The Effect of Growth and Orthodontic Treatment on the Soft Tissue Profile

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1974

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A Thesis submitted in partial
fulfilment of the requirements
for the degree of
Master of Dental Science

Department of Preventive Dentistry
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acknowledgements

Among the many persons who gave me help in the preparation of this thesis, I should like to express my particular thanks to my husband, Dr. John Edye, and my sons, Tony and Christopher Edye; Mr. Keith Godfrey; Mrs. Mary Fletcher; Mr. Paul Benbow; Mr. Alan Burgess; Mr. Jim Mackie.

Preparation of the many photographs contained in the thesis took hours of painstaking work. Mr. P. Ward and Miss B. Birschoff, Department of Photography, United Dental Hospital, carried out this task cheerfully and willingly and my thanks go to them for the results they achieved.

Contents

Introduction

Unexpectedly and dramatically, the effect that growth and development may have on the soft tissue profile was recently demonstrated to me by family colour slides of a male child. These photographs, taken at approximately 12 months, 4 years, 8 years, 12 years, and 20 years of age, clearly show the change from the retrognathic infantile profile, to the more mature, less retrognathic profile of the late adolescent. The change in the 12 years to 18 years period is particularly impressive. Had orthodontic treatment inadvertantly caused further retraction of the denture area, the outcome is only too obvious.

A study of the changes that occur in the soft tissue profile as a result of growth and development, and orthodontic treatment, seemed warranted.

The growing face of the male, at 12 months, 4 years, 8 years, 12 years, and 20 years of age.

The growing face, at 8 months, 6 years, 8 years, and 20 years of age. (Courtesy of William L. Brudon.)

The growing face of the female, at 8 months, 6 years, 8 years, and 20 years of age.
Enlow, D.H 1968, p251

For the Orthodontist, the important features of the profile are:

the mandibular symphysis and chin

the lower incisor

the upper incisor

the upper and lower lips

the nose

The brief review of the literature in Part I, which follows, reveals current thinking about the effect of growth and development on these structures.

Changes brought about in the profile as a result of orthodontic treatment are inseparably linked with those brought about by growth and development.

Research workers, teachers and clinicians in the field of orthodontics, have sought, and still seek, methods of treatment to improve a poor profile, or to maintain an originally good, or acceptable profile, whilst fulfilling the other aims of orthodontic treatment.

The more comprehensive review of the literature later in Part I, reveals the extensive studies undertaken, the parameters suggested, and the vast range of conclusions reached, about dento-facial relationships.

The diverse, often conflicting, opinions expressed emphasise the need for continuing interest and investigation.

Part II describes original work carried out in an attempt to determine further parameters in dento-facial relationships.

Part I

Review of the Literature

"Of course it must be understood that changes in the contour of these young faces must take place with further development. The noses and chins will develop and become more pronounced, and after the eruption of the permanent canines there will be more of an acute angle between the nose and the upper lip."

Angle (1907, p72) made this statement when discussing the faces of two normally developing children. By this statement, Angle indicated his knowledge not only of the effect of growth and development of the soft tissues on the profile, but also the effect on the soft tissue profile outline, of growth changes in the skeleto-dental framework.

Recent investigations have cast doubt on the validity of this traditional concept that soft tissue structures reflect their hard tissue counterparts. The following study of the direction of growth of the skeletal framework, and the soft tissue drape, may assist in determining the validity of this concept.

direction of growth of the craniofacial structures

SKELETAL

Hunter (1788, p101) was the first to note that the jaw bones grow in all directions, but that increase in antero-posterior length occurs by addition of bone on the posterior surfaces.

Enlow (1966) points out that a distinction must be made between the *actual* patterns of growth, and the *apparent* directions of growth movement seen when the skull is studied "in toto", such as by cephalometric methods.

Actual patterns of growth

Enlow and Harris (1964) and Enlow and Bang (1965) serially sectioned human skulls in the deciduous and mixed dentition stages of growth. A detailed analysis of the specific directions of growth in each part of the bone was obtained by mapping the areas of endosteal and periosteal bone deposits.

Enlow and Bang provide the following succinct summary of their findings:

"The maxillary body grows in an apparent downward and forward direction; yet actual increase in size is a result of new bone growth on posterior surfaces resulting in an extension of the dental arch. This paradoxical manner of growth parallels the mechanism of development in the mandible. The mandible, like the maxilla is continuously repositioned in a forward direction as actual new growth proceeds posteriorly. An understanding of this situation is complicated by observations in the present study that much of the anterior facial surface is actually resorptive in character. The face, therefore, is receding as it is simultaneously being repositioned in an anterior direction."

Figs. 1, 2, 3, 4 clearly show the areas of modelling resorption and deposition on the surfaces of the maxilla and mandible, together with the repositioning of these bones, with growth. These growth changes effect the skeletal profile.

Fig.1 Enlow,1966

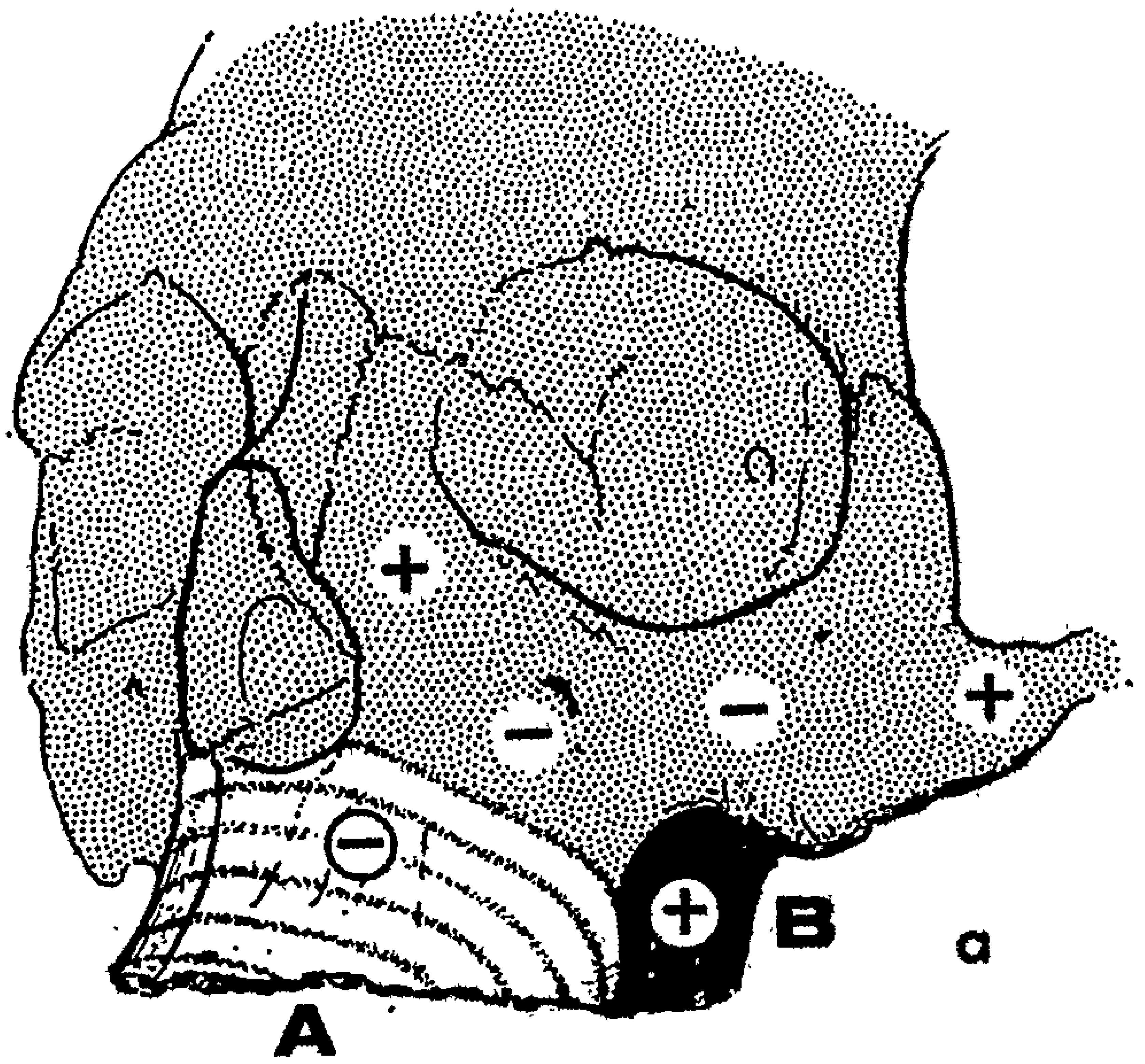
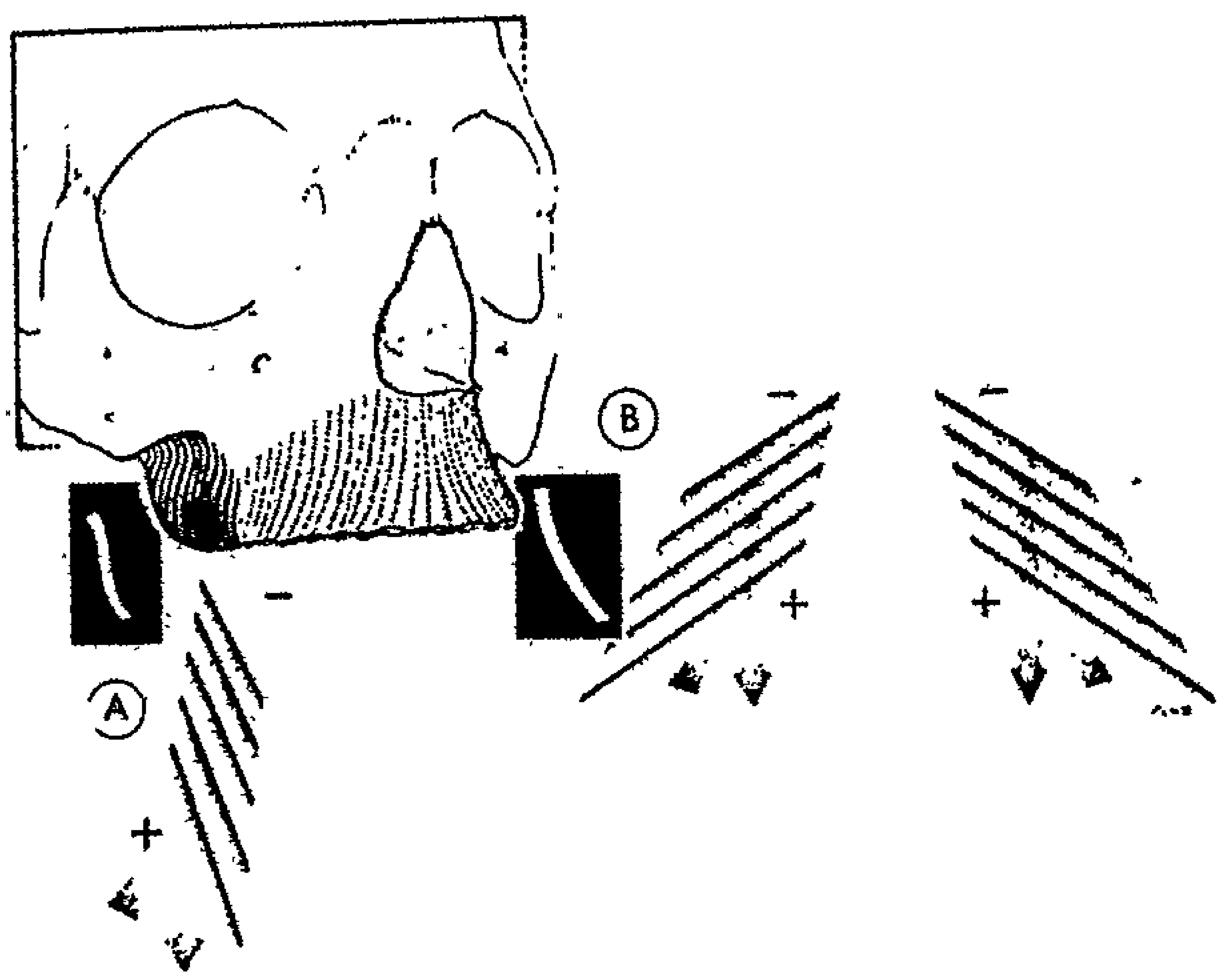


Fig.2 Enlow,1968 p146



Marked differences are present in the surface contours of the maxillary arch anterior to the zygomatic process (B) and that part posterior to the zygomatic process (A). Note that surface B is oriented so that its outer (periosteal) side faces away from the downward direction of growth. This outer surface is resorptive (−). Surface A, in contrast, is oriented so that its outer side faces the direction of growth, which is downward as well as lateral; this surface is depository (+). The line of transition between A and B occurs along the ridge extending from the zygomatic process down onto the dental arch. As in area B, the anterior face of the malar region is also resorptive, a condition associated with the posterior drift of the zygoma. The muzzle of the face grows downward by a combined process of periosteal resorption and endosteal deposition on the outer lamina of bone (B). The nasal and oral sides of the palate move in a corresponding direction. Note that the arch simultaneously becomes widened by an elongation of the free (alveolar) margin. Thus, the arch becomes enlarged even though its outer surface is resorptive. This is an example of the V principle.

Fig.3

The composite of the various regional growth and remodeling movements that occur in the human mandible are summarized in this drawing. See text for detailed descriptions of each area. (From Enlow, D. H., and D. B. Harris: *Am. J. Orthodont.*, 1964.)

Fig.4

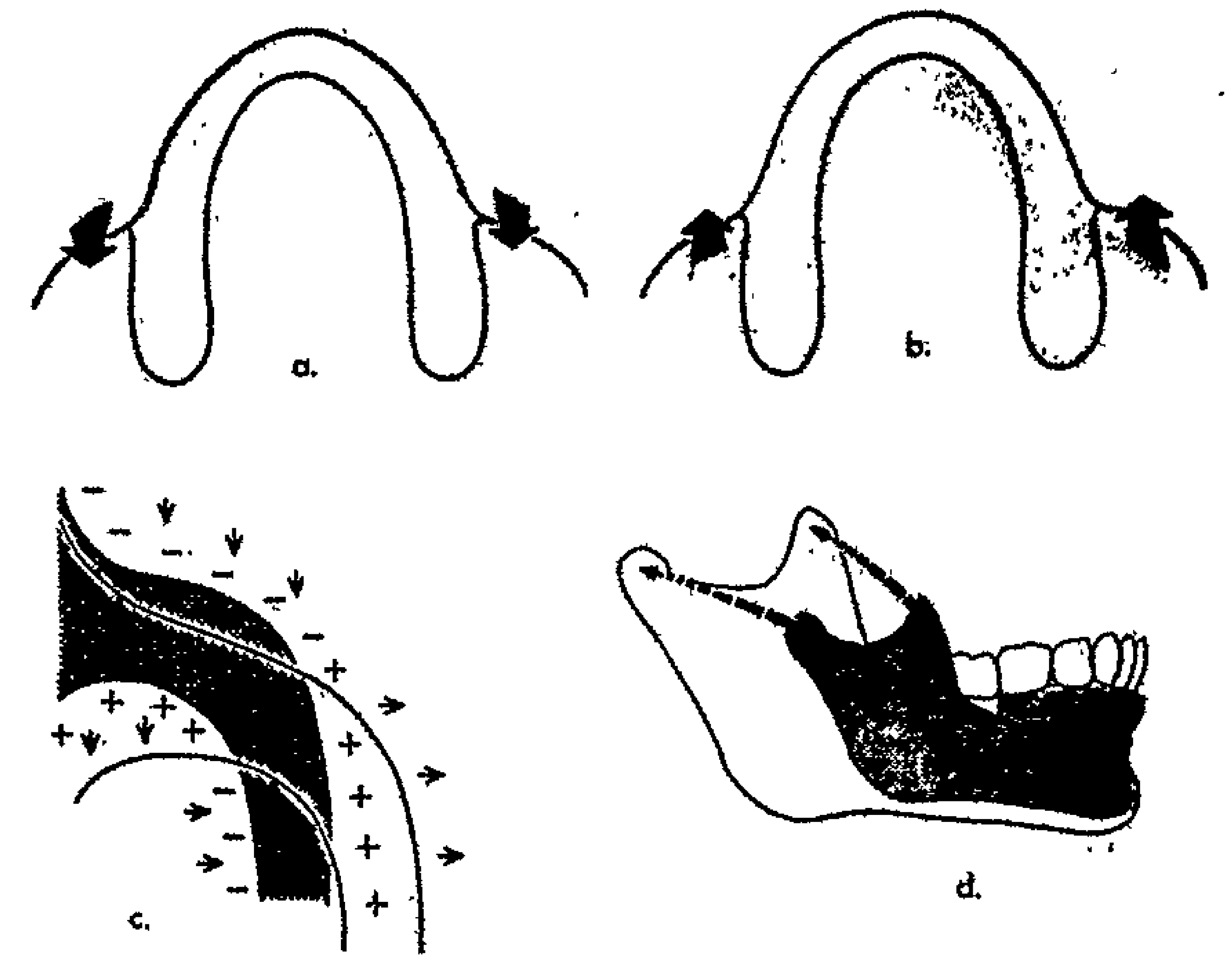


Diagram *a* is an interpretation of posterior growth of the maxillary arch and the zygomatic processes. Bone growth proceeds along the entire inner (lingual) side of the arch as well as along its posterior margin (maxillary tuberosity) and the posterior face of the zygomatic process. Resorptive removal occurs from the outer cortex of the premaxillary area and from the anterior surface of the zygomatic process. Diagram *b* schematizes the *apparent* direction of growth which results from the anterior displacement of the maxillary body accompanying its actual growth in a posterior direction. Diagram *c* illustrates the mechanism of posterior and lateral movement of the combined zygomatic process of the maxilla and the adjacent zygomatic bone. Bone deposition (+) proceeds in lateral and posterior directions (*arrows*), together with complementary resorption (−) from anterior and medial surfaces. The generalized mode of maxillary growth and remodeling parallels that of the human mandible, shown here for comparison (*d*). During posterior growth of the condyle and ramus, the coronoid process is continuously relocated in a posterior direction (*arrows*). Similarly, the zygomatic process of the maxilla also receives proportionate posterior relocation as the maxillary body grows in this direction. (From Enlow, D. H., and S. Bang: *Am. J. Orthodont.*, 1965.)

Apparent directions of growth movement

The technique of Roentgenographic Cephalometry, introduced by Broadbent in 1931, permits longitudinal study of the *apparent* direction of growth of the cranio-facio-dental structures. Such studies, carried out on normal individuals, give a picture of the changes that may be expected in facial contour with growth and development, contributed to by the actual growth changes of the components of the facial skeleton.

These changes are as follows:

There is a pattern of facial form for each individual, which is genetically determined, and established very early in life, probably before birth. This morphogenetic pattern does not change. Growth changes conform to this pre-determined pattern.

Brodie (1941, A), Lande (1952)

From infancy to maturity, there is a decelerating rate of growth, punctuated by growth spurts. There are three growth spurts:

1. The 3 year old growth spurt, which results in the biggest increment in growth.
2. The pre-adolescent growth spurt, which results in the smallest increment in growth. This growth spurt occurs mainly in boys.
3. The adolescent growth spurt, which results in a growth increment between these two extremes.

Brodie (1941, B), Subtelny (1959)
Woodside (1972, p.76)

Illustrated in figs. 5 and 6 are peak velocity curves for females and males.

The face becomes more prognathic with age.
The degree of prognathism may be a racial characteristic.

Bjork (1947), Bjork (1951), Lande (1952)
Subtelny (1959).

Increase in prognathism is greater in the mandible than in the maxilla.

Bjork (1947), Bjork (1951), Lande (1952),
Brodie (1953), Subtelny (1959), Anderson et al,(1973).

However, great variability in the growth pattern of the pre-maxillary region was found by Brodie (1953), Enlow (1966) and Bjork (1966).
Figs. 7, 8, 9 illustrate this variability of growth.

The greater increase in mandibular prognathism brings about a decrease in convexity of the skeletal profile.

Bjork (1947), Lande (1952), Downs (1956)
Subtelny (1959), Baum (1961), Ritchie (1962).

There is a sex differential in the achievement of mandibular prognathism.
By 7 years of age, boys have achieved only one half their degree of mandibular prognathism, so that a significant portion of their total increment will occur

in the pre-adolescent and adolescent years. Subtelny (1959). This increase in mandibular prognathism may continue in boys up to the 23rd year, according to Bjork (1966). By 7 years of age, girls have achieved three quarters of their degree of mandibular prognathism, and show little further increment. Subtelny (1959).

Alveolar bone growth does not keep pace with skeletal growth in an antero-posterior direction, resulting in a recession of the denture area with increasing maturity.

Bjork (1947), Schaeffer (1949), Lande (1952), Subtelny (1959), Baum (1961), Enlow and Harris (1964), Enlow and Bang (1965), Bjork (1966).

The angulation of the incisor teeth to their supporting bases, and to each other, may increase, decrease, or remain stable.

Schaeffer (1949), Bjork (1951), Lande (1952), Brodie (1953), Subtelny (1959), Baum (1961), Schudy (1968).

Angulation of the cranial base remains constant with growth, and the relative position of the dentofacial structures is maintained. In some few individuals, however, angulation of the cranial base does change, with growth. This change may radically alter the spatial relationship of the dentofacial structures, resulting in changes in the facial profile. Disproportionate linear growth of the cranial base, by changing the position of the glenoid fossa may change the position of the mandible, and also change the facial profile.

Ricketts (1955), Bjork (1955,A), Schudy (1965), Mitani (1973).

Normal growth of the mandibular condyle brings about downward and forward growth of the mandible. This occurs in most individuals. When growth does not proceed normally, change in direction of condylar growth changes direction of growth of the mandible, and produces profile changes.

Bjork (1955,B, 1963), Ricketts (1955)
Schudy (1965, 1968), Mitani (1973).

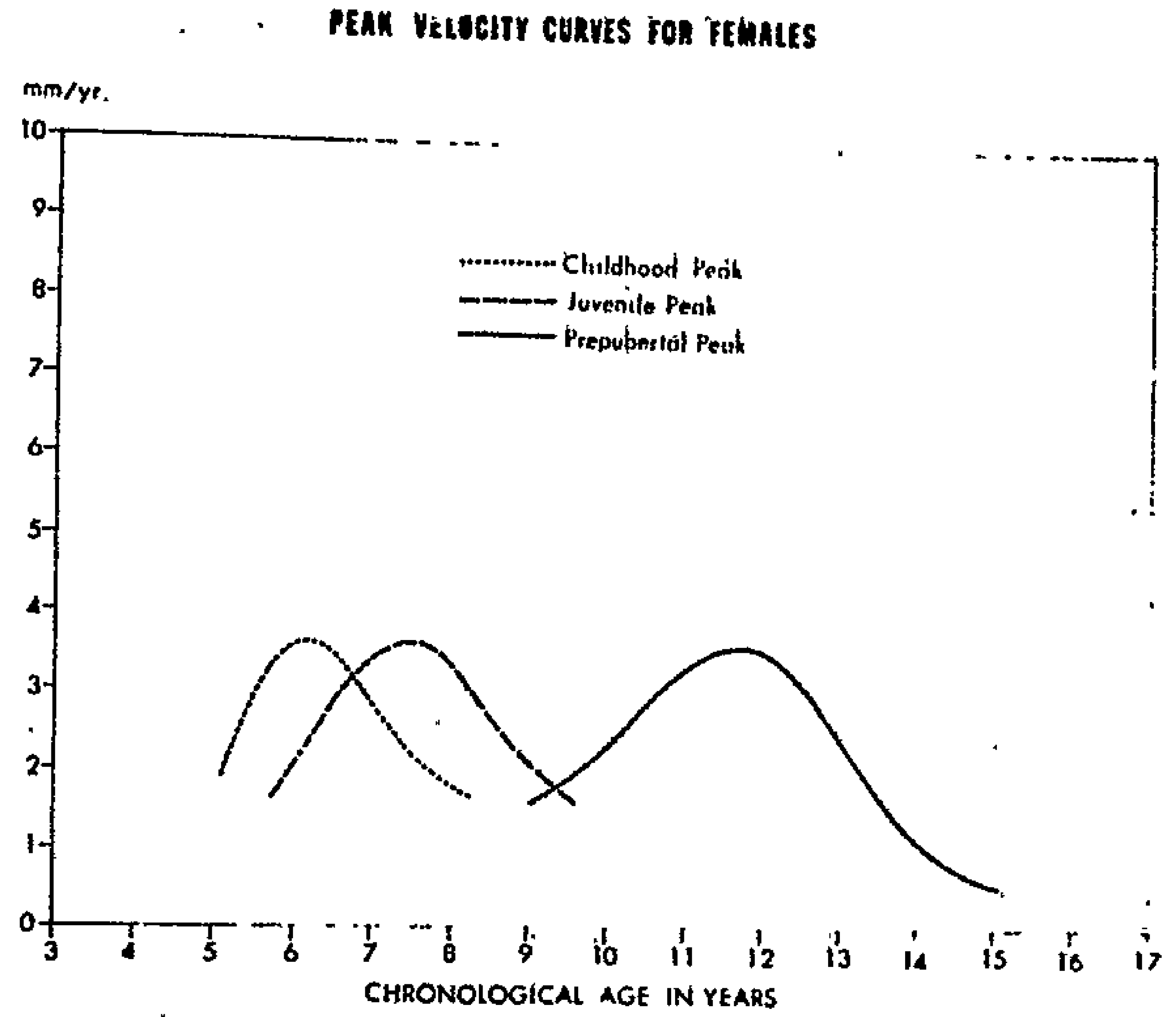
There is wide variation in the amount of growth increment and the rate and direction of growth, from individual to individual, and within each individual

Hellman (1927), Brodie (1954), Subtelny (1959)
Moore (1959), Bjork (1966), Braber (1972, p.75)
Mitani (1973).

Time of onset of the adolescent growth spurt is also extremely variable for each individual. Attempts to determine this factor have been made.

> Krogman (1958 A), Baum (1961) Bambha and Van Natta (1963), Bjork (1967), Woodside (1972, p.76).

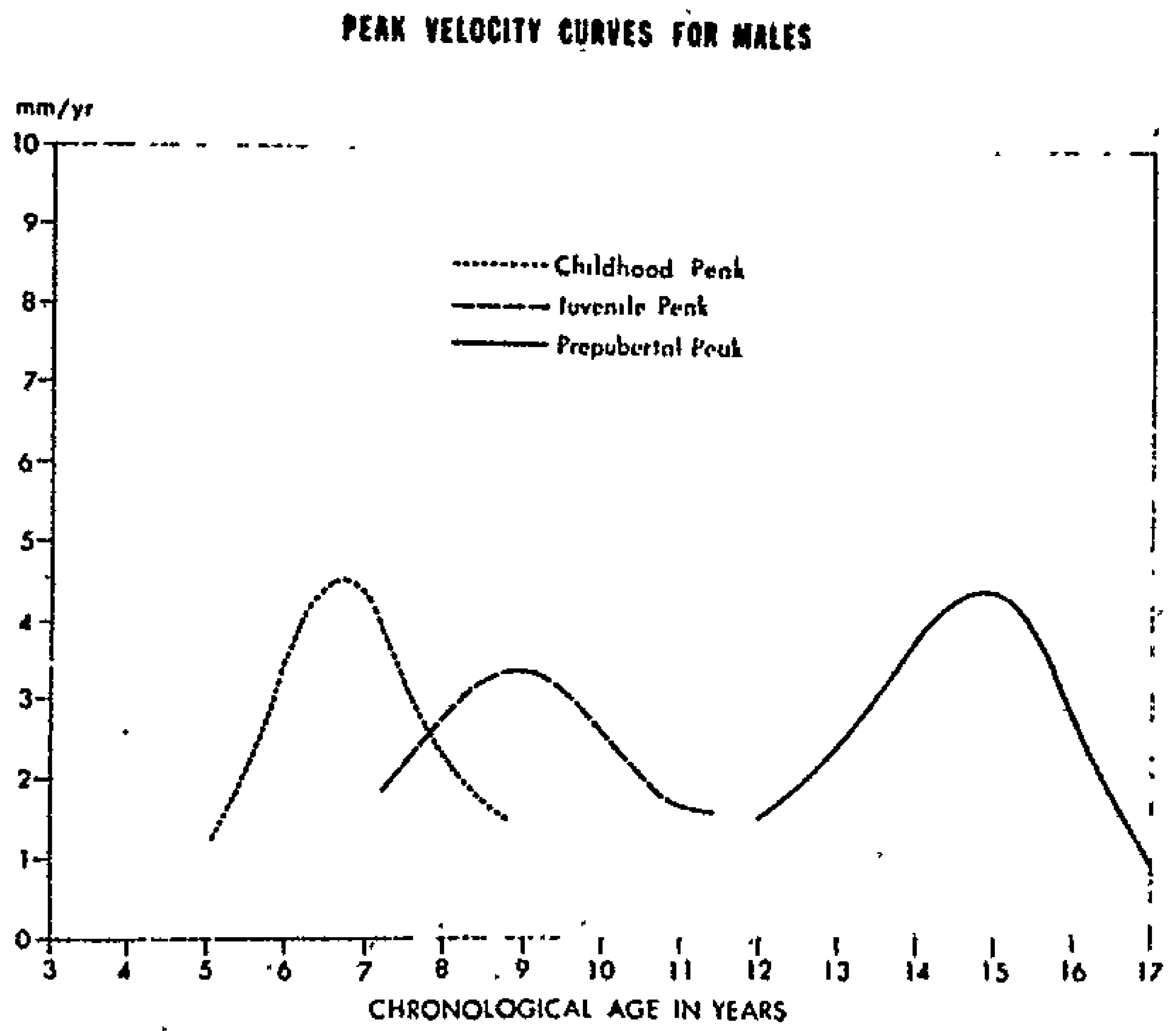
It may be possible to predict growth trends by the study of lateral head plates, taken every 3 - 4 months during orthodontic case management. Caution should be exercised not to exceed a safe radiation dose.



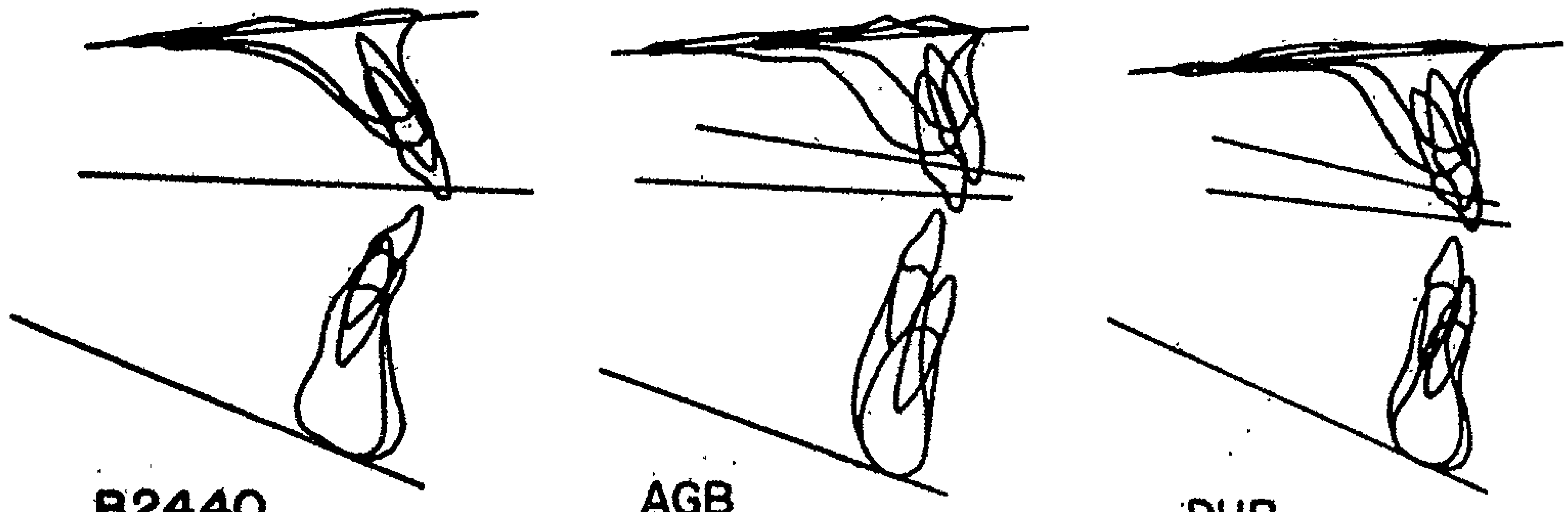
These peak velocity curves, taken from the Burlington study, show three possible periods of accelerated growth that are of interest clinically, if growth amounts are to be optimal. All three peaks for the female are ahead of comparable spurts for males (see Fig. 2–48). (From Woodside, D. G.: Distance, velocity and relative growth rate standards for mandibular growth for Canadian males and females age three to twenty years. Unpublished manuscript, 1969.)

Figs.5 and 6

Woodside,1972 p79



Male peak growth increments also show three possible age-linked associations, but with less overlap than females, and with later spread, particularly of prepubertal and pubertal spurt. Predictability of just when each individual will have a particular spurt is still not accurate enough. And this does not take into account the direction of growth, even though the increments may be large (see Figs. 2–41 to 2–44). (From Woodside, D. G.: Distance, velocity and relative growth rate standards for mandibular growth for Canadian males and females age three to twenty years. Unpublished manuscript, 1969.)



First and last tracings of 3 cases indicating different types of growth changes between dental structures and their skeletal support.

Fig.7 Brodie,1953

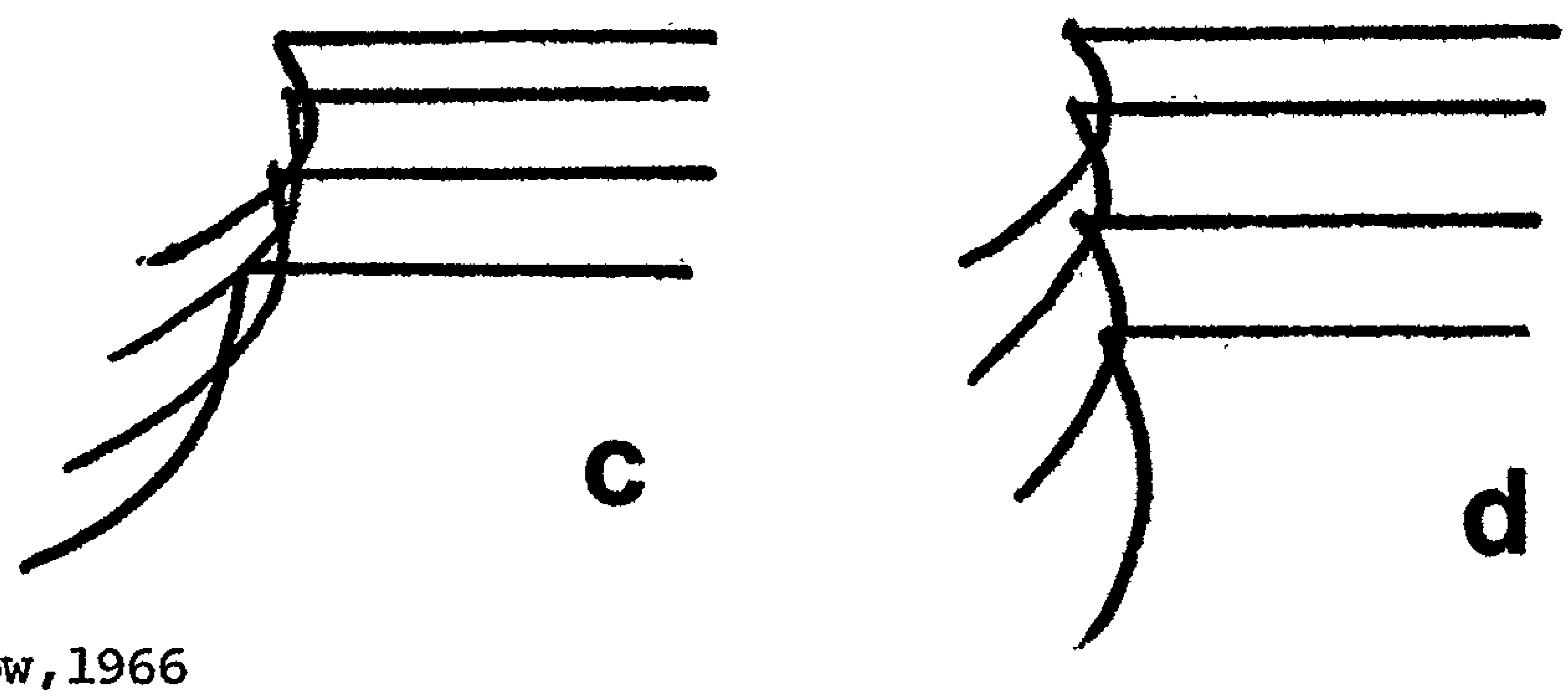


Fig.8 Enlow,1966

Fig.9 Enlow,1966

c and d,elongation of the alveolar margin can bring about a slight forward extension of the premaxilla,even though the periosteal surface of the area in general is resorptive.Note the "tilting" action associated with premaxillary remodelling, in which the upper part of this area undergoes regression while the lower part becomes extended in an anterior direction.In the sixteen cephalometric series studied,all but two showed a premaxillary region that appeared either to drop approximately straight down or extend slightly forward (schematized in c).In two persons,however,the free alveolar margin apparently shifted in a posterior (distal) direction,as in d,e.

SOFT TISSUES

Subtelny (1959) studied growth of the soft tissues in a number of subjects possessing normal skeletal profiles. Equally divided as to sex, these individuals ranged from 6 months to 18 years of age.

Results of this investigation disclose the following salient points regarding growth changes in the soft tissue drape between 7 years and 18 years of age.

1. There is a decelerating rate of growth.
2. There is an increase in thickness of the integumental chin in the male, causing an increase in soft tissue prognathism closely analagous to the increase in skeletal

prognathism. In the female, the increase in thickness in the integumental chin is minimal.

3. When changes in the nose are not considered in the evaluation, a straightening of the soft tissue profile occurs, with growth. This compares with a decrease in convexity of the skeletal profile, with age, and is due to an increase in thickness of the soft tissues in the region of subnasale. The degree of change is the same for both sexes.

   Fig. 10 demonstrates the method of evaluating profile convexity.

   Table 1. shows the average soft tissue thickening for different age groups.

4. Increase in convexity of the profile is seen when evaluation of growth of the nose is considered. Notable differences are found regarding the pattern of growth of the nose and that of other facial structures.

   a. There is no decelerating rate of growth of the nose. Each three year interval is found to have an associated increment of 3 - 5 mm in nasal length.

b. The male nose is longer than that of the female at seven years of age, so that, even though equal increments in length are found for the sexes up to 18 years of age, the mature nose in the male is always longer than the mature nose in the female.

c. In both sexes, the average increment in the vertical dimension of the nose is much greater than the average increment in the anteroposterior dimension. From about 2 years of age, the nose occupies 43% of total face height.

d. Males have a definite nasal growth spurt, which occurs at an average age of 13 - 14 years, but may occur as early as 10 years or as late as 16 years of age. Females rarely have a nasal growth spurt. When this does occur, it is much smaller, and of shorter duration than that of the male and takes place at about 12 years of age.

e. The length of the nasal bone is 40-45% of the total length of the nose.

Generally, the total nose profile is closely related to the path of growth of the nasal bone. In the majority of males, and in some females, when a growth spurt is evident, the nasal bones tend to deviate from a downward and forward path of growth. It projects, or becomes inclined, in a more forward direction, which frequently results in a bump in the bridge of the nose. In most instances, the cartilaginous part of the nose follows the change in angulation of the nasal bone; when it does not follow the change in angulation, but continues to grow in a downward and forward direction, the bump in the bridge of the nose becomes more prominent.

When these changes in nasal contour occur, they appear to have an important influence on the total facial profile. Table 2 gives the mean measurements of the nose in mm.

Fig. 11 shows the method of evaluation of changes in the profile of the nose with growth.

5. By 9 years of age, the upper central incisors have fully erupted; the upper lip covers about two thirds of their labial surfaces.

This relationship between the upper incisors and the upper lip is maintained with growth. The upper lip continues to grow in length up to 15 years of age, keeping pace with vertical alveolar growth of the maxilla. Increase in thickness at the vermillion border of the upper lip equals the increase in length of the upper lip up to 15 years of age. After that age, boys continue to show an increase in thickness, whilst girls do not.

6. The lower lip increases in length and in thickness at the vermillion border, up to 15 years of age. There is no sex differential. The lower lip maintains a constant relationship to the upper and lower incisors, after their full eruption at about 9 years of age. It covers the remaining third of the labial surface of the maxillary incisor.

7. The anteroposterior position of the vermillion border of the upper and lower lips is closely related to the underlying teeth and alveolar processes during growth.

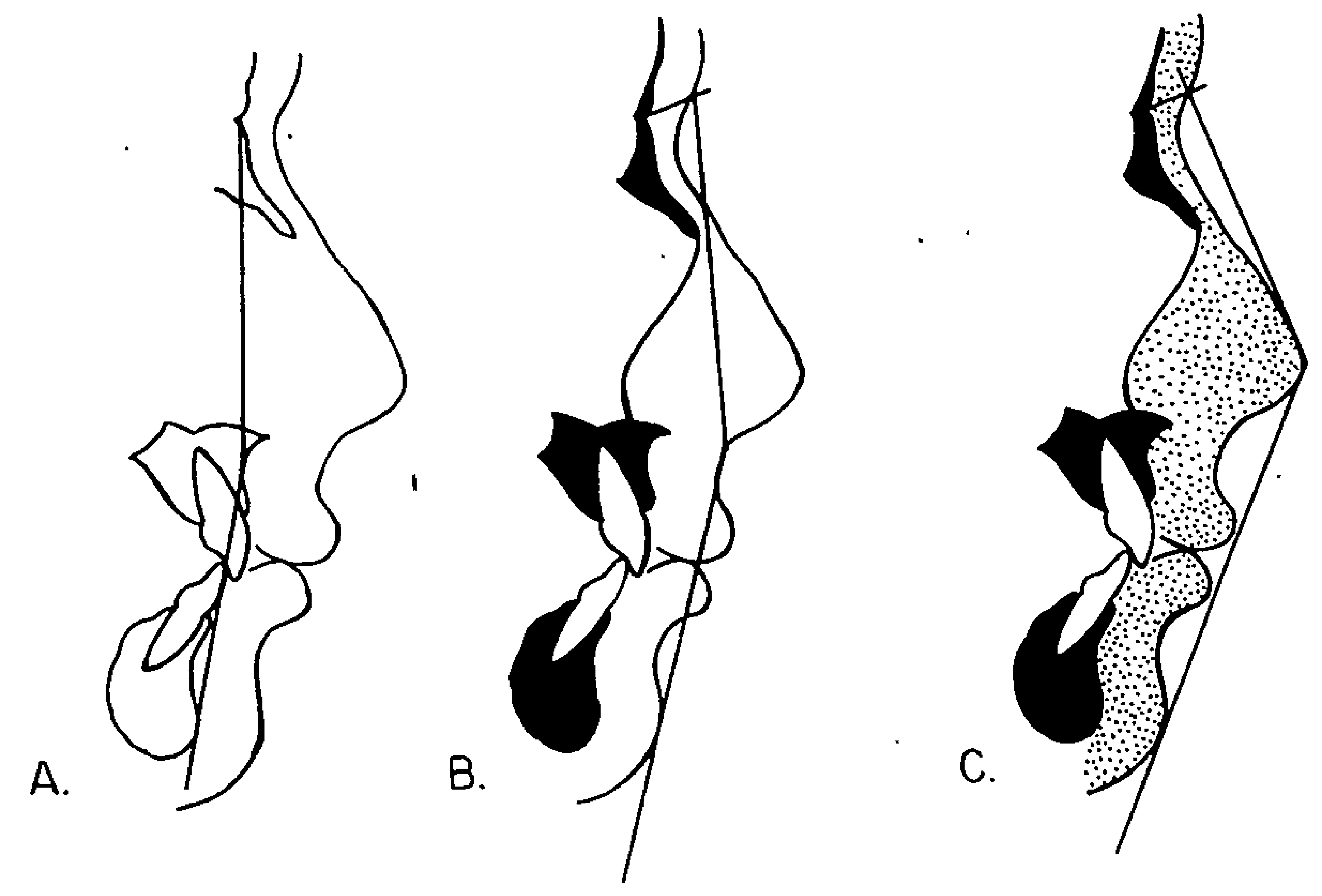


Fig.10 A.Convexity of the skeletal profile (nasion-point A - pogonion). B.Soft tissue profile convexity (soft tissue nasion-subnasale-soft tissue pogonion). C.Total soft tissue profile convexity,including the nose. Subtelny,1959

AVERAGE SOFT TISSUE THICKNESS IN MILLIMETERS

AGE IN YEARS	SOFT TISSUE THICKNESS OVERLYING NASION		SOFT TISSUE THICKNESS OVERLYING POINT A		SOFT TISSUE THICKNESS OVERLYING POGONION	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
1	11.2	11.0	9.8	9.0	9.0	9.0
3	10.2	9.7	12.2	10.7	10.0	10.1
6	9.9	9.0	12.7	11.3	11.0	10.0
9	9.5	8.0	14.0	12.6	10.5	10.2
12	10.0	7.5	15.0	14.0	11.0	10.5
15	10.0	7.6	16.1	15.1	12.0	11.0
18	10.0	9.0	17.5	15.5	12.4	11.1

Table 1 Subtelny,1959

MEAN MEASUREMENTS OF THE NOSE IN MILLIMETERS

AGE IN YEARS	NOSE LENGTH (NASION TO TIP OF NOSE)		VERTICAL HEIGHT OF NOSE		ANTEROPOSTERIOR LENGTH OF NOSE	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
1	34.1	30.8	28.1	25.0	19.5	18.0
3	38.9	37.0	32.0	30.1	21.6	21.4
6	43.3	41.1	36.0	34.2	24.0	23.1
9	47.7	45.2	40.1	37.0	26.1	26.0
12	51.7	50.2	43.5	41.1	28.1	29.4
15	54.9	54.4	46.6	44.3	29.0	32.2
18	60.2	57.8	49.0	46.1	35.2	35.0

Table 2 Subtelny,1959

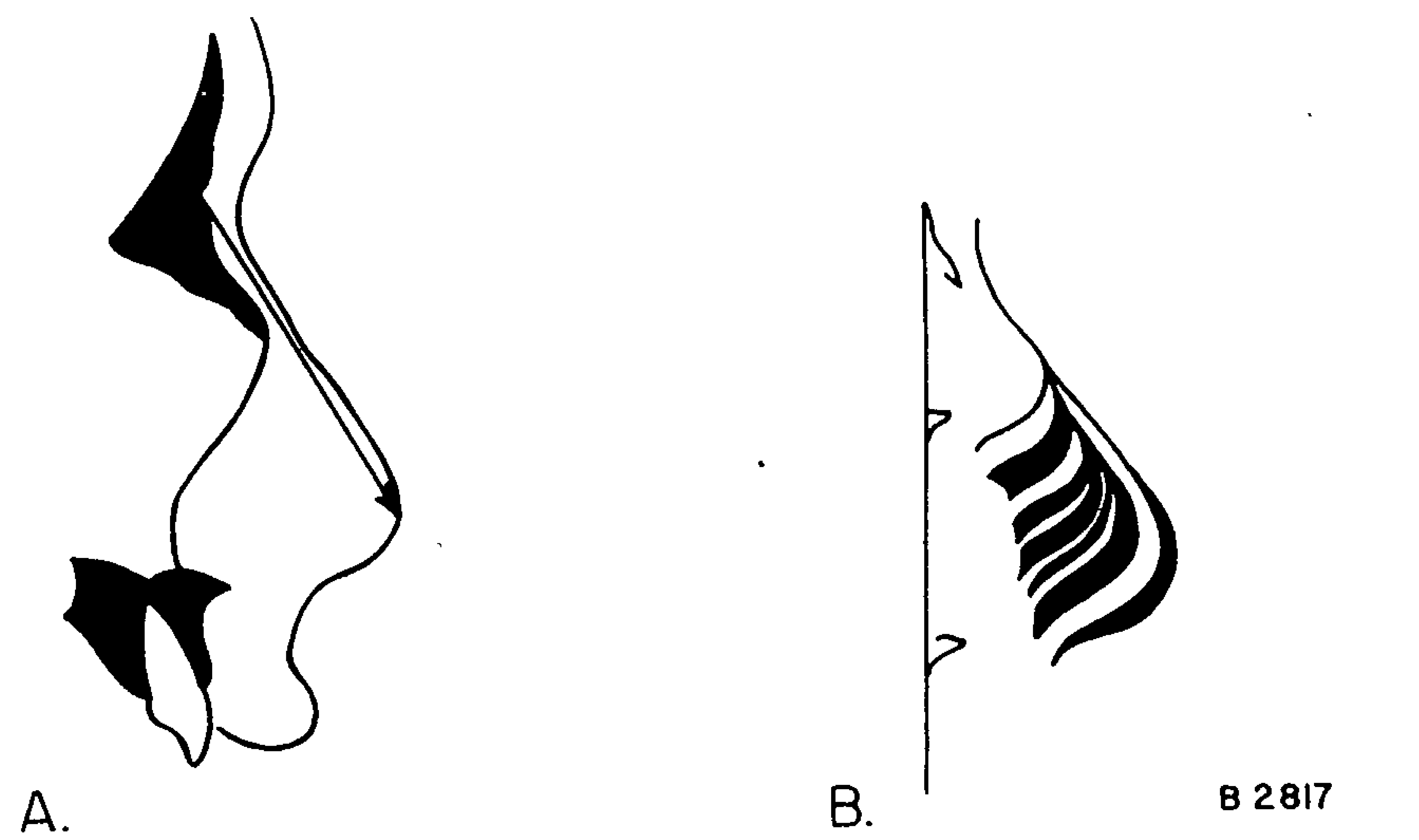


Fig.11 A. Line projected from nasion to the tip of the nose for measurement purposes.This indicates the extent of downward and forward growth of the nose. B.Superimposed tracings of an individual series.The tracings are superimposed on a line connecting nasion and point A,registering on nasion.This depicts the growth pattern of the nose of an individual subject.
Subtelny,1959

Other authors

Ricketts (1957) found that the nose can be expected to grow 2mm in length during the orthodontic treatment period.

Burstone (1959) found that protrusion of the upper lip from the sulcus increases with age, but that the curl of the lower lip shows significant decrease with age; the prominence of the soft tissue chin shows increase, and the total face becomes less convex; variation, not uniformity, exists in the soft tissue veneer. This variation in soft tissue mass is greater when associated with a malocclusion.

Manera and Subtelny (1961) found that the nasal bone shows considerable increase in angulation relative to the facial plane in the late growth stages. Although showing some increase in angulation during the same stages of growth, the cartilaginous part of the nose does not achieve the same degree of angulation as does the nasal bone.

Baum (1961) found that the nose grew 4mm in length in boys, after the 11th, 12th and 13th years. Girls showed negligible increase in length of the nose after those years.

Ritchie (1962) found a pronounced increase in the length of the nose, and a flattening in the area of the upper and lower lips in boys, with growth. He also found a wide range of values for soft tissue measurements.

Rudee (1964) found that in an average treatment period of 32 months, the mandible grew an average of 0.6mm. More significant was the fact that, during the same period, on the average, the soft tissue chin grew twice as much as pogonion. However, this increment was only half that of the nose, which was positioned 2.5mm more anteriorly during the orthodontic treatment period, due to growth.

Posen (1967) considers that a knowledge of the changes that occur with growth of the nose after 13 years of age, is essential. Increase in angulation occurs between the nasal bone and cranial base. This exceeds the increase in angulation that occurs between the nasal dorsum and the cranial base, and results in a straightening of the nasal dorsum. When a discrepancy occurs between the increase in angulation of the nasal bone and the nasal dorsum, a bump in the bridge of the nose results.

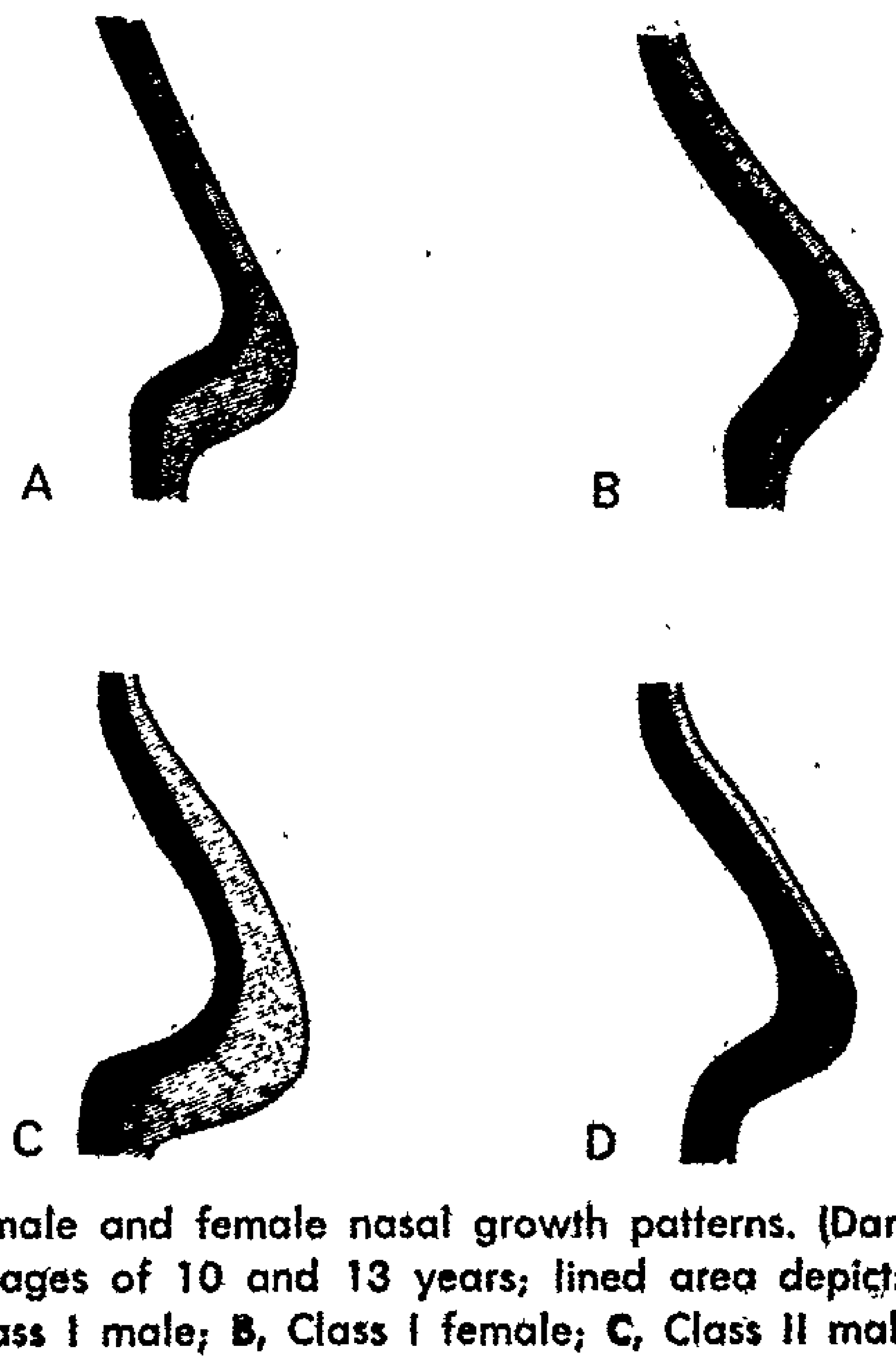
Clements (1969) found that latent changes occur in nasal growth. Downward and forward depression, elongation of the tip, and humping of the dorsum occur during the time of orthodontic treatment.

As a result of his study, Chaconas (1969) came to the following conclusions:

1. The total incremental increase in length of the nose between 10 years and 16 years of age is greater for boys than for girls.
2. By 10 years of age, the greater part of the growth in length of the nasal bone has occurred. The soft tissue nose continues to grow downward and forward. Only a few subjects exhibit elevation of the bridge of

the nose, which is considered to be due to anterior positioning of the nasal bone. Fig. 12 depicts examples of male and female nasal growth patterns.

Anderson *et al.* (1973) found that soft tissue thickness over pogonion increases with age; that nose length when measured to the facial plane increases 4.8 mm in males and 1.8mm in females for the 13 years to 28 years age group. They also found that the soft tissue profile is dependent upon and closely related to, the dentoskeletal profile.



Examples of male and female nasal growth patterns. (Darkened area illustrates growth between the ages of 10 and 13 years; lined area depicts growth between 13 and 16 years.) **A**, Class I male; **B**, Class I female; **C**, Class II male; **D**, Class II female.

Fig.12 Chaconas,1969

musculature

The role of the musculature in the perpetuation of normal growth is discussed. Brodie (1942, 1950), Graber (1958A, 1963), Ballard (1963), Subtelny (1966) Moyers (1973 p.324).

The tongue, by the time of birth, is well conditioned to the role it has to play in the process of deglutition. Unconfined by the presence of teeth, or by the effect of the extra-oral musculature, its pattern of activity is predetermined. With growth of the alveoli, eruption of the teeth, and increasing muscular activity of the lips and cheeks, the tongue becomes confined, and a harmony of the musculature between the intra- and extra-oral tissues becomes necessary. An antero-posterior malrelationship, alone, or with intrinsic or extrinsic oral habits superimposed, may cause a change in the resting posture of the musculature, and its activity during mastication, deglutition, respiration and speech. This applies to both the tongue and the extra-oral musculature, and is well illustrated by Lischers drawings. (Fig.13,14,15)

The force exerted by ever present aberrant muscle function is extremely potent and may effect the configuration of the skeletal and soft tissue structures and the attainment of their inbuilt growth potential.

Elimination of the causative factors of malfunctioning musculature is one of the prime objectives of orthodontic treatment.

Fig. 16 Brodie shows the normal infantile position of the tongue.

Fig. 17 Huber illustrates one stage in the post-natal growth of the facial musculature, in contrast with that of the masticatory musculature.

Fig. 18 Graber illustrates the restraining influence of the buccinator muscle.

Fig. 19 Moyers illustrates aberrant function of the mentalis muscle.

Fig. 20 Ballard illustrates the change of the oral seal pattern as a result of the partial reduction of an increased overjet.

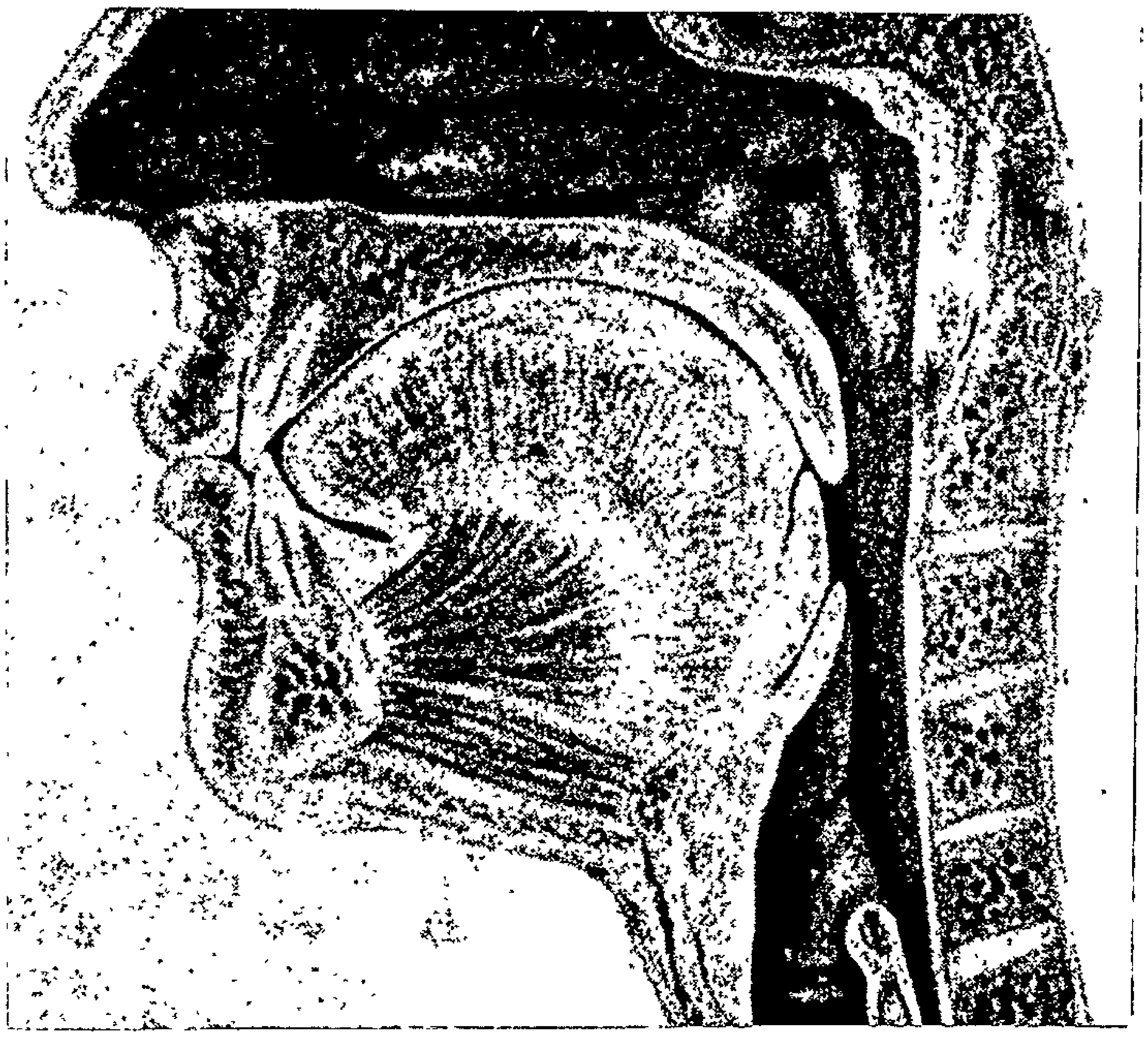


Fig.13 Drawing of mid-sagittal section of a normal structural relationship.
Lischer,1961 p232

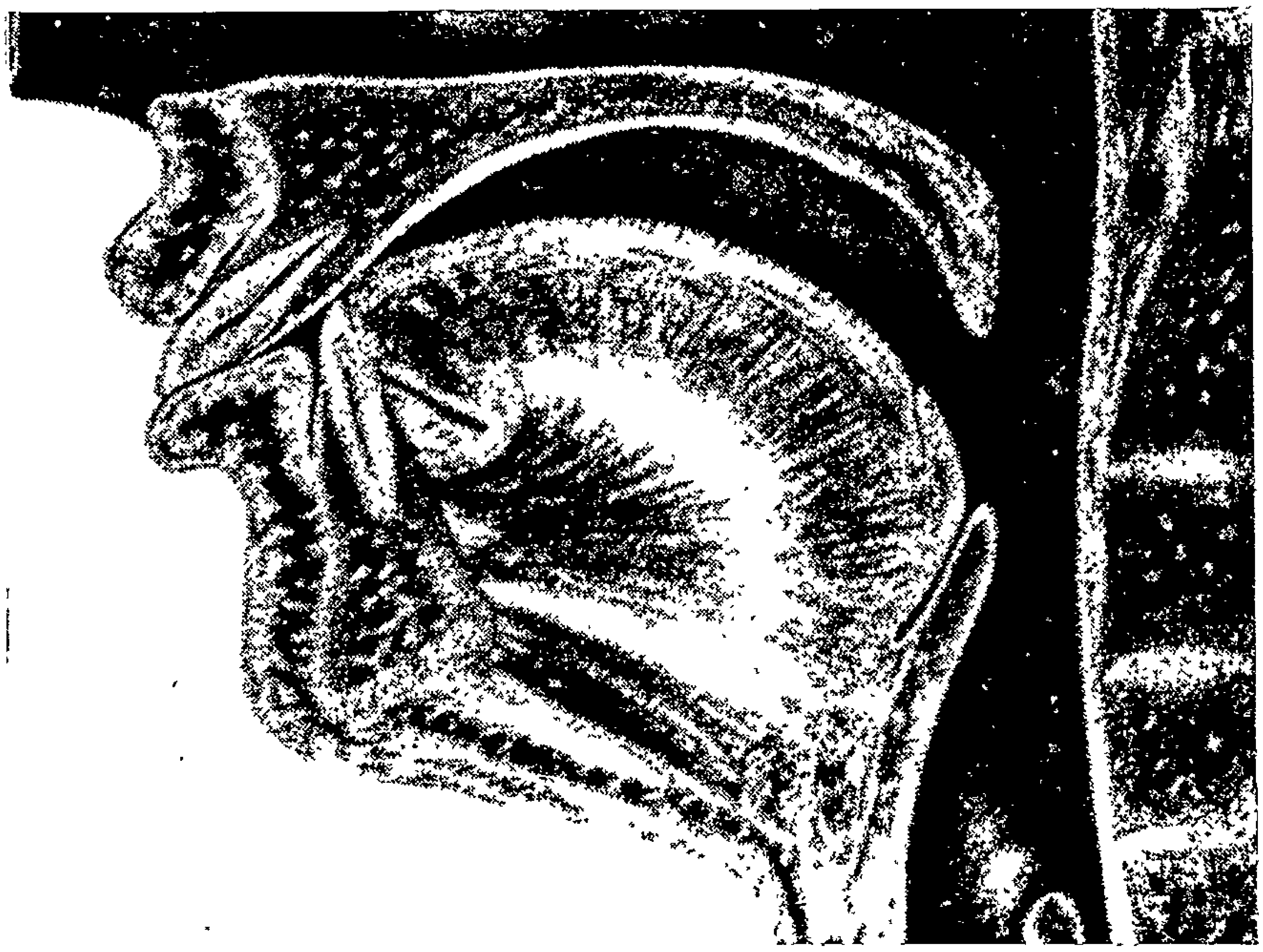


Fig.14 Drawing of midsagittal section of an abnormal structural relationship, such as is associated with a Class II, Division 1 (Angle) malocclusion.
Lischer,1961 p232

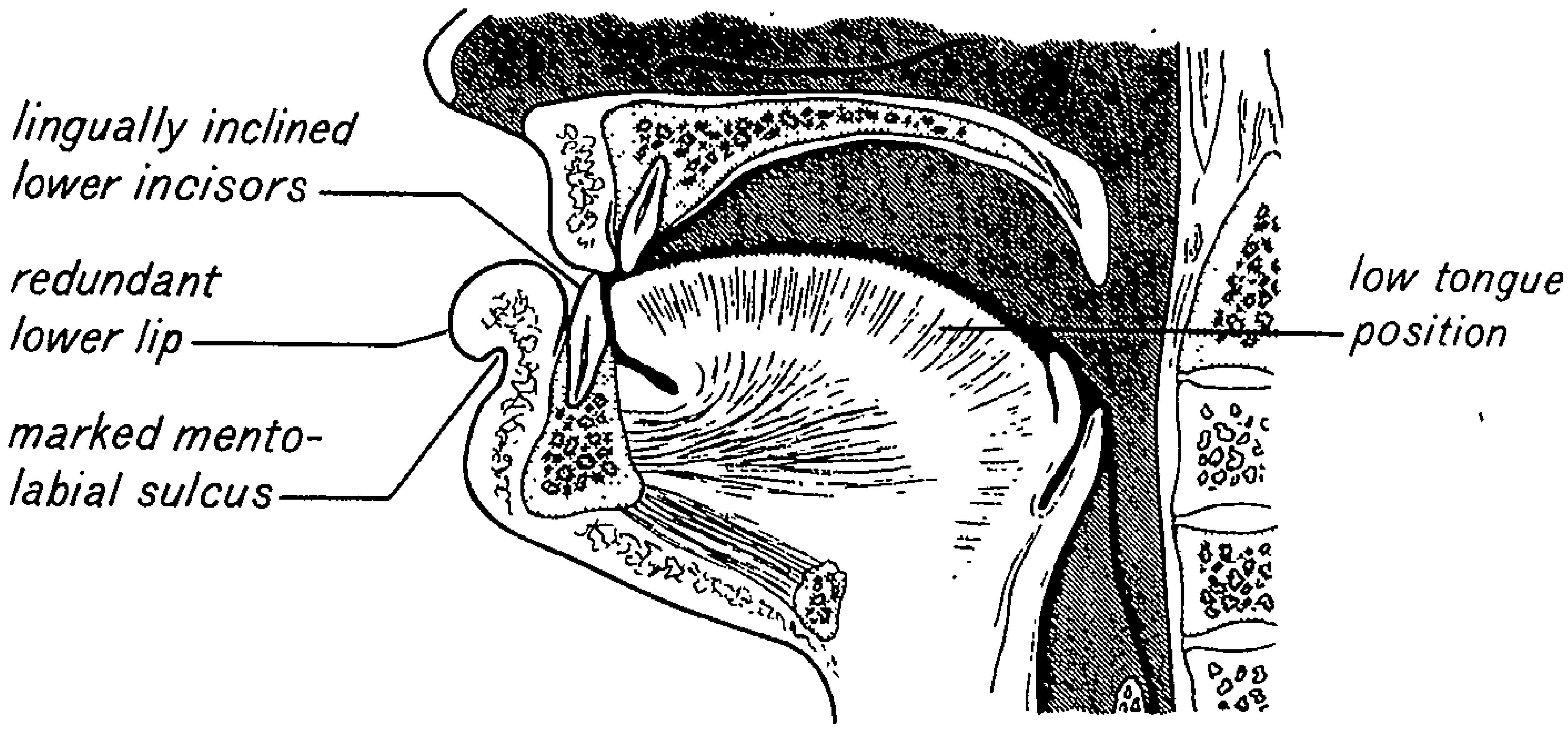


Fig.15 Drawing of midsagittal section of abnormal structural relationship associated with Class III (Angle) malocclusion. Lischer,1961 p235

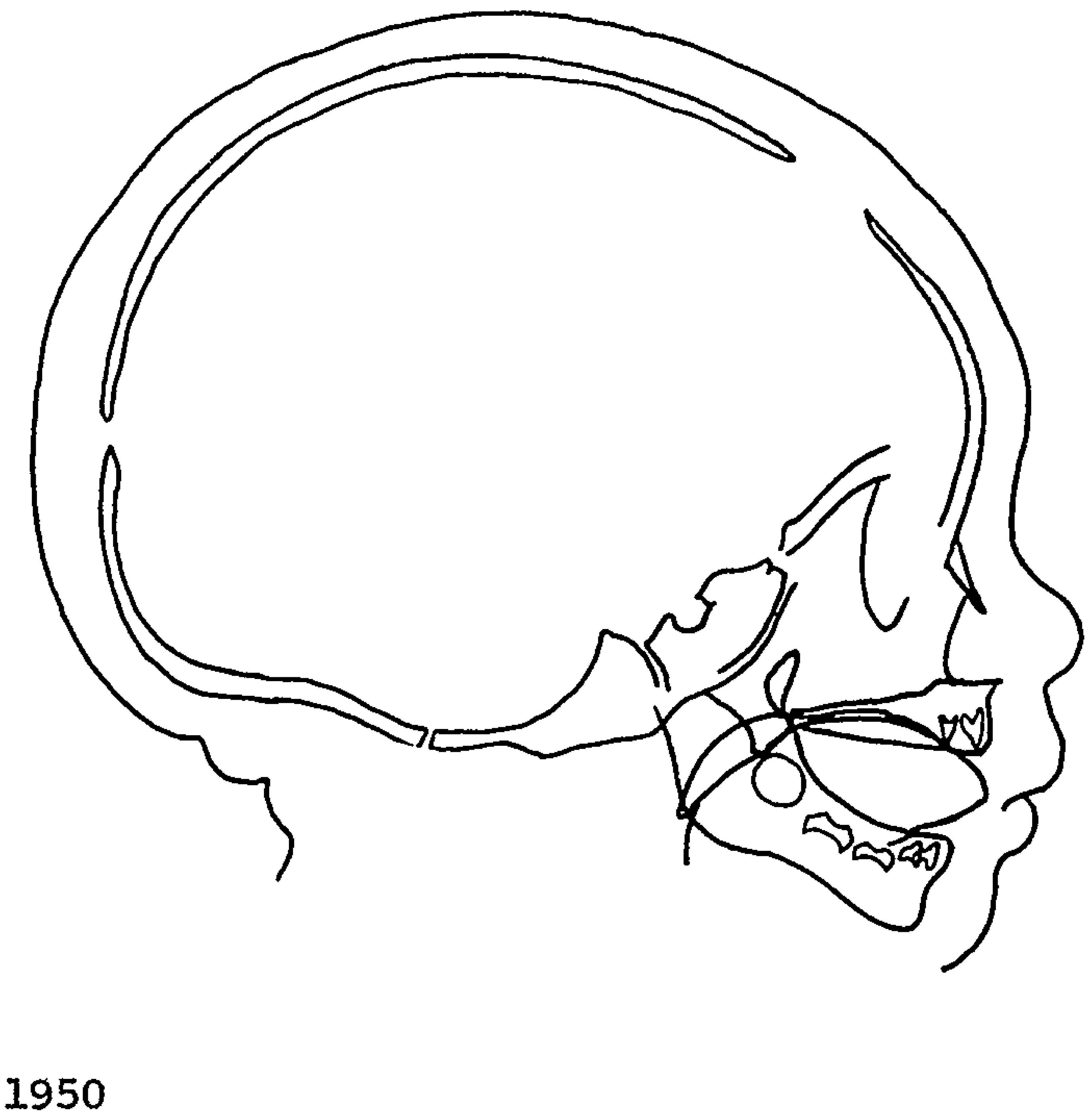
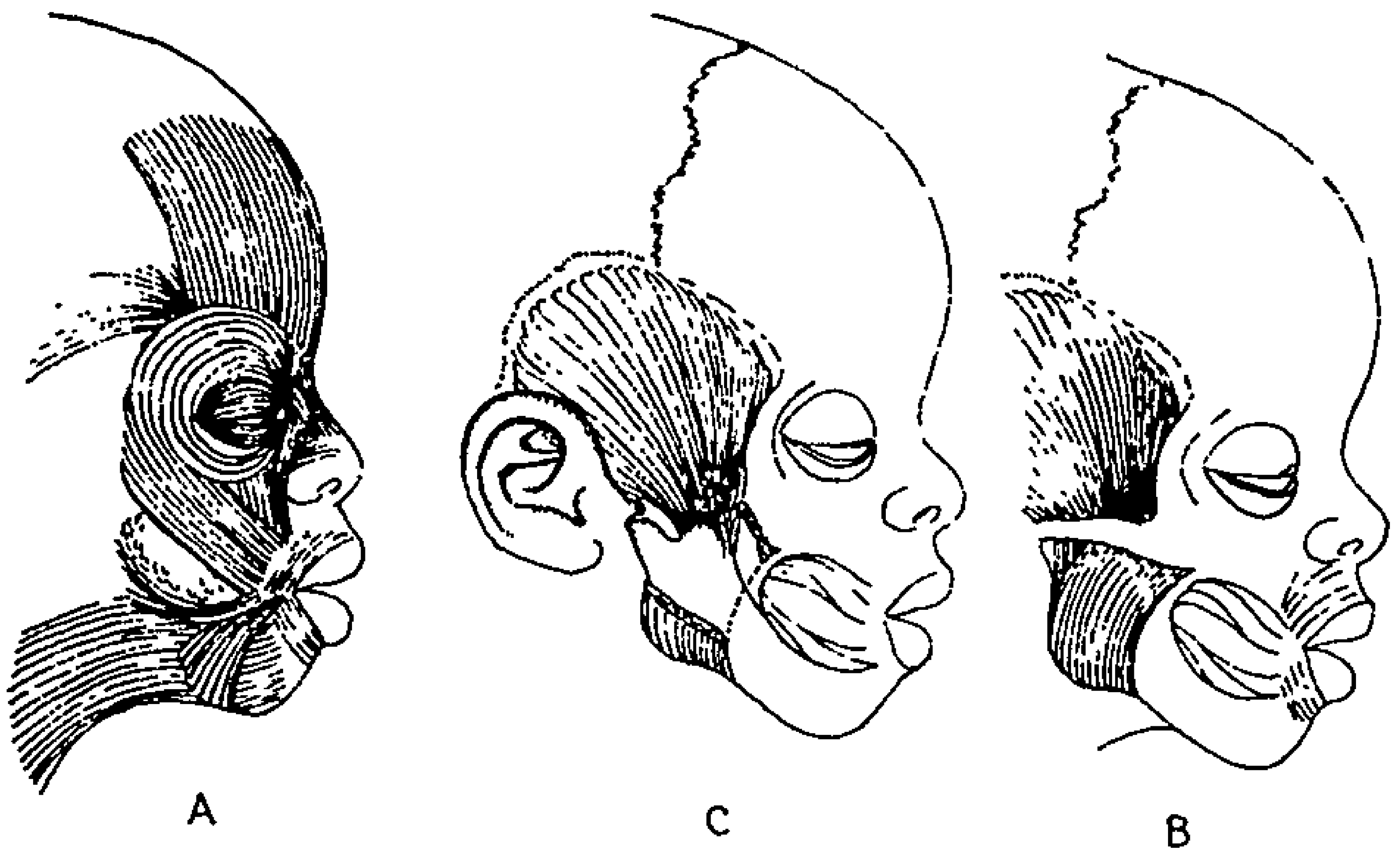
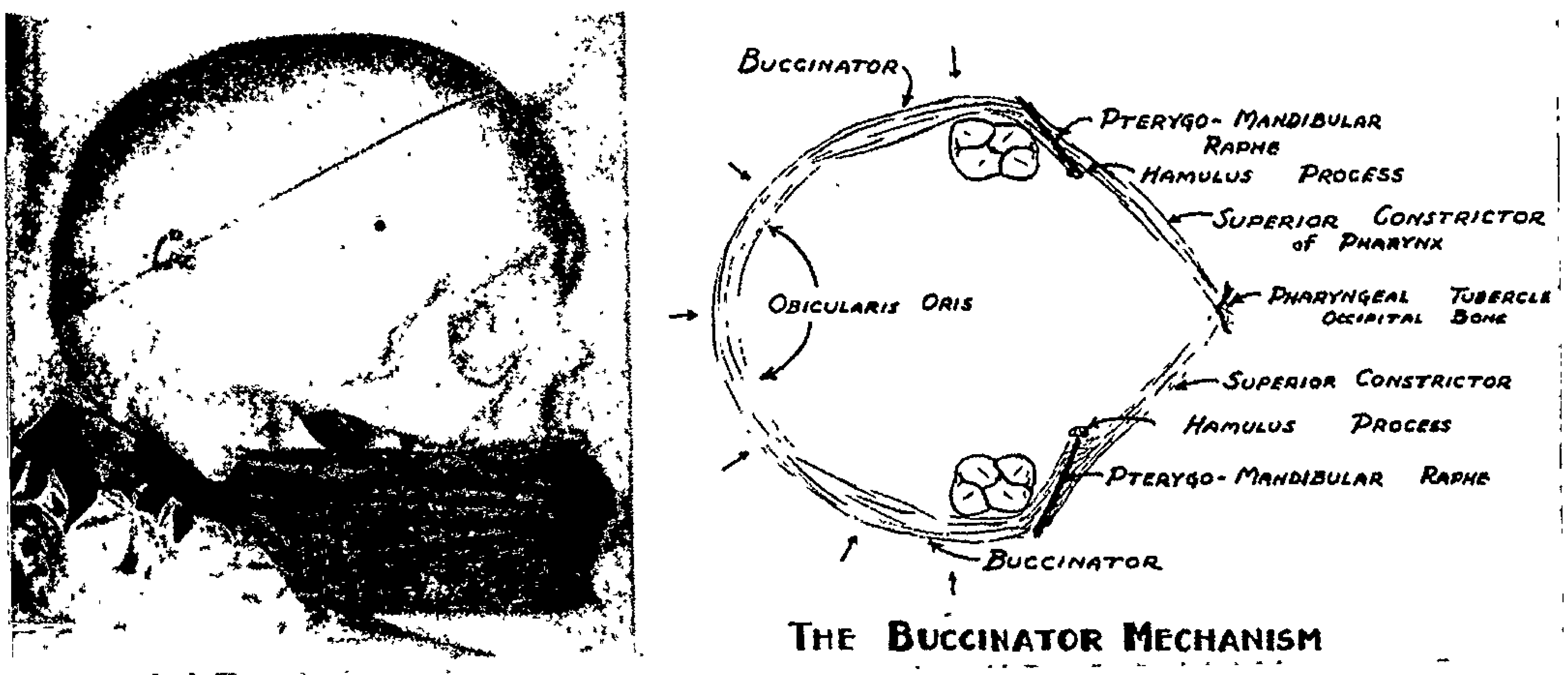


Fig.16 Brodie,1950



Negro girl of about two or three years, showing one stage in the postnatal growth of facial musculature in contrast to the masticatory musculature. While in this stage the facial musculature (A) is fully proportionate to the facial and cranial parts of the skull, the masticatory musculature (B and C), which develops in close correlation with the mandible, is lagging behind. Note especially in C that the m.temporalis covers with its origin just a small area of the temporal plane, while much later in life (Fig.23-vi), probably around the time of adolescence, it expands farther up on the cranium to reach dimensions characteristic of the adult. The other masticatory muscles, the m masseter, m.pterygoideus externus and m. pterygoideus internus, develop accordingly (Huber).

Fig.17 Huber,1957 p101



A. B.

Fig.18 Graber, 1961 p233

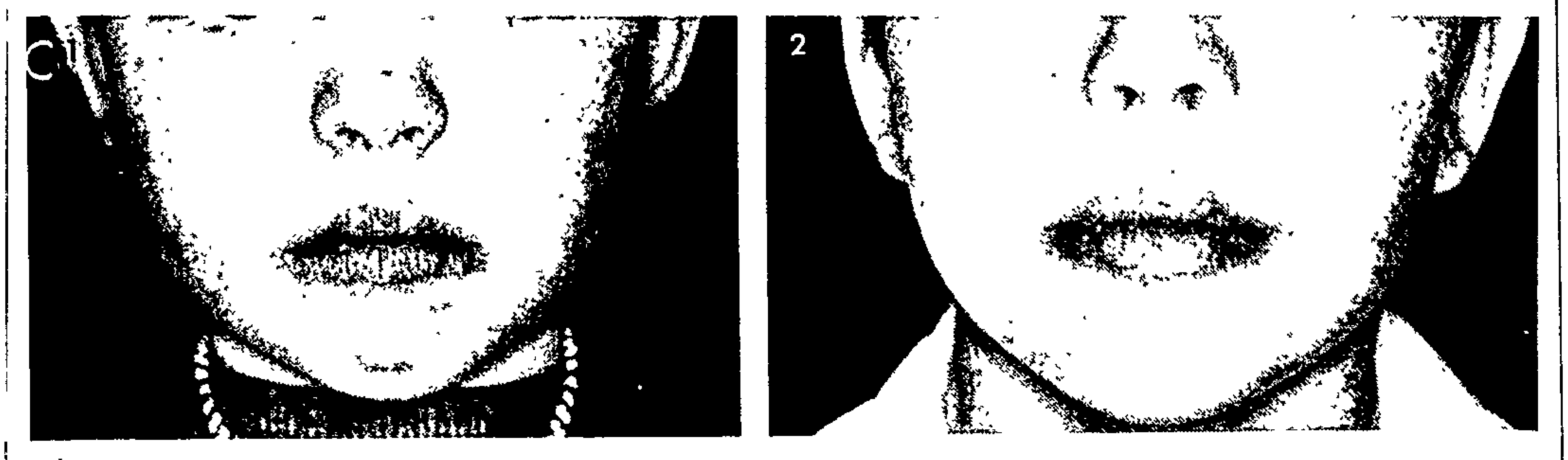
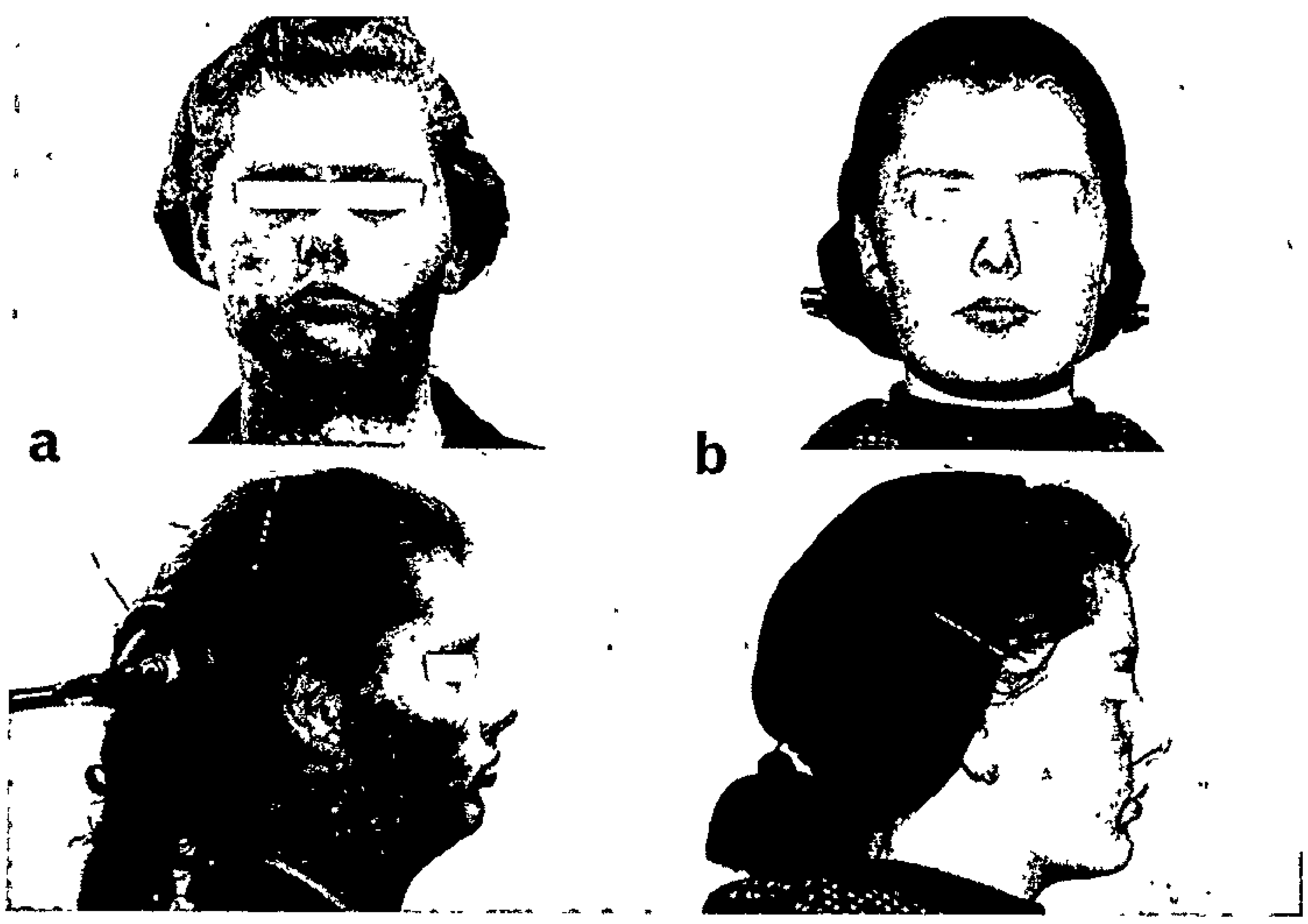


Fig.19 Moyers,1973 p728



Change of anterior oral seal pattern as a result of partial reduction of an increased overjet.

a. [Before treatment. Lower lip tucked under the upper incisors. No forward posture of the mandible.

b. After treatment. Mandible postured forward; no part of the lower lip behind the upper incisors.

Fig.20 Ballard,1963

significant dentofacial relationships

Over the years, significant dentofacial relationships have been sought by orthodontists in order to determine the effect of growth and development and orthodontic treatment on the profile.

Hunter (1788, p.101, p.107) found that growth occasioned no increase in length of the dental arch anterior to the 6th tooth, after that tooth was in position. He advocated extraction of an adjoining posterior tooth, to allow room for the eruption into the arch of a mal-aligned anterior tooth. This improved facial aesthetics.

Angle (1900, p.17) proposed "the line of harmony" as a basic line to indicate harmony of proportion of the features. By (1907, p.61), Angle no longer used the "line of harmony". He had found that the range of application was very limited in gauging different facial types. He now determined (1907, p.78) "When lips are closed naturally over teeth in normal occlusion, the lower lip rests against the labial surface of the upper incisors (approximately the first third), as has before been stated, and it is the upper teeth, not the lower, that establish the curve of the lower lip."

He believed that for the best balance and harmony of the mouth with other features of the face, the full complement of teeth must be placed in normal occlusion; he deplored the extraction of teeth, particularly for orthodontic purposes, as he believed that growth would achieve the increase in width and anteroposterior length of the dental arches necessary to accommodate all teeth.

Case (1911, 1921 p.186), was aware that small movements of the teeth and alveolar processes may bring about remarkable physical changes in the dentofacial area. Fig. 21 diagramatically illustrates these changes. Aware, also, of genetic influence on facial form and malocclusion, Case was prepared to extract dental units in order to reduce an unsightly bimaxillary protrusion. In order to assess the change taking place in profile outline and soft tissue harmony during treatment, Case made facial casts of his patients. Fig.22.

In 1927, Hellman, measuring skulls, found that there are facial types for different racial groups, and for individuals within those groups; that when abnormalities of facial development occur, they represent the same aspect in all racial groups, and are recognisable as malocclusion types.

Nance (1947) found that, after the eruption of the first permanent molars, the dental arch does not increase in length between these teeth, with growth. An actual decrease in length of the arch takes place with the forward positioning of the first permanent molars after exfoliation of the second deciduous molars. He advocated judicious extraction of dental units, followed by proper orthodontic treatment, in order to improve the facial profile by reducing the prominence of the lips.

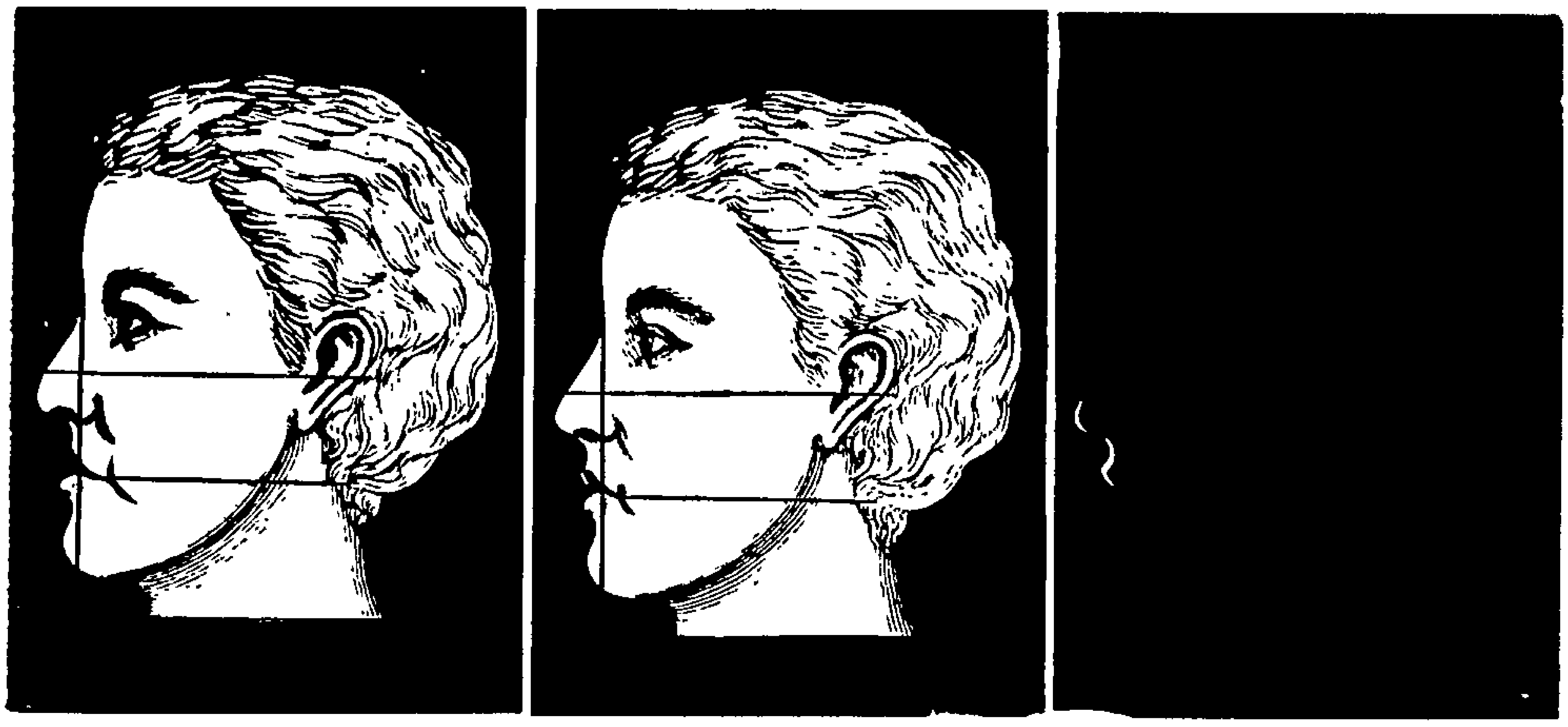


Fig.21 A slight change in the profile outline of the upper lip and end of the nose in these two photographs,shows how a very little depression of the central features of the physiognomy,will produce the effect of prognathism of the lower jaw.The amount of change is seen in the photograph on the right.
Case,1921 p187

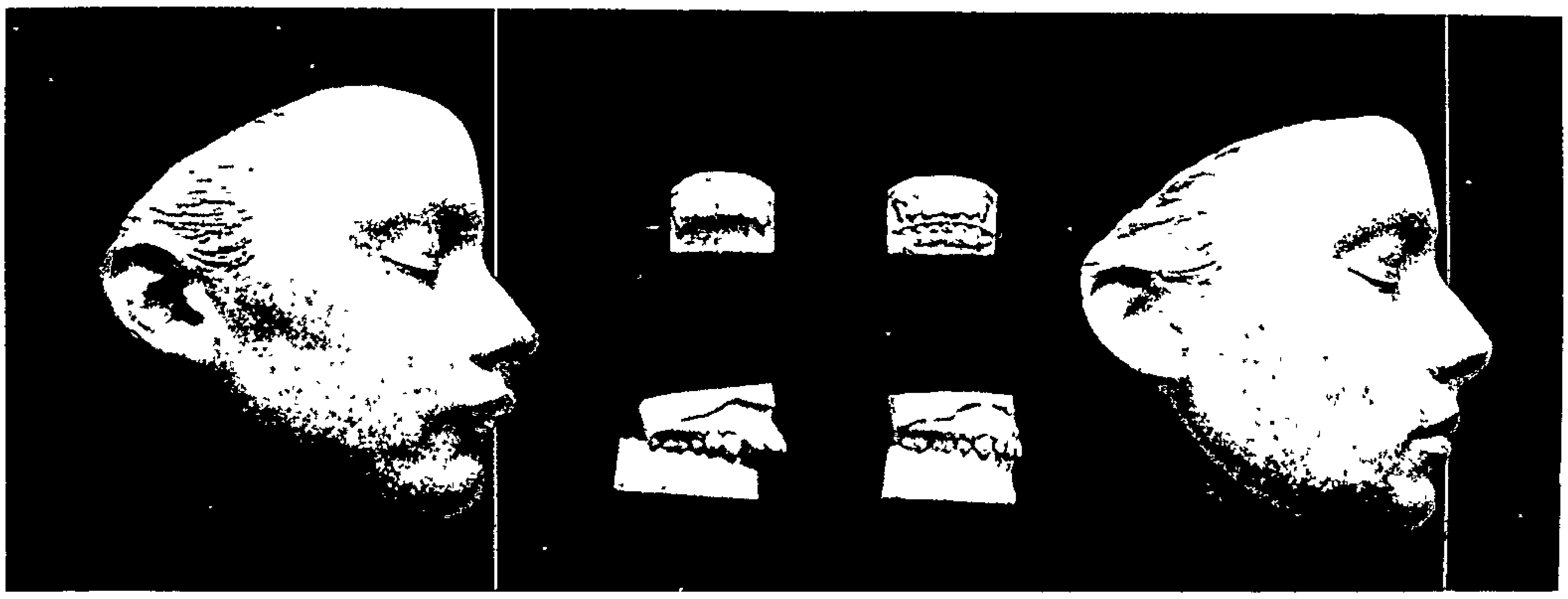


Fig.22 Case,1921 p983

Establishing Profile Norms

Using Roentgenographic Cephalometry as his method of study, Downs (1948) determined a range of normals within the facial and denture pattern. By comparing these measurements with those of a child with a malocclusion, he could obtain a total picture of dental and facial balance. Excessive disharmony of the skeletal pattern and areas of disharmony in the malocclusion could be noted, together with the tooth movements that must be made to recover harmony.

Using the same method of study, Downs (1948), Steiner (1953), Riedel (1952), Sassouni (1955), and many others, formulated parameters from which it is possible to evolve the salient characteristics of the skeletal pattern, and the relation of the denture to the skeletal pattern.

These parameters are:

The degree of mandibular prognathism.

The Y axis angle.

The cant of the mandibular plane to a cranial base plane.

The anteroposterior position of the maxilla relative to the cranial base.

The degree of facial convexity.

The thickness of the "chin button".

The angulation of the upper incisor to the cranial base.

The distance of the tip of the upper incisor from the profile, in mm.

The angulation of the lower incisor to the mandibular plane.

The distance of the tip of the lower incisor from the profile, in mm.

The angulation of the upper incisor to the lower incisor.

The cant of the occlusal plane to the mandibular plane.

The importance of the angulation and position of the lower incisor has been particularly noted in dentofacial relationships.

Tweed (1969) used the Diagnostic Facial Triangle to relate the angulation of the lower incisor to the Frankfort-Horizontal and mandibular planes.

Riedel (1950) and Ricketts (1960,B), and others, related the angulation of the lower incisor to the A-Pog. plane.

Riedel (1950) sent a series of profile outlines to practicing orthodontists for assessment of their aesthetic value. Subsequently, an analysis was made of the underlying skeletal and dental pattern of the profile outlines. Riedel concluded from this study that the profession agrees on what constitutes a good profile, but lacks objective criteria by which it may be determined; that the soft tissue profile closely follows the skeletal profile; that, generally speaking, the more convex the profile, the more upright must be the incisors to produce good facial balance, and conversely, if the skeletal profile is straight, the incisors may be allowed greater procumbency in proportion.

Riedel (1957) undertook a further study, in which he set out to determine the modern concept of facial aesthetics held by the general public. In this study, he examined the lateral head plates of thirty girls chosen as the Seattle Seafair Princesses, and their Queen. He found that the public's concept of acceptable aesthetics is apparently in good agreement with standards established by orthodontists on the basis of normal occlusion.

Ricketts (1957) found that in excessively protruding cases the upper lip may appear to be thin and stretched, but, as the teeth are retracted, thickening of the lips will occur during its relaxation. Also, the upper lip thickens with growth. Therefore, a 2 - 4mm increase in thickness may be expected in severely protruding cases and a 1 - 2mm increase in cases where the upper incisors are not to be moved so excessively.

The lower lip does not change in thickness during the treatment period. The sub-labial area seems to behave in conformity with the roots of the lower incisors; if the roots of the lower incisors are retracted, an increase in sub-labial depression will occur; if the lower incisors are brought forward, this portion of the lip will be brought out.

In cases demonstrating active mentalis habits, where the soft portion of the chin is rolled upward and forward, this condition will often be relaxed by treatment, and the soft tissue of the chin come to occupy a normal position.

As a matter of interest, Macary (1957) notes an increase in the number of individuals of recent generations possessing a retrognathic mandible. He attributes this increase not only to hereditary influences, but also to a decrease in physiologic nutrition resulting from an alteration in the digestive and respiratory functions, and an alteration in masticatory stimulation caused by the ingestion of soft, pulpy foods.

Burstone (1958) considers that the face influences the social acceptance and psychological well-being of the individual. He used an Integumental Grid, prepared from profiles chosen by artists, with which to compare the soft tissue profile outlines of his patients. However, he found that such an integumental analysis may be misleading, as the patient or parent could have a different concept of facial balance from that of artists; that appearance is not only a function of morphology, but may be influenced by subtle factors of personality. He found that variation exists in the soft tissue veneer and that its contour could not be predicted by a study of the skeletal profile.

Relevant to the determination of dentofacial relationships are some of the findings of the Cephalmoetric Workshop, set up by the American Association of Orthodontists, and reported by Graber in 1958,B.

The Workshop found;

1. A list of points, lines and planes, and angles for use in Cephalometric study and analysis. (See Glossary)
2. That no one analysis had advantages over the other - many were presented, all had merit. However, following Downs' concept of a skeletal and denture analysis, the Workshop advocated the use of three basic components for a cephalometric analysis;

a. *skeletal* analysis, which gives an appreciation of facial type, and an appraisal of antero-posterior apical base relationships, particularly with reference to Class II and Class III malocclusions.

Some of the Workshop participants considered of value the inclination of the palatal, occlusal and mandibular planes, as measured to the cranial base.

b. *profile* analysis, which is primarily an appraisal of the soft tissue adaptation to the bony profile; of lip size, shape and posture; of soft tissue thickness over the symphysis; of nasal structure contour, and relationship to the lower face. However, it is recognised that certain skeletal angular criteria influence the profile. In addition to the facial angle and the angle of convexity, there are such criteria as angles SNA, SNB, SNP, NSGn, and the inclination of the mandibular plane to a cranial base plane.

c. A *denture* analysis, which consists primarily of those descriptive elements which appraise tooth relationships with each other, and with their respective bony bases.

The opinion was expressed that it is unwise to attach too much importance to single criteria, such as the axial inclination of the lower incisors.

In the Workshop's cephalometric synthesis, none of the three analyses - skeletal, profile or denture - can stand alone. Integration with one another is essential, and then the conclusions require careful conditioning by other equally important clinical diagnostic aids, such as plaster casts, dental radiographs, photographs, and visual and digital examination of the patient.

Figs. 23, 24, 25, demonstrate the three basic components of a cephalometric analysis.

Values for these basic relationships are presented by Krogman and Sassouni (1957, p. 324). However, they stress that "Great caution should be exercised in the use, interpretation, and application of these tabulated norms."

Tables indicating these values are contained in the Glossary.

Krogman (1958) urged caution in the use of tabulated patterns, or "norms", which are not qualified by standard deviation, range, facial type, ethnic origin, basal relationship, age and sex factors, functional forces, growth and development.

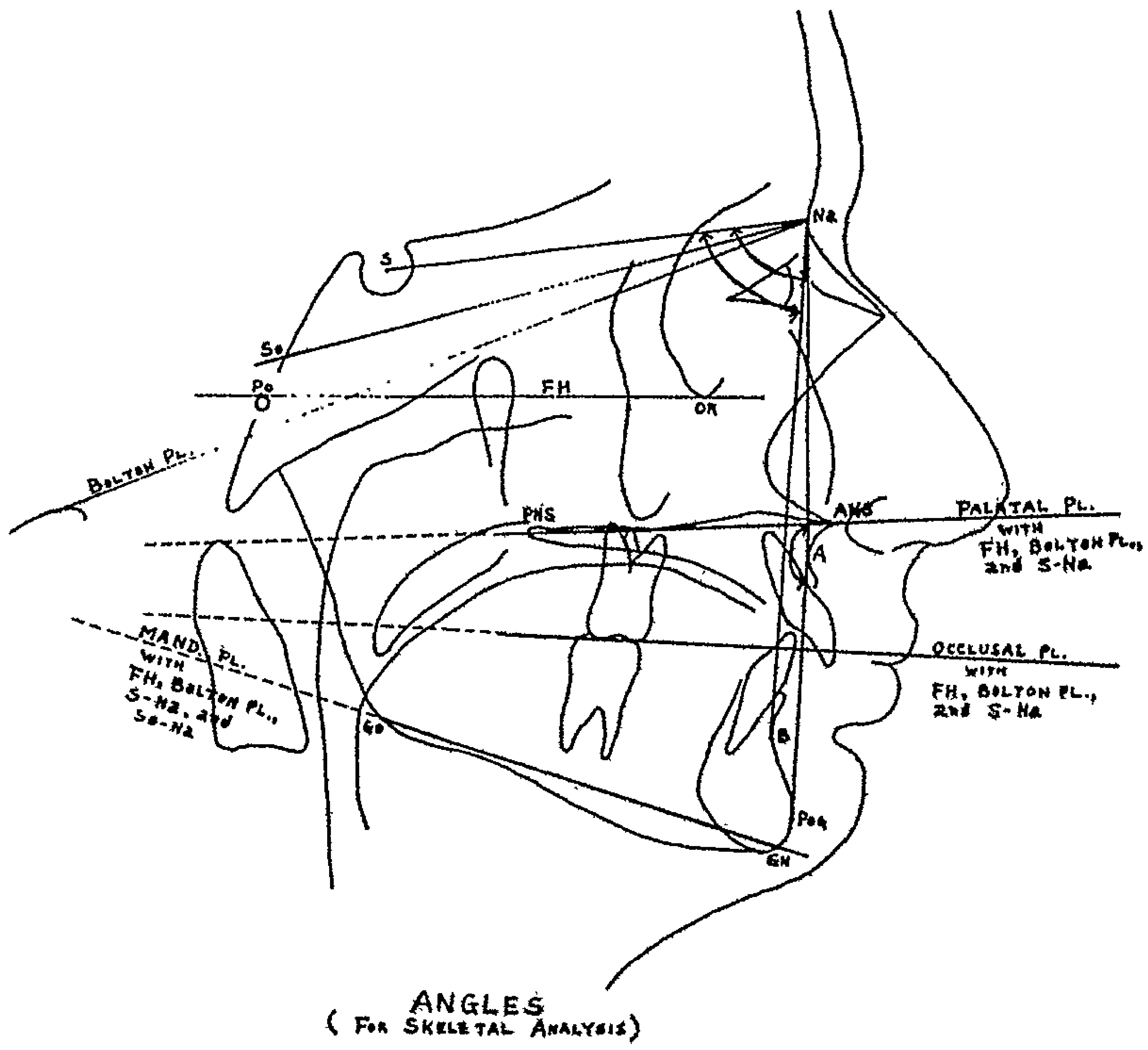


Fig.23 Graber,1958 B

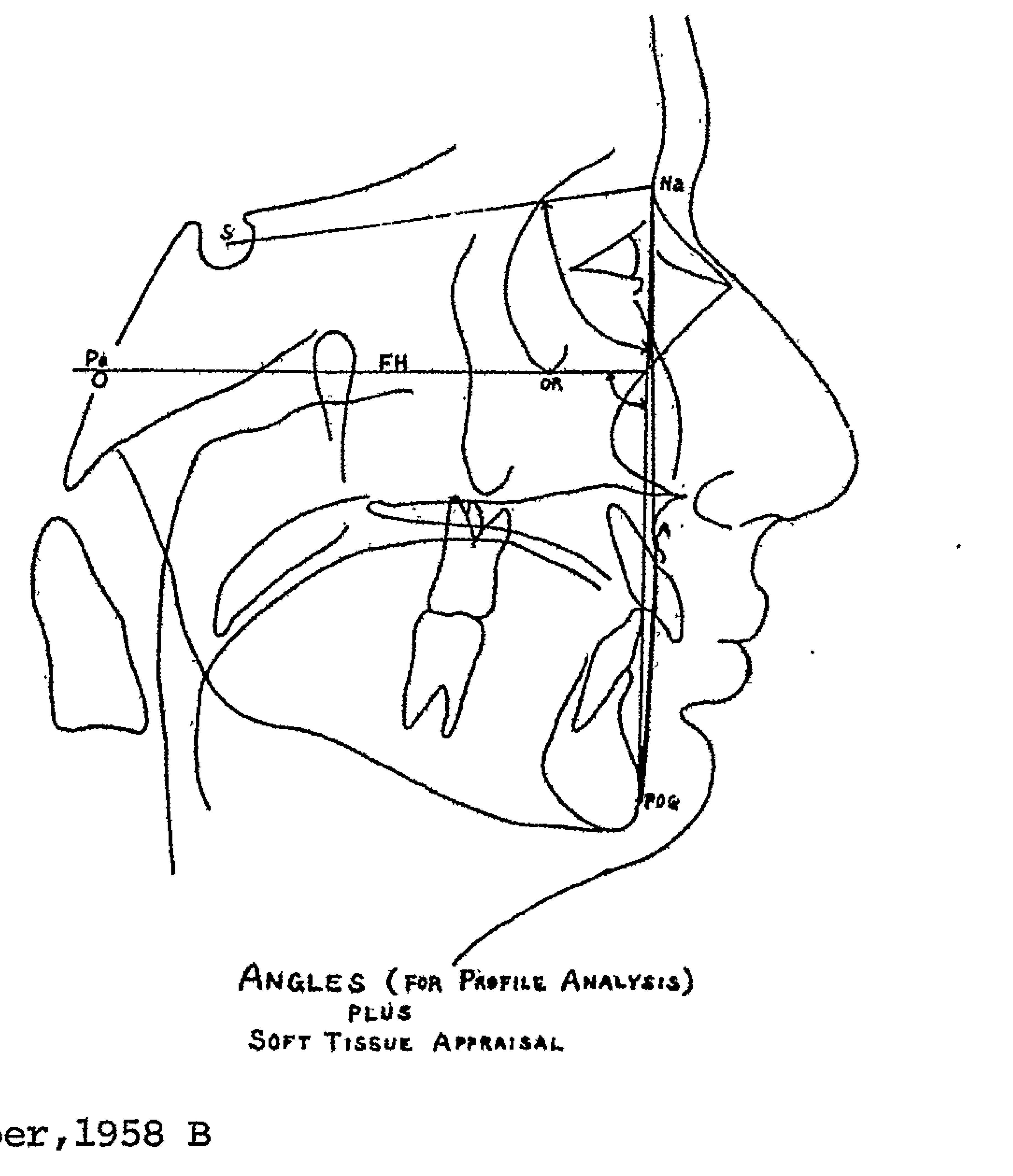


Fig.24 Graber,1958 B

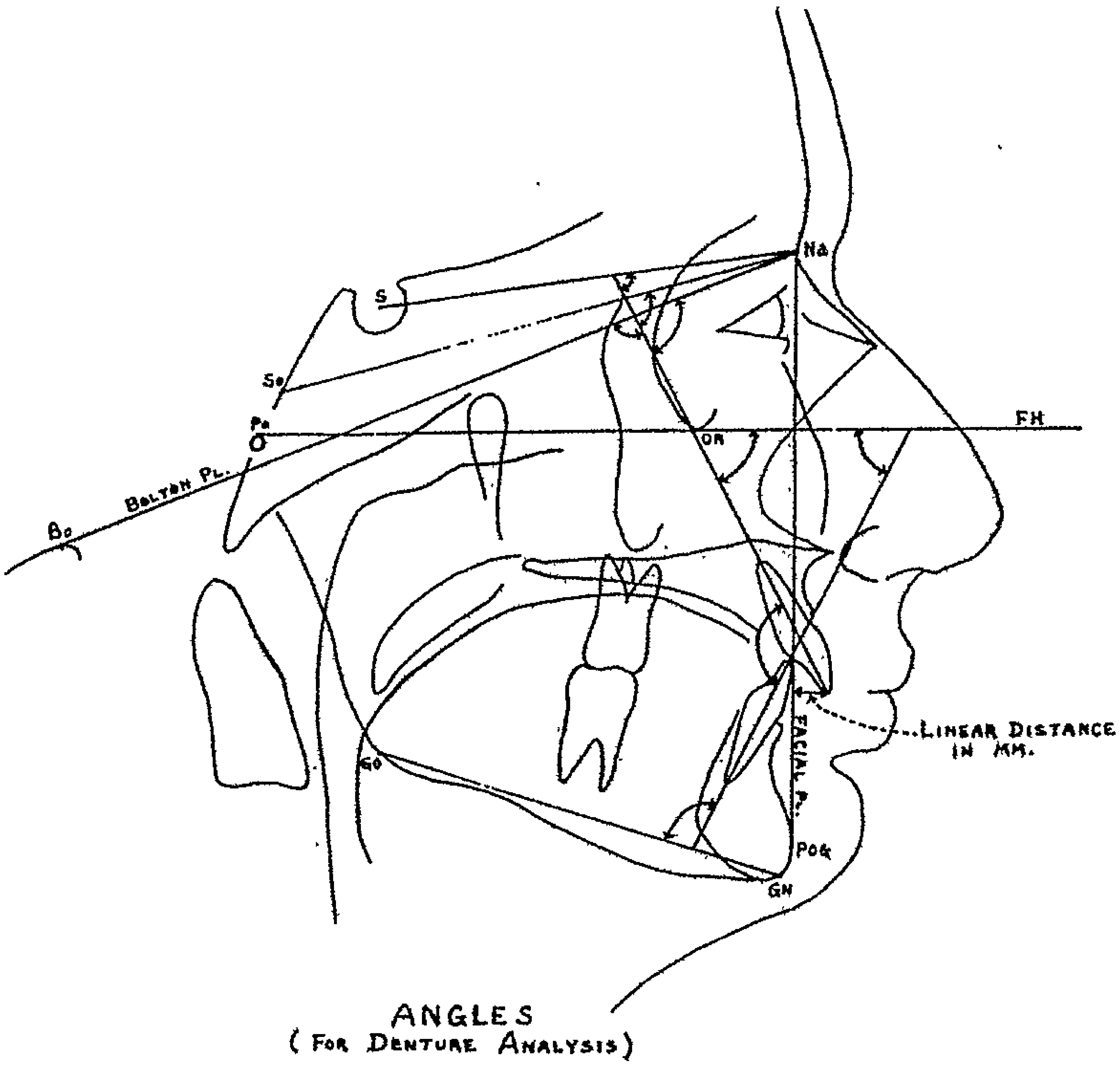
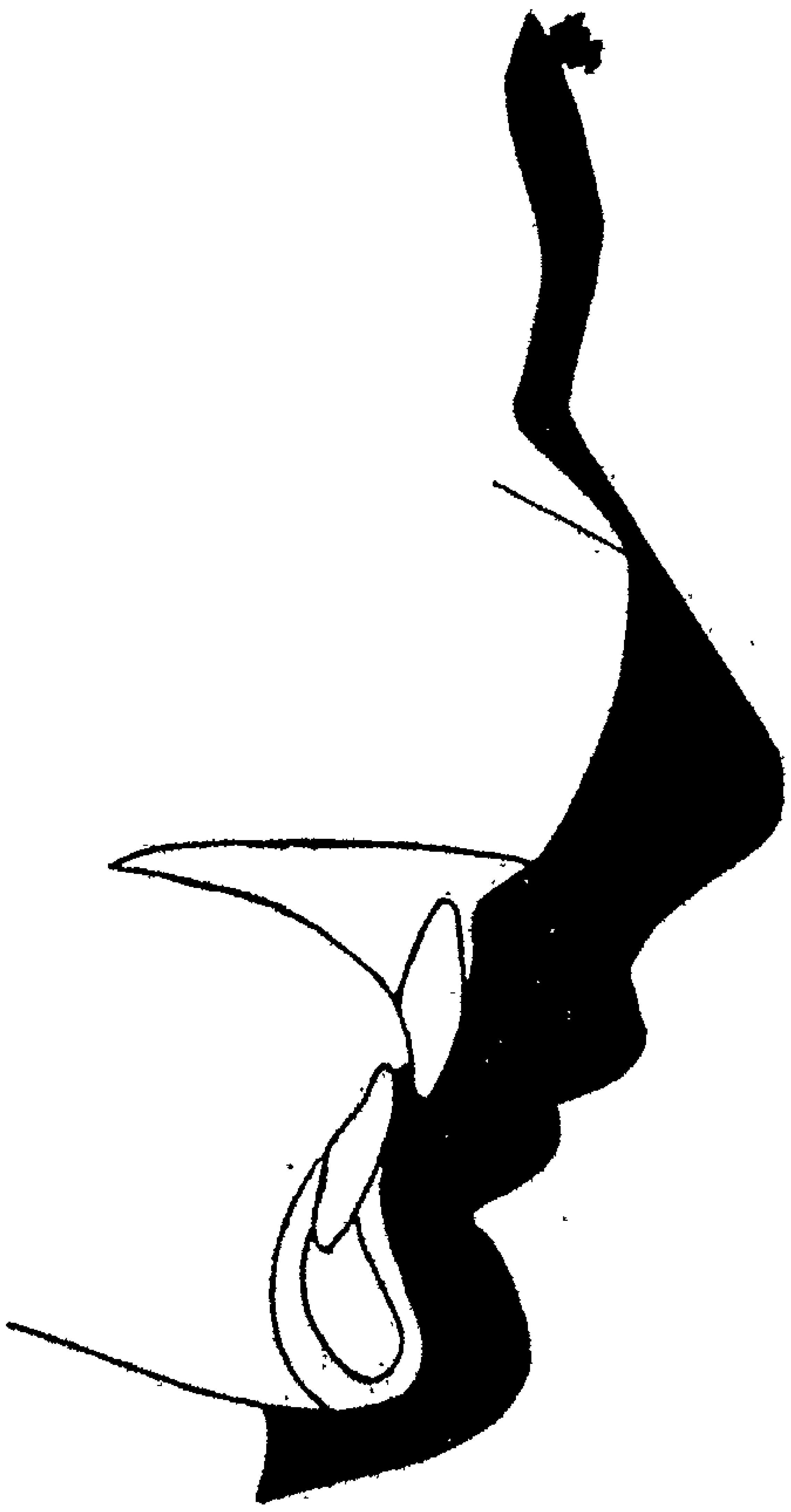


Fig.25 Graber 1958 B

Burstone (1959) indicated that soft tissue variation may produce disharmony in a profile, but that it may also mask a dento-skeletal discrepancy (figs. 26, 27); that further investigations are needed to show whether it is possible to change the soft tissue mass of the face by the movement of dentoskeletal structures, or by the institution of myofunctional therapy.

Neger (1959) found that proportionate change, or improvement, in the soft tissue profile does not necessarily accompany extensive dentition changes. Facial deformity, such as deficiency in the area of pogonion, should be recognised early, and pointed out to the patient, so that the patient will have a realistic concept of the improvement likely to occur as a result of orthodontic treatment.

Baum (1961) found that when orthodontic treatment is completed before or during the period of developmental growth, the denture will become progressively less protrusive, relative to the rest of the face, as growth proceeds. The sex of the patient is also a consideration. A 13 year old boy can accept a fuller dental area than a girl of the same age, since the girl probably will experience little or no change in distance from the central incisor plane to the nose and chin point, while the boy can expect a significant increase in these dimensions.



A

B

Fig.26 A large amount of maxillary horizontal extension is contrasted by a defiency of mandibular extension.

Fig.27 Accumulated variation between horizontal extension values at subnasale and menton.

Burstone,1959

Subtelny (1961) found that any evaluation of the dentition, and the skeletal structures of the face, must be tempered by an evaluation of the size, configuration, relative position and growth potential of the soft tissues of the nose, lips, and chin. Orthodontists should beware of excessively retracting the lips in an individual with a large nose - some procumbency of the lips and denture may be desirable. On the other hand, in an individual with an inherently small nose, procedures that will cause the lips to retract may be desirable.

Bloom (1961) found that soft tissue response is closely related to that of the orthodontically moved hard tissue structures, and that it is possible to predict the peri-oral soft tissue profile changes in relation to the expected amount of anterior tooth movement. The lower lip follows the movement of the lower incisor more closely than the upper lip follows the upper incisor.

Ballard (1963) found that the primary factors in the determination of labial segment position are the form, posture, and behaviour of the lips, superimposed on the skeletal pattern. Posture and patterns of behaviour of the soft tissues (lips and tongue) are "built-in", and frequently these inherited characteristics are not physiologically compatible with the inherited skeletal pattern. The type and severity of the original malocclusion may be influenced by the competence or incompetence of the lips, and their ability to form an oral seal independent of the tongue. The stability of a treated case is frequently dependent upon the adaptive postures and behaviour of the lips.

Fig. 28 illustrates the strap-like lip in Class II, Division 2 malocclusion.

. Strap-like or retracting lower lip in expressive behaviour with the high lip line in lip seal posture typically associated with, and the major aetiological factor in, the Angle Class II Division 2 incisor relationship.

Fig.28 Ballard,1963

McCoy (1963) is concerned with the correct diagnosis of "double protrusion" and recommends the use of gnathostatics supplemented by photostatics for a satisfactory diagnosis. Incorrect diagnosis may lead to the extraction of four first bicuspids, resulting in a "dished in" face and weak chin, which characterise what McCoy calls "Dish pan sans bicuspidi". He gives urgent advice never to extract a premolar for treatment in the normal (10 - 14) orthodontic years.

Rudee (1964) found great variability in upper lip movement relative to upper incisor retraction. 17% of his cases showed upper lip *protraction* with maxillary incisor retraction. The remaining cases showed that *average* lip retraction is *one third* that of the upper incisor, but *more* lips retract one half the distance, or equally. The lower lip retracts an average of 1mm for every 0.6mm of lower incisor retraction, which shows the direct influence of both the upper and lower incisors on the lower lip. In this investigation, the average amount of upper lip retraction is approximately equal to the average amount of the forward growth of the chin, and only half the average forward growth of the nose.

Hambleton (1964) examined the relative values of the following three "planes" used for soft tissue diagnosis:

Rickett's "Aesthetic Plane" - a line from the tip of the nose to the end of the chin. The lips should be *on* this line in childhood, and behind it with increasing maturity, the lower lip lying slightly *ahead* of the upper lip.

Steiner's "S Plane" - a line from the chin to the middle of the "S" formed by the lower border of the nose and the upper lip. The lips should fall along this line.

Holdaway's "H line" - drawn on a lateral head tracing, from the point of the soft tissue chin tangent to the upper lip. This line creates an angle - the "H angle" - with the line NB, which can be measured and used for soft tissue appraisal. When the ANB angle is 1 to 3 degrees, the "H angle" should be 7 to 9 degrees for a resultant good profile. The analysis is flexible, and should the ANB angle be greater or smaller than 1 to 3 degrees, the same amount is added to, or subtracted from, the "H angle".

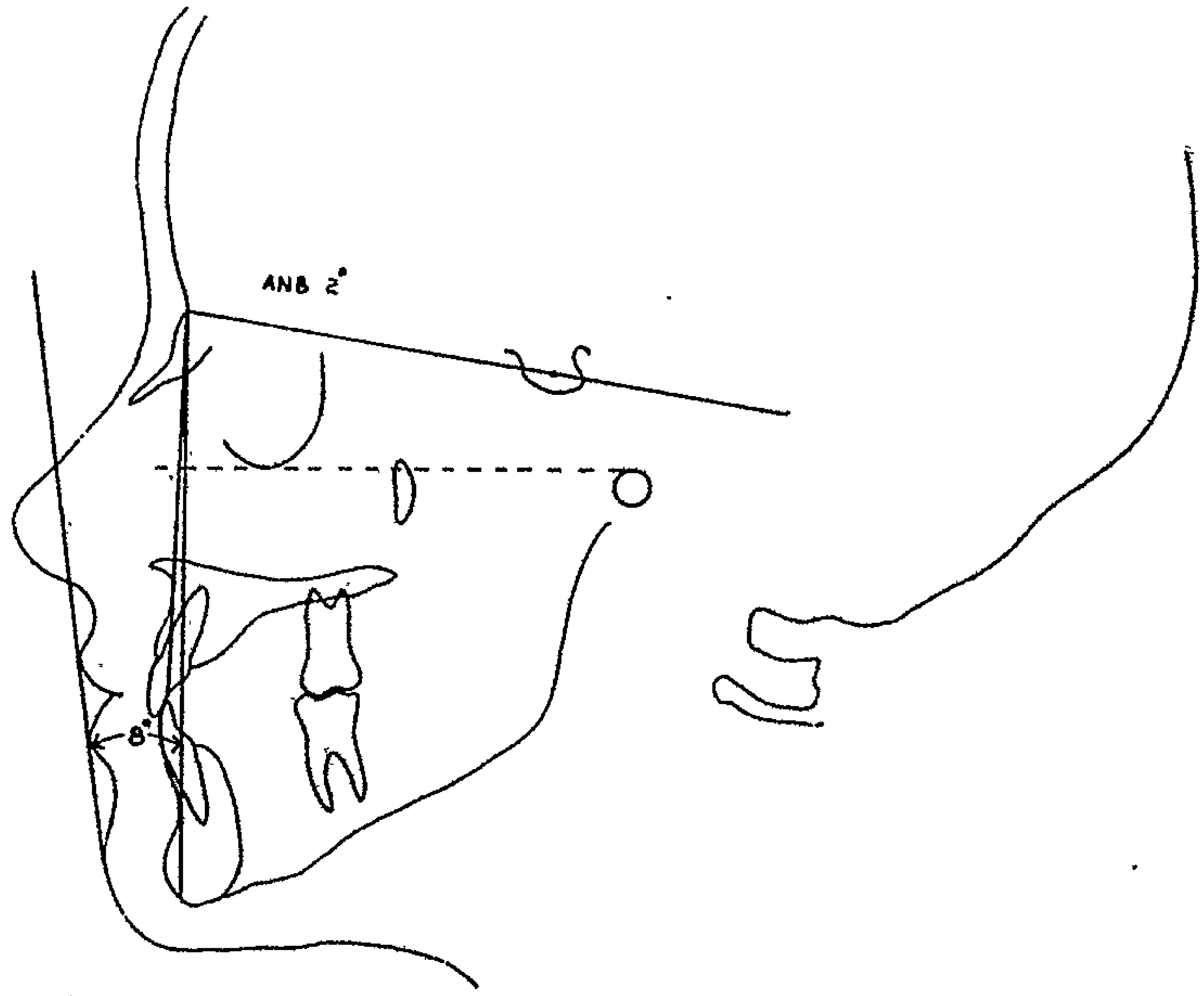
Hambleton found the "H line" to be the most practical approach to soft tissue appraisal.

Figs 29, 30, 31, 32, illustrate the lines used by Angle, Ricketts, Steiner, Holdaway.

Fig.29 Angle's "Line of Harmony".
Angle,1907 p64

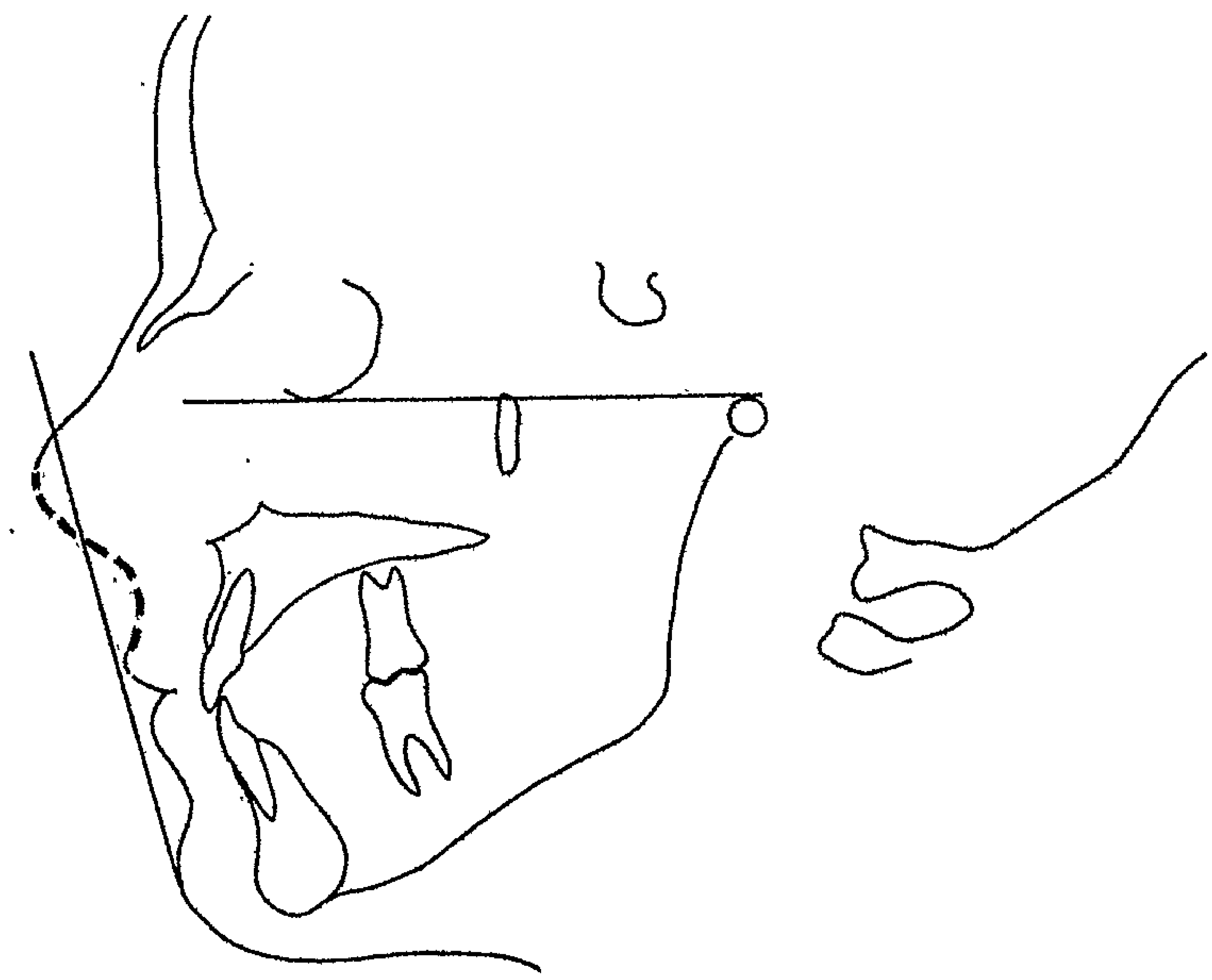
Rickett's law of lip relationship.

Fig.30 Hambleton,1964



Holdaway's "H" line.

Fig.31 Hambleton,1964



Steiner's plane.

Fig.32 Hambleton,1964

Of equal importance are individual factors which must be considered for each patient - tissue tone and abnormalities, smiling, and its effect on the profile, the amount of intraoral structure exposed during smiling, lip thickness, and thickness of the chin pad.

Merrifield (1966) studied the mouth profile and chin relationship. He found that the upper lip should be tangent to the profile line, (Fig. 33) whilst the lower lip should be tangent to, or slightly behind, the profile line. Total chin thickness he found to be of prime importance in profile evaluation; either bony chin, or soft tissue chin may be ill-proportioned. As long as one compensates for the other, profile balance will not suffer.

Merrifield also found that vertical facial relationships are important for over-all facial balance.

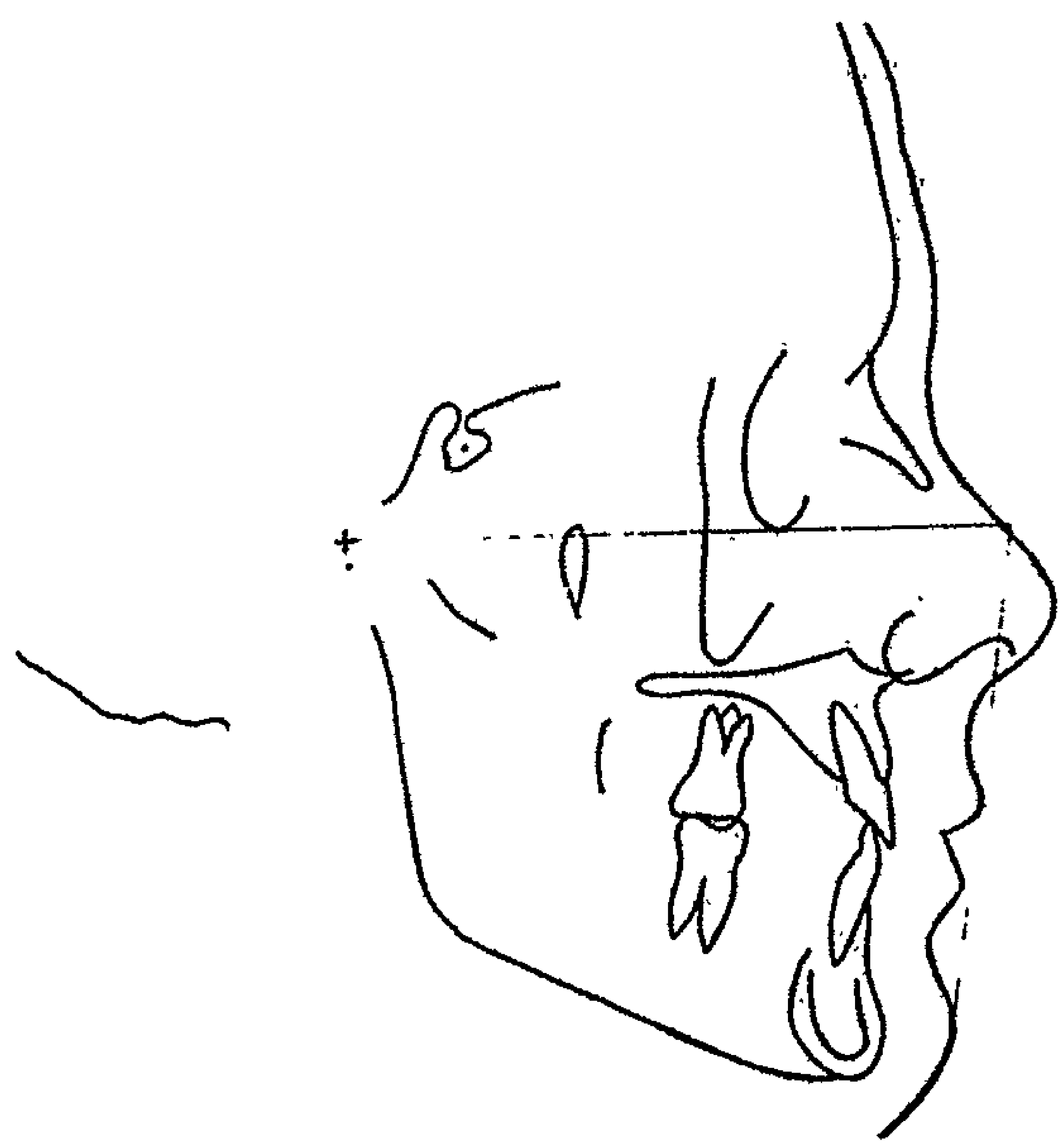


Fig.33 Merrifield,1966

The profile line.

Burstone (1967) stressed the important influence that the inherent postural position of the lips, and the size of the inter-labial gap, may have on the effect of growth and orthodontic treatment on the profile. When a protrusive lip posture, or redundant lip length exists, concomitant retraction of the lips with retraction of the skeletodental structures can not be anticipated. He suggests that soft tissue changes, following retraction of the incisors, may be predicted more accurately if the relaxed-lip posture is used for the basis for prediction. He also found that, clinically, the naso-labial angle may be significant. Following retraction of the anterior teeth, an obtuse naso-labial angle in Class II, Division 1 cases may increase to the point of deformity, giving the patient a typical "orthodontic look", with a sunken-in upper lip.

Studying the control of vertical overbite, Schudy (1968) wrote:

"By correcting axial inclinations, reducing overbite, eliminating overjet, and placing a fixed retainer, we gave nature a chance to produce normal growth in the post-treatment period".

Peck and Peck (1970) devised a system of photographic "profilemetric" analysis, in order to provide a meaningful concept of facial aesthetics, and an additional source of clinical data. Important in their analysis is the orientation of the soft tissue profile to the cranium, and the assessment of an aesthetically pleasing profile in both horizontal and vertical directions.

Visualising a harmonious "profile flow" as a series of reversed S's, they found that regularity and evenness are essential traits of the aesthetically pleasing profile. However, they found no equation for facial beauty.

A result of their study showed that the general public admires a fuller, more protrusive dentofacial pattern than customary cephalometric standards would like to permit.

Subtelny (1970) gave a comprehensive review of dento-facial relationships. Discussing the role of extraction in orthodontic procedures, he states:

"However, the biologic environment as well as the relationship of the incisor teeth to their respective bony bases, to the supporting jaws, and to the skeletal and soft tissue profiles, should determine whether teeth are to be extracted, and which teeth are to be extracted."

He questions the validity of the concept that four first premolars must be extracted in order to achieve a Class I relationship and retraction of mandibular incisors. Where a skeletal discrepancy, such as an excessively protruded maxilla, or a retrognathic mandible, exists, it may be desirable to bring the maxillary arch to the mandibular arch, by the extraction of upper first premolars only, and to accept a Class II relationship. This could be especially pertinent in the case of a somewhat retruded mandible with a high mandibular plane angle. In certain facial profiles it may be undesirable to retract the lips further, and extraction of second premolars, or a combination of first and second premolars may be indicated.

Subtelny is aware of the difficulties of predicting growth changes, but remarks that a somewhat educated guess should be made as to anticipated, or hoped for, growth. Growth changes may facilitate or hinder treatment procedures. He found the following points important in determination of the vertical or horizontal growth potential of the mandible.

1. A highly divergent Y axis shows that a more vertical than horizontal development has taken place in the positioning of the chin. This disproportionate growth may

continue through succeeding years. A closed Y axis may indicate a more forward positioning of the chin with growth.

2. The configuration of the mandible. The differences in mandibular configuration are described in Fig. 34.

The implications with respect to the eventual facial profile are readily obvious, resultant upon these differing growth factors.

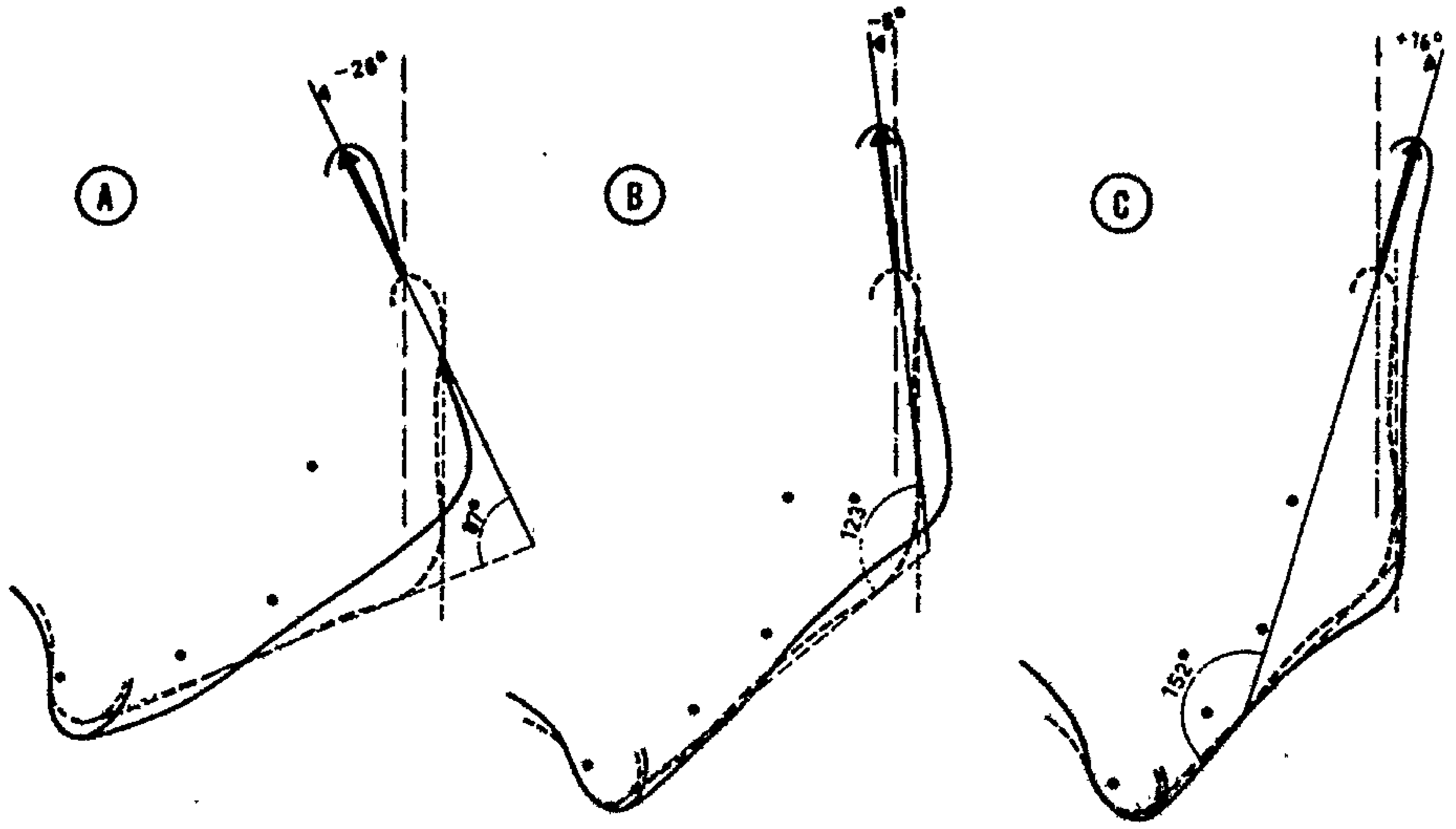
Diagrammatic representation of two different mandibular configurations. **Left:** Potential horizontal grower, as indicated by a condyle that is facing forward; lower arrow indicates probable direction of growth expression. **Right:** Potential vertical grower with a condyle facing in an upward and backward direction; lower arrow indicates the probable direction of growth expression.

Fig.34 Subtelny,1970

Also relevant to the eventual facial profile are the studies of mandibular growth reported by Bjork (1955,B., 1963, 1966, 1969). Bjork found that *more vertical* growth of the condyle is expressed by an increase in curvature of the mandibular base, marked resorption beneath the angulus and excessive deposition under the symphysis; that *more horizontal* growth is expressed by a flattening of the mandibular base, moderate resorption and sometimes even deposition beneath the angulus, and little apposition under the symphysis. He found great individual variation in the growth pattern of the mandibular condyle, and that the pattern may change from predominantly horizontal growth in the juvenile, to predominantly vertical growth in the adolescent.

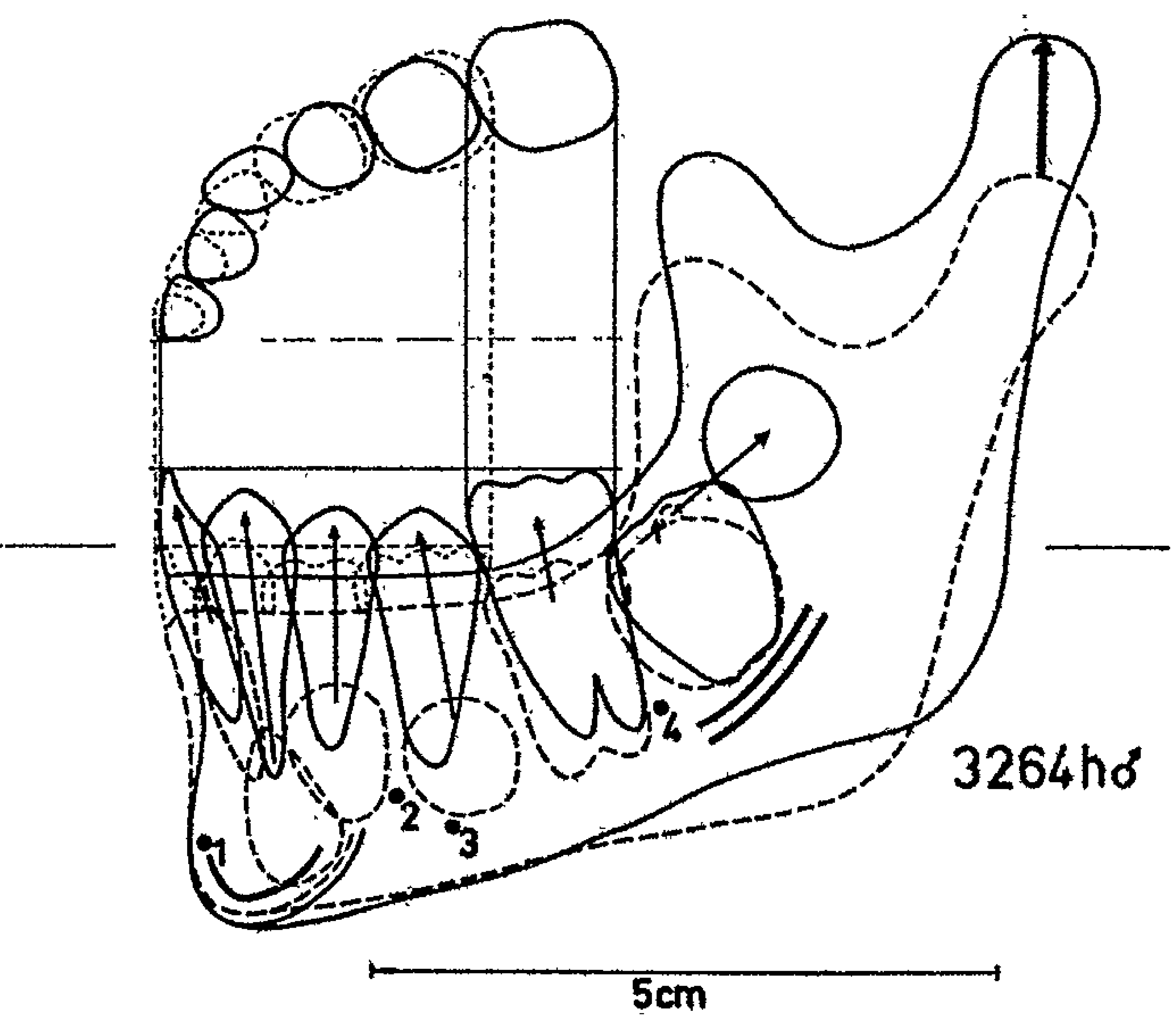
Fig. 35 illustrates the mean direction of growth at the condyles.

Figs. 36, 37, 38, illustrate the changes brought about in the conformation of the mandible by variation in the growth pattern of the condyle. Also demonstrated are the paths of eruption of the teeth associated with these growth patterns.



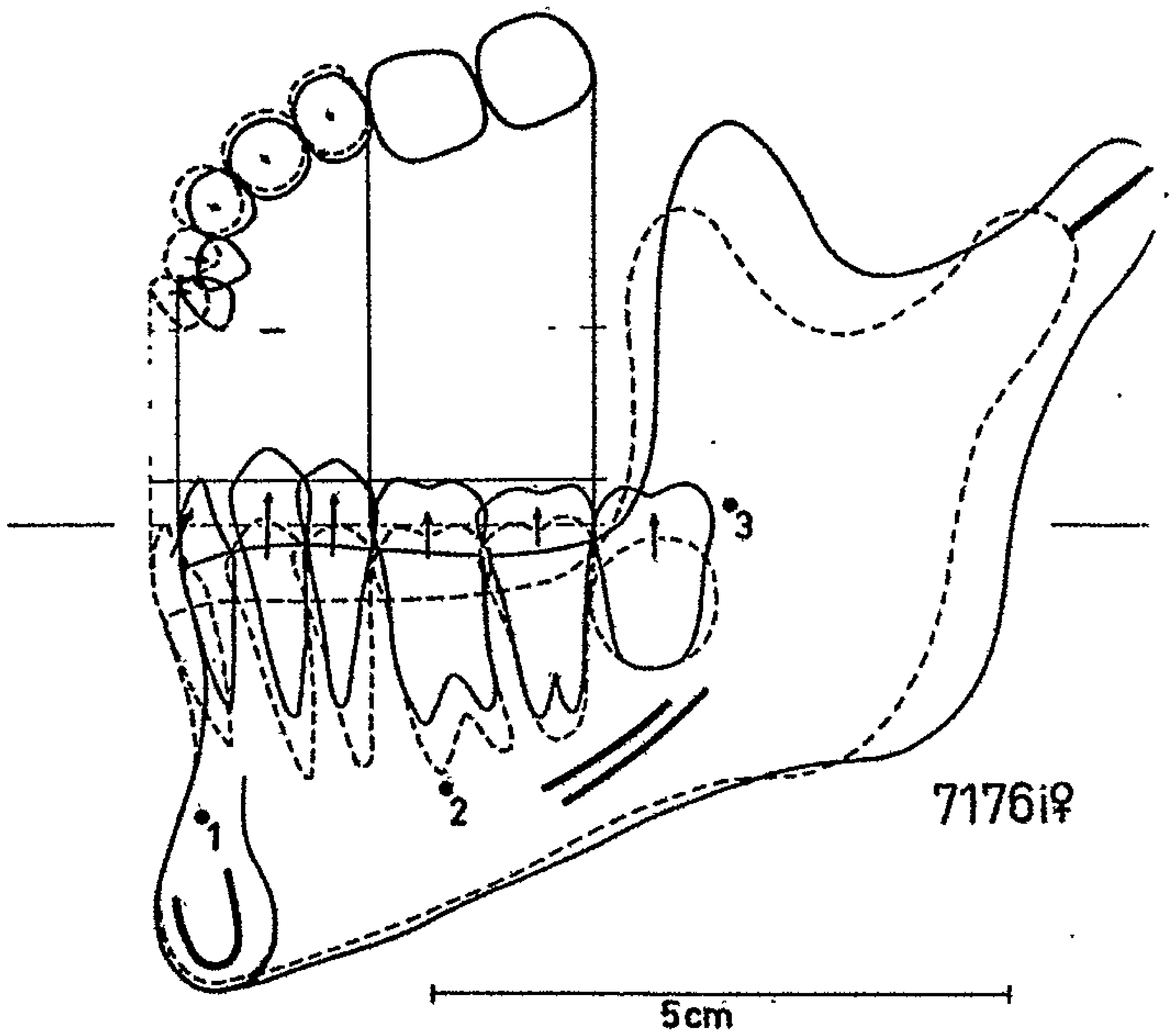
.—Diagram illustrating mean direction of growth at the condyles and extreme vertical and sagittal directions for 45 subjects of the male sample. The direction of growth is measured with respect to the tangent to the ramus and to the lower border of the mandible on the first radiograph in each age series. The direction of growth is determined from the first to the last film of each series. *A* = extreme vertical; *B* = mean; *C* = extreme saggital.

Fig.35 Bjork,1963



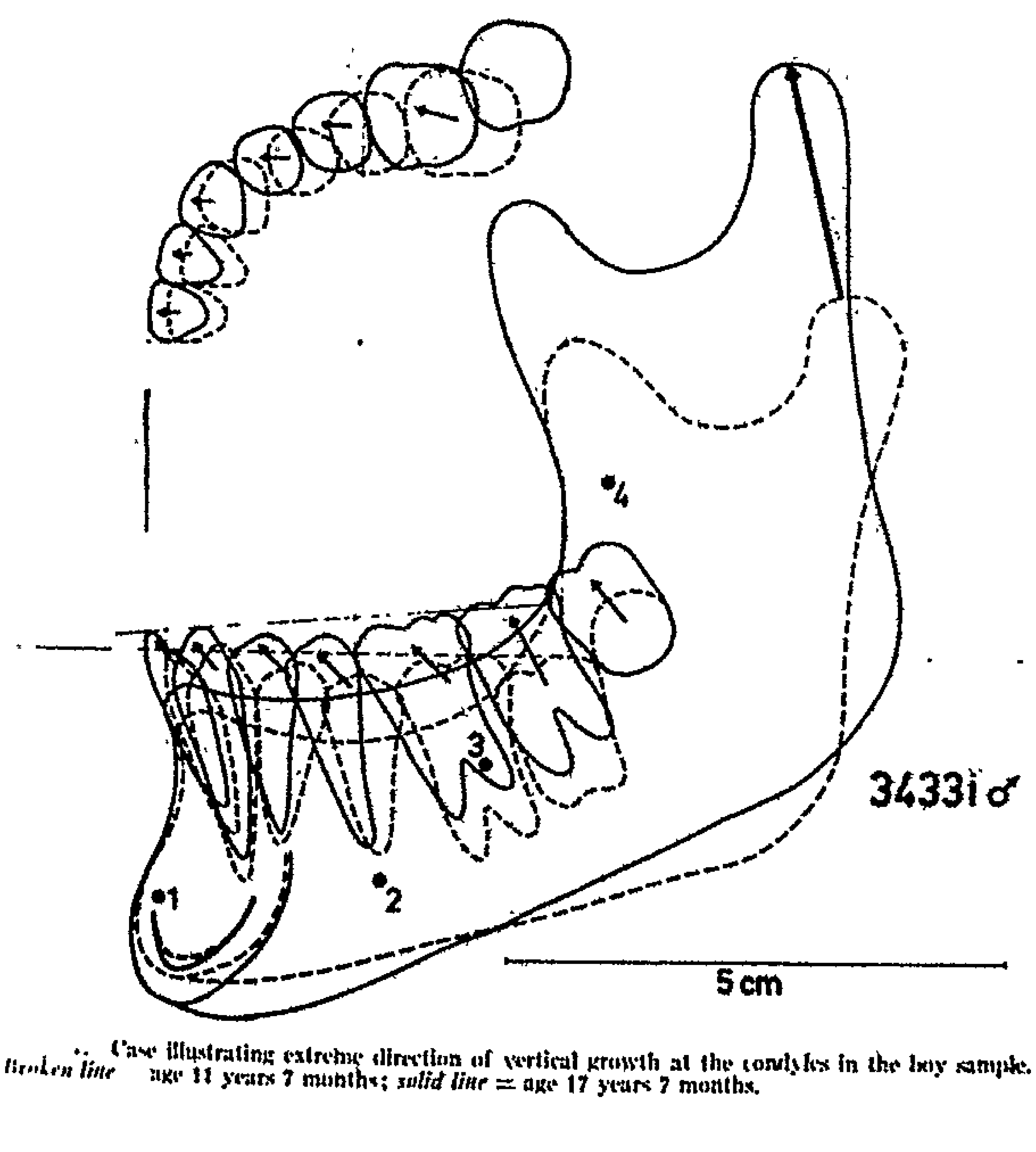
-A case from the boy sample representing mean direction of growth at the condyles. *Bro line* = age 5 years 8 months; *solid line* = age 10 years 8 months.

Fig.36 Bjork,1963



Case illustrating extreme direction of sagittal growth at the condyles in the female sam
Broken line = age 10 years 6 months; *solid line* = age 15 years 6 months.

Fig.37 Bjork,1963



Case illustrating extreme direction of vertical growth at the condyles in the boy sample.
Broken line age 11 years 7 months; *solid line* = age 17 years 7 months.

Fig.38 Bjork,1963

Contributions of the nose to Profile character

As a result of his study, Clements (1969) says:

1. Efforts to plan therapy in order to avoid excessive retraction, and even to treat extraction cases on a non-extraction basis, are nullified when excessive nasal growth continues inexorably to its final dimension and form.
2. Orthodontists must discuss nasal imbalance with parents, since the latent changes - downward and forward depression and elongation of the tip, and humping of the dorsum - occur during the time of orthodontic treatment. The orthodontist becomes

involved whether changes were causally related to treatment, or occurred through natural maturational processes.

3. In many cases, the simple retraction of maxillary anterior teeth produces a face which may be less attractive than it was before treatment.

4. Signs almost pathognomonic of eventual nasal imbalance upon correction of the malocclusion and continued growth are:

    a. Class II, Division 1 malocclusion with extensive overjet.

    b. Short maxillary lip.

    c. Long anterior nasal spine.

    d. Prominent and projecting nasal bone.

5. Cases which occur frequently, and should be watched for nasal imbalance, show

    a. A rather prominent nose

    b. An obtuse columella lip angle

    c. A protrusive upper lip

    d. A well developed pogonion

    e. A lower third of the face which appears to lack vertical and horizontal development

    f. A deep overbite

    g. A prominent anterior nasal spine

    h. An ANB angle of 6 degrees or more.

Chaconas (1969) found the following characteristics in nasal configuration, and in the relationships of the nose to the upper lip and mandible:

Class II subjects exhibit a more pronounced elevation of the bridge of the nose than Class I subjects.

The configuration of the dorsum of the nose in Class II subjects follows the general convexity of the Class II face. (Fig. 10).

Class I subjects tend to have straighter noses, whilst Class III subjects reveal a concave configuration of the dorsum of the nose.

The nose and the upper lip grow forward as a unit.

A long nose seems to be associated with a large mandible. Perhaps nature tries to compensate for a large nose and convex profile by increasing the soft tissue depth of the chin.

The anterior nasal spine grows forward concomitantly with the forward growth of the nose.

Branoff (1971) found that profile changes related to orthodontic treatment are affected by both lip changes related to tooth movement, and growth changes in the tissue thickness of the nose and the chin, and are very difficult to predict.

The study carried out by Anderson et al (1973) encompasses the period from immediately before treatment to 10 years post-retention, and provides the following information:

1. The soft tissues are closely related to, and dependent upon, the underlying skeletal framework.
2. Treatment results in reduction of dento-facial protrusion, with both upper and lower lips becoming less procumbent during treatment. Retraction of the lower lip is related to retraction of both the upper and lower incisors.
3. There is 1mm increase in upper lip thickness for every 1.5mm of maxillary incisor retraction. During and after retention, this lip thickness decreases, but does not go back to its original dimensions. Thickness of the lower lip is not affected by orthodontic treatment.
4. All of the soft tissue changes that occur following treatment have the effect of flattening the dental area of the facial profile. Males show significantly more growth than females in the soft tissue of the nose, base of the upper lip, and chin.

Lecturing to the Australian Society of Orthodontists, N.S.W. Branch, in October 1973, Woodside discussed mid-face prognathism. About 10 per cent of the Class II, Division 2 cases at the Burlington Growth Centre have been detailed as being straight forward, pure, mid-face prognathisms, and quite a high proportion of other Class II cases have some mid-face prognathism in them.

The following characteristics of mid-face prognathism were listed by Woodside:

A straight upper lip

An obtuse nasolabial angle, which becomes more obtuse as the nose grows in length and pulls the lip forward.

Any indication of a bump in the nose, at an early age.

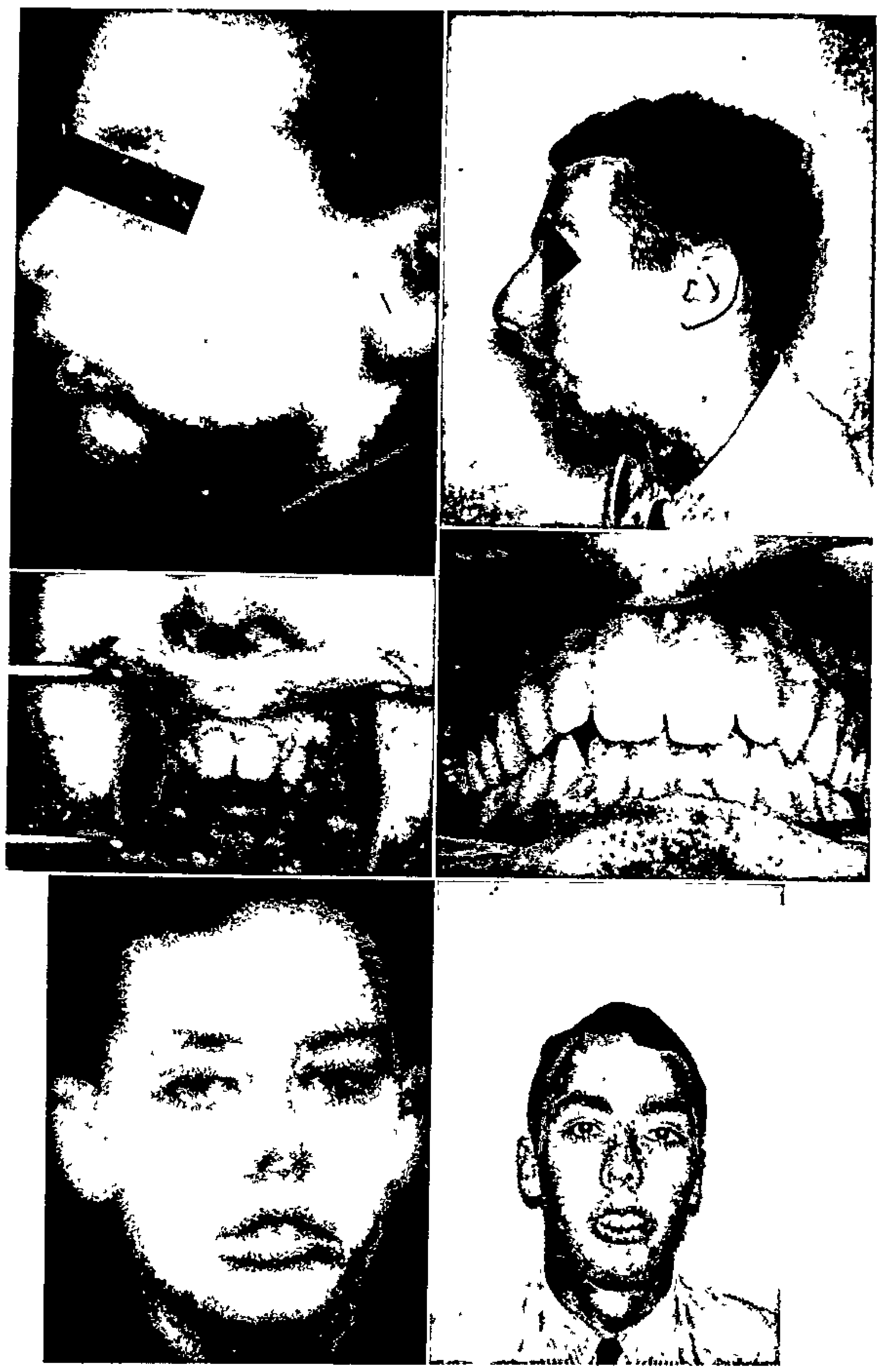
Added thickness in the width of the nose.

Class II, Division 2 or Division Zero type malocclusion.

S-Na-A angle of 83 - 86 degrees.

Any, or all, of these characteristics may be present, the most commonly occurring one being the obtuse nasolabial angle.

Salzmann 1966 p. 983 illustrates developing mid-face prognathism in the male (fig.39.)



(*Top*) *Left*, profile view before treatment. *Right*, profile view at age 18 years, 5 years out of retention. (*Center*) Dentition before treatment age 10 years. B. Dentition of same patient at age 18 years, 5 years out of retention. (*Bottom*) *Left*, face before treatment at age 10 years. *Right*, face at age 18 years, 5 years out of retention. *Note*. Posterior teeth in good occlusion. Mandibular incisors show slight relapse. The mandible in retrognathic.

Fig. 39 Salzmann, J.A. 1966, p.983.

Part 2

Original Work

Aim of the study

Early diagnosis of incipient mid-face prognathism must surely be an advantage to the orthodontist.

With the excessive protrusion of the upper incisor teeth evident in most Class II, Division 1 malocclusions, it is sometimes difficult to assess the degree of change that will occur in the naso-labial angle resultant upon growth and development and orthodontic treatment.

The aim of the present study is twofold.

Firstly, by the use of lateral cephalometric roentgenograms, to test for the incidence of incipient mid-face prognathism in an Australian population of Class II, Division 1 individuals.

Secondly, using the same method and material, to test for correlation between the size of the naso-labial angle (as defined below) and the angulation of the maxillary incisor to the cranial base.

Material and Method

Pre-treatment roentgenographic cephalograms of 24 female subjects were selected at random from the files of the University Orthodontic and Orthodontic Departments of the United Dental Hospital, Sydney. These individuals ranged in age from 11 years 2 months, to 15 years 1 month.

A tracing of hard tissue and nasal and superior labial soft tissue outlines was made of each cephalogram, and the following points marked:

Sella Turcica (S)

Nasion (Na)

Point A

Point B (Fig. 40)

Five angles were constructed and measured:

1. Upper incisor to S-Na (Graber, 1958 B) - the angle made by a line drawn through the long axis of the upper incisor to the cranial base plane Sella Turcica-Nasion. This angle gives the degree of angulation of the upper incisor to the cranial base.

2. S-Na-A (Bjork, 1947). Sella Turcica - Nasion - Point A. This angle gives the antero-posterior relationship of the maxilla to the cranium.

3. S-Na-B (Bjork, 1947). Sella turcica - Nasion - Point B. This angle gives the antero-posterior relationship of the mandibular denture base to the cranium.

4. A-Na-B (Riedel, 1952). Point A - Nasion - Point B. This angle gives the difference between the maxillary and mandibular base position relative to the cranium in an antero-posterior direction.

5. The naso-labial angle, or the "columellar-lip angle" : the angle formed by a line tangent to the columella of the nose and a line tangent to the philtrum of the upper lip. This angle is a measure of the degree of angulation between the columella of the nose and the upper lip.

Fig. 41 illustrates these angles.

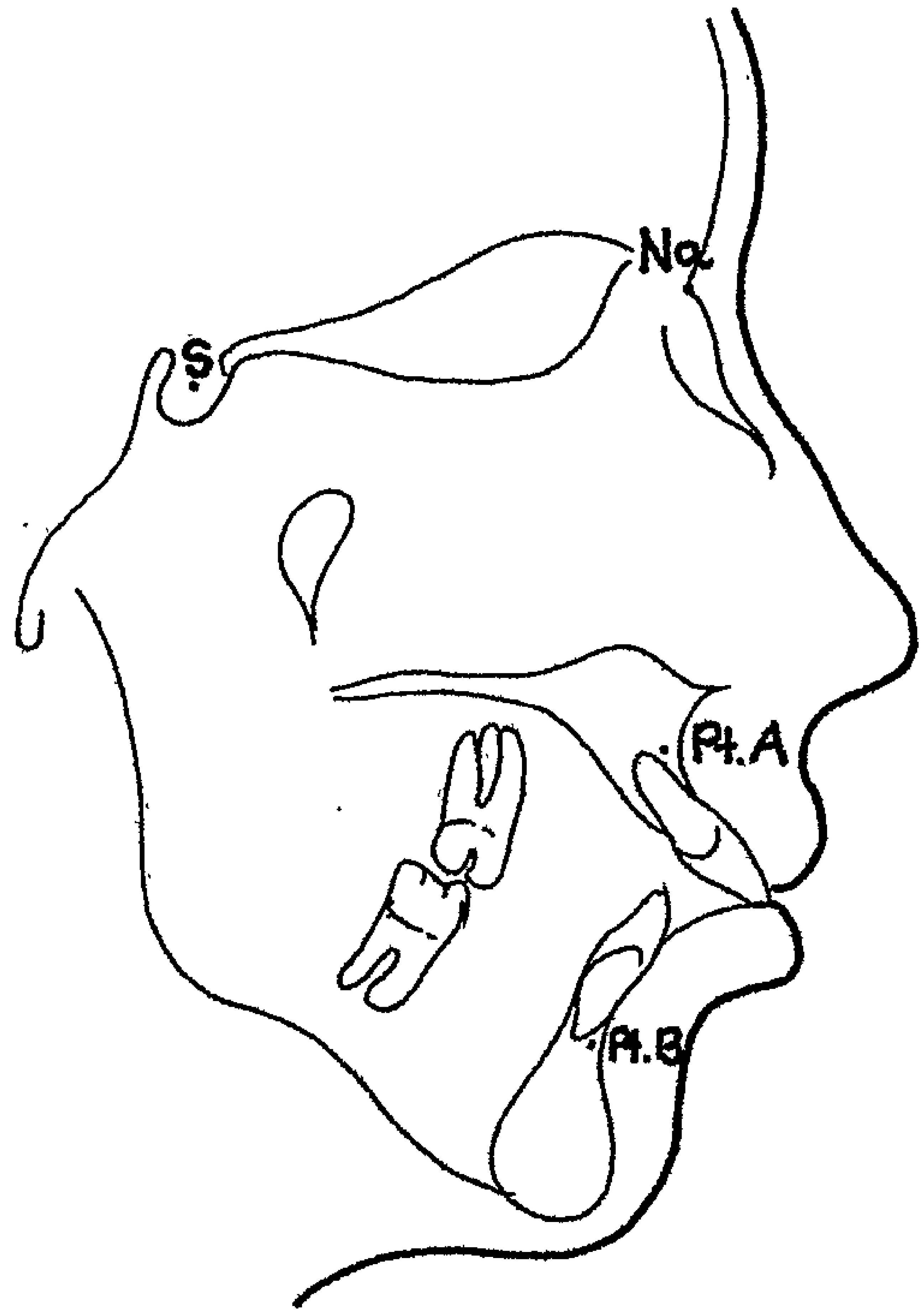


Fig. 40

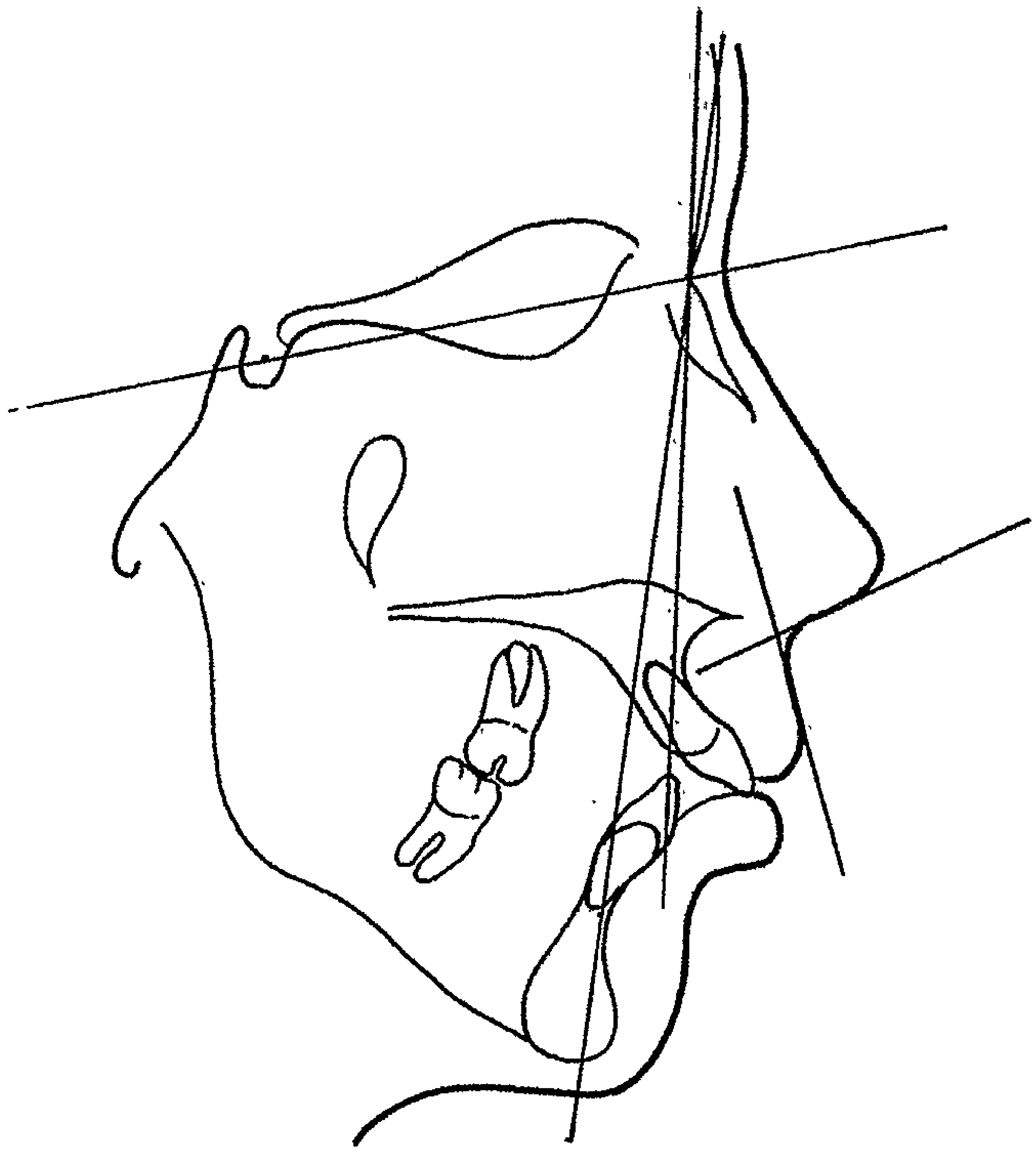


Fig. 41

Plastic surgeons assess the columella – lip angle as the angle made by a line tangent to the prominence of the forehead and the most anterior part of the upper lip, and a line tangent to the columella of the nose (Brown and McDowell, 1951,p 21). Fig. 42 illustrates this method of assessment and indicates the degree of angulation considered satisfactory for aesthetics.

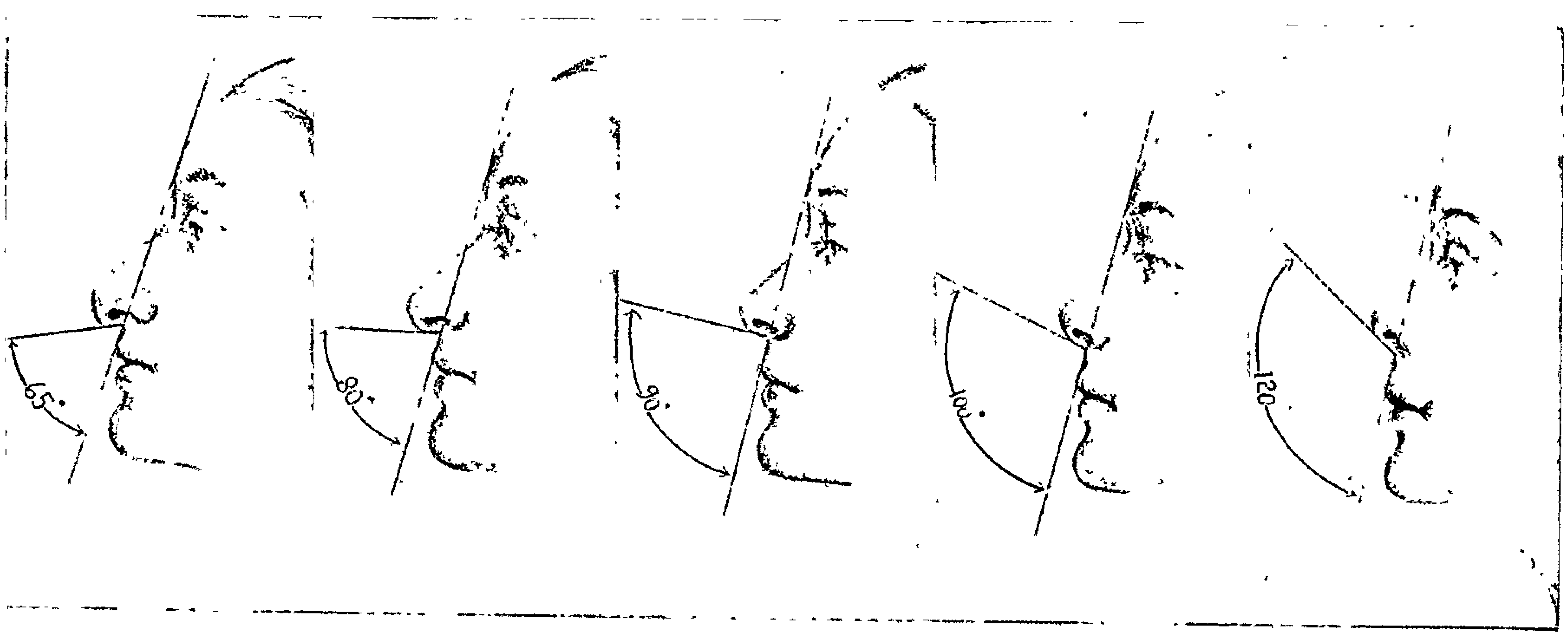


Figure 12. Columellar-lip angles with 90° to 110° seeming ideal, but certain piquant faces with straighter lips can tolerate an angle of 120°. The three profile planes of the nose are seen in 90° and 100° drawings. The need for elevating the whole columella toward the vertex in addition to opening the angle is seen in the 65° nose.

Fig. 42

This method was found unsatisfactory in the present study, due to the excessive anterior positioning and curl of the upper lip which occurs in most Class II, Division 1 malocclusions.

Also found unsatisfactory was the construction, directly from the tracing, of the tangents necessary for the determination of the naso-labial angle, as defined in 5. above. "Within observer" testing for variability of two identical tracings of each of the 24 lateral head plates, disclosed such inconsistency in the positioning of the tangents, that the resultant angle could vary as much as 20 degrees.

In the present investigation, an overhead projector was used to obtain an enlarged image approximately 3 times the size of the cephalometric tracing. Two tracings were made from each projected image.

Draughtsman's French Curves (templates) were then selected by trial to best fit the ends of the variable "S-curves" which represented the columellar and labial profile lines.

With a plastic curve (template) fitting the internal aspect of the curves at each end of the "S", it was possible to construct a straight line tangent to these two templates. The same method of construction was employed to establish straight lines of best fit to represent the nasal columellar and upper lip profiles. The intersection of these two lines formed the "naso-labial angle" which was then measured to the nearest degree, using a protractor. (Fig. 43 illustrates this method).

This method of construction was developed in the hope of assisting reproducibility of naso-labial angular estimations. It was necessary to test the method for within- and between observer variability. This test was carried out using two observers, each of whom made two independent naso-labial constructions and measurements for all 24 of the selected cephalometric X-rays. All profile soft-tissue tracings were made by one observer and these were enlarged by the overhead projector method referred to earlier. Multiple copies were made by 1 x 1 photocopying (3M machine).

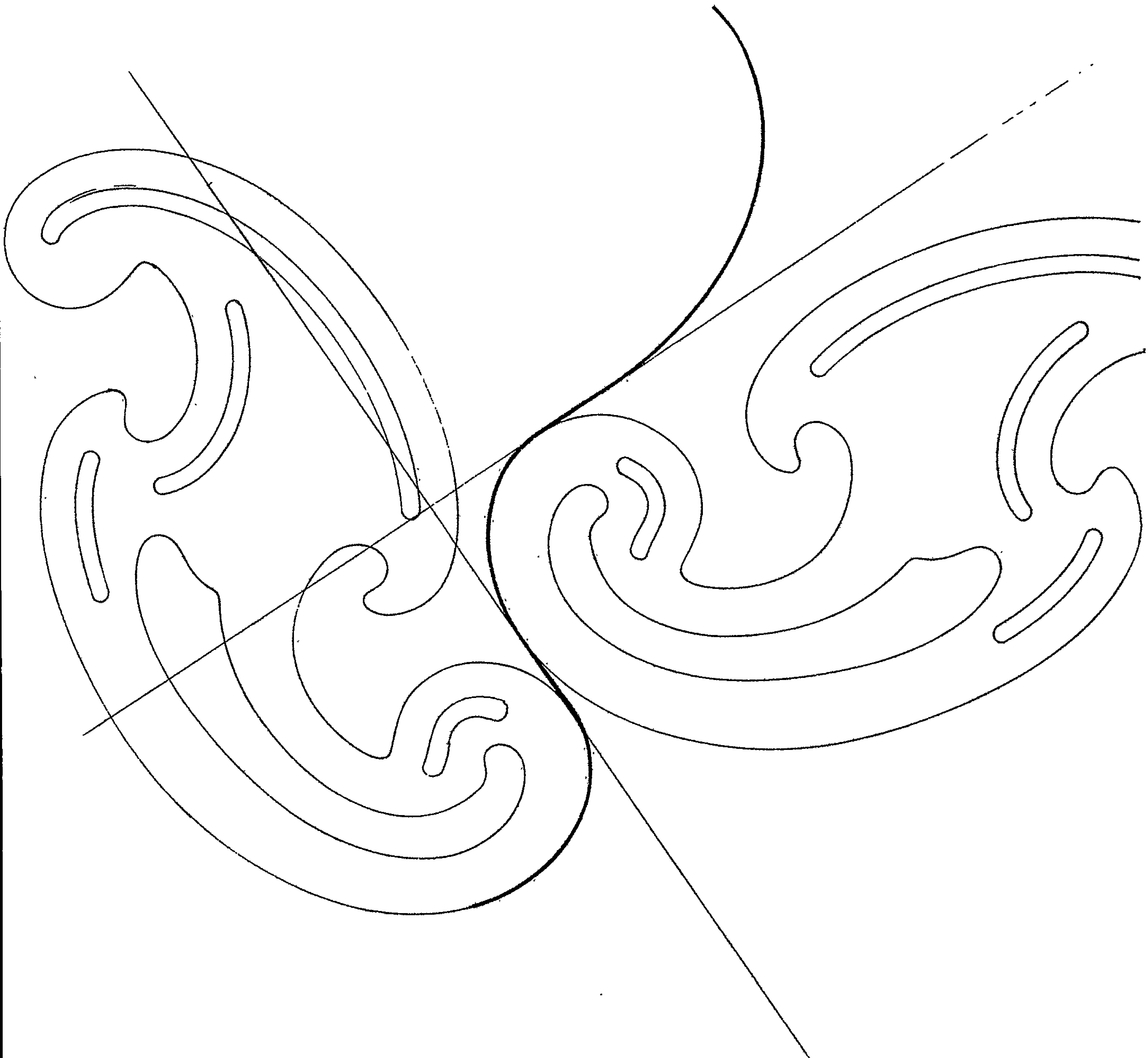


Fig. 43

Table 3 indicates the measurements obtained by the observers in the comparative study.

	1st OBSERVER			2nd OBSERVER		
Case no.	Tracing 1.	Tracing 2.	Difference	Tracing 1.	Tracing 2.	Difference
1	54	52	2	55	57	-2
2	60	63	-3	57	57	0
3	71	70	1	70	67	3
4	73	75	-2	74	75	-1
5	78	80	-2	80	77	3
6	80	78	2	78	77	1
7	81	81	0	82	81	1
8	82	83	-1	79	81	-2
9	82	86	-4	81	84	-3
10	92	91	1	92	95	-3
11	89	90	-1	87	91	-4
12	91	90	1	86	86	0
13	94	92	2	86	89	-3
14	94	94	0	94	93	1
15	95	94	1	93	95	-2
16	95	98	-3	91	93	-2
17	98	97	1	93	93	0
18	96	100	-4	97	99	-2
19	98	99	-1	100	98	2
20	101	99	2	100	99	1
21	104	102	2	105	103	2
22	108	106	2	106	106	0
23	109	112	-3	109	108	1
24	110	113	-3	106	110	-4

STATISTICAL ANALYSIS

The results of repeat determinations of the naso-labial angle by the two observers, according to the method described, are summarized in the table of analysis of variance.

Analysis of Variance

	S.S.	D.F.	M.S.	F.	
a. Observers	45.37	1	45.37	a/c	8.79
b. Subjects	19309.96	23	839.56	b/c	162.7054
c. Interactions (Obs. x Subs)	118.63	23	5.16	c/d	2.25
d. Error	110	48	2.29		
	19583.96	95			

S.S. = sums of squares of deviations

D.F. = degrees of freedom

M.S. = mean square deviation

F. = " F " ratio, or variance ratio

There was a significant difference ($p = 0.01$) between observer-subject interaction and error in the duplicate values. The contribution of the error variance (within observers) was small, which indicated consistency as far as the method of angular determination was individually applied by the observers.

However, the high variance ratio (F value) obtained from the observer-variance related to the interaction variance indicated that there was between-observer variation of the method. Therefore, it could be concluded that one important aspect of reproducibility for such a quantitative determination was not met. This could indicate a basic deficiency of the measurement procedure, or of its application in the present study. It may well be that the basic lack of agreement between the observers could have been cleared with better agreement on methodology; e.g. more clearly defined criteria for curve-fitting and tangent marking to the lip and nose-line profile tracings.

Despite the problems of methodology, highly significant between-subject variability in the naso-labial angle was demonstrated.

Results

First Study

Following Woodside's observations, to assist in the diagnosis of incipient mid-face prognathism (p.77), the presence of the following characteristics were recorded visually from the roentgenographic tracings:

1. A straight upper lip
2. Any indication of a "bump" in the nose.

The following angles were measured:

1. The naso-labial angle
2. S-Na-A

No angle can be considered obtuse if it is less than 90 degrees. Since we were concerned with an obtuse naso-labial angle, a division was then made between the tracings with angles above and below 90°. It is interesting to note that half the number fell into each category. (A and B).

Table 4 indicates the presence (x) or absence (o) of the characteristics noted by visual estimation, together with the size of the two angles. (Figures for the naso-labial angle represent the average of the two tracings previously mentioned).

Also of interest

In A there were no straight lips
two bumps in the nose
naso-labial angles which had a range of
37.5° and a mean size of 78°.
S-Na-A angle range 13, mean 78.2°.

In B there were eight straight lips
four bumps in the nose
naso-labial angles which had a range of
18.5° and a mean size of 100.1°.
S-Na-A angle range of 8°, mean 80.5°.

Tracing No.	Lip	Bump	Naso-Labial Angle	S-Na-A	Tracing No.	Lip	Bump	Naso-Labial Angle	S-Na-A
A.					B.				
1	O	X	53	78.5	13	O	O	93	82
2	O	O	61.5	78	14	O	O	94	80
3	O	O	70.5	80	15	O	O	94.5	82.5
4	O	O	74	86	16	X	O	96.5	80.5
5	O	O	79	78	17	O	X	97.5	78
6	O	O	80.5	76	18	X	X	98	82
7	O	X	81	74	19	X	O	98.5	71
8	O	O	82	80.5	20	X	O	100	85
9	O	O	84	73	21	X	O	101	86
10	O	O	91.5	73	22	X	X	107	78
11	O	O	89.5	78.5	23	X	O	110.5	74.5
12	O	O	90.5	84	24	X	X	111.5	82

Table 4.

Woodside (p. 77) stated that the existence of any, or all of the following characteristics are indicative of incipient mid-face prognathism.

A straight upper lip.

Any indication of a bump in the nose at an early age.

An S-Na-A angle of 83 - 86 degrees.

An obtuse naso-labial angle which becomes more obtuse as the nose grows in length and pulls the lip forward

From the data obtained from this study, together with visual examination of the roentgenographic tracings, it does not appear possible to diagnose incipient mid-face prognathism in this group of Australian individuals.

Study 2.

The angulation of the upper incisor to the cranial base (S-Na) was measured for each of the roentgenographic tracings.

The graph illustrated in fig. 44 shows the relationship between the naso-labial angle and the angulation of the upper incisor to the cranial base.

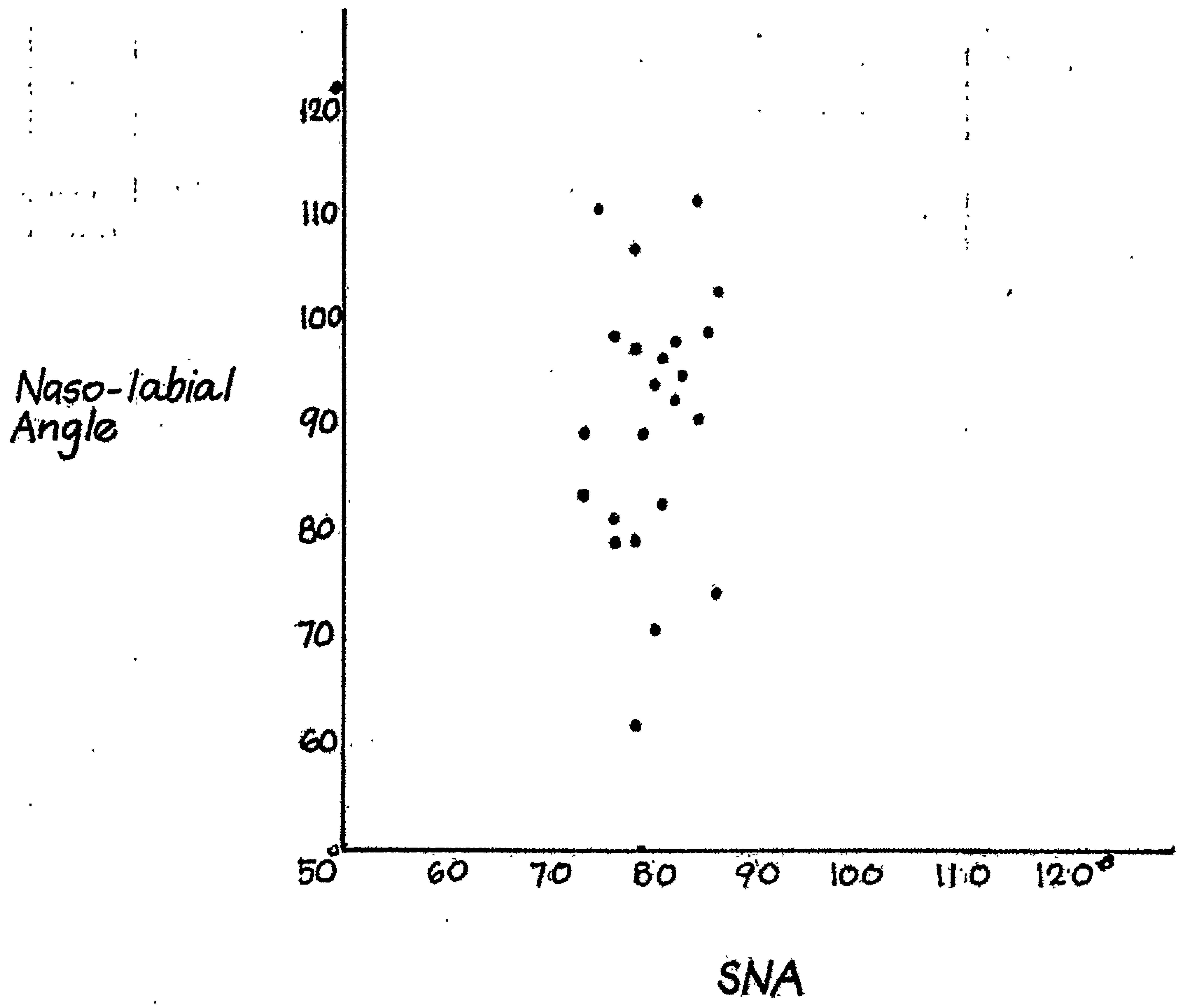


Fig. 44

The large scatter indicates that no relationship exists.

Discussion

Interest in mid-face prognathism and/or nasal imbalance in the general population was originally aroused by the colour slides mentioned in the Introduction. Stimulation was added by Woodside in his lecture on mid-face prognathism in relation to orthodontic patients (p. 77).

Although no positive results have been achieved in this investigation, a greater awareness of the importance of the nose in aesthetic evaluation has been impressed upon the author.

It may have been noted that much of the Literature Review in which dento-facial relationships are discussed is devoted to investigations which include the nose. These particular investigations were not consciously selected for discussion, but occurred spontaneously as part of soft tissue appraisal and measurement studies. However, literature relating to assessment of nasal contour and a measurable relationship of the nose to the upper lip is notably lacking. The reason soon becomes obvious when an attempt is made to carry out a study of this nature.

We assess a child visually as having an obtuse naso-labial angle. The word "angle" implies the area contained by the intersection of two straight lines. In few instances can this be applied to the junction of the columella of the nose and the upper lip. "Contour" would be a more appropriate word to use to describe the web-like attachment of the upper lip to the nose in most cases.

Attempts made to measure this angle proved frustrating. A synthetic construct was employed in an attempt to overcome the problem. Extensive statistical evaluation of the results has subsequently thrown doubt on the validity of this construct. However, this method of measurement was employed on all tracings and is uniform for this study.

Visual inspection of the tracings soon revealed that a straight upper lip was present in most of the tracings deemed to have an obtuse naso-labial angle. The "straight upper lip" was not necessarily a straight lip hanging vertically from the nose, but a lip that in itself is straight, with no curve at the philtrum. Salzmann's illustration (p.78) of the 10 year old male exhibiting early mid-face prognathism confirms this observation.

Awareness of the presence of a straight upper lip in a patient could prove valuable.

Some correlation was expected between the angulation of the upper incisors and the size of the naso-labial angle. None was found. Perhaps a longitudinal study before, and after, treatment involving the retraction of the upper incisors, would be of interest.

A bump in the bridge of the nose is present in 6 of the 24 tracings studied. This is a large proportion in a small sample and supports the observations of Chaconas (1969) and Woodside (p.77) concerning individuals with Class II, Division 1 malocclusions. No immediate association appeares to exist between the presence of the bump and other features of possible mid-face prognathism.

The presence of an S-Na-A angle of 83° - 86° at an early age would alert any orthodontist to the fact that he was dealing with a maxilla positioned more anteriorly in relation to the cranial base than is normal. Elucidation of the other factors examined in this study could assist in determining the existence of an incipient mid-face prognathism.

A study of the factors mentioned by Clements (1969) - the length and protrusion of the anterior nasal spine; the angulation of the nasal bone, and its length in comparison with the length of the dorsum of the nose, at an early age; the antero-posterior depth and vertical height of the nose at an early age, would be of interest in an attempt to find diagnostic criteria for the determination of mid-face prognathism and nasal imbalance.

Summary and Conclusions

An attempt has been made to test for the incidence of mid-face prognathism in an Australian population of Class II Division 1 individuals; to test for correlation between the size of the naso-labial angle and the angulation of the maxillary incisor to the cranial base in the same individuals.

From the criteria used in this study, it did not seem possible to determine the incidence of incipient mid-face prognathism. No correlation existed between the size of the naso-labial angle and the angulation of the maxillary incisor to the cranial base.

Difficulty was experienced in measuring the naso-labial angle. The synthetic construct employed was found to have problems relating to methodology. More careful instruction regarding the use of the construct may overcome these problems.

Further criteria for use in the diagnosis of incipient mid-face prognathism have been suggested.

The following landmarks or measure points were accepted as valid by the Workshop. The definitions are those used in the *Workshop Manual* developed by Krogman and Sassouni

A *(Subspinale).* The deepest midline point on the premaxilla between the anterior nasal spine and prosthion (Downs).

ANS *(Anterior nasal spine).* This point is the tip of the anterior nasal spine seen on the x-ray film from norma lateralis.

Ar *(Articulare).* The point of intersection of the dorsal contours of process articularis mandibulae and os temporale (Björk).

B *(Supramentale).* The most posterior point in the concavity between infradentale and pogonion (Downs).

Ba *(Basion).* The lowermost point on the anterior margin of the foramen magnum in the midsagittal plane.

Bo *(Bolton point).* The highest point in the upward curvature of the retrocondylar fossa (Broadbent).

Gn *(Gnathion).* The most inferior point in the contour of the chin.

Go *(Gonion).* The point which on the jaw angle is the most inferiorly, posteriorly, and outwardly directed.

Me *(Menton).* The lowermost point on the symphysial shadow as seen in norma lateralis.

Na *(Nasion).* The intersection of the internasal suture with the nasofrontal suture in the midsagittal plane.

Or *(Orbitale).* The lowest point on the lower margin of the bony orbit.

PNS *(Posterior nasal spine).* The tip of the posterior spine of the palatine bone in the hard palate.

Po *(Porion).* The midpoint on the upper edge of the porus acusticus externus located by means of the metal rods on the cephalometer (Björk).

Pog *(Pogonion).* Most anterior point in the contour of the chin.

Ptm *(Pterygomaxillary fissure).* The projected contour of the fissure; the anterior wall represents closely the retromolar tuberosity of the maxilla, and the posterior wall represents the anterior curve of the pterygoid process of the sphenoid bone.

"R" *(Broadbent registration point).* The midpoint of the perpendicular from the center of sella turcica to the Bolton plane.

S *(Sella turcica).* The midpoint of sella turcica, determined by inspection.

SO *(Spheno-occipital synchondrosis).* The uppermost point of the suture.

As has been pointed out, there is some duplication, since individual investigators have a preference for certain combinations. Not all measurepoints would be used in any one analysis.

Table I. Upper to lower incisor axis

Author	Date	Sample					Values				Observation
		No	Sex	Age	Ecol.	Selection	Mean	S.D.	Range	C.V.	
Bjork + Palling	1954	243	M M	12 20		N.S. "	128.1 130.1	8.3 9.0			
Bushra	'48	40			Exo		135.3	7.32	118.0-152	5.41	
Cotton	'51	20		11-36	N	Negro	123.0		105 -144		
Wong	"	"		11-16	N	Chinese	120.8		105 -137		
Takano	"	"		21	N	Nisei	126.4		114 -152		
Riedel	'52			Ad	N		130.98	9.24			
				Ch	N		130.40	7.34			
Downs	'48	20	M F	12-17	Exo	Selected	135.4		130 -150.5		
Iyer	'53	50	F	Ad	N	N.S.	132.44	9.55	114 -154		
Noyes + Rushing + Sims	'43	9			N	Ind.Sk.	131.4	7.4	24°		
		14	M	22-34	N	Living	129.3	5.37	21°		
Steiner	'53				N		130				
Schaeffer	'49	22		8	Mix		130.27		113.5-154.5		
		45		12	"		130.7		113.5-147.0		
		18		16	"		130.7		114.0-141.5		
Lindegard	'53		M				130.3	9.0	110 -159		

Table II. Lower incisor axis to mandibular plane

Author	Date	Sample					Values				Observation
		No	Sex	Age	Ecol.	Selection	Mean	S.D.	Range	C.V.	
Bjork + Palling	1954	243		12		Swedish	92.1	6.7			Mand.pl. = lowermost border
				20			90.5	7.2			
Bushra	'48	40			Exo		92.6	6.15	79.5-104.0	6.64	Mand.pl. = Downs
Cotton	'51	20		11-34	N	Negro	96.6		-3.5- 22		Add 90° to values
Wong		20		11-16	N	Chinese	97.8		0 - 18		Mand.pl.=Downs
Takano		20		21	N	Nisei	96.55		-6 -+13		
Riedel	'52			Ad	N		93.09	6.78			⊥ to Go-Gn
				Ch	N		93.52	5.78			
Hoffer	'54						85				No sample
Downs	'48	20		12-17	Exo		91.4		-8.5- +7		Mand.pl.=Downs
Iyer	'53	50	F	Ad	N	N.S.	88.53	6.30	73 -101.5		Lowermost border
Margolis	'47	100		6-19	Exo	Selected	90	3.			"
Noyes, Rushing, Sims	'43	9			N	Ind.Sk.	92.0	4.2	12°		Lowermost border
		14	M	22-34	N	Living	89.4	4.6	23°		
Renfroe	'48	43			I		95.3				Go-Gn
Steiner	'53						93.0				Go-Gn contour
Schaeffer	'49	27		8	Mix		96.07		81-111		Go-Gn "
		46		12	"		95.0		83-108.5		
		19		18	"		96.94		87-109.5		

Table VIII. Na-A-Pog

Author	Date	Sample					Values				Observation
		No	Sex	Age	Occl.	Selection	Mean	S.D.	Range	C.V.	
Bjork + Palling	1954	243		12		Swedish	6.2	5.3			
		243		20		"	2.3	6.1			
Bushra	'48	40			Exo		-0.9	4.95	9 to -4		
Cotton	'51	20	M F	11-34	N	Negro	9.6		4 to 20		
Wong	'51	20	M F	11-16	N	Chinese	7.5		1.5to 14		
Takano	'51	20	M F	21	N	Nisei	3.65		12 to -1		
Riedel	'52			Ad	N		1.62	4.78			
				Ch	N		4.22	5.38			
Higley	'54	25	M		N	Iowa	9.6	4.0	2 to 17		
		25	M	8	N		6.9	4.4	0 to 15		
		25	F	4	N		12.2	4.0	2.5to 21.		
		25	F	8	N		8.4	2.9	4 to 19		
Downs	'48	20		12-17	Exo		0		+10 to -8.5		
Lande	'52	32		7			11.0				
		27		12			8.2				
		27		18			5.2				

Table IV. S-Na-Pog

Author	Date	Sample					Values				Observation
		No	Sex	Age	Occl.	Selection	Mean	S.D.	Range	C.V.	
Bjork	1953	243		12		Swedish	78.8	3.3			
				20			80.7	3.9			
Bjork	'51	44		12-20							
Downs	'48	20		12-17	Exo	Selected	80		74 -85.5		
Riedel	'52			Ad	N		79.29	3.39			
				Ch	N		76.93	3.02			
Iyer	'53		F	Ad	N	N.S.	79.96	2.47	76 -86		
Lande	'52	32	M	7	Mix		75.7				
		27	"	12	"		77.1				
		27	"	18	"		79.6				
		20	"	7	"		76.9	2.5	72.5-82		
Musj + Maj	'51	90		Ad			78.5	4.53	68 -88		
Margolis	'47	100		6-19	Exo	Selected	75	3.5			
Renfroe	'48	43			I		75.2				
Silverstein	'54	15	M	8-9	Mix		77.73	3.73			
		15	M	15-17	"		80.25	4.41			
		10	F	8-9	"		79.5	3.23			
		8	F	15-17	"		80.37	4.04			
Nair	'54	20	M	12:6	I		75.22	4.19			
		20	F	12:6	I		76.08	3.13			
		40	M F	12:6	I		75.65	3.57			

Table V. Ma-S-Gn (Y axis)

Author	Date	Sample					Values				Observation
		No	Sex	Age	Ocol.	Selected	Mean	S.D.	Range	C.V.	
Brodie	1941	66	all ages				67.95	2.86			
Blair	'54	20	M	12:6	I		67.2	5.63			M-S-C = C = mand. plane (Downs) and perp. thru pogonion
		20	F	12:6	I		68.78	4.81			
		40	M F	12:6	I		67.99	5.20			
Baldridge	'41	58			I		68.59	3.63			
Bushra	'48	40			Exo		65.7	3.42	58.0-73.2	5.25	
Epstein	'48	12		5-18					64.9-76.7		
Gilmore	'50	31	M	16-42	Exo		68.3	4.0			
		30	F	"	"		66.7	3.7			
Hedges	'48	14		6-21					63.3-76.7		
Higley	'54	25	M	4	N	Iowa	66.6	3.0	62.0-71.0		
		25	M	8	N		67.1	3.0	61.5-73.0		
		25	F	4	N		68.1	3.2	61.0-76.5		
		25	F	8	N		69.5	3.8	63.0-84.0		
Lande	'52	32	M	7	Mix		66.7				
		27		12	"		67.0				
		27		18	"		66.6				
		20		7	"		66.8	2.3	63 -72		N-S-Pog
Muzj + Maj	'51	90		Ad			69.6	4.13	60 -78		Gn = bisectrice
Renfroe	'4[illegible]	43			I		67.9				

Table VI. S-Na-A

Author	Date	Sample					Values				Observation
		No	Sex	Age	Cool.	Selection	Mean	S.D.	Range	C.V.	
Bjork	1953	243		12			81.3	3.3			12 to 2C diff
				20			82.0	3.6			2.6 ± 1.5
Blair	'54	20	M	12:6	I		79.4	3.95			
		20	F	"	I		80.7	3.55			
		40	M F	"	I		80.05	3.77			
Riedel	'52			Ad	N		82.01	3.89			
				Ch.	N		80.79	3.85			
Lande	'52	32	M	7	Mix		81.16				
		27		12	"		81.0				
		27		18	"		82.2				
Steiner	'53				N		82				
Silverstein	'54	15	M	8-9	Mix		79.86	3.06			
		15	M	15-17	"		80.0	2.34			
		10	F	8-9	"		82.1	3.33			
		8	F	15-17	"		82.87	4.05			

Table VII. S-Na-B

Bjork	'53	243		12			77.8	3.3			Diff.N 12-20
				20			79.3	3.7			1.5 ± 1.6
Blair	'54	20	M	12:6	I		75.45	3.81			
		20	F	"	I		76.8	2.97			
Riedel	'52			Ad	N		79.97	3.60			
				Ch	N		78.02	3.06			
Lande	'52	32	M	7	Mix		76.7				
		27	M	12	"		77.2				
		27	M	18	"		79.1				
Steiner	'53				N		80				
Silverstein	'54	15	M	8-9	Mix		76.6	2.88			
		15	M	15-17	"		78.43	4.33			
		10	F	8-9	"		78.6	3.37			
		8	F	15-17	"		78.75	3.33			

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