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A SERIAL HEADFILM EVALUATION OF ADENOID RELATIONSHIPS DURING FACIAL GROWTH

by

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ABSTRACT

Nasorespiratory function and its relation to craniofacial growth is of great interest today for clinicians and researchers involved in treatment of dentofacial deformities. Successful treatment may depend on recognizing and addressing the factors causing such deformities. Developmental effects of altered nasorespiratory function and morphology on the ultimate size and shape of the craniofacial complex are presently incompletely understood.

This study evaluated relationships between morphology and growth in the craniofacial complex involving enlarged adenoids. Specific structural differences with and without adenoidectomy were determined at successive age levels, and the nature of developmental changes subsequent to adenoidectomy was accounted for with regard to morphogenic pattern. The Counterpart Analysis was utilized for serial headfilm evaluation. Records of 54 individuals, obtained from the Bolton-Brush Study Center, were divided into 3 groups. Group I comprised 18 cases having excessive adenoid tissues without adenoidectomy. Group II comprised 13 cases with adenoidectomy at age 10 years. Group III consisted of 23 cases with adenoidectomy before age 6 years. Tracings were prepared from lateral headfilms at 6, 8, 10, 12, and 14 years, and comparisons made on the nature and incidence of anatomical dif-

ferences.

The findings led to the following conclusions:

1. Group III (adenoidectomy before age 6 years) demonstrated that the composite of regional, part-to-part relationships essentially sustained the existant early pattern from ages 6 to 14 years. The growth process in this group, with early adenoidectomy, stabilized to a greater degree than in the other groups.

2. With constrained nasopharyngeal space, counterclockwise rotation of palatal alignment occurred in Groups I and II.

3. Counterclockwise rotation of the palate stabilized in Group II, following adenoidectomy, by age 14 years.

4. The Class III tendency of mandibular size relative to the maxilla sometimes expressed as a downward/backward rotation (skeletal open bite tendency) in Groups I and II (preoperative period). After adenoidectomy in Group II, this condition stabilized. Skeletal open bite was actually noted in 2 cases in Group I.

5. Marked divergency between the jaws occurred in Group I between ages 6 and 10 years, and this continued to a lesser degree. In Group II, divergency increased during pre-operative periods, but after adenoidectomy, it stabilized.

6. In Groups I and II (during preoperative periods), downward rotation of the mandibular and gonial angle opening were greater than in Group III. After adenoidectomy in Group II, upward rotation of the mandibular plane and closed gonial angle occurred.

7. In Group I, imbalanced relationships among regional anatomic parts, involving the MCF alignment, the ramus alignment, the PM vertical dimension, the corpus/occlusal alignment, the occlusal plane, and the palatal plane alignment, stabilized without significant change after 12 years.

8. After adenoidectomy in Group II, imbalanced relationships that had existed became stabilized.

9. In Group I between ages 6 and 8 years, and also 10 and 12 years, marked changes occurred in regional relationships involving the aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A/B points, the PM

vertical dimension, the skeletal horizontal arch lengths at A/B points, the palatal plane alignment.

10. The adenoids are to be regarded as a significant factor leading to morphogenic changes of regional parts throughout the craniofacial complex.

11. Adenoidectomy has a direct morphogenic effect on subsequent craniofacial pattern.

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DEDICATED

TO

My parents, Mr. and Mrs. Kwang-shik Choi,
who have made my education possible, and
who have waited patiently for so long.

and

My wife, Jin, for her love and under-
standing. She will now no longer be a
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INTRODUCTION

Nasorespiratory function and its relation to craniofacial growth is of great interest today for clinicians and researchers involved in the treatment of dentofacial deformities. Successful treatment may depend on recognizing the factors causing such deformities.

The nature of relationships between nasorespiratory function and craniofacial growth has been debated for many years. The developmental effects of altered nasorespiratory morphology and function on the ultimate size and shape of the craniofacial complex are presently incompletely understood.

The adenoids have often been regarded as a principal factor underlying the causes of abnormal growth changes in craniofacial morphology, although the factors involved are unquestionably multiple. Many investigative approaches have been utilized, including clinical observations, aerodynamic studies, experimental animal procedures, the use of computer tomography and xeroradiography, and cross-sectional and longitudinal cephalometric studies. Numerous theories have been proposed to account for the morphogenic observations. It has been asserted on the one hand that adenoids combined with mouthbreathing lead to special facial characteristics and, on the other, that this combination has no such effect.

Some authors hypothesize that enlarged adenoids leading to mouthbreathing during childhood exert a lasting influence on the dentition and facial configuration, and causes the so-called "adenoid face." This facial type, as commonly described, is characterized by a retrognathic mandible, protruding maxillary anterior teeth, a high palatal vault, a constricted maxillary arch, a flaccid and short upper lip, flaccid perioral musculature, and a somewhat dull appearance due to a constant, mouth-opened posture.

Other authors, however, hold that adenoids have no influence on the development of any special type of dentition or craniofacial morphology.

It is, therefore, timely that the diagnosis and prognosis of abnormal conditions in the nasopharyngeal function be clarified, with an evaluation of possible implications with regard to craniofacial growth. Since there appears to be considerable uncertainty concerning relationships among the occurrence of adenoids and specific types of dentition or morphologic craniofacial characteristics, the purpose of the present study is to evaluate these relationships utilizing the counterpart analysis for serial headfilms.

LITERATURE REVIEW

The relation of nasorespiratory function to craniofacial growth has been investigated by many authors, and discussions on this topic have appeared in the literature for over a century. However, opinions are still diverse and often conflicting despite the abundant literature on the subject. There is no universal agreement regarding the possible variety of effects of altered nasorespiratory function on the growth of the facial complex.

In an effort to catagorize the questions involved, the following review will focus on three separate premises, as proposed by Linder-Aronson (1970). These are:

1. Enlarged adenoids in certain types of faces and dentitions lead to mouthbreathing.
2. Enlarged adenoids leading to mouthbreathing results in a particular type of facial form and dentition.
3. Enlarged adenoids leading to mouthbreathing do not substantially influence facial form or type of dentition.

In addition, a review dealing with the size and the growth pattern of the adenoid tissues will be presented.

Size and Growth

Enlarged adenoids increase the chances of constricting the nasopharyngeal airway. Consequently, a relationship between the size of the bony nasopharynx and the size of the adenoids is of particular importance (Ricketts, 1954; Subtelny, 1954; and Linder-

Aronson, 1970). When the nasal and pharyngeal lumina are narrow, they can more easily become occluded. Brash (1929) mentioned that even very small adenoids may cause mouthbreathing, and this hypothesis is recurrent in many present-day textbooks (Mitchell-Nelson, 1945; Steuer, 1947; and Negus, 1955).

The importance of nasopharyngeal volume has been emphasized by Bernfeld (1927) in cases of nasal obstruction associated with enlarged adenoids. He pointed out that the size and configuration of the nasopharynx is of prime importance to the problem of potential airway obstruction. Lubarth (1960) also maintained that children often have a small nasopharynx, so that nose breathing may be impeded by only a moderate enlargement of adenoids.

Lymphoid tissue is normally present in the form of a series of tonsilar masses known as the "ring of a Waldeyer" (DuBrul, 1980). If the nasopharyngeal lymphoid tissue becomes so hypertrophied that clinical symptoms exist, it is denoted as an "adenoid vegetation or adenoids." This enlarged lymphatic mass usually develops during childhood, and marked symptoms become most common between two and twelve years of age (Linder-Aronson, 1970).

Subtelny (1954), using the combined methods of cephalometric roentgenography and cephalometric laminagraphy, found that adenoid tissue follows a definite growth pattern. Adenoid tissue grows predominantly downward and forward, in concert with other pharyngofacial components, more rapidly during the early postnatal period to approximately age 3 years, and then at a declining rate until its

greatest size is attained. In Subtelny's sample, the peak mass was reached as early as 10-11 years of age, but sometimes not until 14-15 years of age. After the peak of adenoid growth is reached, the growth process seems to reverse itself, and the adenoid tissue then progressively decreases in mass. By adulthood the adenoids slowly become diminished in size so that some time during late adolescence they are reduced to adult dimensions (Todd, 1936; Ballenger, 1943).

It is of importance to remember that this lymphoid tissue is growing within a constantly changing morphologic and functional environment -- the pharyngeal cavity itself is continuously growing and changing in configuration (Subtelny, 1954). Much is known concerning the vertical growth of the nasopharynx.

King (1952) stated that the vertical dimension of the nasopharynx normally continues to increase until approximately 17-18 years of age, at which time the maxilla essentially completes its growth. Rosenberger (1934) presented longitudinal data on human material, and he concluded that growth of the cranial base makes a significant contribution to the forward positioning of the face. This increases the depth of the pharynx by the amount equalling such growth. Ricketts (1954) and Bergland (1963) also demonstrated a positive correlation between the cranial base and nasopharyngeal depth; the more obtuse the cranial base, the greater the depth. Ricketts pointed out that the effective vertical dimension of the airway space is influenced by the adenoid tissue, but the actual

size of the adenoids was not as important as the available space it filled. Equal amounts of adenoid tissue can have different effects depending upon the size and form of the bony nasopharyngeal compartment.

As mentioned, Todd (1936) found that obstruction of the postnasal space by adenoidal enlargement tends to disappear as growth of the former occurs in conjunction with either no further enlargement or reduction in size of the latter. In other words, as the size of the nasopharynx increases during growth, the relative size of the lymphoid masses becomes smaller, and in the adolescent stage even large lymphoid masses can tend to become less obstructive. This circumstance seems to be supported by the classic growth curve published by Scammon (1930). He pointed out that hyperplasia of all the lymphoid tissues of the body normally occurs in children between two and six years of age. This is a period characterized by physiologic lymphoid hyperplasia. Scammon applied a lymphoid growth curve to tonsils and adenoids and noted a rapid rise during infancy and early childhood. This was followed by a continued but slower increase during late childhood and puberty, peaking before adolescence and then gradually declining thereafter to adult values.

However, Pruzansky (1975) pointed out that tonsilar and adenoidal lymphoid tissues do not necessarily involute simultaneously and that the adenoids may begin to shrink in mass before the onset of puberty. He also stated that Scammon's curve of lymphoid

behavior may not apply in all cases.

Subtelny and Baker (1956) emphasized that growth in the nasopharyngeal area must strike a fine state of equilibrium between the pace of adenoid tissue growth and that of the surrounding structures if the airway is to be maintained. Sometimes, however, there can occur a disturbance in this balance -- adenoid tissue can increase in mass at a faster rate than the secondary displacement and corresponding enlargement of the palate (King, 1952). This may cause, by an approximation or near approximation of the adenoid tissue with the superior surface of the soft palate, a blockage of the nasopharyngeal cavity.

In support of the above finding, Vig (1974) expanded this hypothesis to include other enlarging soft tissues as well -- the tongue and the pharyngeal musculature. He suggested that any proportionate change between skeletal and soft tissue components would be expected to alter spatial equilibrium, and this in turn can affect contiguous dento-alveolar structures.

I. Premise: Enlarged Adenoids in Certain Types of Faces and Dentition Lead to Mouthbreathing

Adenoids have long been regarded as one of the chief causes of mouthbreathing, although the factors involved are unquestionably multiple. Throughout the history of orthodontics, there have been many proponents of this concept, but many other investigators have disputed the possible role of mouthbreathing as a clinically significant factor underlying molocclusion.

As early as 1872, Tomes stated that V-shaped, constricted jaws can be generally found in association with greatly enlarged tonsils and adenoids which necessitated mouthbreathing. He considered that the physical forces at work -- namely, open lips and relaxed tongue -- are sufficient to account for all the phenomena observed.

Howard (1932) reviewed 500 patients with histories of tonsil problems. Of the 159 patients he classified as mouth breathers, 59% presented with normal occlusions, 14% with Class II malocclusions and 27% with either Class I or Class III malocclusions.

Emslie, Massler, and Zwemmer (1982) noted that in children with a narrow nasopharyngeal passage, even physiological enlargement of lymphoid tissue in the nasopharyngeal region may act as an obstruction and lead to mouthbreathing. Reed (1963) also reported that enlarged adenoids are the most common cause of nasopharyngeal obstruction with mouthbreathing as a consequence. Linder-Aronson (1970), in a comprehensive study of 162 children, related the size of the nasopharynx and adenoids to histories of mouthbreathing, and he concluded that adenoids lead to mouthbreathing primarily in those children having a small nasopharynx. Quinn (1978) stated that dramatic deformities of the face, jaws and dentition can be caused by the inability to breathe properly through the nose. He concluded that mouthbreathing is one of the early symptoms of such underlying developmental conditions.

However, as mentioned earlier, it should be pointed out

again that adenoidal size itself is not necessarily a primary concern, as emphasized by several authors (Subtelny, 1954; Ricketts, 1954; and Moyers, 1963).

Subtelny (1954) found, in a longitudinal study on adenoidal changes in configuration with age, that adenoids do not cause mouthbreathing unless they occupy a major portion of the nasopharynx. Moyers (1963) and Ricketts (1954) also emphasized that enlargement of the adenoids can cause mouthbreathing, but that the absolute size of the adenoids is not as important as the size of adenoids relative to the nasopharynx.

II. Premise: Enlarged Adenoids Leading to Mouthbreathing Results in a Particular Type of Facial Form and Dentition

The relation of mouthbreathing to malocclusions and deformities of the jaws, especially a narrow maxilla, has been extensively described (Bloch, 1903; Howard, 1932; Balyeat and Bowen, 1934; Leech, 1958; and Linder-Aronson, 1960). Studies of relationships of airway resistance to facial type were considered to be relevant.

Linder-Aronson and Backstrom (1960) compared facial type and type of occlusion between nose breathers and habitual mouth breathers. They found that children with long, narrow faces have greater nasal resistance, on the average, than those with short, wide faces. Children with a high, narrow palate tend to have greater nasal resistance to airflow than those with a low, wide palate. They also found that there is no direct relationship between mouth-

breathing and type of occlusion, particularly with regard to overbite and overjet.

Linder-Aronson and Woodside (1979) studied serial frontal and lateral headfilms from the Burlington Growth Study. They selected 22 of 120 males in the group who showed high or increasing lower face height and noted that the mean size of the nasal part of the airway and/or the nasopharynx was narrower than in the control group. They concluded that there is support for the concept that some facial characteristics previously thought to be skeletal or genetic in origin may also be created by environmental impact.

Dunn and associates (1973) reported the relationship between variations in pharyngeal airway size and the morphology of the mandible using two groups of monozygote twins. They found that bigonial width and gonial angle variations are inversely related to nasopharyngeal airway size variations. Linder-Aronson noted a case, reported by Bushey (1979), of monozygotic twins in which only the twin member having nasal obstruction developed excessive anterior face height. It was postulated that oral respiration establishes new neuromuscular patterns which, in turn, are expected to correlate with morphological changes.

In the earlier investigations of Linder-Aronson (1972, 1973), it was found that the sagittal depth of the bony nasopharynx was influenced by the mode of breathing. In children who were predominantly mouthbreathers, the nasopharynx was smaller than that found in nose breathers of the same age. Following a change to

nosebreathing, the depth of the bony nasopharynx became normalized. This may be explained, in part, by a change in the muscle tone of the muscle ring consisting of the orbicularis oris, the buccinator and the superior constrictor and, in part, by altered muscle tone due to the accompanying change in posture of the head and jaws (Ricketts, 1958; Solow, 1976).

In support of these findings, relationships between airway obstruction and craniofacial growth have been demonstrated by means of experimental investigation.

Certain functional and morphologic traits which are developed in the rhesus monkey in response to nasal airway obstruction were reported in the experimental studies by Harvold (1973, 1975, 1979, 1981). In these experiments latex plugs were inserted into the nasal chambers of a group of young rhesus monkeys. The facial growth process in these animals gradually adapted from a pattern of nasal respiration to oral respiration. Harvold found that morphologic alterations were not uniform among the animals, but varied depending upon the preferred positioning and movements of the tongue and mandible to accommodate oral respiration. He showed that the more significant changes were associated with changes in positioning rather than the rhythmic movements of craniofacial muscles.

Similar findings were reported by Ricketts (1958) in studies on the nasopharyngeal and orophasyngeal relationships before and after adenotosillectomy in children. The objective was a determination of the influence of nasopharyngeal conditions on tongue posture.

He stated "adenoids have been shown to be of significance in the postural relationship of the tongue and that, by indirect alteration of tongue and lip function, they can influence dental development."

Miller and Vargervik (1979) focused on the correlation of changes in cranioskeletal morphology with adaptations of the neuromuscular system during long-term adaptation of the rhesus monkey to oral respiration. They concluded that experimentally induced alterations of nasorespiratory function modifies sensory feedback which reflexively induces changes in neuromuscular function of craniofacial muscles. Thus, long-term changes in craniofacial function correlate with changes in soft tissue, and these precede the morphological adaptations of the craniofacial skeleton.

Subtelny (1980) agreed with the above concept and stated that the necessity for oral respiration creates postural changes. With the lips apart, the mandible must reposture in a downward and forward position away from the soft palate to open an oral-pharyngeal airway channel. Bosma (1963) stressed that the postnatal development of head and neck posture parallels the stabilization of the pharyngeal airway, and that the development of sight, hearing and vestibular orientation are other guiding mechanisms for the stabilization of an upright head posture.

Ricketts (1968) reported that in subjects with excessive adenoid development, a forward and downward tongue posture and extension of the head is seen, apparently caused by an effort to in-

crease the airway. After removal of the adenoids, elevation of the tongue and downward flexion of the head were noted.

Solow and Greve (1979) found that rotating the whole head upward and backward relative to the cervical vertibral column is associated with a large nasal respiratory resistance in conjunction with a narrow passage between the adenoidal tissue and choanae. They pointed out that the smaller the distance between the adenoids and the choanae, as seen in lateral headfilms, the larger the craniocervical angle.

A similar finding was demonstrated by Woodside and Linder-Aronson (1979), who showed that the position of the head is raised relative to the true vertical plane in subjects with nasopharyngeal obstruction due to enlarged adenoids. Vig (1980) agreed that it is possible that, if altered posture is maintained for a sufficient time during growth, permanent changes in musculoskeletal relations may be produced.

In experimental studies, the occurrence of a relationship between morphology and head posture has been supported by the demonstration of craniofacial morphological changes in animals following artificially induced changes in body posture. These studies (Harvold, 1973, 1975, 1979, 1983; Ricketts, 1958, 1968; Miller and Vargervik, 1979; Subtelny, 1980; Solow and Greve, 1979; Woodside and Linder-Aronson, 1979; and Vig, 1980) seem to show that moderate cranial extension decreases the resistance to airflow in the upper airway passages.

Several authors (Bloch, 1903; Michel, 1908; and Kantorowicz, 1916) postulated that oral respiration alters normal air flow and pressure through the nasal and oral cavities, which in turn relates to impaired development of these structures. Those authors proposed that this is the result of the oral airstream in mouth-breathing individuals leading to a higher palatal vault, and hindering normal downward palatal growth (Bloch, 1903; Michel, 1908, cited by Bushey, 1979).

The air pressure theory was proposed by Kantorowicz in 1916. He believed that the raised negative air pressure difference between the oral and nasal passages in mouth breathers lead to development of a deep palatal vault. It was a different way of thinking from the classical compression theory proposed by Tomes (1872), who reported that children with enlarged adenoids usually displayed V-shaped dental arches. He found that this characteristic narrowing in the upper arch was the result of an unbalanced musculature with a low tongue position, excessive compressive force on the maxillary arch buccal segments, and an atrophic lip development caused by mouthbreathing.

As early as 1889, Bloch (cited by Bushey, 1979) believed that the high palate which develops when there is an impediment to nasal breathing is a result of the upward direction of the air stream which impinges on the palate in mouth breathing. Airflow through the respiratory tract is subject to resistance at various levels. Changes in the dimensions of the respiratory tract, i.e.,

constriction or obstruction of the tract, will decrease airflow (Solow and Greve, 1979; Warren, 1979). Warren pointed out that when changes in airway resistance modifies airflow, respiratory muscles must increase their work to produce changes in intrapulmonary pressure sufficient for air to be moved in and out of the alveoli. Moss and Salentijn (1969) and Frankel (1976) also agreed that pressure from the airflow through the nasopharynx may influence growth of the nasopharynx.

The concept of environmental impact on craniofacial growth is well explained by van Limborgh (1970, 1983). He arrived at the conclusion that the growth of the desmocranium, i.e. the calvaria and the facial skeleton, is mainly controlled by local epigenetic influences originating from both the chondrocranium and other adjacent head structures. He concluded that desmocranial growth is significantly influenced by local environmental factors, particularly muscular forces.

III. Premise: Enlarged Adenoids Leading to Mouthbreathing Do Not Substantially Influence Facial Form or Type of Dentition

While the foregoing descriptions in Premise I and II (above) carries a logical thinking, some authors nevertheless hold the opposite opinion, namely that a characteristic adenoidal facial expression ("Adenoid faces") is not necessarily directly associated with mouthbreathing, and that not all mouth breathers have a certain type of malocclusion.

As early as 1888, Kingsley mentioned that he could not accept the view of Tomes' (1872) compression hypothesis. He felt that the V-shaped palate was inherited and not acquired through mouthbreathing. Brash (1929) stated "It is still to be proved that there is any significant correlation between the presence of adenoids and the incidence of deformity of the jaw and palate." He suggested heredity as the most likely factor.

Sillman (1942), reporting on serial studies from birth to five years of age, expressed the opinion that mouthbreathing does not appear to be a primary cause of malocclusion. Huber and Reynolds (1946) examined 500 male students and discovered that only 27 were mouthbreathers (no finding for the non-mouth breathers). On examination of these 27, it was found that the occlusion of only one was anatomically correct; 16 cases were Class I, 8 were Class II, and 2 were Class III (Angle's classification).

Humphreys and Leighton (1950) examined the mode of breathing in a sample of over 1,000 children, 2.5 years to 5 years of age. They found only 6 children who were totally mouth breathers. Almost 50% of the 500 Class II subjects in the sample had their mouths habitually open but breathed exclusively through their noses.

BACKGROUND OF THE COUNTERPART ANALYSIS

Various methods for the analysis of lateral cephalometric radiographs have been utilized, and most have been based on population norms or means. Most such conventional methods are intended to determine "what" a particular craniofacial growth pattern is as compared with population standards. The various planes and angles used do not usually have any specific relation to actual fields and sites of growth and remodeling throughout the craniofacial complex.

The displacement movements of bones that occur during growth and the regional remodeling and enlargement changes that accompany them frequently follow divergent courses, thereby greatly complicating morphogenic analyses and the understanding of the overall craniofacial growth processes. This problem is the basis for many of the interpretative difficulties that are encountered in conventional cephalometric analyses.

For a more "anatomical" approach to cephalometric analysis, first, the many regional morphologic components of the craniofacial skeleton must be considered separately before they can be assembled into a composite of the craniofacial complex as a whole. Only then can the numerous facets of the aggregate mechanism be understood and the nature of their specific regional roles determined.

The objective of the Counterpart Analysis is to evaluate

the nature of "anatomic fit" among the different structures of the craniofacial complex in one individual at any given age or through time. This analysis explains essentially "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.

The Counterpart Analysis includes two aspects: one is a "form analysis" which deals with facial pattern, construction and dimensions; the second is a "growth analysis" which is concerned with interpretations of incremental changes through time.

This analytic approach does not deal with the "fixed point" concept used in other routine types of analyses. Rather, basic growth principles related to the different facial bones are involved. This includes the various concepts associated with remodeling processes, the factor of progressive relocation, a consideration of directions involved in local growth, differential surface activities, and regional changes of parts relative to other anatomic parts.

This analysis shows where developmental and morphologic balances exist and where and to what the extent the anatomic effects of imbalances occur. The procedure shows the effects of alignment ("rotational") position of the regional parts relative to each other, and the anatomical effect of their sizes (vertical and horizontal) relative to one another. Alignment determinations are necessary in this analytic method because rotational position dir-

ectly affects the expression of a given dimension. The counterpart procedure involves the comparison of the alignment and dimensional relationships among the many regional anatomical parts with developmental and geometric counterparts. The structural effects of the complex interrelationships among them are determined directly, and comparisons with population norms are not ordinarily required.

The anterior cranial fossa, the palate, the maxillary arch, and the mandibular corpus are mutual horizontal counterparts with one another. The middle cranial fossa, the pharyngeal space, and the ramus, similarly, are horizontal counterparts. The ramus-middle cranial fossa composite is a vertical counterpart to the posterior part of the nasomaxillary complex.

In order to achieve anatomical fit among the individual bones of the skull during composite craniofacial growth, the progressive enlargement of any one bone or part of a bone must be accompanied by corresponding, proportionate growth and remodeling changes of the counterparts. Otherwise, disproportionate protrusions or retrusions of the part(s) occur, and this resultant effect is translated from region to region.

The planes and angles used in this analysis are designed to coincide specifically with key fields and sites of growth and remodeling (Enlow, 1982), which is the consideration that makes this procedure appropriate as an "anatomic" analysis. A built-in and morphologically natural set of "standards" is identifiable, and this allows a meaningful evaluation of over-all craniofacial form and pattern with no need for population comparisons.

STATEMENT OF THESIS

This study is an evaluation of anatomic and morphologic relationships in the growing craniofacial complex involving enlarged adenoids. Specific structural differences with and without adenoidectomy are described at different age levels, and the nature of developmental changes subsequent to adenoidectomy are determined and accounted for with regard to morphogenic pattern.

METHODS AND MATERIALS

The sample of cephalograms used in this study consisted of 54 cases obtained from the Bolton-Brush Study Center and was divided into 3 groups:

Group I: 18 cases having excessive adenoid tissues without adenoidectomy;

Group II: 13 cases which underwent adenoidectomy at age 10 years;

Group III: 23 cases which underwent adenoidectomy before age 6 years.

Group I

A sample of 18 cases with excessive adenoid tissues was selected at random without regard to sex or ethnic group. Each individual conformed to the following criteria:

1. Serial headfilms available for 5 time periods: ages 6 years, 8 years, 10 years, 12 years, and 14 years;
2. Upper pharyngeal width had an opening 5.5 mm or less from a point on the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall, during the period age 10 years to age 14 years, as seen in lateral headfilms;
3. No orthodontic treatment had commenced prior to taking the 14 year headfilm;
4. The quality of the headfilm was adequate for landmark identifications.

Group II

A sample of 13 cases was selected which conformed to the following criteria:

1. Serial headfilms available for 5 time periods: ages 6 years, 8 years, 10 years, 12 years, and 14 years;
2. Adenoidectomy had been performed at age 10 (9 years 6 months to 10 years 6 months);
3. No orthodontic treatment had commenced prior to taking the 14 year headfilm.

Group III

A sample of 23 cases was selected that satisfied the following requirements:

1. Serial headfilms available for 5 time periods: ages 6 years, 8 years, 10 years, 12 years, and 14 years;
2. Adenoidectomy had been performed before age 6 years;
3. No orthodontic treatment had commenced prior to taking the 14 year headfilm.

Technical Details

The lateral headfilms for all subjects used in this study were obtained using a Broadbent-Bolton Cephalometer.

Tracings were made, as necessary for representation of landmarks and points, on 0.003" acetate with a Pental (0.3 mm, 2H) lead drawing pencil. The angular values were made using a Dome protractor, and linear measurements with a compass. In cases of double shadows on headfilms, the geometric means were used for determining the course of the lines. The linear values were measured and read to the nearest 0.5 mm, and the angular values to near-

est 0.5 degree.

The assessment of airway clearance was determined utilizing McNamara's method (1983). The upper pharyngeal width was measured from a point on the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall as seen in lateral headfilms. Apparent airway obstruction was indicated by an opening of 5 mm or less in the upper pharyngeal measurement. A lateral headfilm which showed an inverted V-shape soft palate was not considered as airway obstruction. This configuration of the soft palate suggests that the individual was swallowing when the radiograph was taken.

Measurements

All points and planes necessary for the Counterpart Analysis (Enlow, 1971) were located and plotted by the investigator. Thirteen 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 protrusive (-) 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 effect exceeded 2.5 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.

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

Statistical Methods

Frequency distributions were determined for 13 variables in each of the 3 groups. Means and standard deviations were also computed for changes in lower facial heights.

The 13 variables examined were as follows:

1. Aggregate cranial floor/Maxilla and Ramus/Corpus horizontal dimensions at A and B points;
2. Middle Cranial Fossa (MCF) alignment;
3. Ramus alignment;
4. Posterior Maxillary (PM) vertical dimension compared with Ramus/MCF vertical dimensions;
5. Ramus/MCF horizontal dimensions (skeletal);
6. Ramus/MCF horizontal dimensions (dental);
7. Maxillary/Mandibular arches, skeletal dimensions, A point compared with B point;
8. Corpus/Occlusal alignment;
9. Mandibular plane alignment;
10. Gonial angle;
11. Occlusal plane alignment;
12. Palatal plane alignment.
13. Lower facial height.

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	Björk'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 anterior 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.

Figure 1. The points and planes used in the Counterpart Analysis are demonstrated. Solid lines represent the individual's own anatomic positions, while the dashed lines represent neutral positions. This diagram includes additions to the original constructions and procedures presented by Enlow (1971).

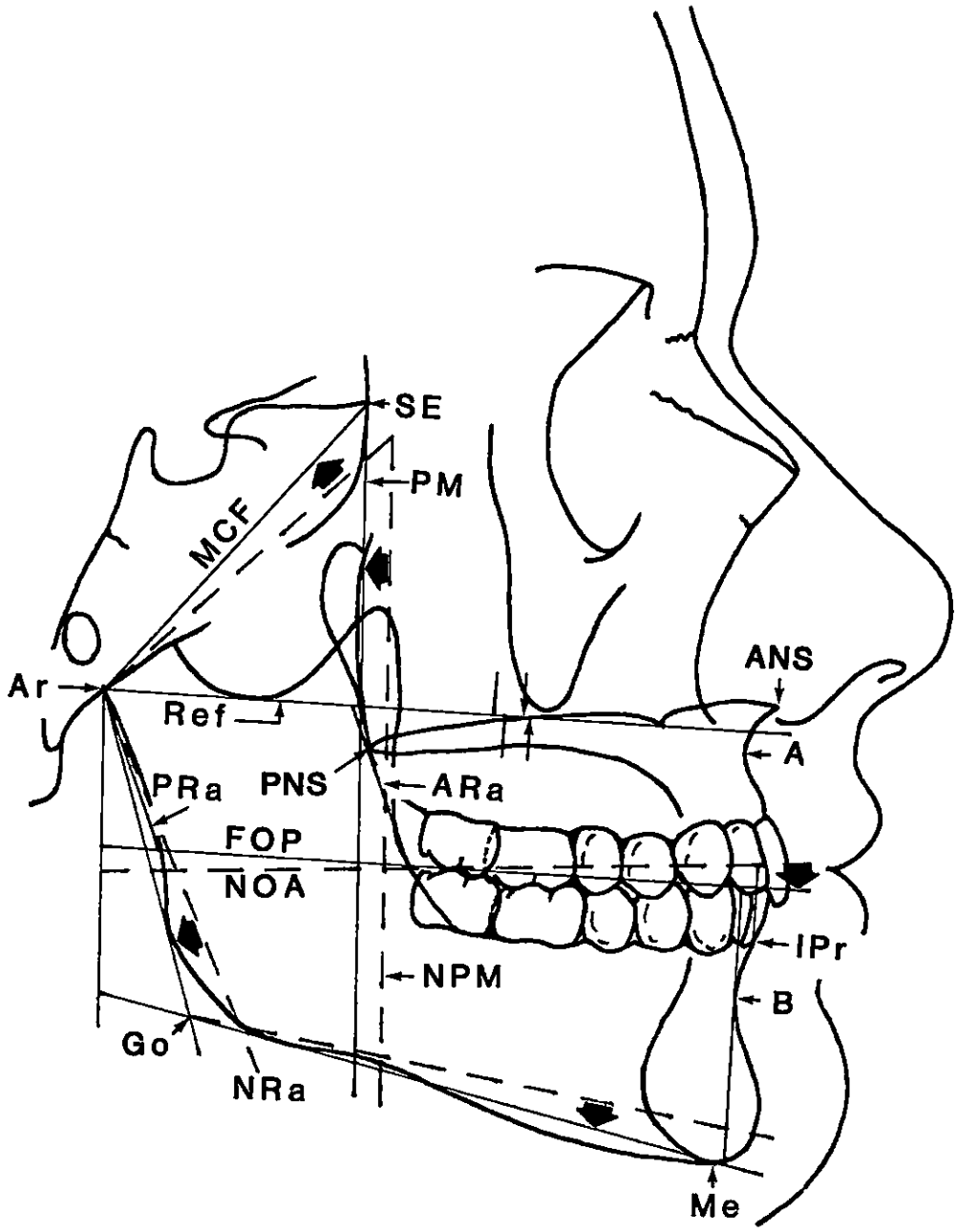

SE
PM
MCF
Ar
Ref
ANS
A
PRa
PNS
ARa
FOP
NOA
IPr
NPM
B
Go
NRa
Me

Figure 2. Aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A and B points. This diagram demonstrates the comparison of cumulative maxillary length from Ar to A point with cumulative mandibular length from Ar to B point. The lines from A point to Ref, and B point to Ref are drawn perpendicular to Ref. Measurements are made in millimeters along Ref. If A point is ahead of B point, a mandibular retrusive (+) effect occurs. If behind, a mandibular protrusive (-) effect is present. If both lines coincide, a neutral (0) effect exists.

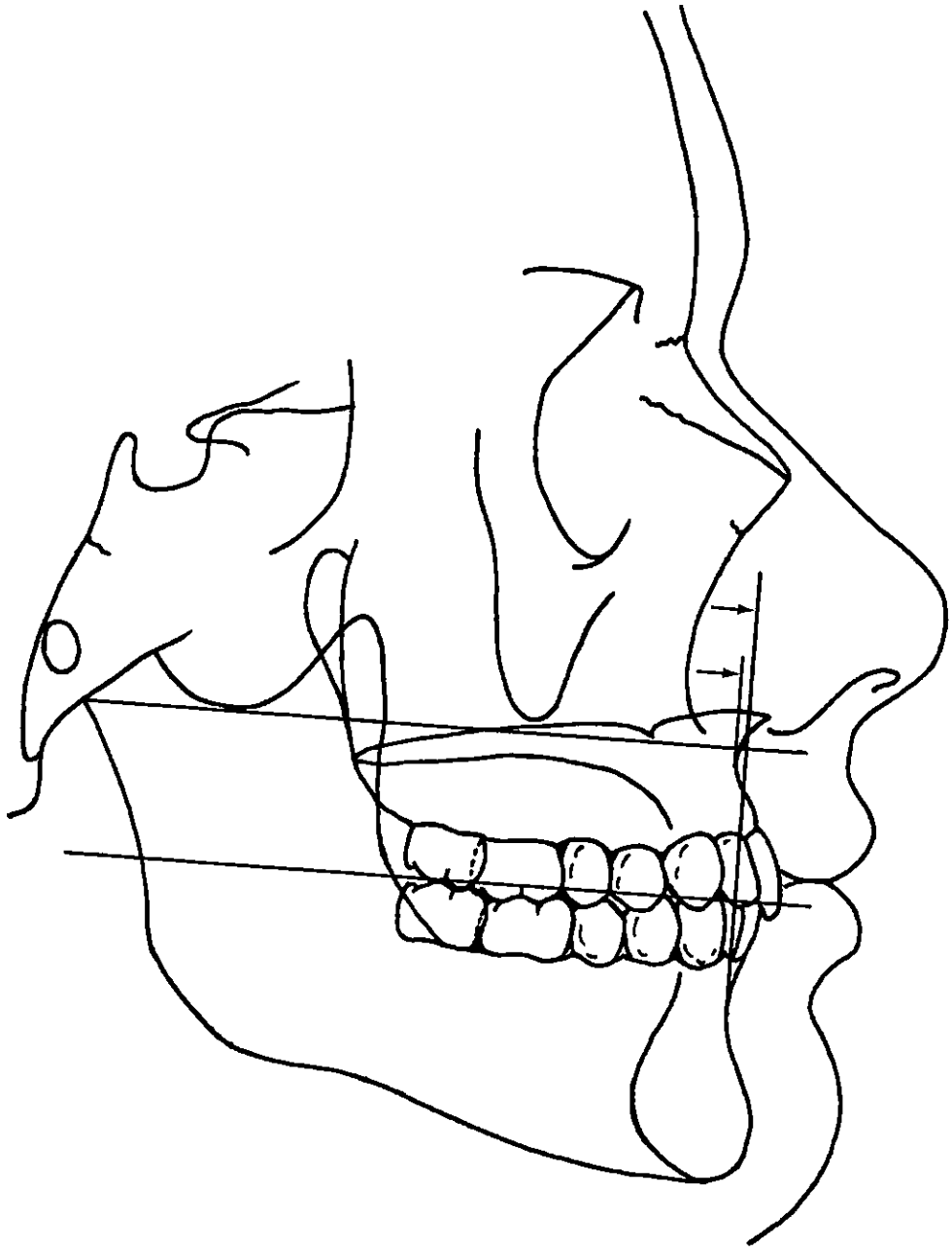


Figure 3. Middle cranial fossa (MCF) alignment. This diagram demonstrates the effects of rotational alignment of the individual's own MCF compared with the neutral MCF on corresponding maxillary and mandibular placement. A backward alignment (shown here) when compared with the neutral plane (dashed line) has a mandibular protrusive (-) effect. A forward alignment has a mandibular retrusive (+) effect. If the neutral MCF plane coincides with the individual's own MCF, a neutral (0) effect is present. To construct neutral MCF/PM, a separate preconstructed template is made consisting of two lines forming an internal angle of 40.3°. With dividers, determine the length of the individual's own MCF plane, then transfer this measurement to the corresponding line on the template. This step assures that the length of the individual's MCF and the neutral MCF will be the same. Place the tracing of the subject over the template superimposing on Ar and orienting the subject's PM vertical and the neutral PM parallel to each other. Draw the neutral MCF/PM with a dashed line on the subject's tracing. The distance between the neutral PM and the subject's PM vertical can now be measured along Ref in millimeters. When the subject's PM vertical lies behind the neutral PM, it is recorded as a (-) number. When it is in front of the neutral PM, it is recorded as a (+) number. When they coincide, it is recorded as (0).

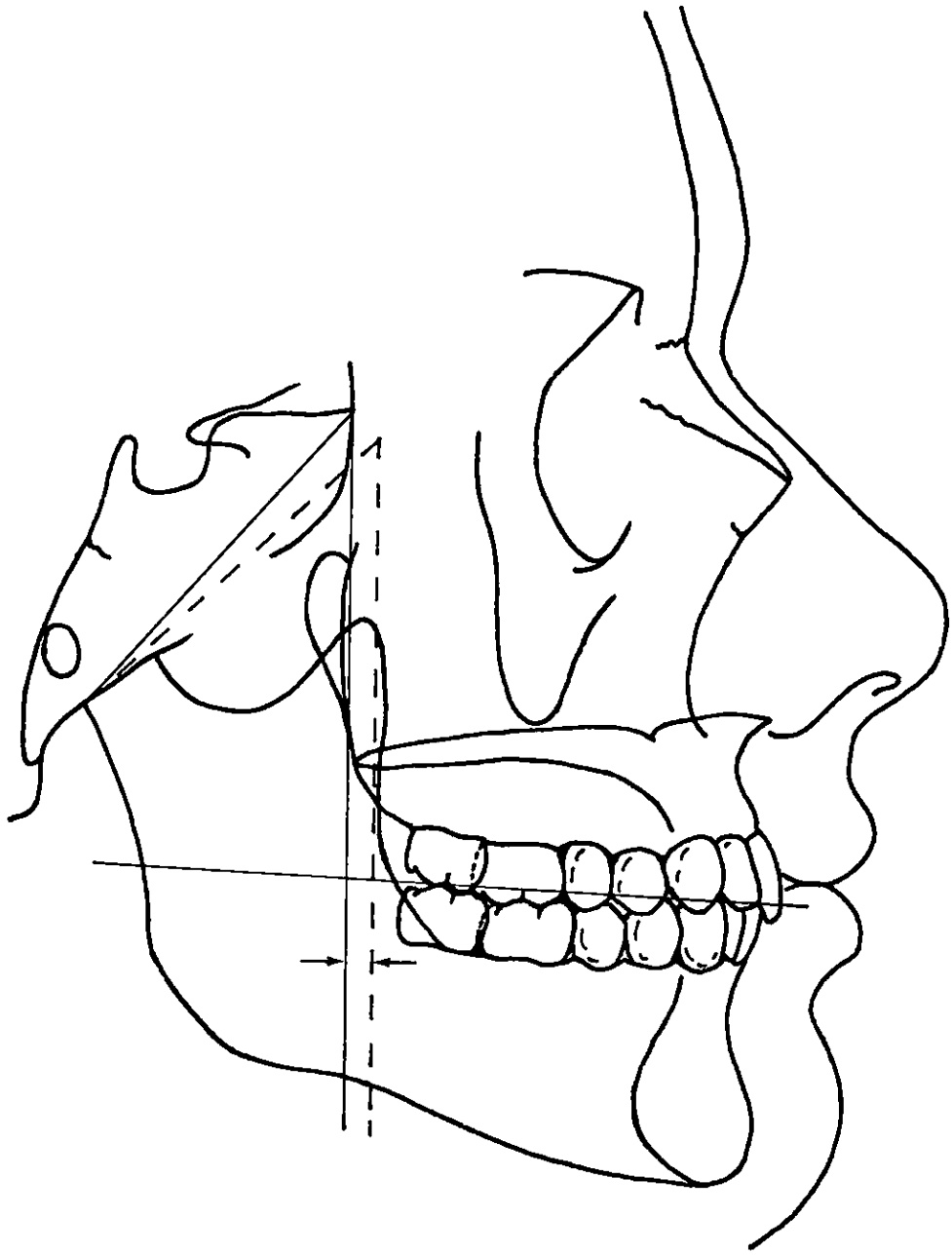


Figure 4. Ramus alignment. This measurement determines the direction and magnitude of ramus rotational alignment. The magnitude is determined by measuring the distance between the individual's ramus plane (Ar to Go) and the neutral ramus plane (NRa) where they intersect the functional occlusal plane (FOP). If the subject's ramus plane (Ar to Go) lies anterior to the neutral line (mandibular protrusive), it is given a (-) or (--) value, and if posterior to the neutral line (mandibular retrusive), a (+) or (++) value.

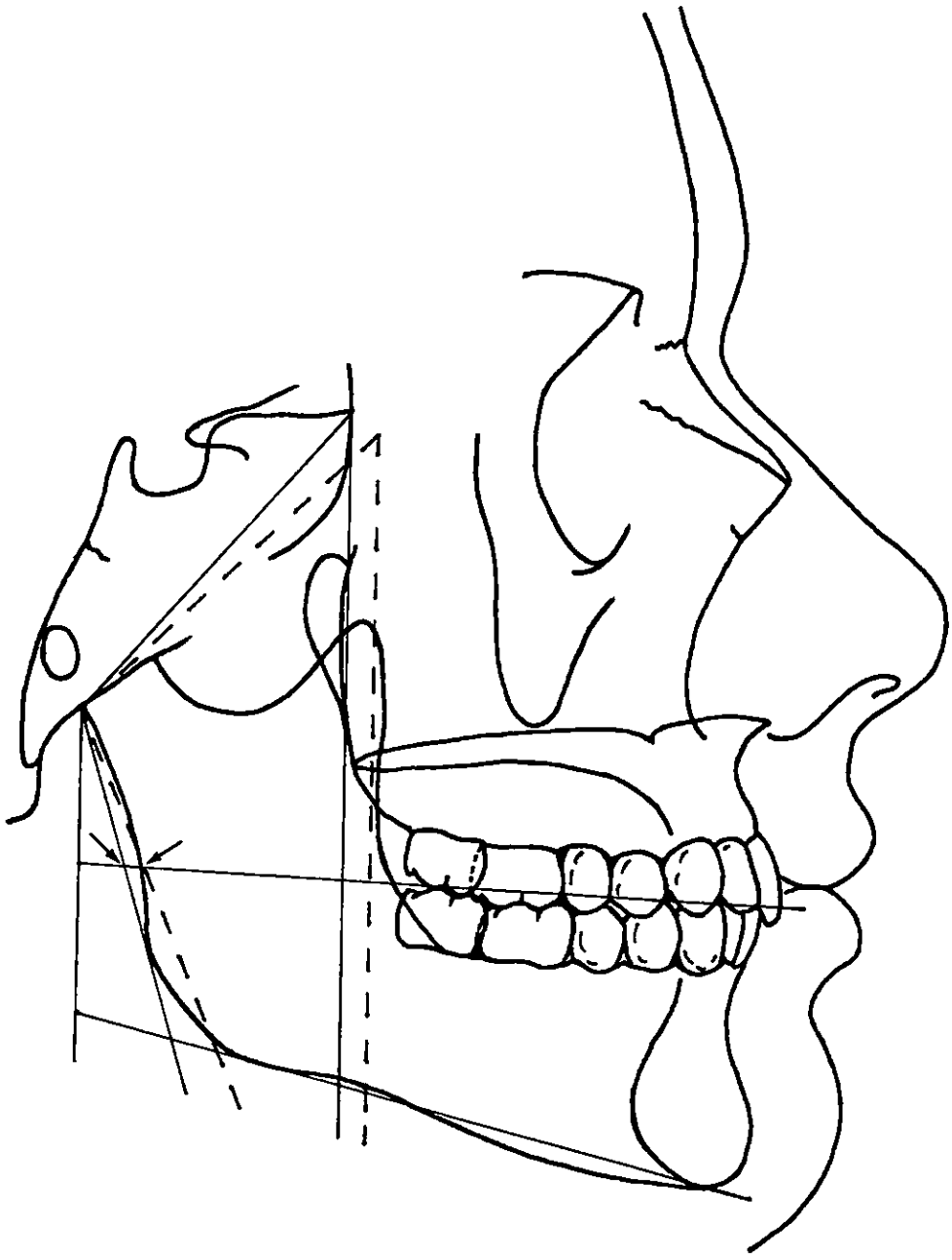


Figure 5. Posterior Maxillary (PM) vertical dimension compared with ramus/MCF vertical dimensions. The individual's own relative vertical length of PM is determined simply by comparing the direction and the extent of MCF rotation with the direction and extent of ramus rotation. The MCF rotation is determined by measuring the difference between PM and neutral PM along FOP. If PM is ahead of neutral PM, MCF has a forward and downward rotation. If PM is behind the neutral PM, the MCF has an upward and backward rotation. Ramus rotation is determined by measuring the difference between PRa and NRa along FOP. If PRa is ahead of NRa, the ramus has a forward rotation and if behind NRa, it has a backward rotation. Now, these two values (MCF value and ramus value) are compared with each other, and the composite effect is recorded as a "long" (+) or "short" (-) PM vertical dimension relative to the middle cranial fossa and the ramus. A schematic explanation is provided in Table III. This is a different consideration from any population tendency toward a vertically long or short midface as seen in various ethnic groups.

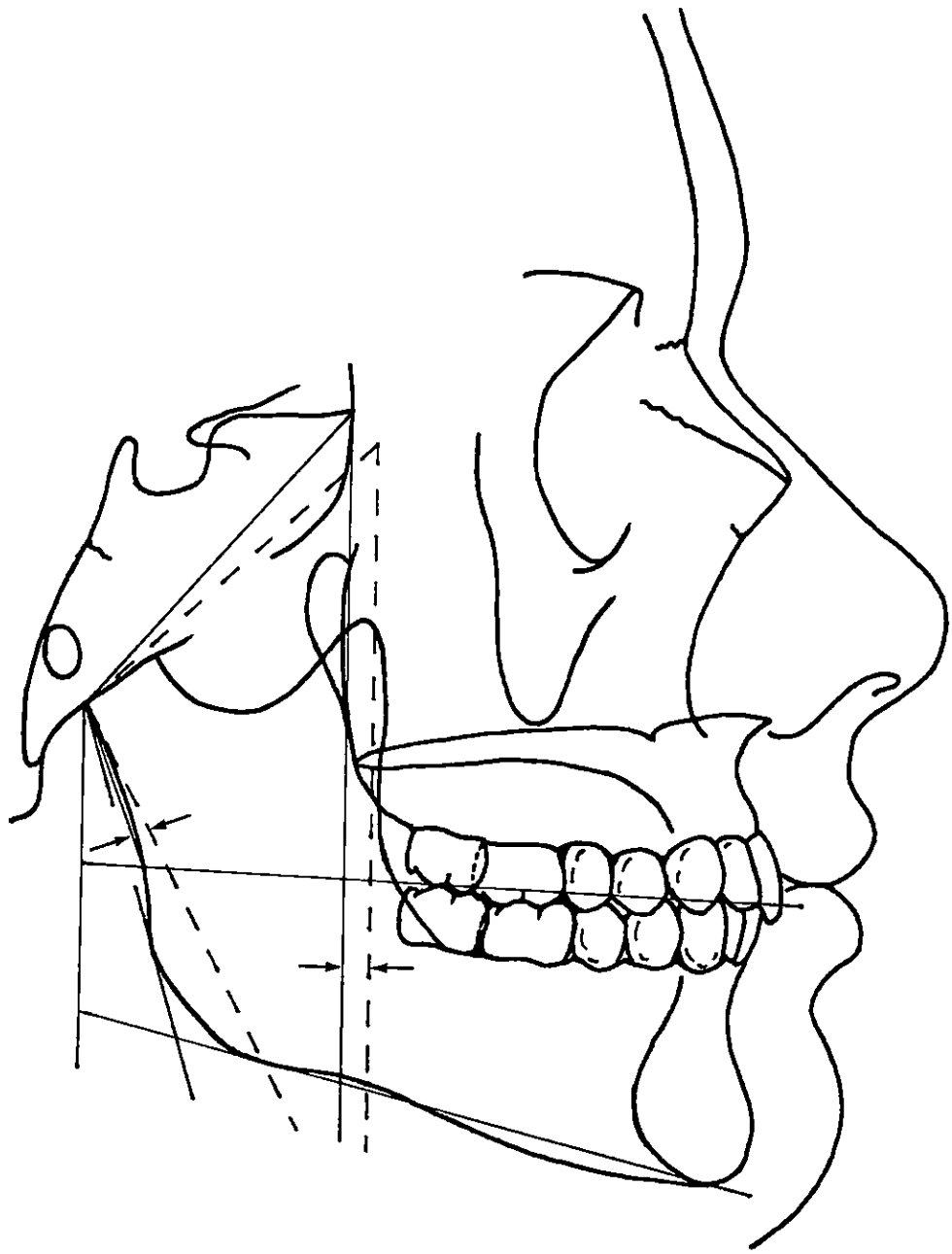


Figure 6. Ramus/MCF horizontal dimensions (skeletal). This diagram demonstrates the comparison of the horizontal dimensions of the middle cranial fossa with the width of the ramus. The distance from Ar to ARa and Ar to neutral PM are measured along Ref. A (-) effect occurs when the ramus width is greater than Ar to neutral PM, and a (+) effect when less. When the measurements are the same, a neutral (0) effect results.

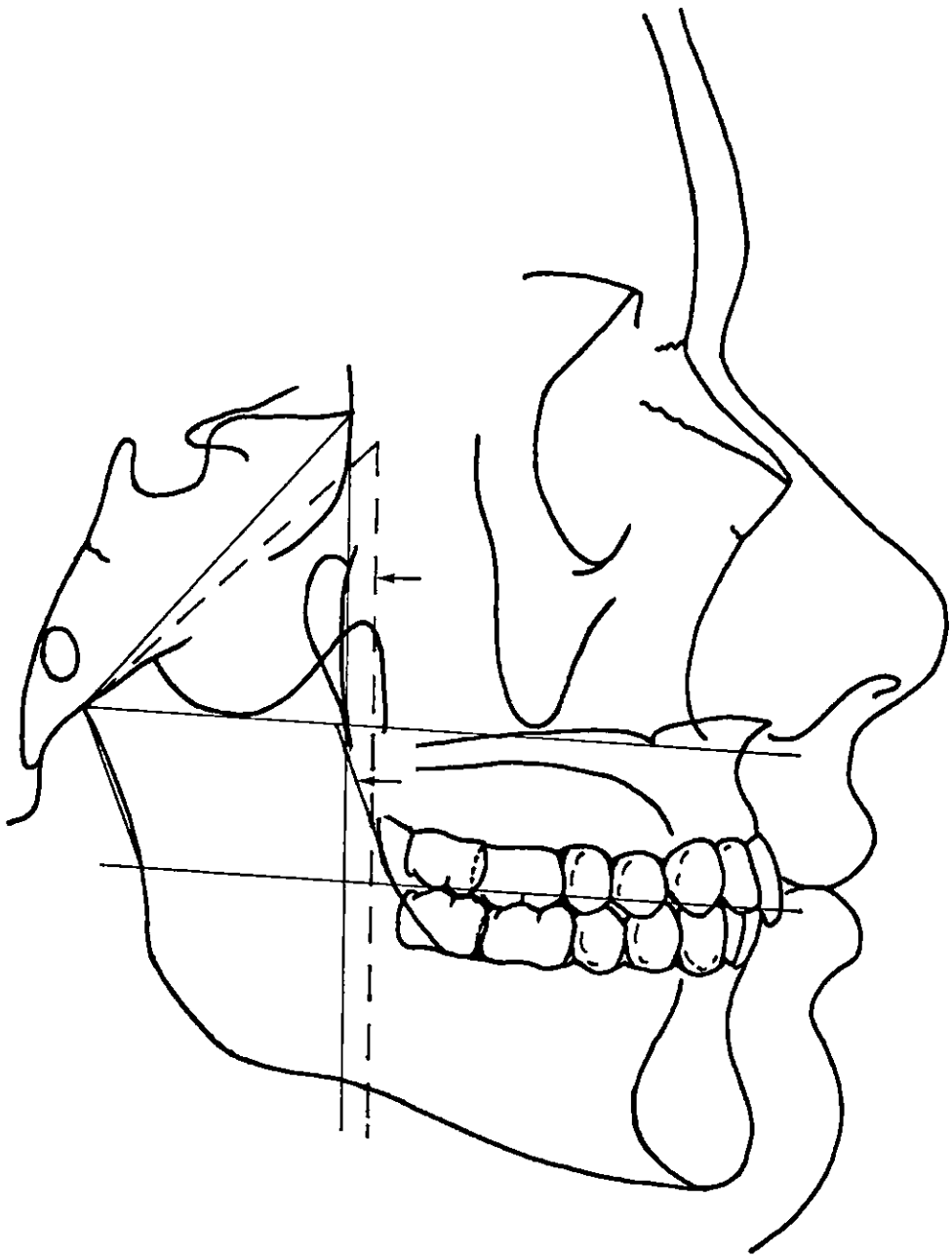


Figure 7. Ramus/MCF horizontal dimensions (dental). The neutral positions of the molars are demonstrated with this measurement. The purpose is to compare ramus width to the last erupted mandibular molar with the counterpart, which is the middle cranial fossa to the last erupted maxillary molar when the alignments of Ra and MCF have been "neutralized". 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 rotates forward and downward (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. That is, the correction is toward Ar along Ref. The mandibular molar is corrected to its neutral by adding or subtracting the distance from NRa to PRa along Ref. 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. That is, the correction is away from Ar 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. In Class I individuals, a slight mandibular protrusive effect is considered normal to provide for intercuspation, and is recorded as a (0) effect.

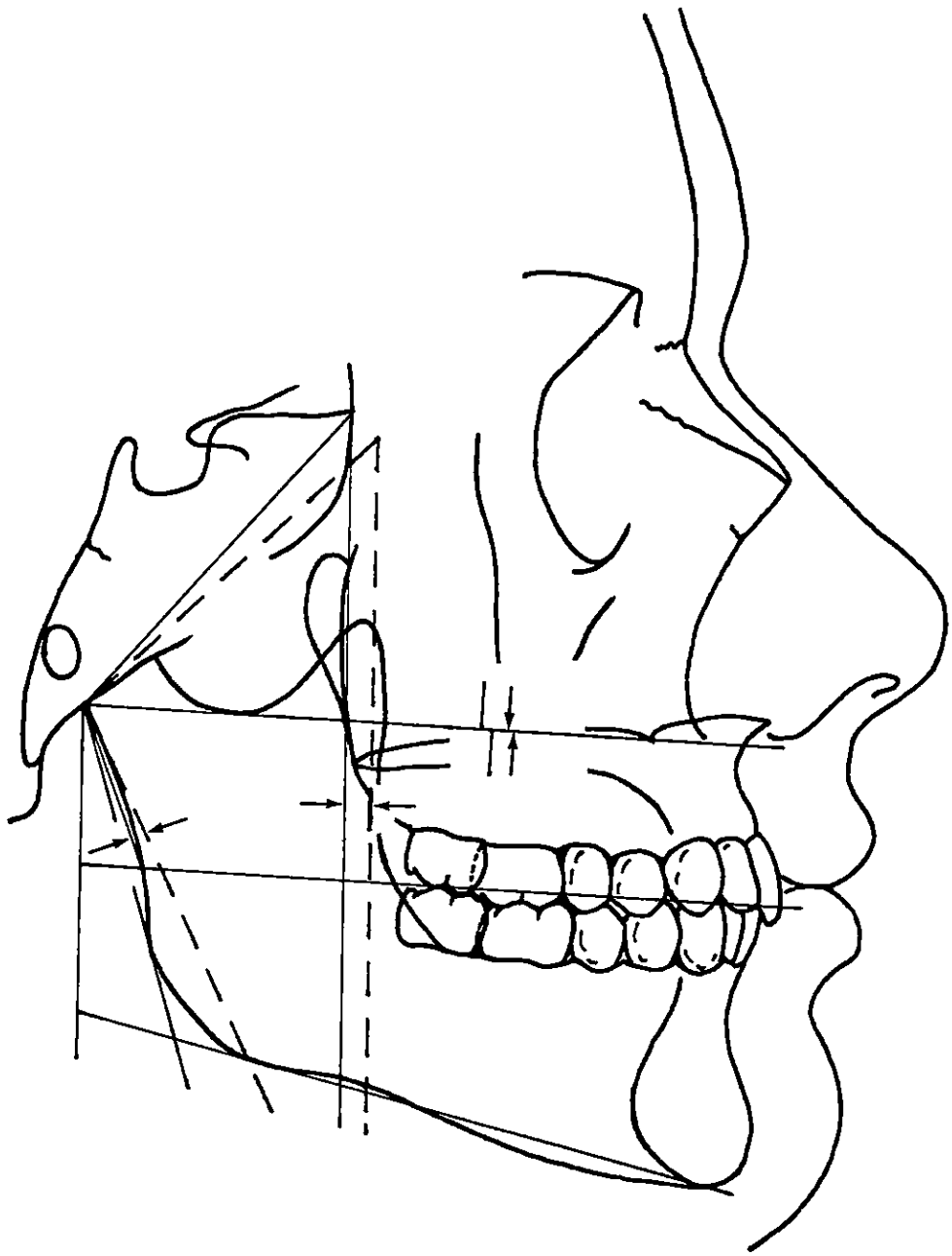


Figure 8. Maxillary/Mandibular arches, skeletal dimensions. A point compared with B point. This diagram compares the horizontal lengths of the maxillary and mandibular skeletal arches. The maxillary arch is measured from PM (solid line) to A point along Ref. The mandibular arch is measured along Ref from ARa where it intersects Ref to B point. If the distances are equal it is recorded as (0). If either a mandibular retrusive or protrusive effect exists, a (+) or (-) value is recorded, respectively.

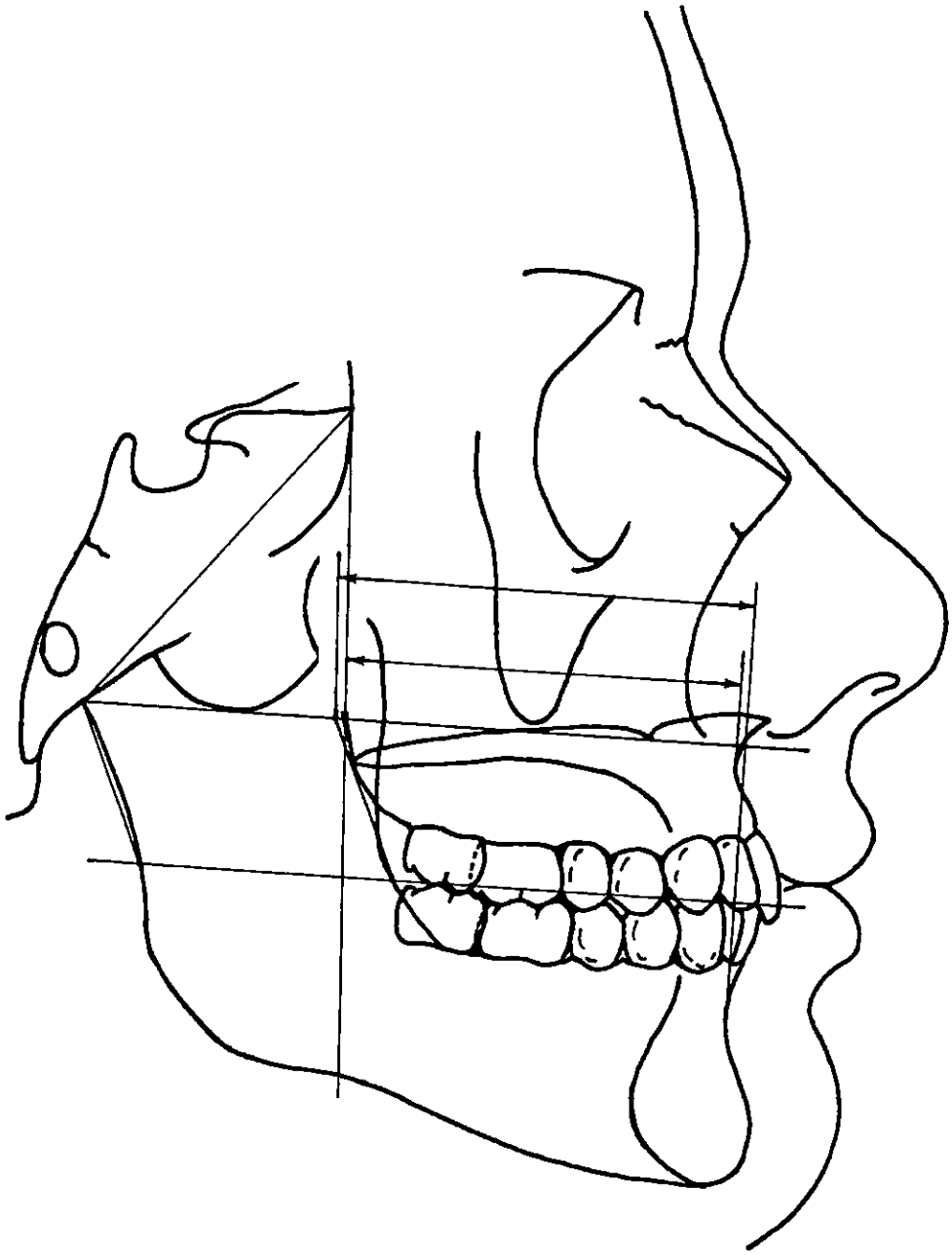


Figure 9. Corpus occlusal alignment. This diagram demonstrates the extent of occlusal rotation as compared to the extent of ramus rotation. NOA acts as a reference line to determine the amount and direction of occlusal rotation in a particular individual. NRa acts as a reference line to determine the amount of ramus rotation. Two arcs of equal radius are drawn, and radius length is determined by measuring the distance from the posterior-most occlusal contact point of the last fully erupted maxillary and mandibular molars to the point where the perpendicular from B point to Ref crosses 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 molar contact point, as the vertex, crossing NOA and FOP. The distance between Ar to Go and NRa is measured at the points of arc intersection. If Ar to Go is behind NRa, it is a (+) value, if in front it is a (-) value. The distance between FOP and NOA is measured at the points of intersection with the arc. If FOP is above NOA it is a (+) value, if below it is a (-) value. If FOP and Ar to Go rotate equally in amount and direction, the occlusal/corpus rotation is neutral (0). A (-) effect results from a greater downward corpus/occlusal rotation relative to the ramus rotation. A (+) effect occurs if a greater upward corpus/occlusal rotation relative to ramus rotation or if the backward ramus rotation is greater than the downward corpus/occlusal rotation.

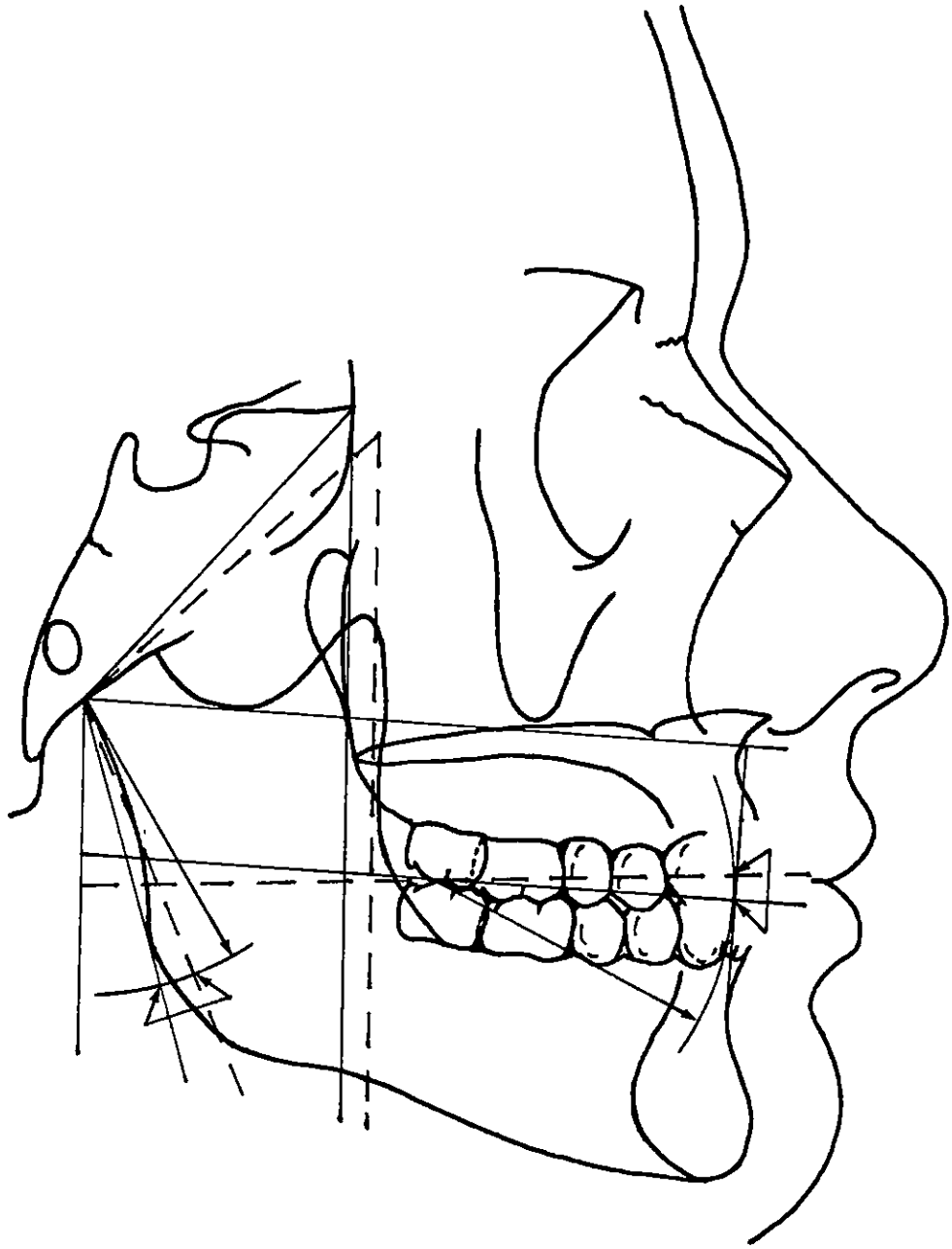


Figure 10. Mandibular plane alignment. The mean gonial angle as presented in the Michigan Standards (Riolo et al., 1975) is used as a neutral value, as indicated by dashed line. The individual's mandibular plane is indicated by the line Me to Go. The distance between the neutral mandibular plane and the individual's mandibular plane is measured along the line through B point perpendicular to Ref. If the individual's mandibular plane is above the neutral mandibular plane, it is (+); if below, it is (-). If they coincide, a neutral effect results.

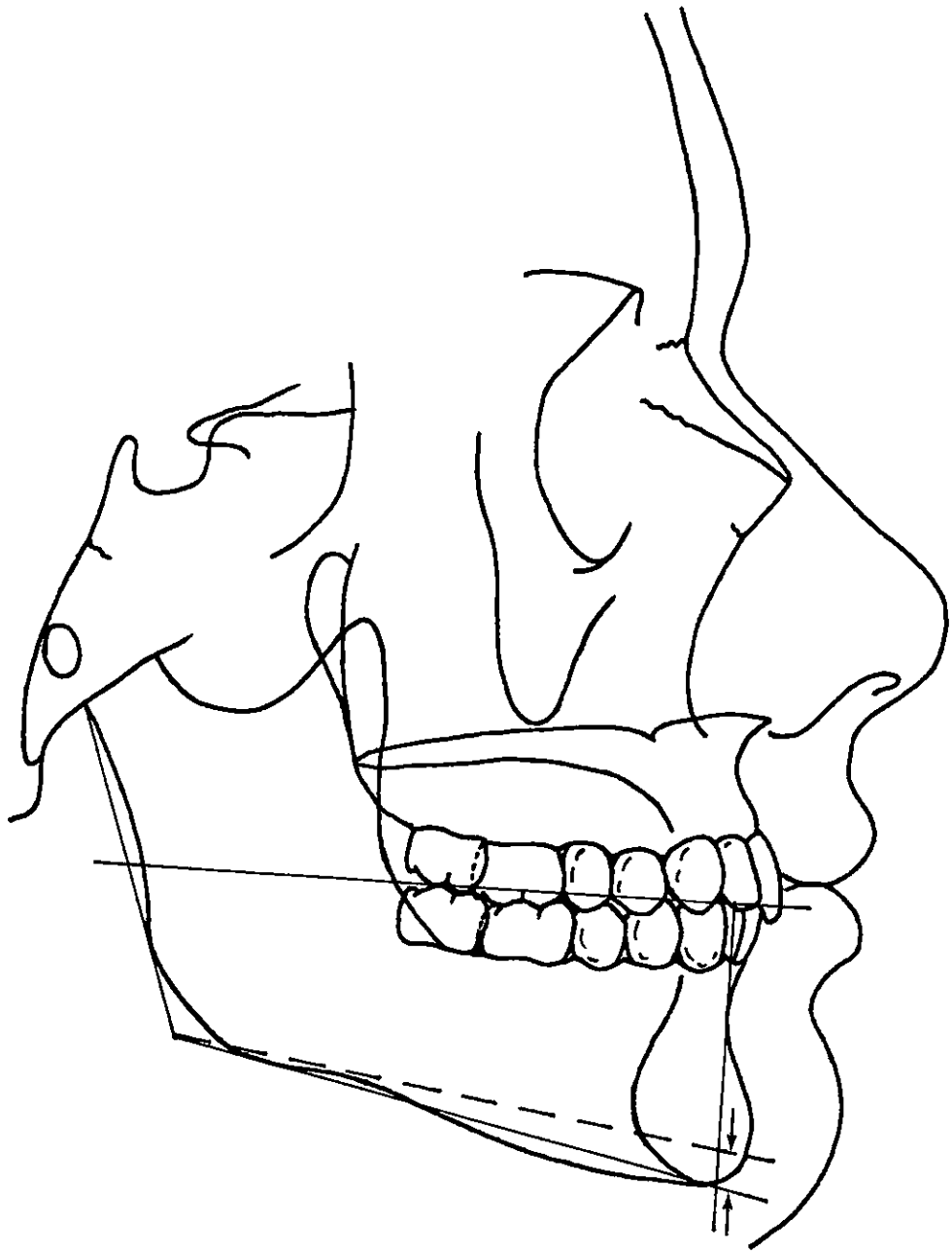


Figure 11. Gonial angle. This diagram is similar to that in Figure 10. However, the measurement here is of two angles made in degrees. The neutral gonial angle and Ar to Go to Me.

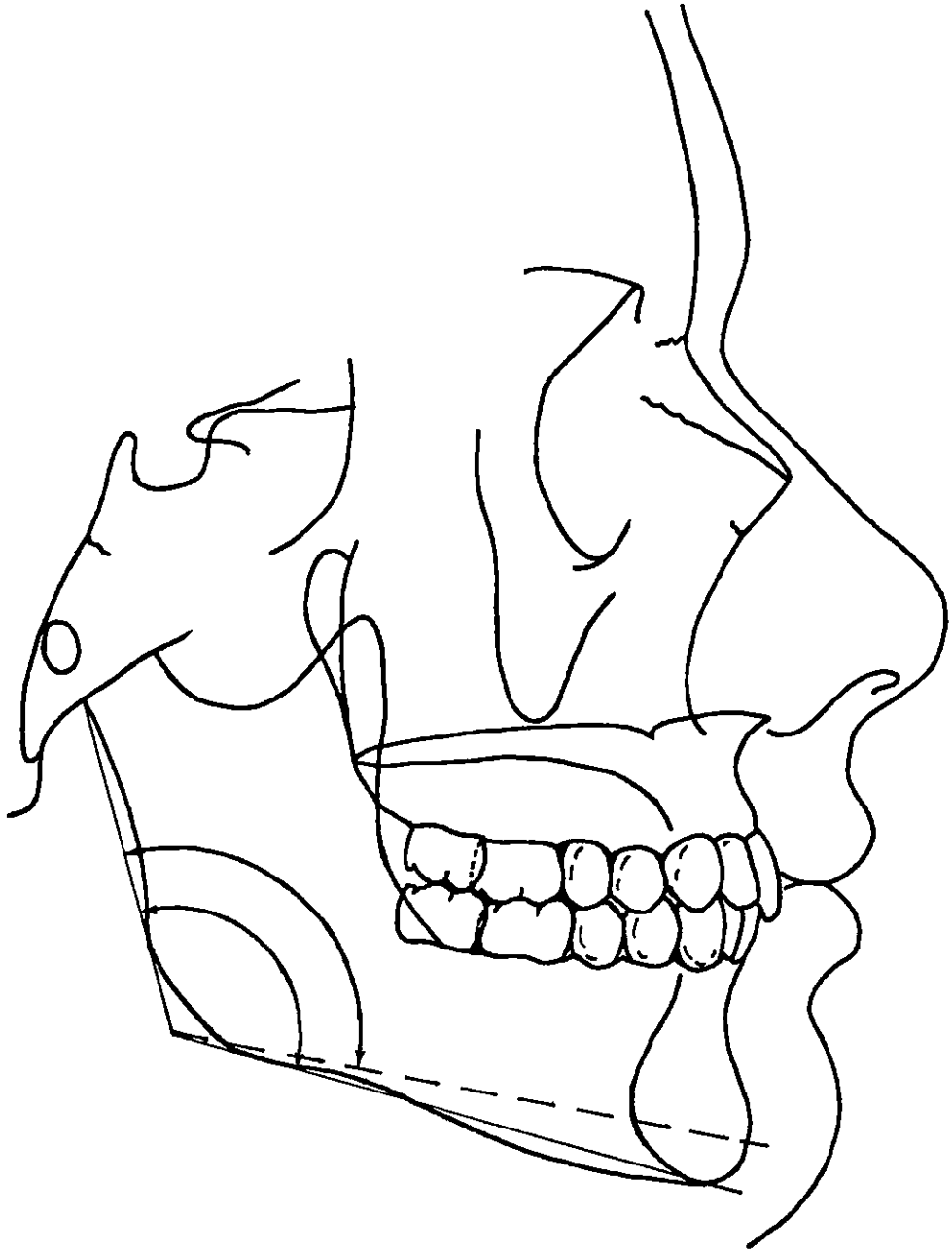


Figure 12. Occlusal Plane alignment. This diagram demonstrates the direction and the amount of occlusal plane rotation. The measurement is made between FOP and NOA along a perpendicular from IPr to FOP. If FOP is above NOA, it is a (+) value, if below NOA, it is a (-) value. Positive and negative values indicate counterclockwise and clockwise rotations, respectively.

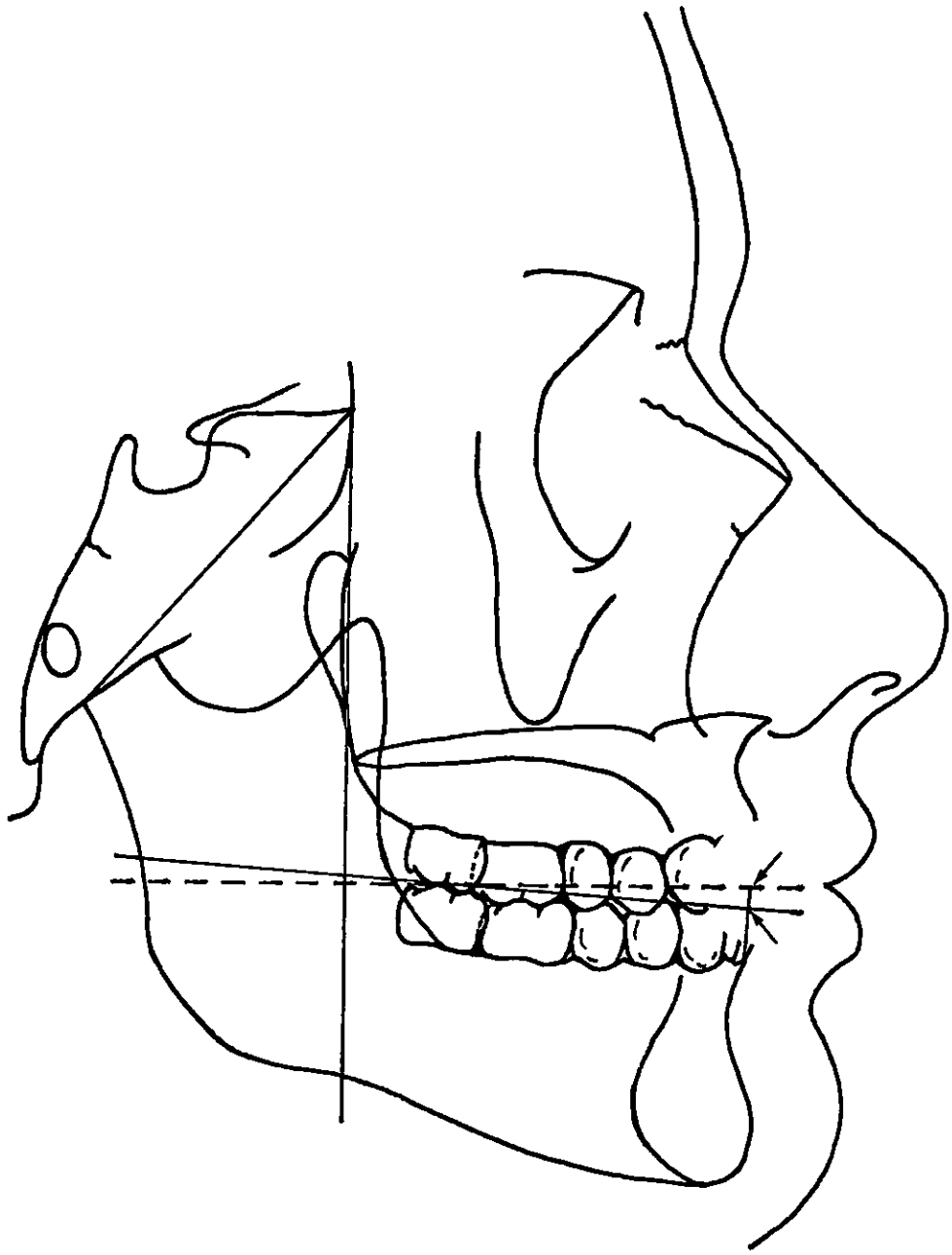


Figure 13. Palatal plane alignment. This diagram demonstrates the alignment between the palatal plane and is represented by a line from ANS through PNS projected posteriorly. The distance and direction of this plane relative to occipital point is determined. If the palatal plane is above occipital point, it is a (+) value. If it is below occipital point, it is a (-) value. Positive and negative values represent clockwise and counterclockwise rotations, respectively. If the extent of effects is 5.0 mm or less in either direction, it is given a single (+) or (-) value. If the effect of palatal plane rotational alignment exceeds 5.0 mm, it is given (++) or (--) value.

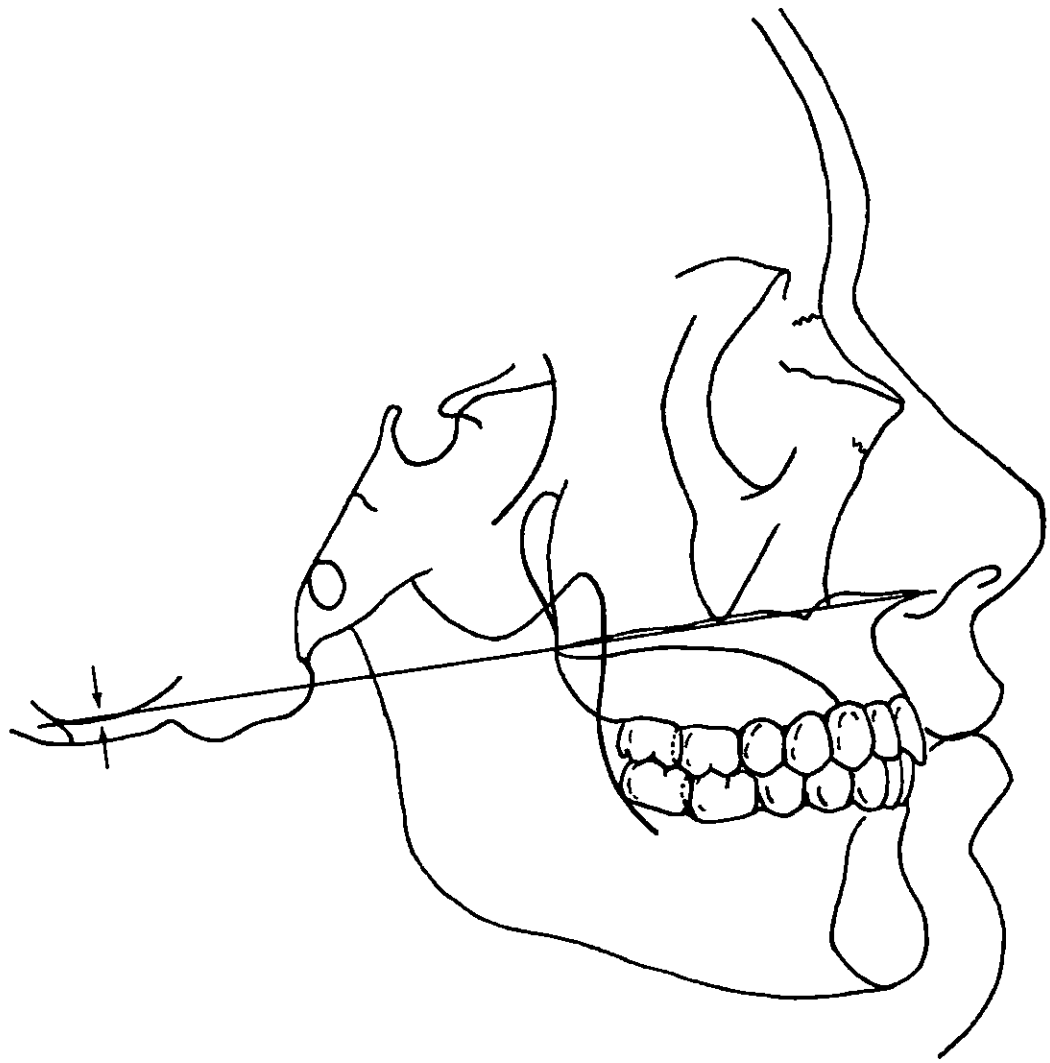
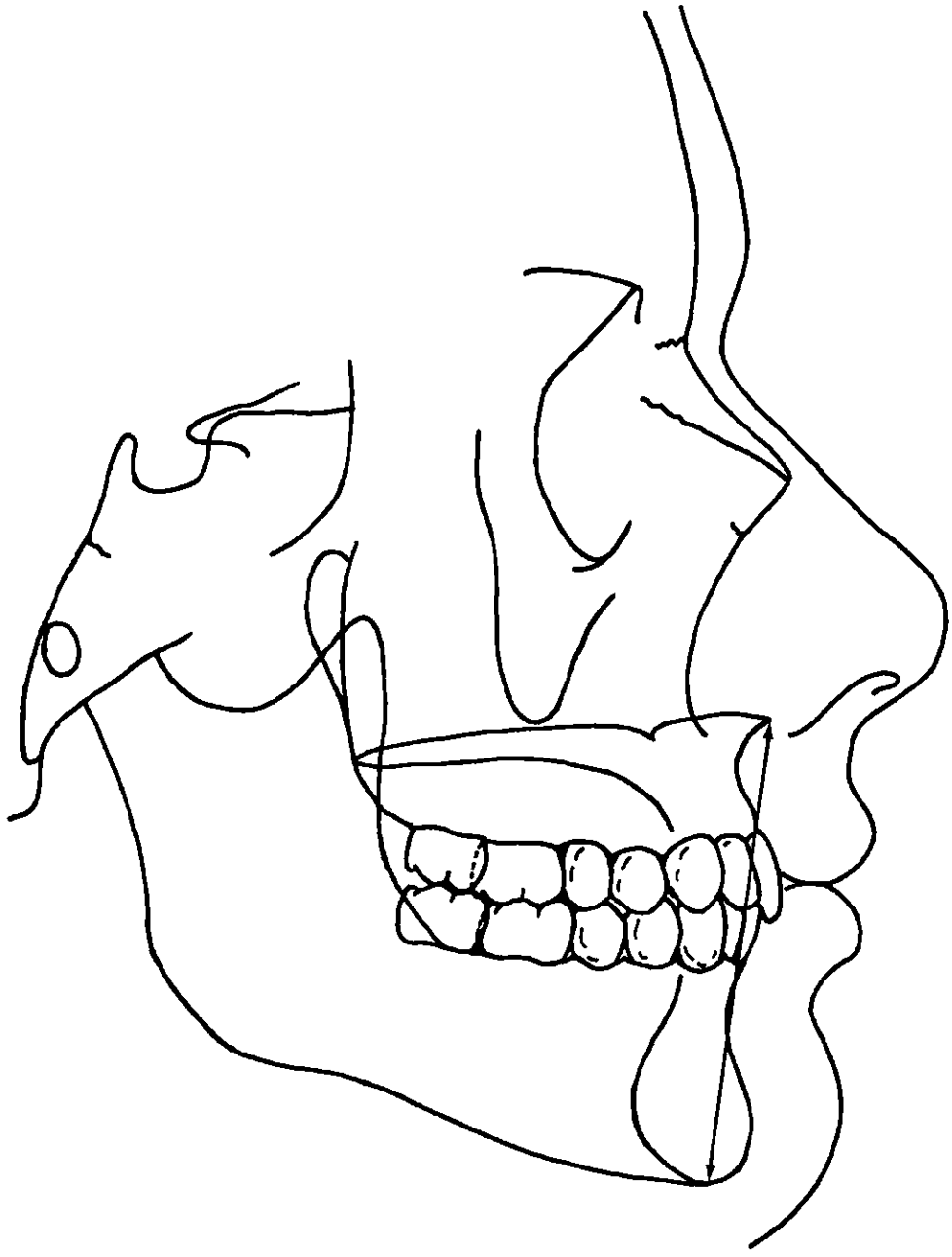


Figure 14. Lower facial height. This diagram demonstrates the height of the lower face (defined here as that facial height from the palate to the inferior border of the mandible). It is measured from ANS to Me (McNamara, 1982).



FINDINGS

1. Aggregate Cranial Floor/Maxilla and Ramus/Corpus Horizontal Dimensions at A and B Points

Group I (Excessive adenoids without adenoidectomy): at age 6 years, 67% of the cases demonstrated a mandibular protrusive effect. By age 14, however, this decreased to 45%.

Group II (Adenoidectomy at age 10 years): this group showed a tendency toward mandibular protrusion. At age 6 years, we can see a great incidence of a mandibular retrusive effect (46%). This, however, drops to 31% at age 8, with 61% of the cases then exhibiting mandibular protrusion. This increases to 69% by age 14.

Group III (Adenoidectomy before age 6 years): at age 6 years, 74% of the cases showed a mandibular protrusive effect. At age 14, this incidence had remained constant.

2. MCF Alignment

Group I (Excessive adenoids without adenoidectomy): at age 6 years, 67% of the cases exhibited a mandibular retrusive effect (forward alignment). This stayed about the same until age 10 but dropped to 44% by age 12.

Group II (Adenoidectomy at age 10 years): from age 6 to 10 years, a mandibular retrusive effect increased from 54% to

69%. This dropped to 54% by age 12 and to 46% at age 14.

Group III (Adenoidectomy before age 6 years): there existed a trend toward a forward rotation of cranial floor (mandibular retrusive effect) in this group. At age 6 to 14 years this increased from 48% to 65%.

3. Ramus Alignment

Group I (Excessive adenoids without adenoidectomy): this group showed a tendency for a clockwise rotation, and the extent was greater than noted in the other two groups. At age 6 years, 44% showed a (+) backward-aligned ramus and 39% showed a (++) backward-aligned ramus. By age 14 years, a (++) backward-aligned ramus increased to 67%, while a (+) decreased to 17%.

Group II (Adenoidectomy at age 10 years): from age 6 to 8 years, a marked mandibular retrusive effect existed. It increased from 85% to 92%, and dropped to 69% at age 10. However, this increased again to 77% at age 12, and declined to 69% by age 14 years.

Group III (Adenoidectomy before age 6 years): ramus alignment in this group was also marked but somewhat more stable. From age 6 to 14 years, it increased slightly from 87% to 91%.

4. Posterior Maxillary (PM) Vertical Dimension Compared with Ramus/MCF Vertical Dimensions

Group I (Excessive adenoids without adenoidectomy): this group demonstrated a marked change in the relative PM vertical dimen-

sion during the successive periods. At age 6 years, a tendency for a short PM vertical relationship existed. By ages 8 and 10 years, however, a tendency for an increasingly long PM vertical relationship had developed. That is, the midface was becoming progressively longer in relative vertical size. From age 6 to 14 years, a long PM vertical relationship increased from 39% to 72%.

Group II (Adenoidectomy at age 10 years): a relatively short PM vertical effect existed as a whole compared to Group I, and this stayed the same from age 6 to 10 years (39%). At age 12 years, it was reduced to 31%. This demonstrates that the relative vertical length of the midface became shorter after the 10-year level in this group.

Group III (Adenoidectomy before age 6 years): a relatively long PM vertical dimension existed at age 6 years (57%), but a decrease occurred through age 14 years (26%).

5. Ramus Compared to MCF Horizontal Skeletal Dimensions

Group I (Excessive adenoids without adenoidectomy): there existed a marked change in ramus width relative to MCF dimension from ages 6 to 14 years. A mandibular retrusive effect became progressively larger (22% to 45%). At age 6 years, there existed a marked tendency toward a mandibular protrusive effect (72%) and remained about the same until age 10 years. At age 12 years, a lesser incidence of mandibular protrusive

effect was noticeable than at age 10 (from 72% to 56%) and more so at age 14 years (39%).

Group II (Adenoidectomy at age 10 years): this relationship contributed to mandibular retrusion in 46% by age 10 years. After the 10-year level, however, ramus width had increased relative to MCF.

Group III (Adenoidectomy before age 6 years): there existed a marked tendency for a mandibular protrusive effect (wide ramus) from ages 6 to 10 years (70% to 74%). This dropped to 48% at age 12 years and continued a decline at age 14 years (35%).

6. Ramus Compared to MCF Horizontal Dimension, Dental Relationship

Group I (Excessive adenoids without adenoidectomy): a marked tendency toward a mandibular protrusive effect was found in 72% to 83% of the cases examined from ages 6 to 14 years. This relationship stayed about the same from ages 6 to 14 years (72% to 72%).

Group II (Adenoidectomy at age 10 years): a strong tendency toward mandibular protrusion is also demonstrated except at age 6 years. At age 6 years, 46% of the cases showed a mandibular protrusive effect and this increases to 85% at age 8, and stayed about the same until age 12 years. This decreases slightly to 77% at age 14 years.

Group III (Adenoidectomy before age 6 years): a great tendency

for a mandibular protrusive effect was also seen in this group. A continual increase of mandibular protrusive effect occurred (78% to 96%).

7. Maxillary/Mandibular Arches, Skeletal Dimensions, A Point Compared with B Point

Group I (Excessive adenoids without adenoidectomy): at age 6 years, a slightly higher incidence (50%) of a relatively long maxillary arch was observed, and at age 12 years a tendency toward a relatively "short" maxillary arch (61%) had occurred. An even greater tendency for a relatively "short" maxillary arch was found at age 14 years (83%).

Group II (Adenoidectomy at age 10 years): at age 6 years, a tendency for a relatively long maxillary arch existed (54%). At ages 8 and 10 years, however, a marked change had taken place (54% to 23%), that is, from a relatively long to a relatively short maxilla. After the 10-year level, however, this increased slightly to 31% and stayed about the same through age 14 years.

Group II (Adenoidectomy before age 6 years): this group showed a continual increase of a long mandibular arch relative to the maxilla (57% to 87%).

8. Corpus/Occlusal Alignment

Group I (Escessive adenoids without adenoidectomy): at age 6 years, there existed a strong trend for a mandibular protrusive effect (83%). That is, 17% showed a mandibular retrusive ef-

fect relative to the maxilla; this increased to 22% by age 10 years, but declined again to 17% by age 12 years and then stayed about the same through age 14 years.

Group II (Adenoidectomy at age 10 years): an incidence of maxillary retrusive effect was increasing by age 10 years (from 69% to 85%). At age 12 years, the incidence dropped sharply to 62% but then increased to 77% by age 14 years.

Group III (Adenoidectomy before age 6 years): there was a tendency for a mandibular protrusive effect (61%) at age 6 years, and this increased slightly to 70% by age 10 years. It then returned to 61% by age 14 years.

9. Mandibular Plane Alignment

Group I (Excessive adenoids without adenoidectomy): at age 6 years, 78% of the cases demonstrated a mandibular retrusive effect. By age 14 years, this decreased to 45%, showing that mandibular plane alignment rotated downward with age.

Group II (Adenoidectomy at age 10 years): from ages 6 to 10 years, mandibular plane alignment in this group also rotated downward (from 85% to 62%). After the 10-year level, however, the incidence of upward rotation of mandibular plane alignment had increased from 62% to 69%.

Group III (Adenoidectomy before age 6 years): from ages 6 to 14 years, mandibular plane alignment showed a progressive down-

'ward rotation (from 22% to 52%).

10. Gonial Angle

Group I (Excessive adenoids without adenoidectomy): at age 6 years, 78% of the cases illustrated a closed gonial angle relative to the population standard (Riolo et al., 1975). By age 14 years, this showed a marked decrease to 45%, showing that gonial angle opened with age.

Group II (Adenoidectomy at age 10 years): from ages 6 to 10 years, gonial angle in this group opened markedly (from 85% to 62%). After the 10-year level, however, gonial angle had closed (from 62% to 69%), and this had opened again (62%) by age 14 years.

Group III (Adenoidectomy before age 6 years): from ages 6 to 14 years, gonial angle had opened progressively (from 61% to 39%).

11. Occlusal Plane Alignment

A general tendency toward clockwise (downward) rotation occurred in all groups.

Group I (Excessive adenoids without adenoidectomy): there was no great pattern change with age in this group, but a trend for a counterclockwise (upward) rotation increased progressively from ages 6 to 14 years (17% to 22%).

Group II (Adenoidectomy at age 10 years): from ages 6 to 12

years, 62% of the cases showed a tendency for a clockwise (downward) rotation, and this remained about constant during this period except at age 8 years (85%). At age 14 years, the clockwise (downward) rotation had increased to 77%. On the other hand, 23% of the cases showed a counterclockwise (upward) rotation at age 6 years, and this incidence decreased to 15% by age 10 years. After the 10-year level, however, it increased to 31% but dropped to 15% again at age 14 years.

Group III (Adenoidectomy before age 6 years): a slight increase of the marked frequency of clockwise (downward) rotation was seen from ages 6 to 14 years (87% to 91%).

12. Palatal Plane Alignment

Group I (Excessive adenoids without adenoidectomy): at age 6 years, a tendency toward clockwise (downward) rotation of the palate was observed (61%). By age 14 years, however, a high incidence of counterclockwise (upward) rotation of palatal plane had occurred (78%).

Group II (Adenoidectomy at age 10 years): a general tendency toward a counterclockwise (upward) alignment was present. From ages 6 to 10 years, the incidence increased from 77% to 85%. It stayed about the same after the 10-year level.

Group III (Adenoidectomy before age 6 years): a general trend for counterclockwise (upward) rotation was seen (ranged from 61% to 65%). No noticeable change took place with age in this group.

13. Lower Facial Height

Group I (Excessive adenoids without adenoidectomy): at age 6 years, the average mean of lower facial height demonstrated 57.2 mm. By age 8 years, this showed an increase to 59.8 mm. After the 10-year level, lower facial height is slightly longer than the population mean.

Group II (Adenoidectomy at age 10 years): from ages 6 to 14 years, the average mean of lower facial height in this group was shorter than the population mean. There is no marked change with age in this group.

Group III (Adenoidectomy before age 6 years): during ages 6 and 8 years, lower facial height demonstrated an increase (from 58.3 mm to 60.4 mm).

TABLE III

Determinations of the
PM Vertical Dimension

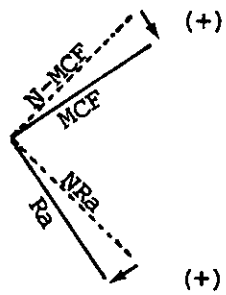
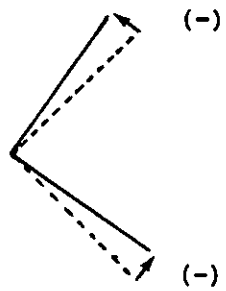
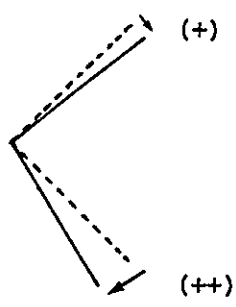
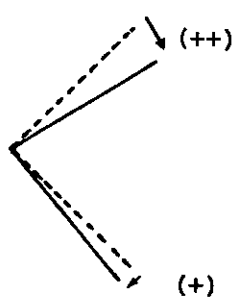
	Description	Effect
	Forward rotation of MCF and backward rotation of ramus are equal in extent.	Neutral (0) effect.
	Backward rotation of MCF and forward rotation of ramus are equal in extent and direction.	Neutral (0) effect.
	Backward ramus rotation is greater than forward rotation of MCF.	Long (+) 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 III continued

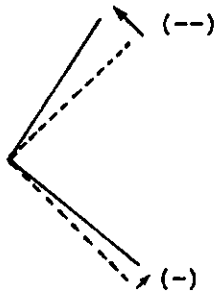
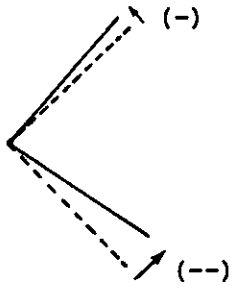
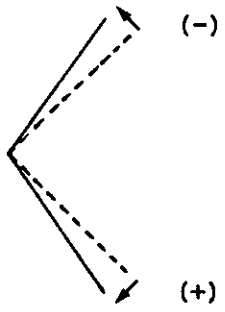
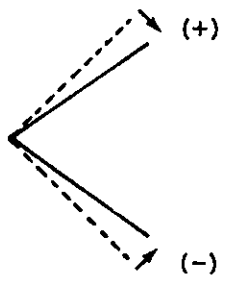
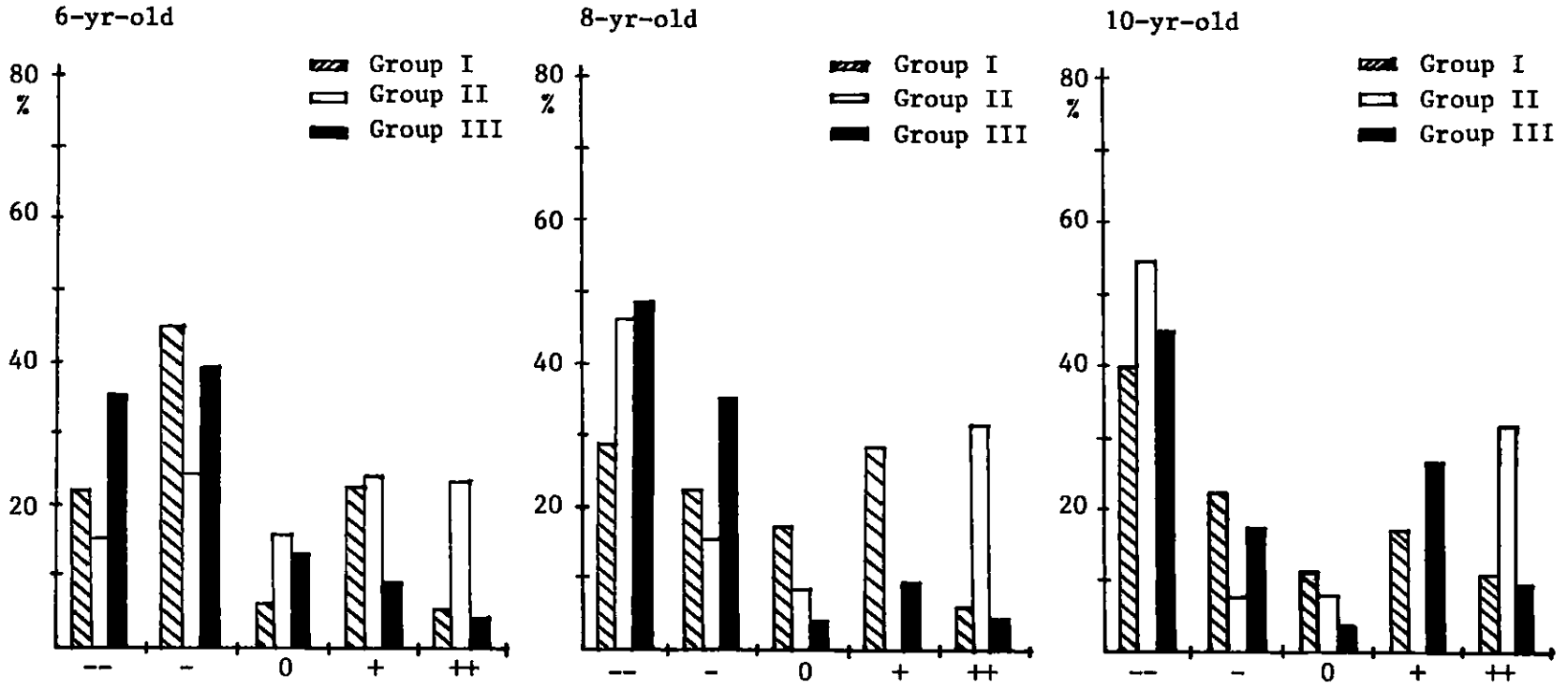
	Description	Effect
	Backward rotation of MCF is greater than forward rotation of ramus.	Long (+) PM vertical. Extent determined by the difference between the two values.
	Forward rotation of ramus is greater than backward rotation of MCF.	Short (-) PM vertical. Extent determined by the difference between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

TABLE IV

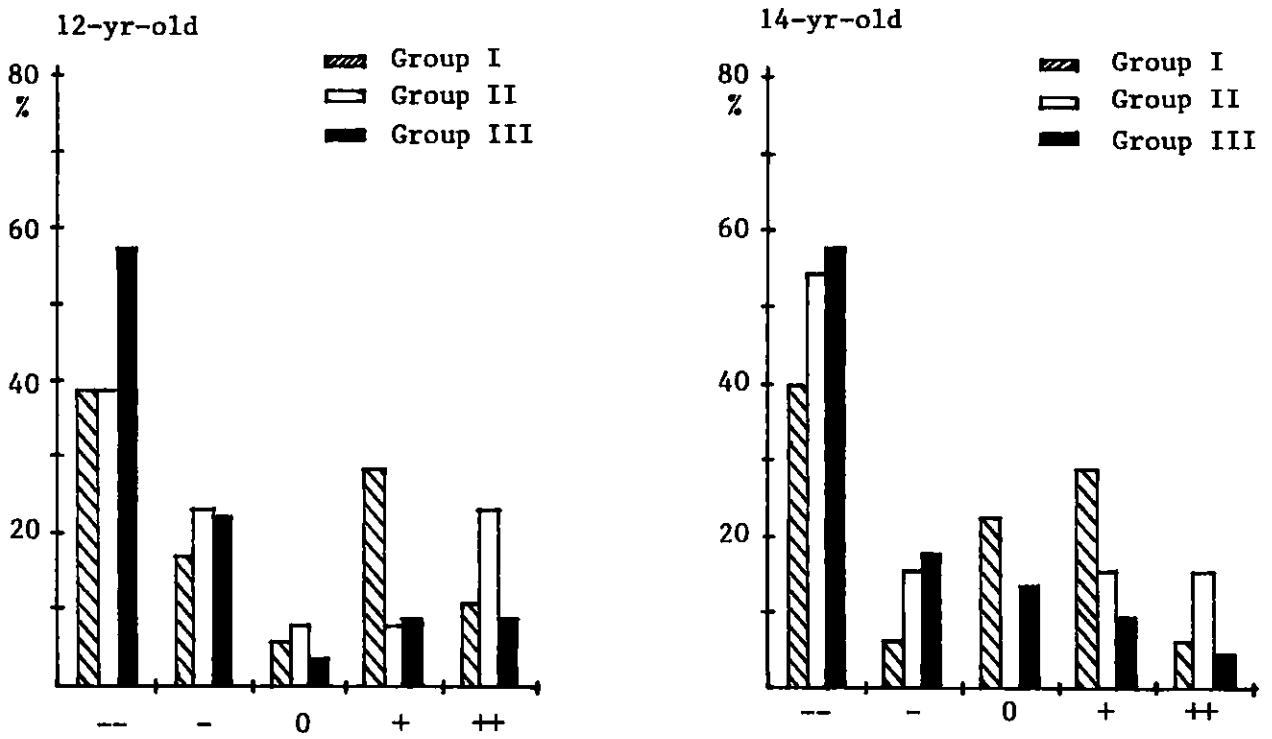
FREQUENCY DISTRIBUTION FOR: AGGREGATE CRANIAL FLOOR/MAXILLA AND RAMUS/CORPUS HORIZONTAL DIMENSIONS AT A AND B POINTS



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE IV (continued)

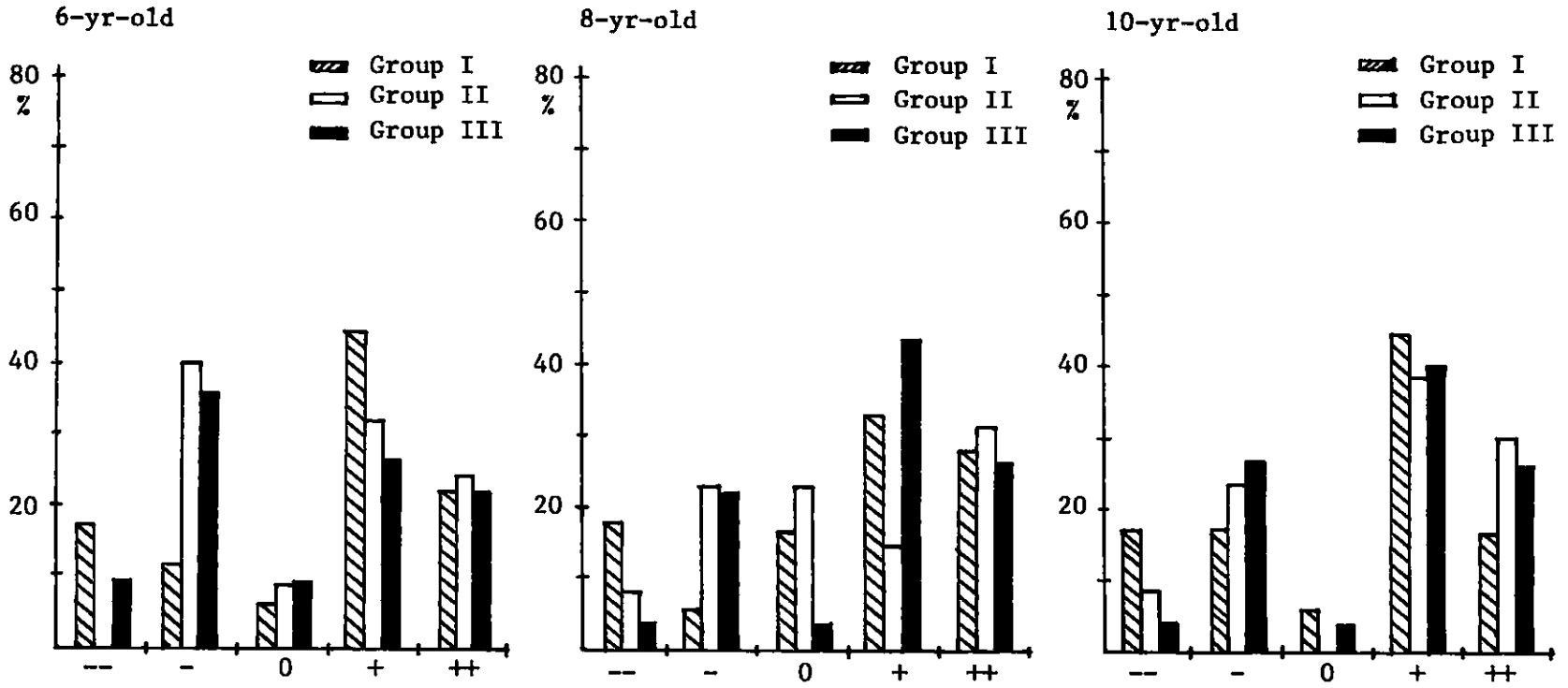
FREQUENCY DISTRIBUTION FOR: AGGREGATE CRANIAL FLOOR/MAXILLA AND RAMUS/CORPUS HORIZONTAL DIMENSIONS AT A AND B POINTS



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE V

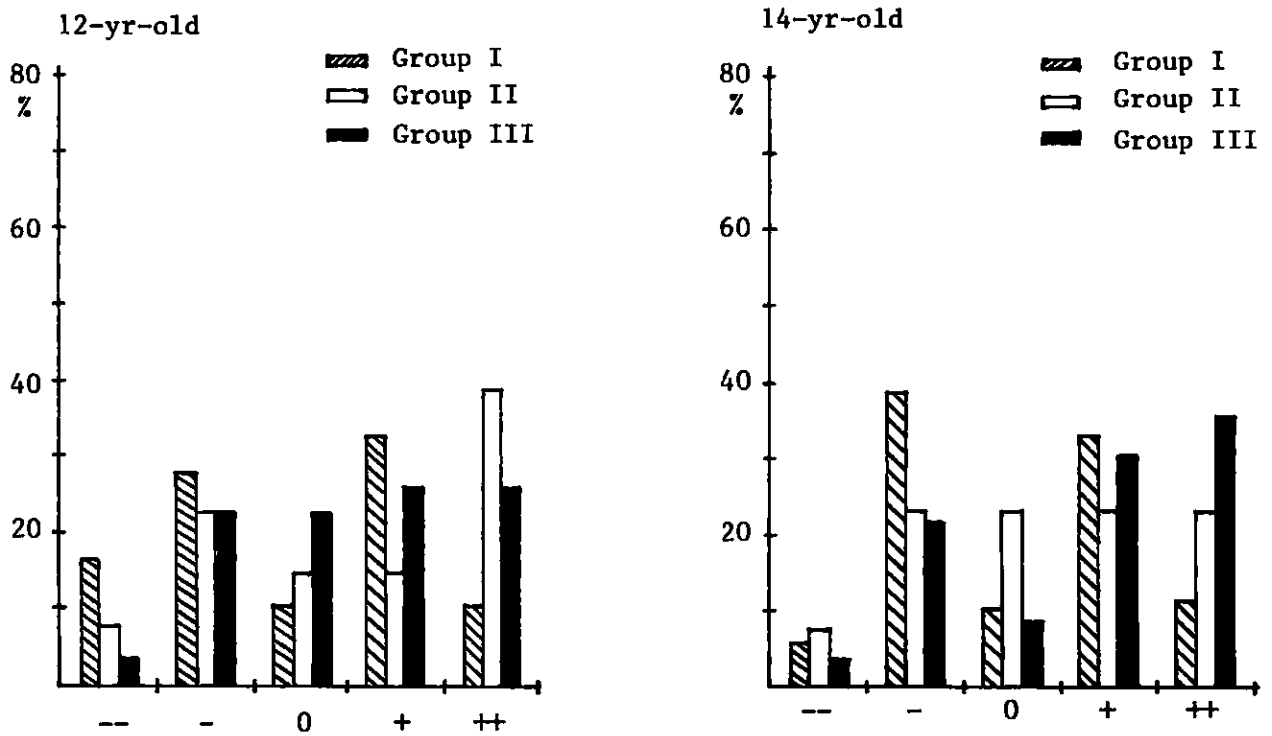
FREQUENCY DISTRIBUTION FOR: MIDDLE CRANIAL FOSSA (MCF) ALIGNMENT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE V (continued)

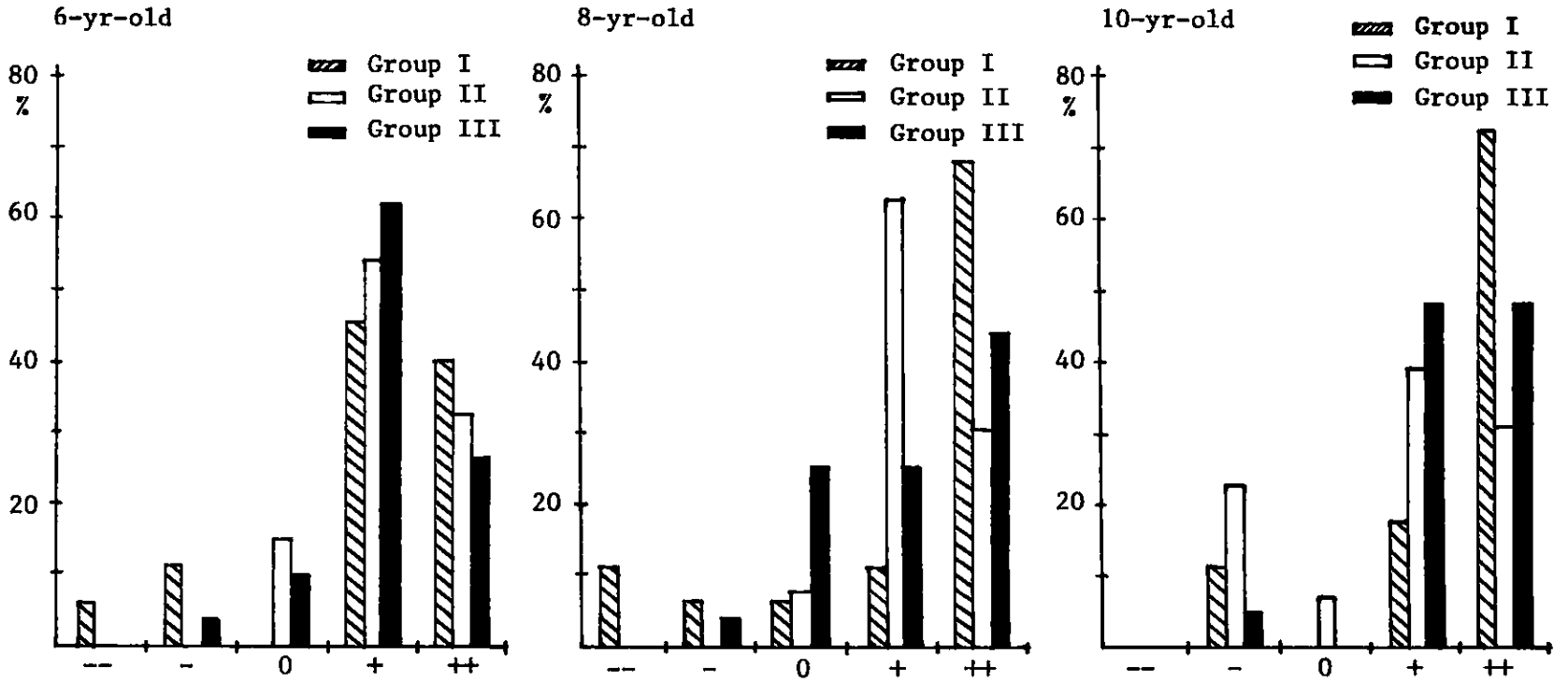
FREQUENCY DISTRIBUTION FOR: MIDDLE CRANIAL FOSSA (MCF) ALIGNMENT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE VI

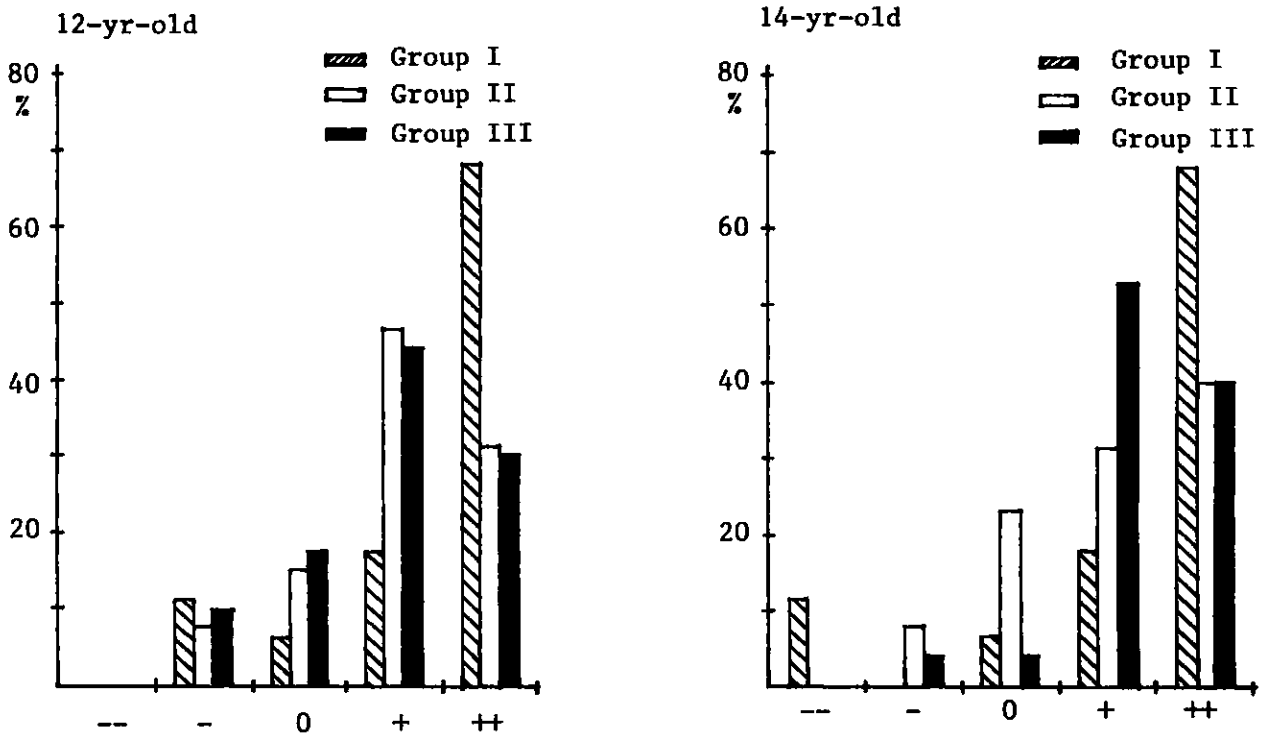
FREQUENCY DISTRIBUTION FOR: RAMUS ALIGNMENT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE VI (continued)

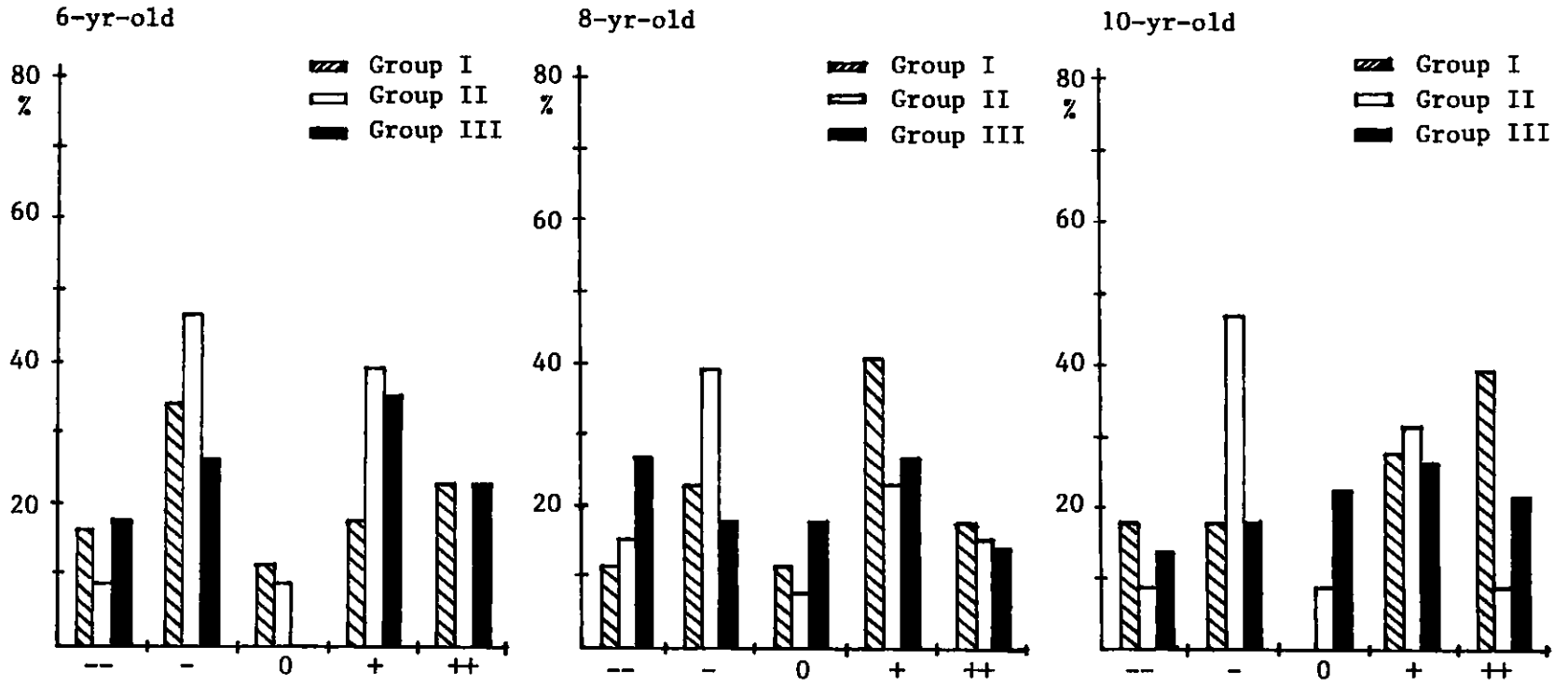
FREQUENCY DISTRIBUTION FOR: RAMUS ALIGNMENT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE VII

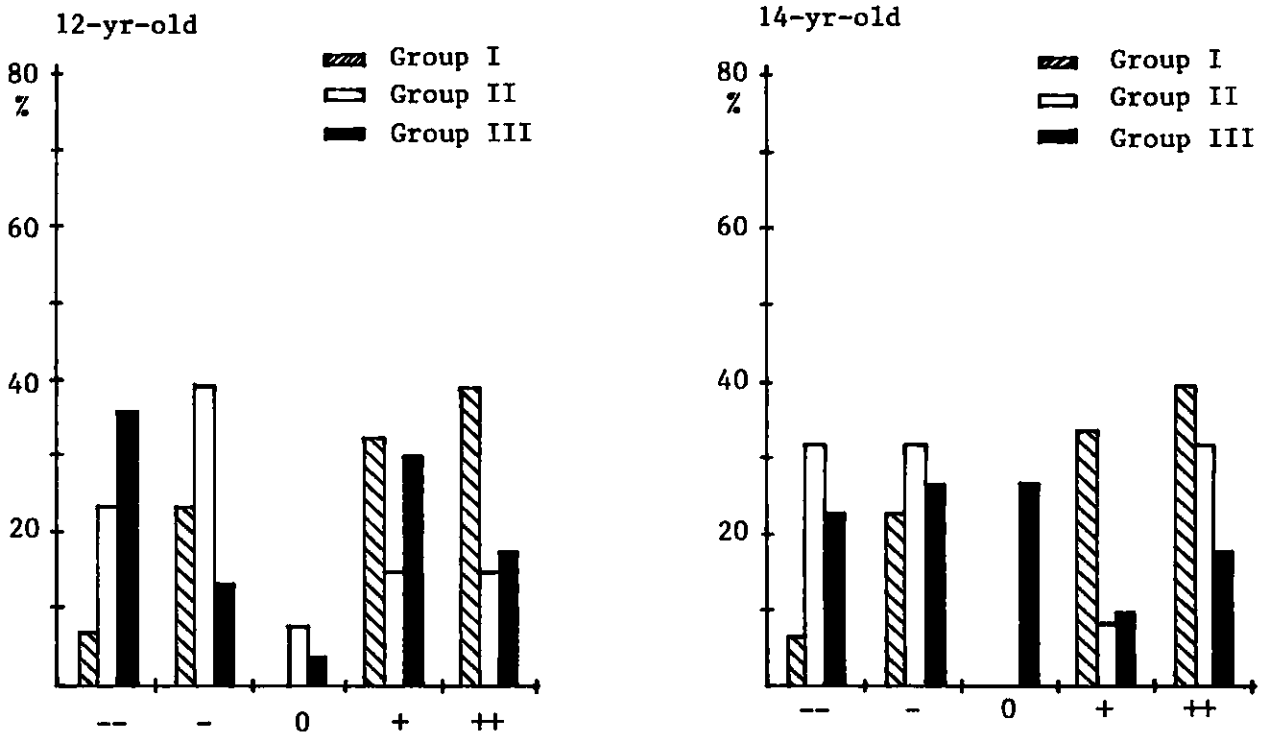
FREQUENCY DISTRIBUTION FOR: POSTERIOR MAXILLARY (PM) VERTICAL DIMENSION
COMPARED WITH RAMUS/MCF VERTICAL DIMENSIONS



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE VII (continued)

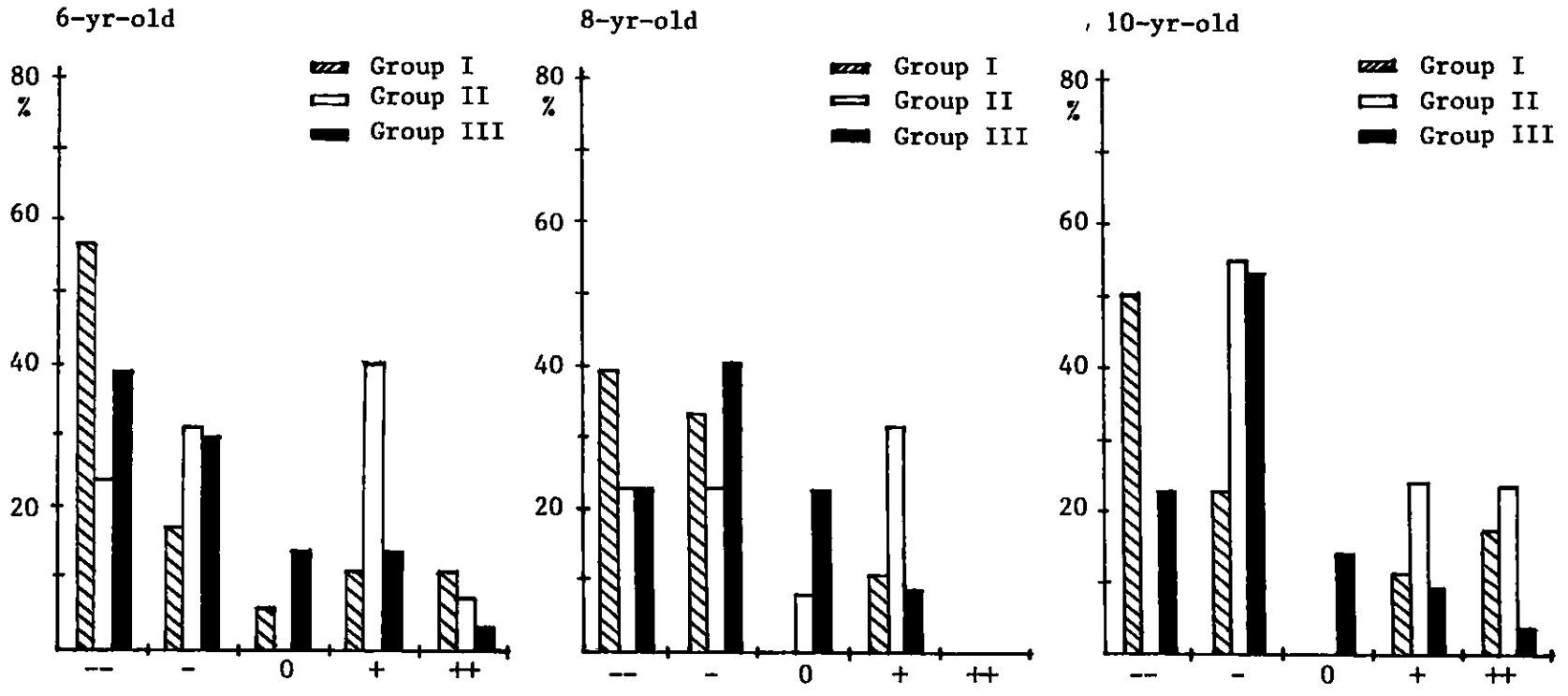
FREQUENCY DISTRIBUTION FOR: POSTERIOR MAXILLARY (PM) VERTICAL DIMENSION COMPARED WITH RAMUS/MCF VERTICAL DIMENSIONS



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE VIII

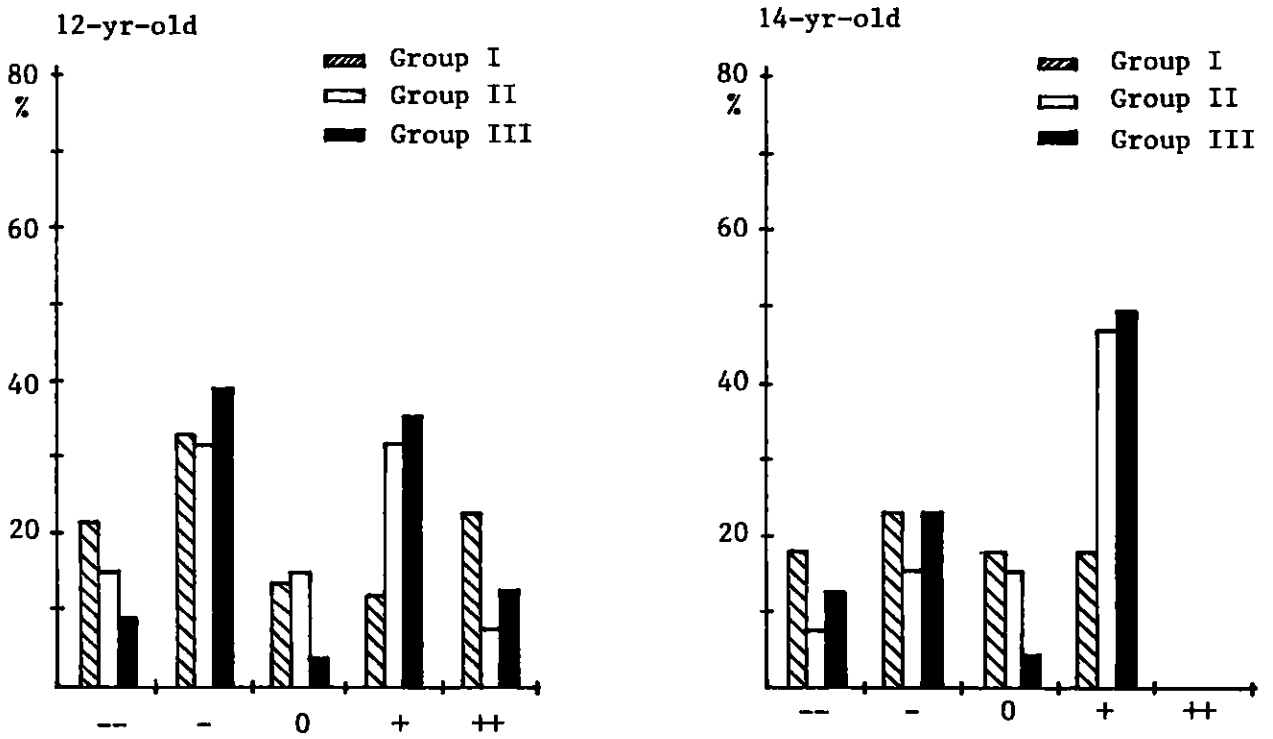
FREQUENCY DISTRIBUTION FOR: RAMUS/MCF HORIZONTAL DIMENSIONS (SKELETAL)



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE VIII (continued)

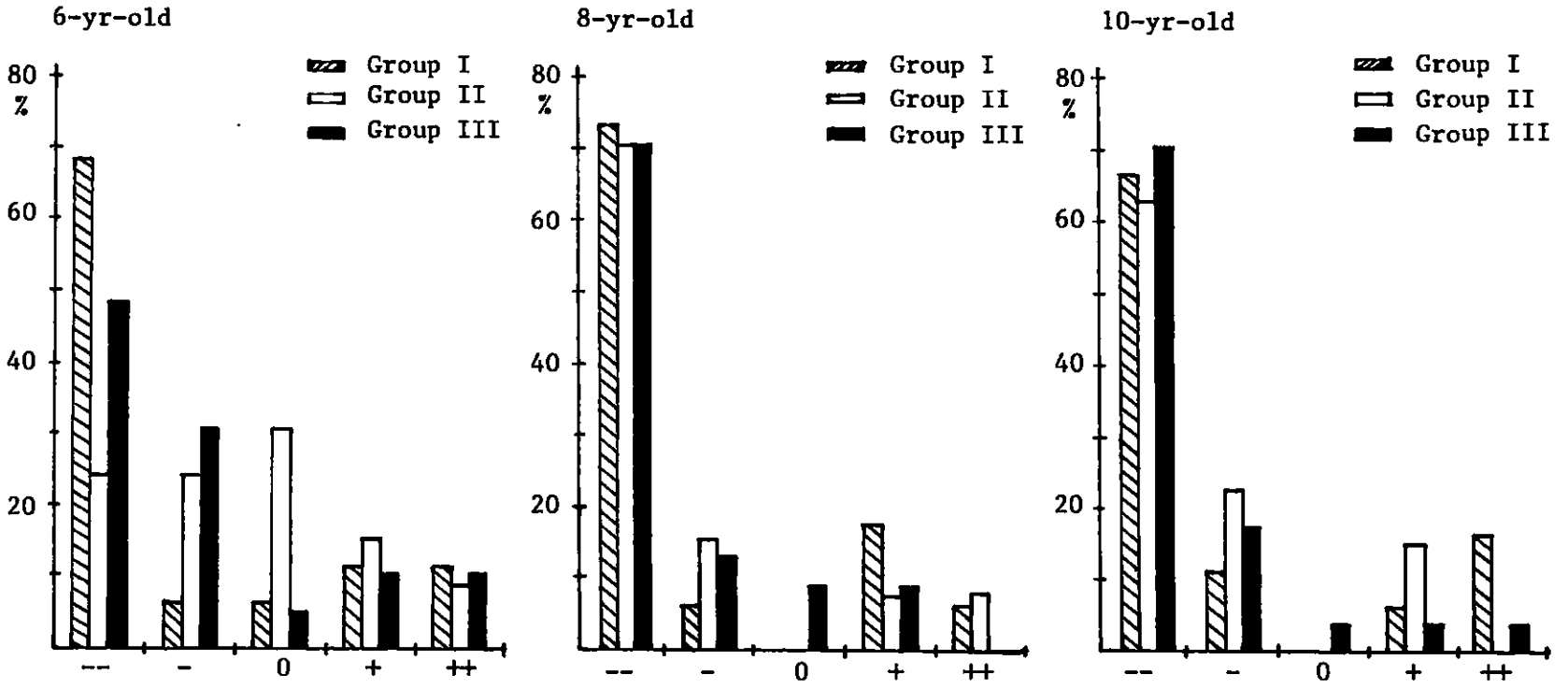
FREQUENCY DISTRIBUTION FOR: RAMUS/MCF HORIZONTAL DIMENSIONS (SKELETAL)



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE IX

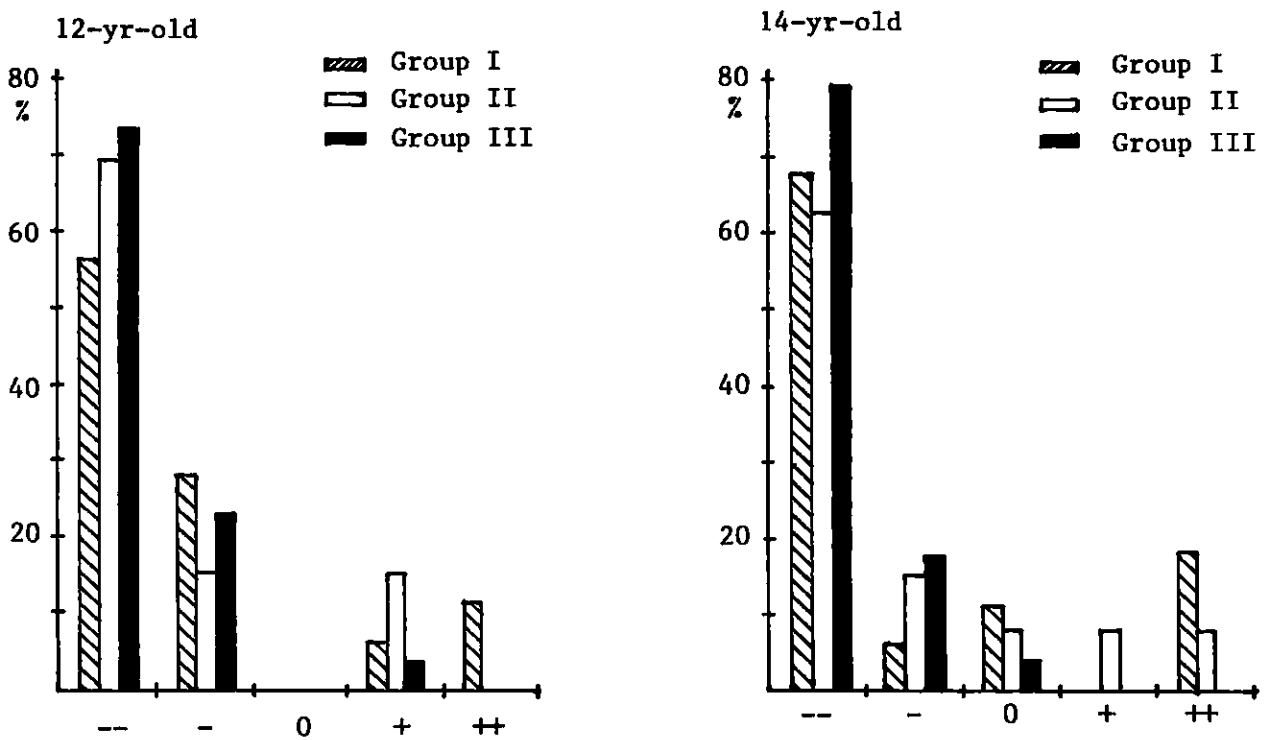
FREQUENCY DISTRIBUTION FOR: RAMUS/MCF HORIZONTAL DIMENSIONS (DENTAL)



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE IX (continued)

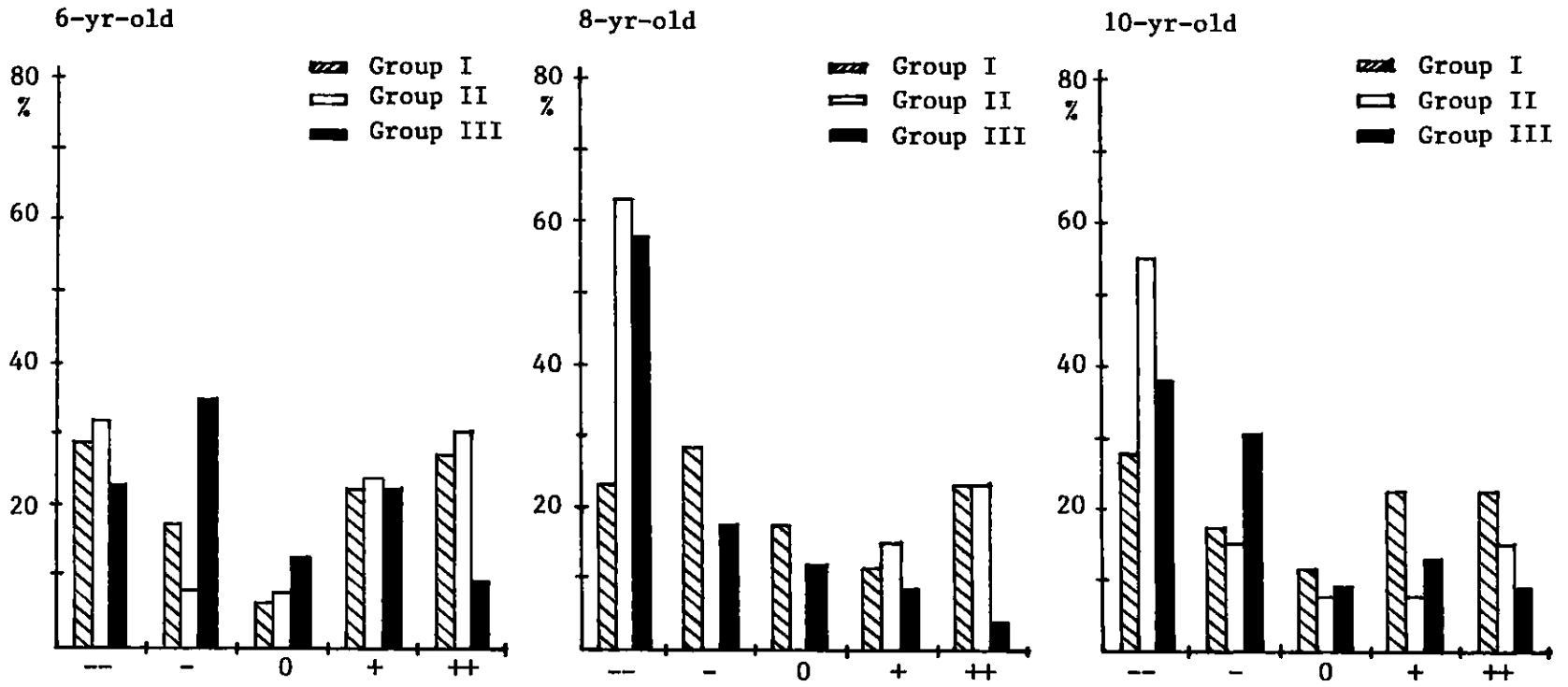
FREQUENCY DISTRIBUTION FOR: RAMUS/MCF HORIZONTAL DIMENSIONS (DENTAL)



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE X

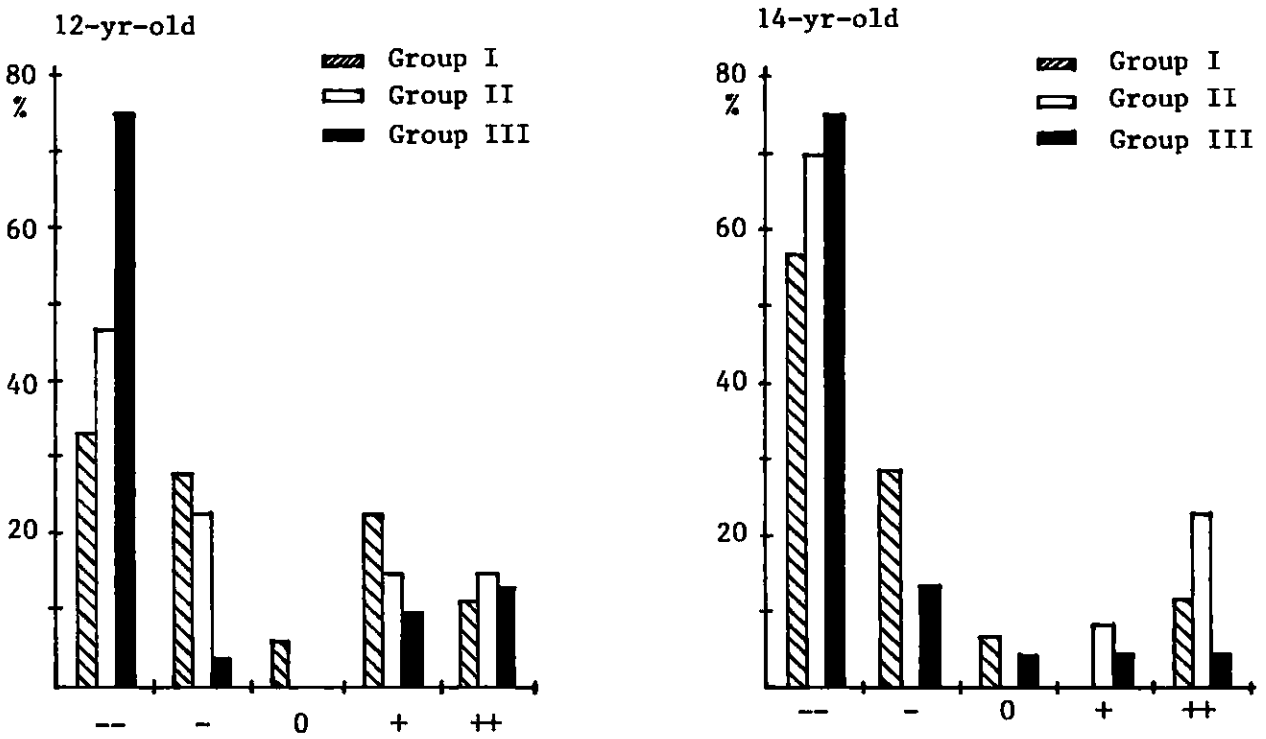
FREQUENCY DISTRIBUTION FOR: MAXILLARY/MANDIBULAR ARCHES, SKELETAL DIMENSIONS, A POINT COMPARED WITH B POINT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE X (continued)

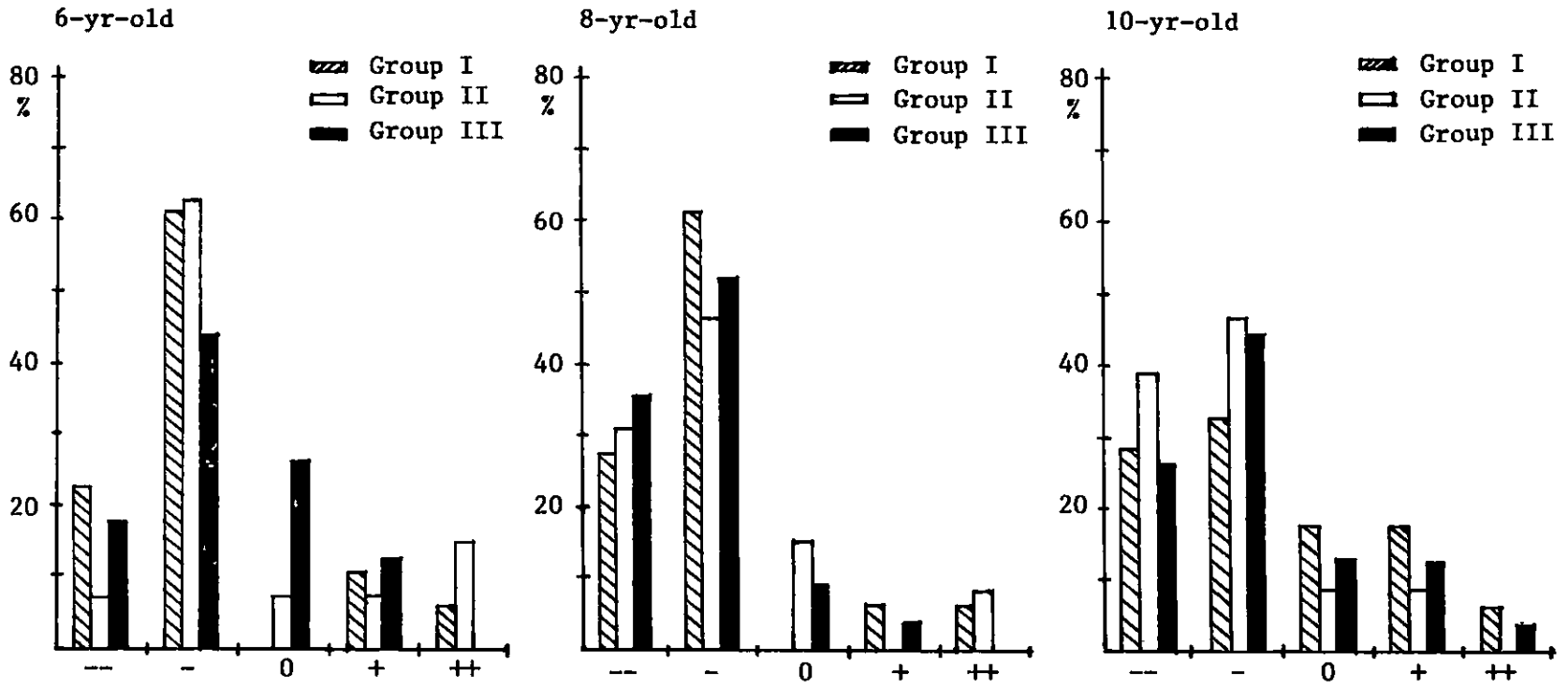
FREQUENCY DISTRIBUTION FOR: MAXILLARY/MANDIBULAR ARCHES, SKELETAL DIMENSIONS, A POINT COMPARED WITH B POINT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE XI

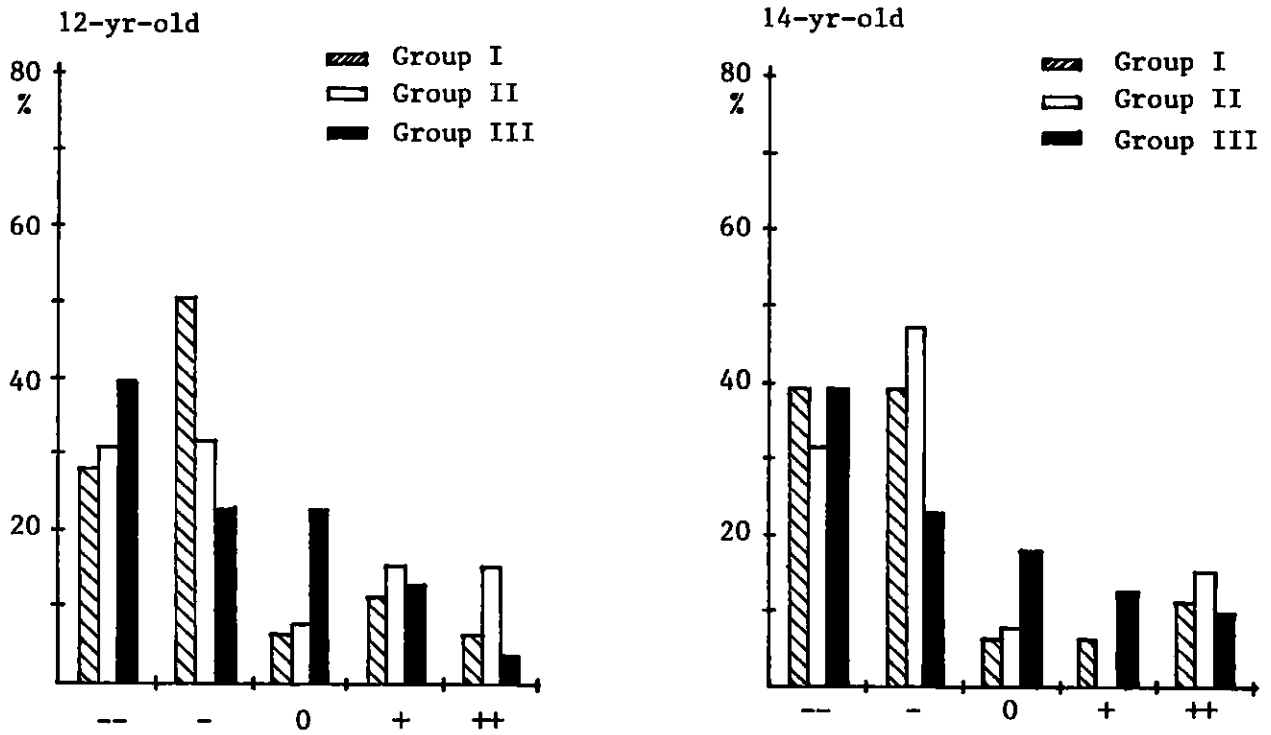
FREQUENCY DISTRIBUTION FOR: CORPUS/OCCLUSAL ALIGNMENT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE XI (continued)

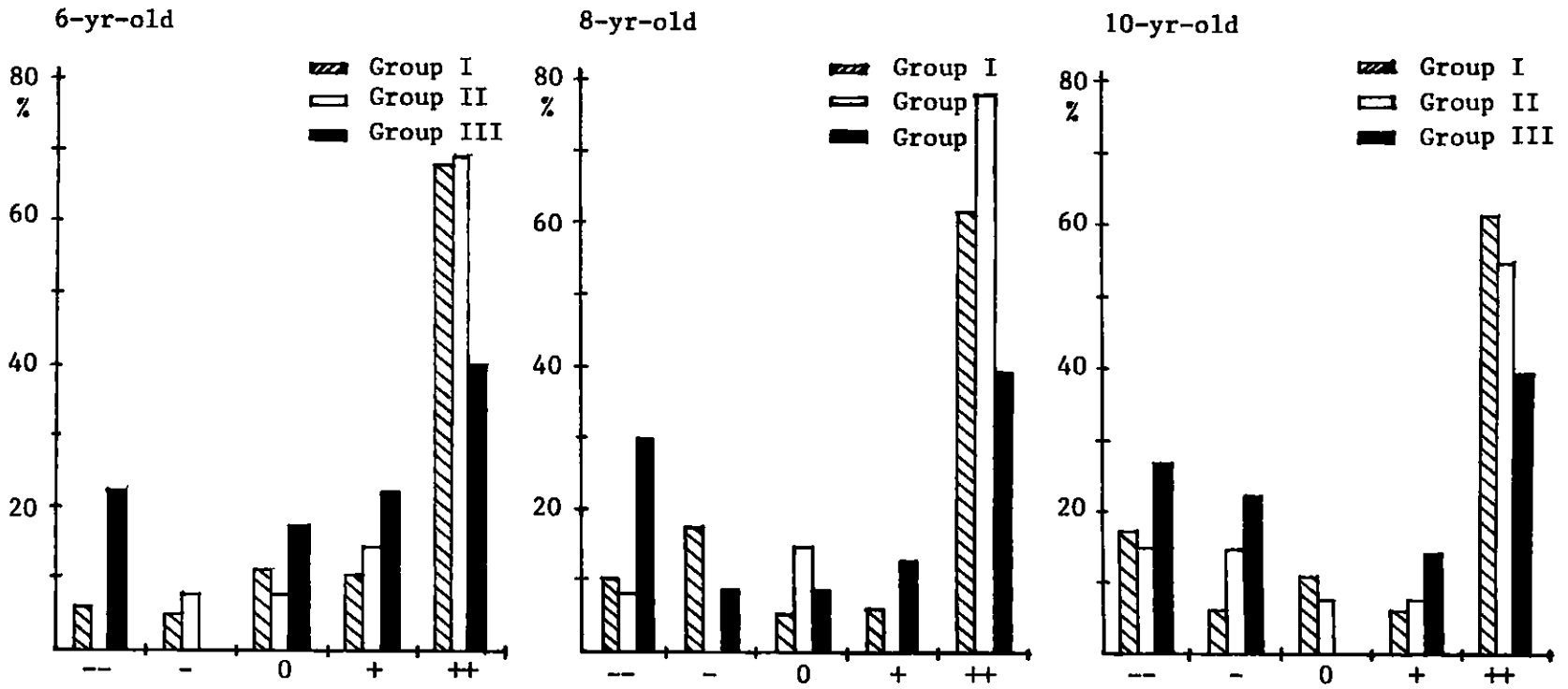
FREQUENCY DISTRIBUTION FOR: CORPUS/OCCLUSAL ALIGNMENT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE XII

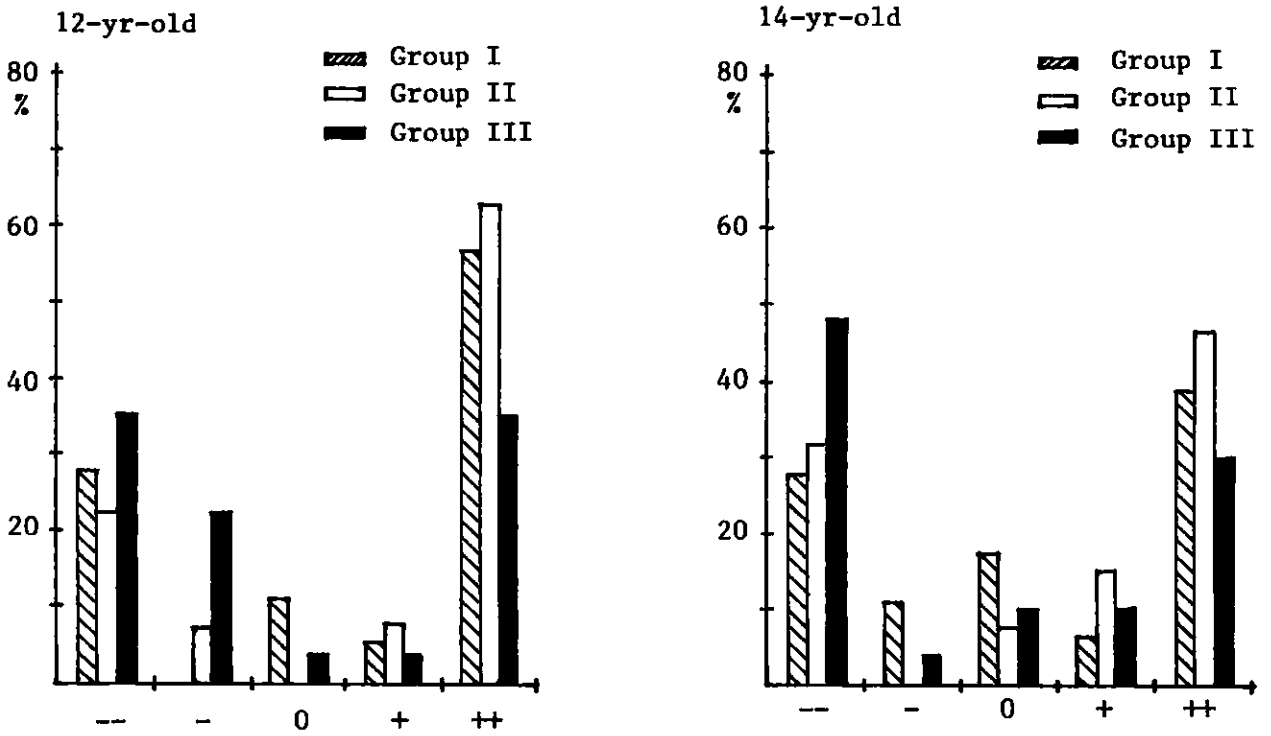
FREQUENCY DISTRIBUTION FOR: MANDIBULAR PLANT ALIGNMENT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE XII (continued)

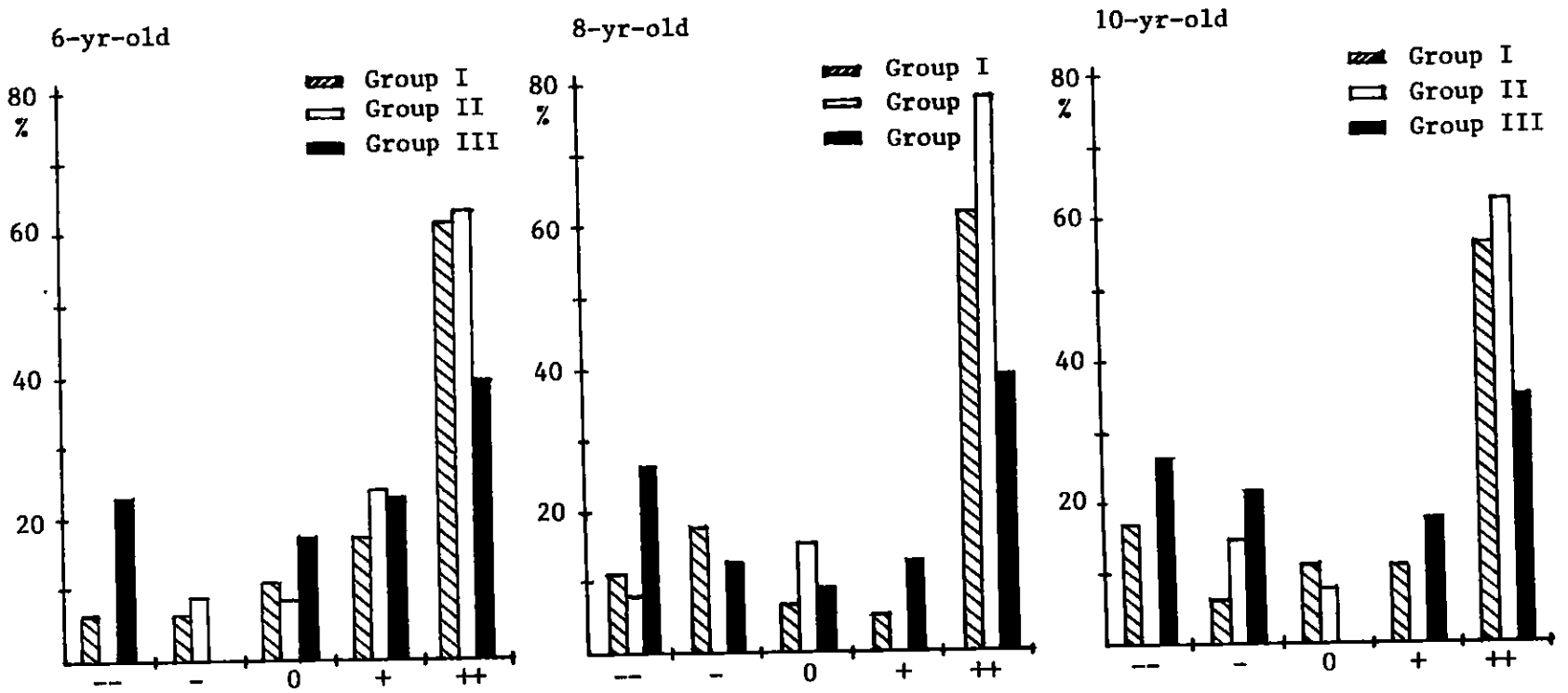
FREQUENCY DISTRIBUTION FOR: MANDIBULAR PLANT ALIGNMENT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE XIII

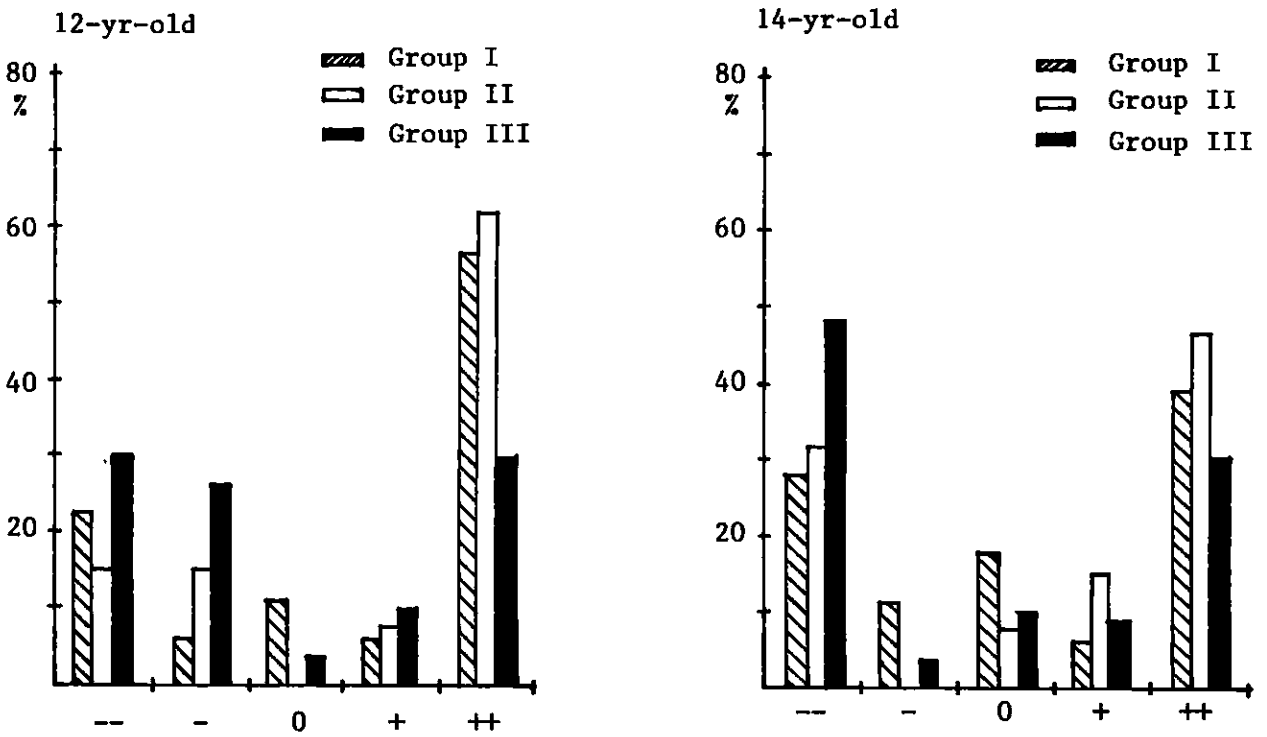
FREQUENCY DISTRIBUTION FOR: GONIAL ANGLE



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE XIII (continued)

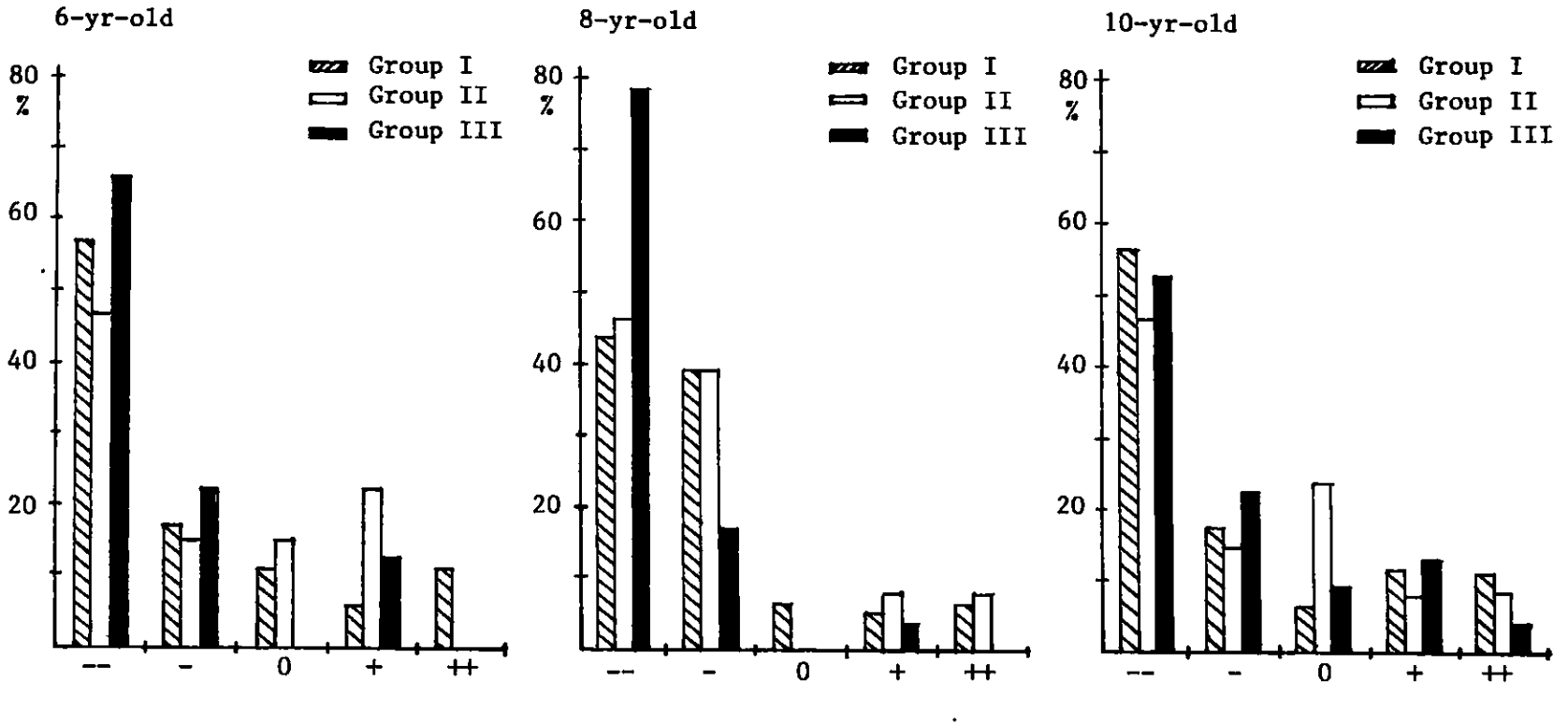
FREQUENCY DISTRIBUTION FOR: GONIAL ANGLE



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE XIV

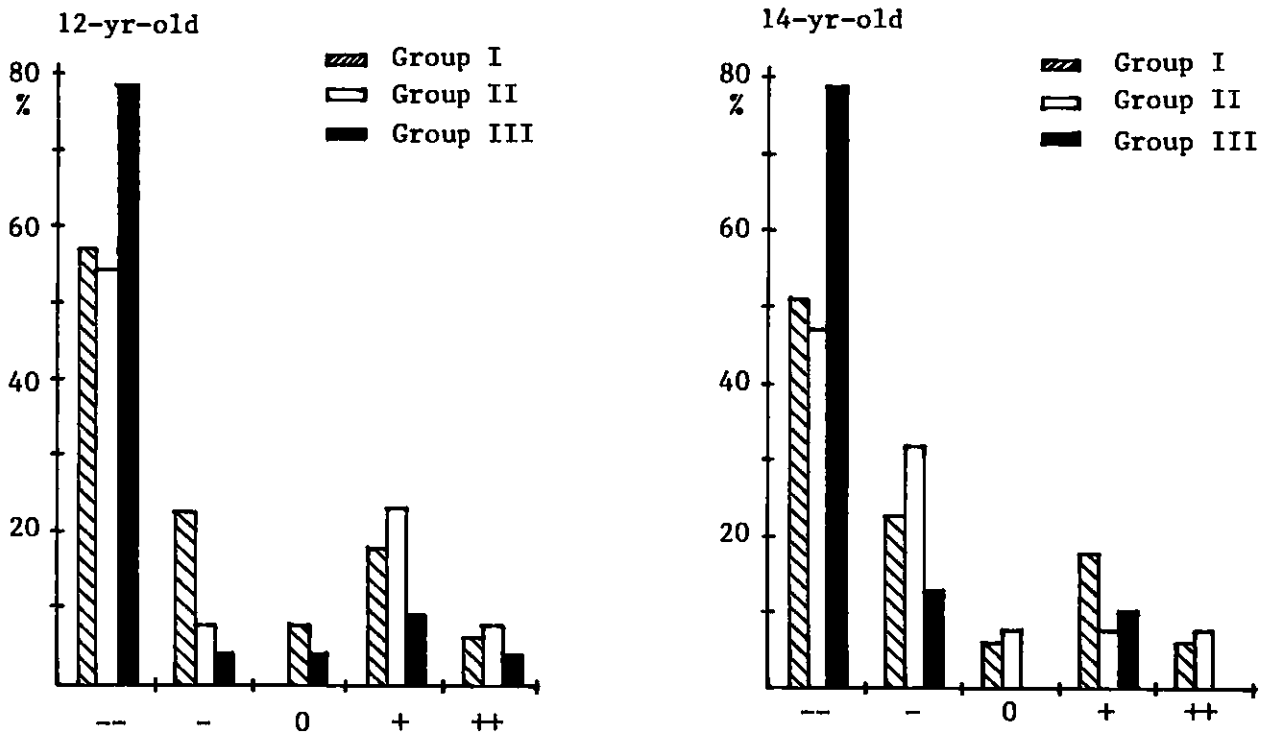
FREQUENCY DISTRIBUTION FOR: OCCLUSAL PLANE ALIGNMENT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE XIV (continued)

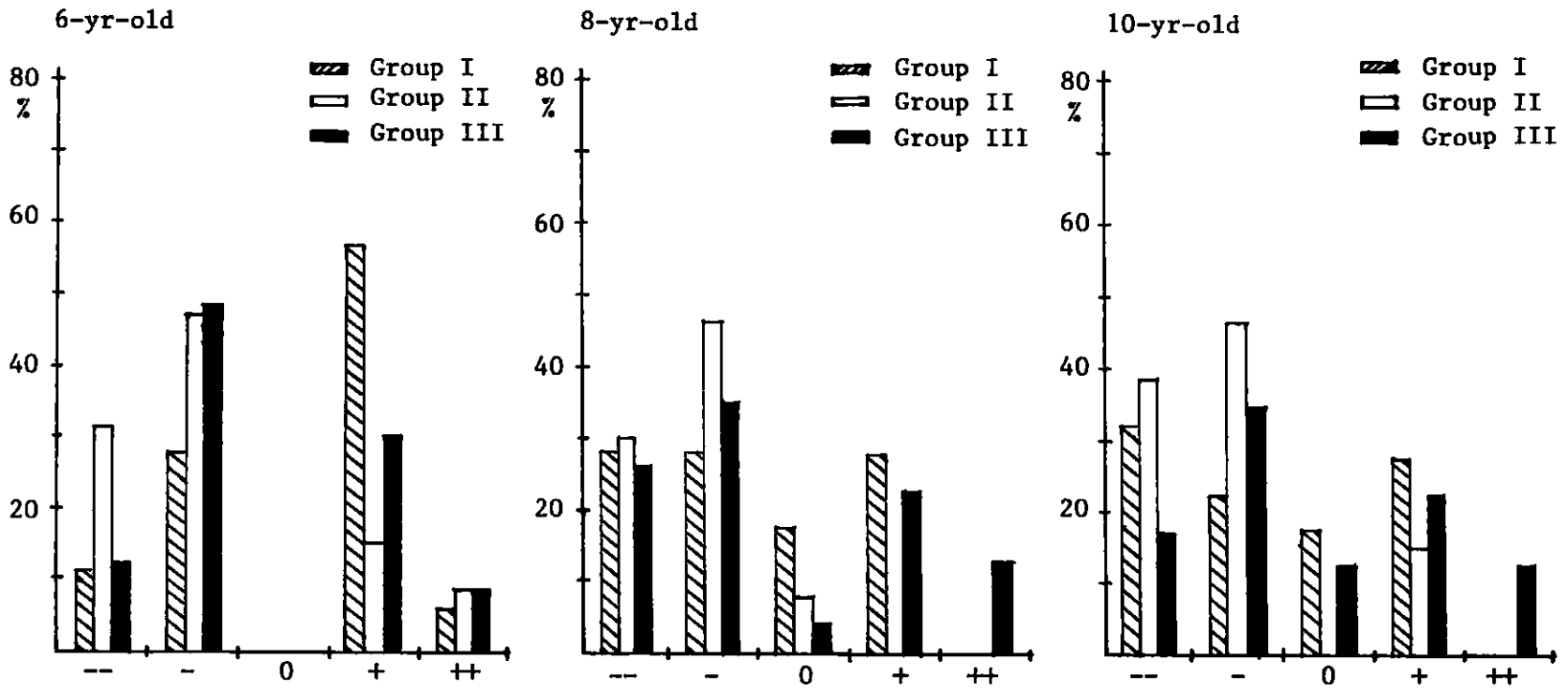
FREQUENCY DISTRIBUTION FOR: OCCLUSAL PLANE ALIGNMENT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE XV

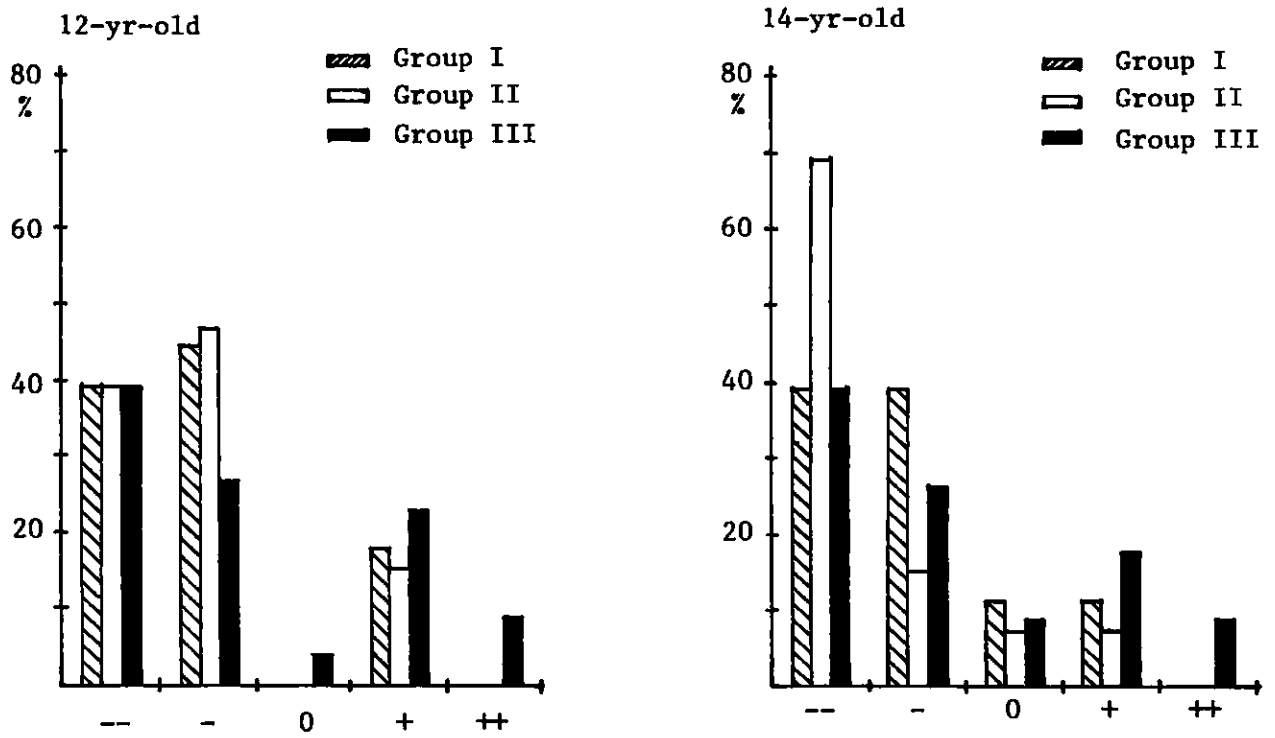
FREQUENCY DISTRIBUTION FOR: PALATAL PLANE ALIGNMENT



Percentage distributions for anatomical relationships at 6, 8, and 10 years

TABLE XV (continued)

FREQUENCY DISTRIBUTION FOR: PALATAL PLANE ALIGNMENT



Percentage distributions for anatomical relationships at 12 and 14 years

TABLE XVI

SUMMARY OF DISTRIBUTION PERCENTAGES

(GROUP I)

	6 Years		8 Years		10 Years		12 Years		14 Years	
	-*	+	-	+	-	+	-	+	-	+
Ar-A, Ar-B	67%	28%	50%	33%	61%	28%	56%	39%	45%	33%
MCF Alignment	28	67	22	61	33	61	45	44	45	44
Ra Alignment	17	83	17	78	11	89	11	83	11	83
PM Vertical	50	39	33	56	33	67	28	72	28	72
Ra/MCF (sk)	72	22	72	28	72	28	56	33	39	45
Ra/MCF (de)	72	22	78	22	78	22	83	17	72	17
Mx/Md (sk)	45	50	50	33	45	44	61	33	83	11
Cor/Occl	83	17	89	11	61	22	78	17	78	17
Occl. Plane	72	17	73	11	72	22	78	22	72	22
Palatal Plane	39	61	56	28	56	28	73	17	78	11

*(+) and (-) stand for mandibular retrusive and protrusive effect, respectively.

TABLE XVII

SUMMARY OF DISTRIBUTION PERCENTAGES

(GROUP II)

	6 Years		8 Years		10 Years		12 Years		14 Years	
	-*	+	-	+	-	+	-	+	-	+
Ar-A, Ar-B	39%	46%	62%	31%	62%	31%	62%	31%	69%	31%
MCF Alignment	39	54	31	46	31	69	31	54	31	46
Ra Alignment	0	85	0	92	23	69	8	77	8	69
PM Vertical	54	39	54	39	54	39	62	31	62	39
Ra/MCF (sk)	54	46	46	46	54	46	46	39	23	62
Ra/MCF (de)	46	23	85	15	85	15	85	15	77	15
Mx/Md (sk)	39	54	62	39	69	23	69	31	69	31
Cor/Occl	69	23	77	8	85	8	62	31	77	15
Occl. Plane	62	23	85	15	74	17	62	31	77	15
Palatal Plane	77	23	77	15	85	15	85	15	85	8

* (+) and (-) stand for mandibular retrusive and protrusive effect, respectively.

TABLE XVIII

SUMMARY OF DISTRIBUTION PERCENTAGES

(GROUP III)

	6 Years		8 Years		10 Years		12 Years		14 Years	
	-*	+	-	+	-	+	-	+	-	+
Ar-A, Ar-B	74%	13%	83%	13%	61%	35%	78%	17%	74%	13%
MCF Alignment	44	48	26	70	30	65	26	52	26	65
Ra Alignment	4	87	4	70	4	96	8	74	4	91
PM Vertical	44	57	44	39	30	48	48	48	48	26
Ra/MCF (sk)	70	17	61	17	74	13	48	48	35	61
Ra/MCF (de)	78	17	83	9	87	9	96	4	96	0
Mx/Md (sk)	56	30	74	13	70	22	78	22	87	9
Cor/Occl	61	13	87	4	70	17	61	17	61	22
Occl. Plane	87	13	96	4	74	17	83	13	91	9
Palatal Plane	61	39	61	35	52	35	65	30	65	26

* (+) and (-) stand for mandibular retrusive, and mandibular protrusive effect, respectively.

TABLE XIX

SUMMARY OF DISTRIBUTION PERCENTAGES FOR
MANDIBULAR PLANE AND GONIAL ANGLE

(GROUPS I, II AND III)

		6 Years		8 Years		10 Years		12 Years		14 Years	
		-	+	-	+	-	+	-	+	-	+
Group I	Mand. Pl.	11%	78%	28%	67%	22%	67%	28%	61%	39%	45%
	Go. Angle	11%	78%	28%	67%	22%	67%	28%	61%	39%	45%
Group II	Mand. Pl.	8%	85%	8%	77%	31%	62%	31%	69%	31%	62%
	Go. Angle	8%	85%	8%	77%	31%	62%	31%	69%	31%	62%
Group III	Mand. Pl.	22%	61%	39%	52%	48%	52%	57%	39%	52%	39%
	Go. Angle	22%	61%	39%	52%	48%	52%	57%	39%	52%	39%

TABLE XX

PHARYNGEAL SPACE DIMENSIONS
(GROUP I)

Numbers*	6 Years	8 Years	10 Years	12 Years	14 Years
3795	5.0 mm	4.5 mm	5.0 mm	9.0 mm	9.0 mm
3047	3.0	6.5	5.5	6.0	8.0
2324	7.5	8.5	8.0	8.0	4.0
2285	4.0	6.0	6.5	5.0	4.0
2281	3.5	6.0	5.0	6.0	9.5
2189	2.0	2.5	2.0	7.5	9.0
2118	2.5	3.0	4.5	6.0	5.0
2107	4.0	5.5	2.5	4.0	8.0
2053	3.5	4.0	4.0	7.5	6.0
2808	4.5	2.0	2.0	1.5	5.0
2699	3.0	4.5	4.0	5.5	5.0
2600	7.0	8.0	5.5	4.5	6.0
2581	4.0	7.0	7.0	4.5	9.5
2459	3.0	4.5	5.5	5.0	11.0
2434	5.0	3.5	3.0	8.0	10.0
106	7.0	5.0	7.5	5.5	9.5
2183	3.0	8.0	8.5	5.0	11.5
2329	7.5	7.0	7.5	5.5	9.0

* Bolton case numbers

TABLE XXI

AVERAGE PHARYNGEAL SPACE DIMENSIONS
(GROUP I)

	6 Years	8 Years	10 Years	12 Years	14 Years
Mean	4.39 mm	5.33 mm	5.19 mm	5.78 mm	7.72 mm
S.D.	1.71	1.89	1.98	1.72	2.36
Male*	6.9	--	--	12.5	13.0
Female	6.5	--	--	13.6	14.9

*Based on McNamara's Data (1981) - Bolton Standard

TABLE XXII

PHARYNGEAL SPACE DIMENSIONS
(GROUP II)

Numbers*	6 Years	8 Years	10 Years	12 Years	14 Years
2878	6.0 mm	7.0 mm	12.0 mm	10.5 mm	13.0 mm
2444	8.5	5.0	12.5	11.0	12.0
2418	8.0	8.0	7.0	12.0	14.0
3720	6.0	4.0	6.5	6.5	12.5
3005	5.0	5.5	7.0	7.5	8.0
2037	5.0	6.0	13.0	12.0	15.5
1197	7.0	6.0	18.0	19.0	19.0
2566	3.5	3.0	7.0	6.5	8.5
2507	8.0	8.5	13.0	15.0	15.5
2809	5.0	7.0	12.0	18.0	21.0
2342	5.5	6.0	7.5	11.0	14.0
2315	6.0	6.0	18.0	16.0	18.0
2254	4.5	4.0	5.5	14.0	17.0

*Bolton case numbers

TABLE XXIII

AVERAGE PHARYNGEAL SPACE DIMENSIONS
(GROUP II)

	6 Years	8 Years	10 Years	12 Years	14 Years
Mean	6 mm	5.85 mm	10.69 mm	12.23 mm	14.46 mm
S.D.	1.44	1.52	4.11	3.91	3.66
Male*	6.9	--	--	12.5	13.0
Female	6.5	--	--	13.6	14.9

*Based on McNamara's Data (1981) - Bolton Standard

TABLE XXIV

PHARYNGEAL SPACE DIMENSIONS
(GROUP III)

Numbers*	6 Years	8 Years	10 Years	12 Years	14 Years
117	13.0 mm	11.0 mm	13.0 mm	13.0 mm	16.0 mm
2378	6.0	8.0	9.5	11.0	10.0
2425	6.0	4.0	9.0	11.5	14.0
1983	2.5	6.0	5.0	4.5	7.0
1952	7.0	11.0	11.0	10.5	12.0
1433	10.0	11.5	16.0	14.5	16.0
1892	13.5	17.0	18.0	18.0	19.0
107	12.0	12.5	15.0	14.5	14.5
1836	10.0	10.0	9.0	12.5	5.5
1860	14.0	14.0	16.0	15.0	15.5
1874	11.0	10.0	12.0	13.0	15.5
2035	12.0	11.5	12.0	12.5	12.0
2136	8.0	5.5	17.5	13.0	15.0

TABLE XXIV (continued)

PHARYNGEAL SPACE DIMENSIONS
(GROUP III)

Numbers*	6 Years	8 Years	10 Years	12 Years	14 Years
2154	13.5 mm	11.5 mm	9.0 mm	9.0 mm	14.0 mm
2615	7.0	16.0	16.5	20.5	22.0
2419	13.0	10.0	9.0	15.0	15.0
2252	5.0	7.0	13.0	15.0	14.5
2284	12.0	15.5	15.5	15.0	18.0
1158	4.0	4.0	9.0	10.0	11.0
1188	5.0	4.5	3.5	11.0	16.0
1198	12.0	14.0	13.0	14.5	14.5
2362	9.0	5.0	13.0	10.5	14.0
2333	13.0	16.0	15.5	15.0	15.0

*Bolton case numbers

TABLE XXV

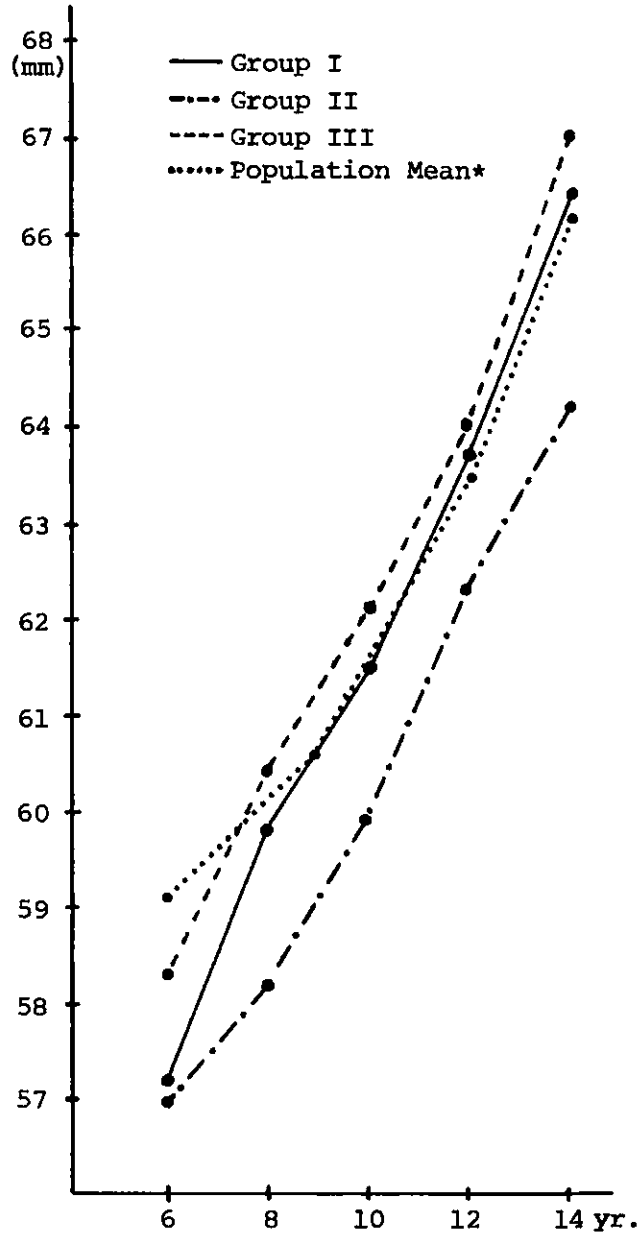
AVERAGE PHARYNGEAL SPACE DIMENSIONS
(GROUP III)

	6 Years	8 Years	10 Years	12 Years	14 Years
Mean	9.5 mm	10.22 mm	12.17 mm	13 mm	14.17 mm
S.D.	3.46	4.02	3.78	3.15	3.48
Male*	6.9	--	--	12.5	13.0
Female	6.5	--	--	13.6	14.9

*Based on McNamara's Date (1981) - Bolton Standard

TABLE XXVI

LOWER FACIAL HEIGHT DIMENSIONS



* Based on McNamara's Data (1981) - Bolton Standard

TABLE XXVII

AVERAGE LOWER FACIAL HEIGHT DIMENSIONS

(GROUPS I, II AND III)

	6 Years		8 Years		10 Years		12 Years		14 Years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Group I	57.2	3.2	59.8	4.4	61.5	4.5	63.7	5.1	66.4	5.6
Group II	57.0	3.0	58.2	3.0	59.9	4.0	62.3	3.6	64.2	4.6
Group III	58.3	3.6	60.4	3.6	62.1	3.9	64.0	4.7	67.0	5.4

	6 Years		9 Years		12 Years		14 Years	
	Male	Female	Male	Female	Male	Female	Male	Female
Pop. Mean*	58.4	59.8	61.1	60.0	64.3	62.6	66.8	65.6

* Based on McNamara's Data (1981) - Bolton Standard

TABLE XXVIII

NUMBERS OF MALOCCLUSION
IN EACH GROUP

	Group I	Group II	Group III
Class I	11	8	16
Class II	7	5	6
Class III	0	0	1
Total	18	13	23

DISCUSSION

The present study focused on an evaluation of relationships among craniofacial morphology, growth, and the status of adenoid tissues. The Counterpart Analysis was utilized for serial headfilm evaluation.

In Group III (early adenoidectomy, average age for adenoidectomy was 3 years and 2 months), the aggregate pattern (Table XVIII) shows a composite combination of regional anatomic relationships that resulted in mandibular B point protrusion beyond maxillary A point.

The nature of the regional relationships serve to explain the structural basis for this composite pattern. At the age of 6 years in Group III, the MCF and ramus alignment position and the PM vertical dimension all have mandibular retrusive effects. However, the horizontal dimension of the ramus, palatal plane alignment, skeletal arch lengths, corpus/occlusal alignment, and occlusal plane alignment all produced effects which were mandibular protrusive, and the resultant composite pattern is thereby characterized by a protrusion of B point relative to A point.

The status of aggregate balance or imbalance can change through time by correcting (or improving), or by aggravating, early dimensional and alignment relationships among the various parts and counterparts (Enlow, 1982). With increasing age in

Group III, the manner of rotation of the MCF and the skeletal horizontal dimension of ramus have a progressively greater mandibular retrusive effect. However, the PM vertical relative dimension reduced their effects with increasing age. As Enlow (1969) mentioned, regional counterpart inequality may be normal, such as those that occur due to age, sex, and ethnic differences, or they may exceed the boundaries for acceptable normality and thereby underlie part of the anatomic and developmental basis for a dysplasia.

In comparison with Group I and II, it is seen in Group III that a composite effect of regional, part-to-part relationships essentially sustained the composite pattern from ages 6 to 14 years. It is therefore possible that the growth process in this group, having undergone adenoidectomy during early craniofacial development, was stabilized to a greater degree.

During the course of growth, a developmental mechanism is continuously operative for adjustments to intrinsic, regional anatomic imbalances (Enlow, 1982). This allows the development of a morphologic assembly that is usually more or less functional among all of the separate but interrelated soft and hard tissue parts.

In Group I (excessive adenoids without adenoidectomy), in comparison with Group III (adenoidectomy before age 6 years), more of the regional counterpart relationships contribute to a tendency toward mandibular retrusion at age 6 years, including the rota-

tional alignment of the MCF, ramus alignment, skeletal arch length as measured at A/B points, and the manner or rotational alignment of the palatal plane. The aggregate, cumulative pattern, nevertheless, shows a mandibular protrusion result, as an over-all pattern, at age 6 years. There appeared marked changes in skeletal arch length, and the rotational alignment of the palatal plane at 8 years. These two conditions had increased progressively by age 14 years.

In cases of mouthbreathing due to nasal obstruction, it is probable that the disturbed nasal breathing process results in functional changes of the perioral musculature. This influence is envisaged as related to the mode of breathing and the changed actions of the muscles of the lips, cheeks, and tongue. The tongue at rest, for example, becomes positioned downward/forward to create space between it and the soft palate for an oral airway. Remodeling of the palate in normal growth process involves differential anterior/posterior amounts of resorption/deposition to produce a palatal rotation that reciprocally offsets an opposite direction of rotation simultaneously occurring during the downward maxillary displacement process. As a consequence, palatal remodeling in conjunction with palatal rotation during maxillary displacement process may be in a state of imbalance when involved with mouth breathing. With constrained nasal breathing due to enlarged adenoids, it could be anticipated that a counterclockwise remodeling rotation of the palatal plane alignment would

occur. This indeed is seen in Groups I and II (Table XVI and XVII). This counterclockwise rotation of the palatal plane stabilized in Group II, by age 14 years following adenoidectomy. The postoperative changes may be due to a raised tongue position caused by the transition to nasal breathing made possible by adenoidectomy.

In addition, such environmental disturbances may also be superimposed on an existing dysplasia or malocclusion, or the converse. It is probable that the presence of a disproportionately large mandible carrying the tongue mass downward/forward could greatly enhance the effect of an already low tongue posture in the mouthbreathing individual by not supporting upper arch width development. In turn, a repeated and consistant downward/forward tongue posture could serve to increase the overall size of mandible in a circumstance of relaxed perioral musculature. Relative sizes between the maxillary/mandibular arches may be of great importance as an explanation for increase in lower facial height. If an individual, having a Class I or Class II dental relationship, shows a tendency toward a skeletal Class III arch dimension, the Class III tendency may then be expressed as a downward/backward rotation of the mandible into a skeletal open bite. An open bite tendency can be identified by linear measurement of lower facial height and determinations of the composite rotational positions of the ramus and palate. In Group I, it was noted that marked changes of maxillary/mandibular arch lengths occurred be-

tween ages 6 and 8 years, 10 and 12 years, and 12 and 14 years (Table XVI) in accordance with changes during the same periods in lower facial heights (Table XXVI).

Hower, tongue position is likely not the only primary factor contributing to the characteristic craniofacial morphology in adenoid airway blockage. Recent study of head posture and related craniofacial morphological variations suggests that a changed head posture is also involved (Solow and Tallgren, 1976).

Compared to Group I (excessive adenoids without adenoidectomy), Group II showed similar effects among the various regional antomical relationships during the periods before adenoidectomy (ages 6, 8, and 10 years). After adenoidectomy in Group II, however, these imbalanced relationships became stabilized during subsequent growth.

The PM vertical dimension is determined by comparing the direction and the extent of MCF rotation with the direction and extent of ramus rotation (Table III). This relationship therefore reveals the nature of the relative vertical lengths among the MCF, ramus, and the nasomaxilla within a particular individual. As seen in Tables XVI through XVIII, Group I demonstrated a marked increase in the relative PM vertical dimension during the successive periods, while Group III showed a continual decrease with increasing age. In Group II, a relatively short PM vertical effect existed compared to Groups I and III. After adenoidectomy in Group II, the relative vertical length of the midface then became

even shorter than during periods before adenoidectomy.

Changes in the relative PM vertical dimension in conjunction with rotational status of mandible and palatal plane alignment contribute to divergency or convergency between the middle and lower face. This is because the rotational status of the ramus, with the condyle as a pivot, is directly dependent on the long or short nature of the relative PM vertical dimension. In Group II, while the Pm vertical dimension remained constant during periods before adenoidectomy, the mandible was in a downward/backward (clockwise) rotational position, and the palatal plane was rotated upward (counterclockwise). This situation suggests that divergency had increased at some time during the preoperative periods. After adenoidectomy, the extent of this effect became stabilized. In Group I, however, a marked change in divergency of face occurred during ages 6 and 8 years, and this continued with increasing age. In Group III, these regional parts tend to compensate for each other.

During normal growth, when the ramus rotates downward/backward, the alignment of corpus is necessarily carried downward with or without opening of the gonial angle, and the mandibular occlusion is also carried into such a downward-aligned position. In Group I, however, while the ramus is rotated downward/backward, occlusal plane alignment had remained constant. This condition could increase the possibility of an anterior open bite situation. During the preoperative periods in Group II and Group I,

the magnitude of downward rotation of the mandibular plane and gonial angle were larger than in Group III. After adenoidectomy in Group II, however, an upward rotation of the mandibular plane and closed gonial angle occurred. This reversal appears to be among the resulatant effects of the rotational response of the mandible to adenoidectomy and the excessive posterior dentoalveolar development.

It is seen that Group II (average age at adenoidectomy was 9 years, 10 months) at age 6 years had aggregate, cumulative mandibular retrusion. After adenoidectomy, the dimensional/rotational disproportions, including aggregate arch length at A/B points, horizontal ramus dimension (dental), skeletal horizontal arch length as measured at A/B points, and the rotational alignment of the palatal plane had been sustained.

The pharyngeal airway was found to widen with increasing age, relative to the population mean (Table XXI). The enlarging pharyngeal space with increasing age may be due to a diminution of the adenoid tissue itself, and also in relative size within the surrounding, enlarging structures. This may explain the observation that imbalanced relationships among the regional anatomic parts in Group I had sustained their relationships without significant changes after age 12 years. Presumably, the nasopharyngeal space at age 14 years is thereby relatively less obstructive than during other age periods, with a consequent lesser demand for mouthbreathing during this period.

However, between ages 6 and 8 years there existed marked changes in regional part-counterpart relationships involving the PM vertical dimension, skeletal horizontal arch lengths at A/B points, the palatal plane alignment, and the aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A/B points in Group I, and the aggregate horizontal lengths at A/B points, the horizontal dimension of ramus (skeletal and dental), the skeletal horizontal arch lengths at A/B points, and the occlusal plane alignment in Group II. Between ages 10 and 12 years, in Group I, another marked change occurred in regional relationships, including the MCF alignment, the horizontal dimension of the ramus (skeletal and dental), the skeletal horizontal arch lengths at A/B points, and palatal plane alignment. These marked changes between ages 6 and 8 years, and also 10 and 12 years, agree with the recently reported findings of Linder-Aronson (1983). He reported that large adenoids were most frequently observed between ages 4 and 6 years, becoming less marked in the older groups. And there was a slight increase between ages 10 and 11 years. The over-all effect was to contribute to a functional skeletal alteration by increasing oral airway patency. In Group III, however, changes among the various "imbalanced" regional part-counterparts maintained their relationships with increasing age.

Evidence has mounted that the adenoids could be considered as an important, but not the sole, factor leading to morphological (dimensional/rotational) changes of regional parts throughout the

craniofacial complex. Also, adenoidectomy, which was found to apparently help sustain the morphological (dimensional/rotational) imbalances among regional parts, can therefore be considered to have a direct structural effect on development of the craniofacial complex.

SUMMARY AND CONCLUSIONS

The purpose of the present study was to evaluate relationships among craniofacial morphology, growth, and the status of adenoid tissues utilizing the Counterpart Analysis for serial headfilms. Anatomic effects of adenoidectomy on craniofacial morphology are evaluated.

The sample was divided into three groups: (1) cases having excessive adenoid tissues without adenoidectomy; (2) cases which underwent adenoidectomy at age 10 years; (3) cases which underwent adenoidectomy before age 6 years.

Anatomic counterparts ("dimensional" and "rotational" alignment features of certain key anatomic components) were compared relative to each other utilizing the counterpart procedure. The planes and angles used in this analysis are designed to coincide specifically with major fields and sites of growth and remodeling, which is the consideration that makes this procedure appropriate as a "morphologic" analysis.

The findings led to the following conclusions:

1. Group III (adenoidectomy before age 6 years) demonstrated that the composite of regional, part-to-part relationships essentially sustained the existant early pattern from ages 6 to 14 years. It is believed that the growth process in this group, having undergone adenoidectomy during early craniofacial development, was stabilized to a greater degree than in the other groups analyzed.

2. With constrained nasal breathing due to enlarged adenoids, counterclockwise (upward) remodeling rotation of the palatal plane alignment occurred in Groups I (excessive adenoids without adenoidectomy) and II (periods before adenoidectomy).

3. Counterclockwise (upward) rotation of the palatal plane alignment had stabilized in Group II by age 14 years following adenoidectomy.

4. The Class III tendency of mandibular size relative to the maxilla sometimes expressed as a downward/backward rotation (skeletal open bite tendency in Groups I and II (preoperative period). After adenoidectomy in Group II, this condition became stabilized. Skeletal open bite was actually noted in 2 cases in Group I.

5. A marked divergency between the jaws occurred between ages 6 and 10 years, and this continued to a lesser degree during increasing age in Group I. In Group II, the divergency increased during the preoperative periods. After adenoidectomy, however, the degree of this effect became stabilized.

6. In Groups I and II (during the preoperative periods), the magnitude of downward rotation of the mandibular plane and the gonial angle were larger than in Group III. After adenoidectomy in Group II, however, an upward rotation of the mandibular plane and closed gonial angle occurred.

7. In Group I, imbalanced relationships among the regional anatomic parts, involving the MCF alignment, the ramus alignment, the PM vertical dimension, the corpus/occlusal alignment, the occlusal plane, and the palatal plane alignment, had stabilized relationships without significant change after age 12 years.

8. Compared to Group I, Group II demonstrated similar effects among the various regional anatomical relationships during the periods before adenoidectomy. After adenoidectomy in Group II, however, these imbalanced relationships became stabilized during subsequent growth.

9. In Group I between ages 6 and 8 years, and also 10 and 12 years, there occurred marked changes in regional part-counterpart relationships involving the aggregate cranial floor/maxilla and ramus/corpus horizontal dimensions at A/B points, the PM vertical dimension, the skeletal horizontal arch lengths, at A/B points, and the palatal plane

alignment.

10. In Group II between ages 6 and 8 years, there existed marked changes in regional part-counterpart relationships involving the aggregate horizontal lengths at A/B points, the horizontal dimension of ramus (skeletal and dental), the skeletal horizontal arch lengths at A/B points, and the occlusal plane alignment.

11. On examination of the 18 cases in Group I, it was found that 11 cases (61%) were Angle Class I malocclusions and 7 cases (39%) were Class II. No Class III individuals occurred in this sample. In Group II, of the 13 cases observed, 8 (62%) presented with Class I and 5 (39%) with Class II. No Class III cases were present. In Group III, of the 23 cases observed, 16 (70%) were Class I, 6 (26%) were Class II, and 1 case was Class III.

12. The adenoids are to be considered as a significant factor leading to morphological (dimensional/rotational) changes of regional parts throughout the craniofacial complex during childhood facial growth development.

13. Adenoidectomy can be considered to have a direct effect on the subsequent development of the craniofacial complex.

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