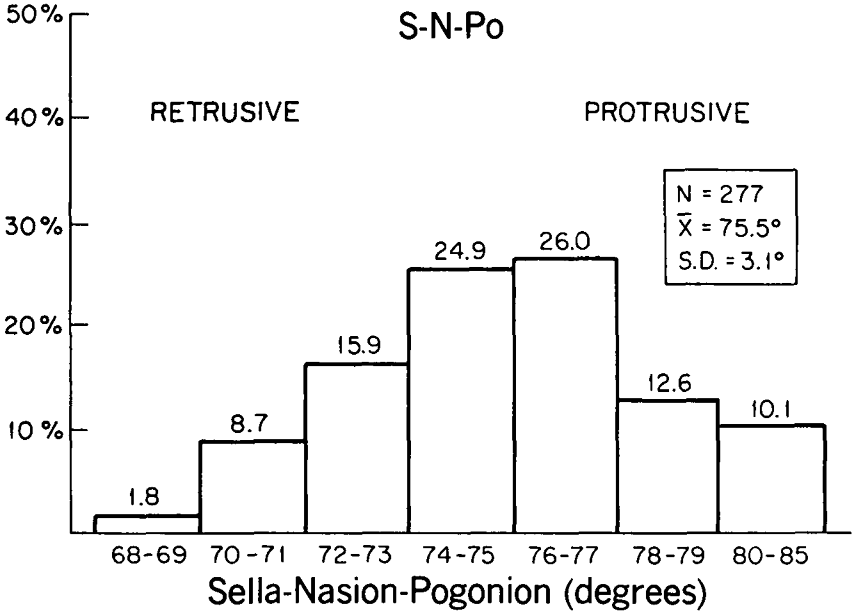

Fig. 14 Distribution of mandibular skeletal position in the Class II sample, as measured by the angle S-N-Po.

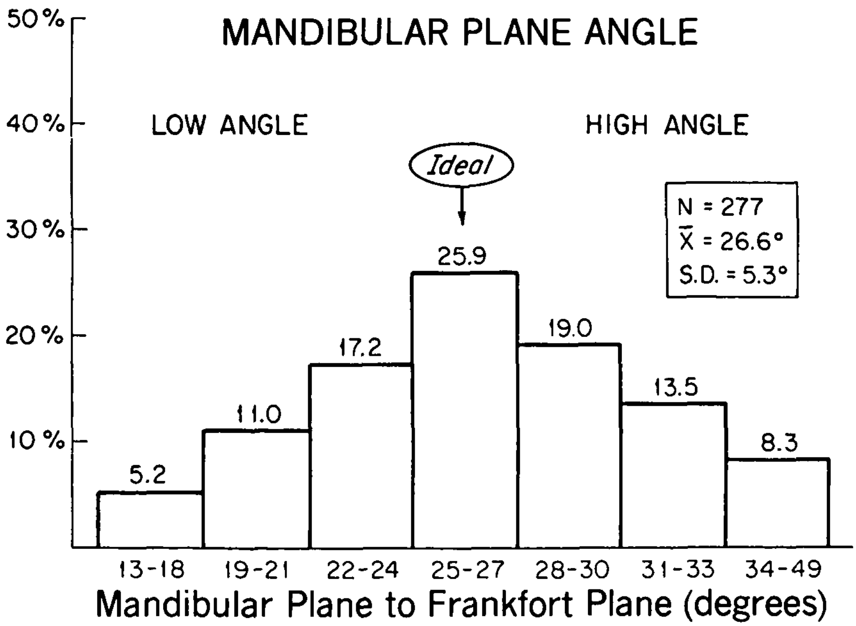

Fig. 15 Distribution of mandibular skeletal position in the Class II sample, as measured by the angle of the mandibular plane to Frankfort plane.

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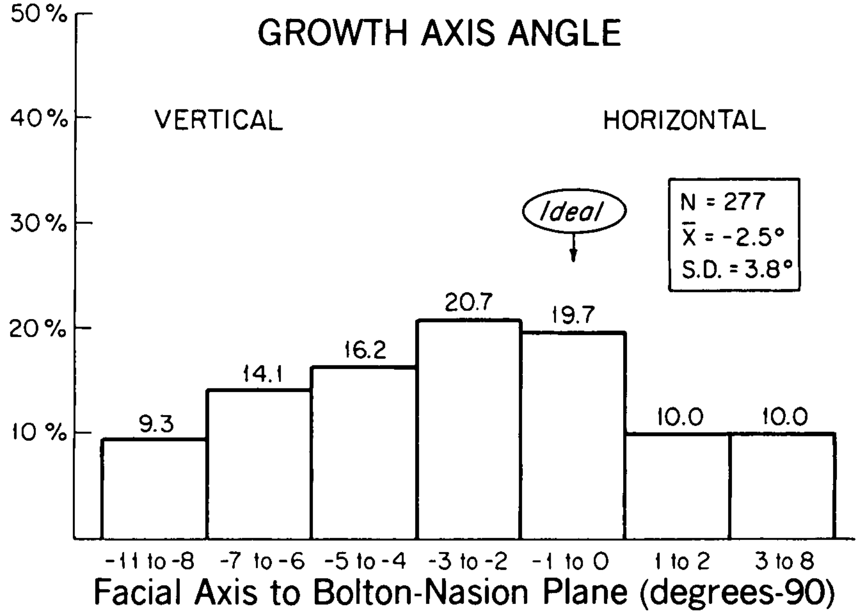

Fig. 16 Distribution of the angle of the facial growth axis (see Fig. 4) in the Class II sample. Ricketts' normal value for this measurement is zero.

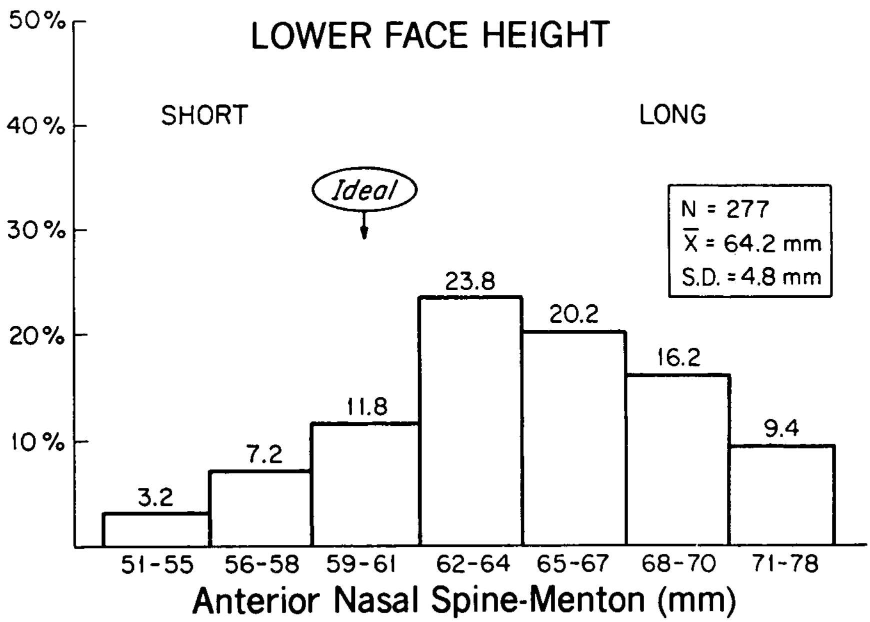

Fig. 17 Distribution of lower face height (anterior nasal spine to menton) in the Class II sample.

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cent of the cases were less than 4 mm ahead of point A, 35% were more than 5 mm ahead.

Mandibular Dental Position

Analysis of the relationship of the lower incisor to the A-Po line indicates that more than 60% of the Class II patients had values between 0 and 3 mm. The average position of the incisor in the whole sample is 1.3 mm in front of the A-Po line (Fig. 10).

Mandibular Skeletal Position

All four measurements used in the analysis of mandibular position relative to upper facial structures indicated frequent mandibular retrusion. For example, the mean facial angle (Fig. 11) was 84.4°, which is less than the ideal 86° in the balanced face of the nine-year-old child. Almost two-thirds of the sample had a facial angle of 85° or less. Likewise, pogonion should lie from 6 to 8 mm behind the nasion perpendicular in a balanced face; but for our sample group (Fig. 12) the average distance was 10.3 mm, 60% of the cases having values of at least 9 mm retrusion. Retrusion of the mandible was also observed in the analysis of the S-N-B angle (Fig. 13), which averaged 74.8° and in the S-N-Po angle (Fig. 14), which averaged 75.5°. No ideal values are given for the last two measures.

Vertical Component

Three variables were used to assess vertical development in the Class II patient. As can be observed in Fig. 15, the sample showed a wide variation in the mandibular plane angle (26.6°, S.D. 5.3°), with a range of 13° to 49°. More than 40% had a mandibular plane angle of 28° or greater.

The determination of lower face height by measuring from anterior nasal spine to menton (Figs. 5, 16) also revealed a wide variation in vertical dimension. The average value for lower face height indicated excessive vertical development in this sample. More than 45% had a lower face height in excess of 64 mm, only 10% had a lower face height of less than 59 mm, while the ideal lower face height for a nine-year-child with a balanced face is 60 mm.

The analysis of growth axis measurements (Figs. 4, 17) also indicated a wide range, with a tendency toward vertical development. More than 60% of the sample had a measurement of −2° or less relative to the basion-nasion plane, indicating a probable vertical direction of future growth (Ricketts, '60). Only 20% of the sample had values of 1° or more, indicative of a horizontal direction of growth.

An Analysis of Component Combinations

To this point we have considered the components occurring in Class II malocclusion only singly. To determine the frequency of appearance of various combinations, we selected arbitrary neutral values (Table 6) bounding a range of normal variability for each of the five components (four horizontal and one vertical). Values less than the neutral range indicate a retrusive position for the horizontal components, a deficient or short vertical development for the vertical component; values greater than the neutral range indicate a protrusive position or excessive vertical development. This reduced each value to a trichotomy into which all subjects could be classified—low, neutral or high.

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TABLE 6. VALUES USED IN COMBINATION TABLES

Variable	Retrusive	Neutral	Protrusive
Maxillary Skeletal (A to Nasion Perpendicular)	<−2.5 mm	−2.5 to +2.5 mm	> 2.5 mm
Maxillary Dental (Maxillary Incisor to A)	< 2.5 mm	2.5 to 6.5 mm	> 6.5 mm
Mandibular Dental (Mandibular Incisor to A-Po)	< 0.5 mm	0.5 to 3.5 mm	> 3.5 mm
Mandibular Skeletal (Pogonion to Nasion Perpendicular)	<−8.5 mm	−8.5 to −4.5 mm	>−4.5 mm
Vertical Development (ANS to Menton)	< 57.5 mm	57.5 to 63.5 mm	> 63.5 mm

Out of five trichotomies we can build 243 possible combinations of components. In fact, there were 77 actual combinations in our sample (Table 7). Only one combination represented even 10% (28 out of 277) of this Class II population (Group I, Table 7). This group was characterized by mandibular skeletal retrusion, excessive vertical development, and neutral positioning of the maxillary dental and mandibular dental components.

The next nine most frequently occurring combinations had from 7 to 12 cases in each group (Groups II-X, Table 7), representing less than 5% each of the total sample. Group III (11 cases) was similar to Group I, with the exception that the vertical dimension in this group was not excessive. Group II (12 cases) was characterized by a retrusive position of both the maxillary and mandibular skeletal components and excessive lower face height. Each of sixty-seven other combinations of components occurred six times or fewer.

Maxillary skeletal position was neutral in eight of the ten most commonly

TABLE 7. COMBINATON OF VARABLES

Possible Combinations = 243 Actual Combinations = 77

Group	N	Max Skel	Max Dent	Mand Dent	Mand Skel	Vert Dim
I	28	Neut	Neut	Neut	Ret	Long
II	12	Ret	Neut	Neut	Ret	Long
III	11	Neut	Neut	Neut	Ret	Neut
IV	9	Neut	Ret	Ret	Ret	Neut
V	8	Ret	Neut	Ret	Neut	Neut
VI	8	Ret	Neut	Neut	Ret	Neut
VII	8	Neut	Neut	Ret	Neut	Long
VIII	7	Neut	Neut	Prot	Ret	Long
IX	7	Neut	Neut	Ret	Ret	Long
X	7	Neut	Neut	Neut	Neut	Neut

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occurring groups, and the mandible was retrusive in seven of the ten groups. Maxillary dentition was in a neutral position in nine of the ten groups, and the mandibular dentition was retrusive in three groups and protrusive in one. The vertical dimension of the face, as indicated by lower facial height, was excessive in five groups and normal in five groups.

Discussion

The analysis of the various components of a Class II molar relationship of the 277 individuals considered in this study confirms that a Class II malocclusion is not a single clinical entity. Rather, it can result from numerous combinations of components. Wylie ('47), Drelich ('48), Craig ('51), Blair ('54), Sassouni and Nanda ('64), and Moyers *et al.* ('80), among others, have also noted wide variation in the size and shape of the various components of the craniofacial complex in Class II individuals.

These results indicate that retrusion of the mandible is the most commonly occurring factor contributing to Class II malocclusion. That the mandible is the most commonly found component is not surprising in view of its developmental characteristics. Embryologically, the mandible is not derived from the primary cartilagenous skeleton. For the most part, it develops independently, lateral to Meckel's cartilage. The cartilage of the mandibular condyle is secondary in origin (Moffett, '64, '66; Symons, '65; Durkin, '72; Durkin *et al.,* '72; Hall, '78), and biochemically has been shown to be distinct from other growth cartilages of both the craniofacial region and the appendicular skeleton (Brigham *et al.,* '77).

Our experimental studies of condylar growth adaptations to alterations in the biomechanical and biophysical environment of the craniofacial region in rhesus monkeys (McNamara, '72, '75, '80; McNamara and Carlson, '79) indicate that mandibular growth can be increased or decreased by changing the mandibular postural position. Similar results have been found in other studies of mandibular growth adaptations in monkeys (e.g., Stöckli and Willert, '71; Harvold *et al.,* '73) and other animal species (e.g., Petrovic *et al.,* '75; Petrovic and Stutzman, '80). These studies all suggest that growth of the condylar cartilage may be in part adaptive, and that the condylar response to alterations in the environment may more closely resemble that of periosteum than that of the epiphyseal cartilages of long bones (Petrovic, '70). Since the growth of the mandible can be influenced by alterations in the functional environment, we conclude that abnormal muscle function, altered occlusal interdigitation, and other factors may affect the size and shape of the mandible in the growing Class II individual.

The measured position of the maxillary skeletal component in Class II malocclusion was also shown in this study to be quite variable. The average position of the maxilla was found to be neutral relative to cranial and cranial base structures. Of those cases with the maxilla in an abnormal position, there were more cases of maxillary skeletal retrusion than maxillary skeletal protrusion in this sample. Maxillary skeletal retrusion was usually found in conjunction with excessive vertical development. Solow and Kreiborg ('77) suggest that a lowering of the mandible, usually prompted by altered respiratory function, may induce a stretching of the facial soft tissue layer. These tissues can then inhibit the forward develop-

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ment of the nasomaxillary complex. The results of this study seem to support that hypothesis. Subjects having retrusive maxillary and mandibular skeletal positions and excessive vertical development numbered 12 in this study, the second most common combination.

Excessive vertical development is a frequent characteristic in Class II malocclusion and may be one manifestation of altered respiratory function. Linder-Aronson ('70) showed that one of the characteristics of patients requiring adenoidectomy is a steep mandibular plane angle; Harvold (Harvold *et al.* '73 and Harvold '79; Miller and Vargervik, '79) state that experimental closure of the nasal airway in monkeys often leads to an increase in the mandibular plane angle and vertical face height. The current study indicates that there may be some association between altered respiratory function and some Class II malocclusions.

The method of analysis of the maxillary dentition is of critical importance in determining the role of the maxillary teeth in a Class II malocclusion. Measurements relative to the maxilla, such as upper incisor to point A or upper incisor to N-A, indicate that protrusion of the maxillary dentition occurs less frequently in Class II malocclusion than has been stated in previous studies (e.g., Drelich, '48; Riedel, '52; Rothstein, '71). When the relationship of the upper incisor to the A-Po line is measured, the upper incisor is generally found in a protrusive position. It appears that measures of maxillary dental protrusion based on a mandibular reference point may be expressing only mandibular skeletal retrusion, not incisor protrusion.

Only one measurement of mandibular dental position was used in this report. The lower incisor is generally well positioned relative to the A-Po line. This supports the findings of Solow ('66) that the position of the mandibular central incisor is more related to maxillary skeletal structures than to mandibular skeletal structures. The position of the lower incisor often may be an adaptive response to the position of mandibular skeletal structures relative to maxillary skeletal structures. Note, however, the significant number of cases with both mandibular skeletal retrusion and mandibular dental protrusion. These dental relationships may be an expression of labial and lingual postural muscle activity.

Summary and Conclusions

The purpose of this study was to determine the frequency of occurrence of key components of Angle Class II malocclusion in order to evaluate the appropriateness of existing therapeutic approaches. Lateral cephalometric radiographs of 277 individuals between the ages of 8 and 10 years were studied for the presence and distribution of four horizontal components and one vertical component.

The following conclusions can be drawn:

1. Class II malocclusion is not a single clinical entity. It can result from numerous combinations of skeletal and dental components.

2. Only a small percentage of the cases in this study exhibited maxillary skeletal protrusion relative to cranial and cranial base structures. On the average, the maxilla was in a neutral position, and when not in a neutral position, it was more often in a retruded than protruded position.

3. The degree of maxillary dental protrusion observed in this study was

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less than that reported by most previous investigators.

4. The lower incisors were usually well-positioned, but cases of mandibular dental retrusion and protrusion were also noted.

5. Mandibular skeletal retrusion was the most common single characteristic of the Class II sample.

6. Although a wide variation in vertical development was observed, almost half of the sample exhibited excessive vertical development.

Abnormalities in both the horizontal and vertical development of the mandible are the most common components of Class II malocclusion. Maxillary skeletal protrusion is not a common finding; in fact, more cases of maxillary retrusion were observed. Thus, it appears that in designing the ideal treatment regime, those approaches which might alter the amount and direction of mandibular growth could be more appropriate in many cases than those which restrict maxillary development.

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