Planning Treatment on the Basis of the Facial Pattern and an Estimate of Its Growth

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Part I

Cephalometrics and Growth Estimation

Cephalometric roentgenography, like all valuable tools, has found several uses. At its beginning it was employed primarily for growth studies of the skull. It was not long, however, until it was recognized as a method for evaluating treated orthodontic cases. The study of movements of the mandible and dynamics of occlusion became another phase of its application, the method still being limited to research.

Cephalometrics did not become popular until it was adapted to routine clinical practice as an aid in diagnosis and treatment planning. Through it, the description and communication of the nature of the orthodontic problem became possible. The application of cephalometric principles to laminagraphy helped to reveal the temporomandibular joint. These combined methods assisted in the understanding of the variation in jaws and disclosed the changes in treatment.

A study has been reported by the author[1] in which facial and denture changes in fifty treated Class II cases were analyzed with a combination of cephalometrics and laminagraphy. It was shown that many similar malocclusions, receiving identical treatment, responded in entirely different facial behaviors, i.e., the chin either came forward, dropped downward or went backward when related to cranial landmarks. In that study it was concluded that the explanation of the variety of facial changes lies within the temporomandibular complex.

Three main factors seemed to explain these differences in behavior (Fig. 1). First to be considered, but perhaps least important during the time of treatment, were the changes in the cranial base (NSBa). The majority did not change but some became more obtuse and some more acute, viz., the skull base flattening or shortening when related to the horizontal. Theoretically at least, since the glenoid fossa is located in the general proximity of the middle cranial fossa, its relation to basion is presumed to remain relatively fixed. Bjork[2] has recently become skeptical of the importance of this relationship but Coben[3] found little change in point articulare to point basion in his serial studies. At any rate, changes in the cranial base or changes in the location of the fossa seemed to explain the behavior of certain cases.

Secondly, as had long been suspected, the condyle was observed to move forward. As described in previous work however, one fourth of all Class II cases during treatment demonstrated a posterior positioning of the condyle. These were observed to influence the chin behavior in a definite manner, contributing largely to an opening of the Y axis or a downward and backward movement of the chin.

The third factor, and that found to be the most important, was the growth at the condyle in amount and direction.

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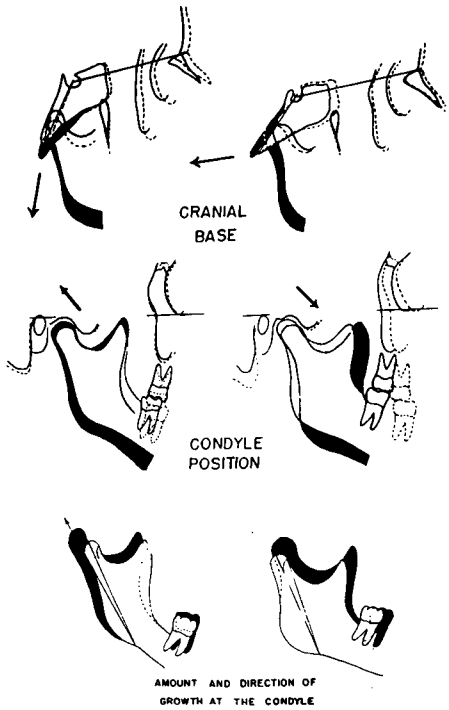


Fig. 1 Changes in the face during treatment were thought to be influenced mainly by three phenomena within the temporomandibular complex. Top—changes in the angle of the cranial base to a more acute or obtuse cranial relationship. Bottom—Forward or backward condyle growth.

Upward and forward growth of the condyle tended to be consistent with increased depth of the face (brachycephalic tendencies) while upward and backward growth was found to be more consistent with increased length of the face (dolichocephalic tendencies). The mechanism of mandibular behavior does not appear to be as simple as has been inferred in the past.

This work introduced a new plane to the orthodontic library. For want of a better name, it was termed the "condylar axis" (Figs. 1, 3, 5). Originally it was designed to represent the inclination of the condylar head and neck. However, for this work, it was selected by bisecting the condylar neck and connecting this point to a point at the greatest curvature of the antegonial depression. Growth of the condyle in a majority of cases tended to follow this plane although great variation was observed.

In a given case, all factors leading to posterior movement of the glenoid fossa, posterior positioning of the condyle, growth of the condyle in an upward and backward direction, and bite opening (rotation of the mandible) could alter the face in the manner seen in Fig. 2—left. Conversely, all factors producing the opposite effect contribute to changes as seen in Fig. 2—center. A comparison of the two conditions leads to an extremely great difference in the chin position as a possibility for the individual Fig. 2—right. These changes are not unrealistic. Cases exhibiting such behavior have been observed. In spite of these great differences in facial behavior, some orthodontists still have the temerity to ask, "What has growth to do with orthodontic treatment?"

These studies suggested that facial form was to a large degree determined by the position of the chin. In addition, it appeared that the chin position was mainly influenced in the developing face by these three factors, viz., the cranial base, the condylar position and condylar growth. Through a consideration of these factors the changes in any given case could be analyzed and could be understood. It therefore was thought feasible and rational to attempt to prognosticate the changes in a case by conceiving the changes in each contributing part.

More was entailed in a growth estimation procedure than simply observing a head plate or manipulating a group of figures. Projecting the behavior of the given case was noted to encompass the careful analysis and consideration of the many individual parts that contribute to the total behavior. The probability of change of each part was estimated on the basis of the similarity

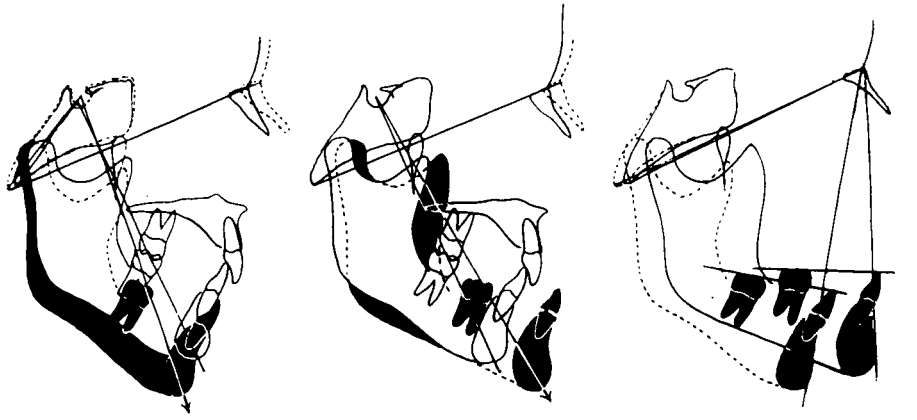


Fig. 2 Possibility of change in an individual case. Left—Cranial base development in a backward direction together with posterior positioning of the condyle in addition to obtuse development of the mandible all contribute to dropping of the chin. Center—No cranial base growth, forward positioning of the condyle plus acute development of the mandible yields forward positioning of the chin. Right—Range of possibility when opposite extremes are compared.

or dissimilarity to cases previously observed.

The Procedure for Growth Estimation

It goes without saying that the first requisite for growth estimation depends upon an accurate tracing of the lateral head plate (Fig. 3). Certain bilateral structures, such as the angles of the mandible and the pterygomaxillary fissures are bisected to procure an imaginary midsagittal image free of distortion. For growth estimation work, the cranial plane basion-nasion is employed. Basion is observed by following the clivus from the post-clinoid process to the anterior border of foramen magnum to a point which intersects the inferior border of the basioccipital. The basioccipital should not be confused with superimposing structures such as the tympanic plate or other parts of the temporal bone.

A Class II Div. 1 extraction case was selected to demonstrate this procedure (Fig. 4). The first step in growth estimation is a projection of probable changes in the basi-cranium (Fig. 5). The basi-cranium includes points N, S,

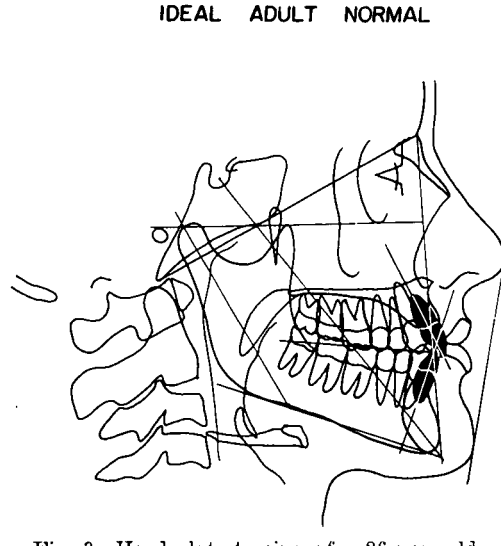


Fig. 3 Head plate tracing of a 26 year old female with excellent occlusion of all teeth. Good harmony of the mouth with the remaining features is demonstrated. The lower incisor is 1 mm. forward at 23° inclination to the APo plane. The FMIA angle is 68°.

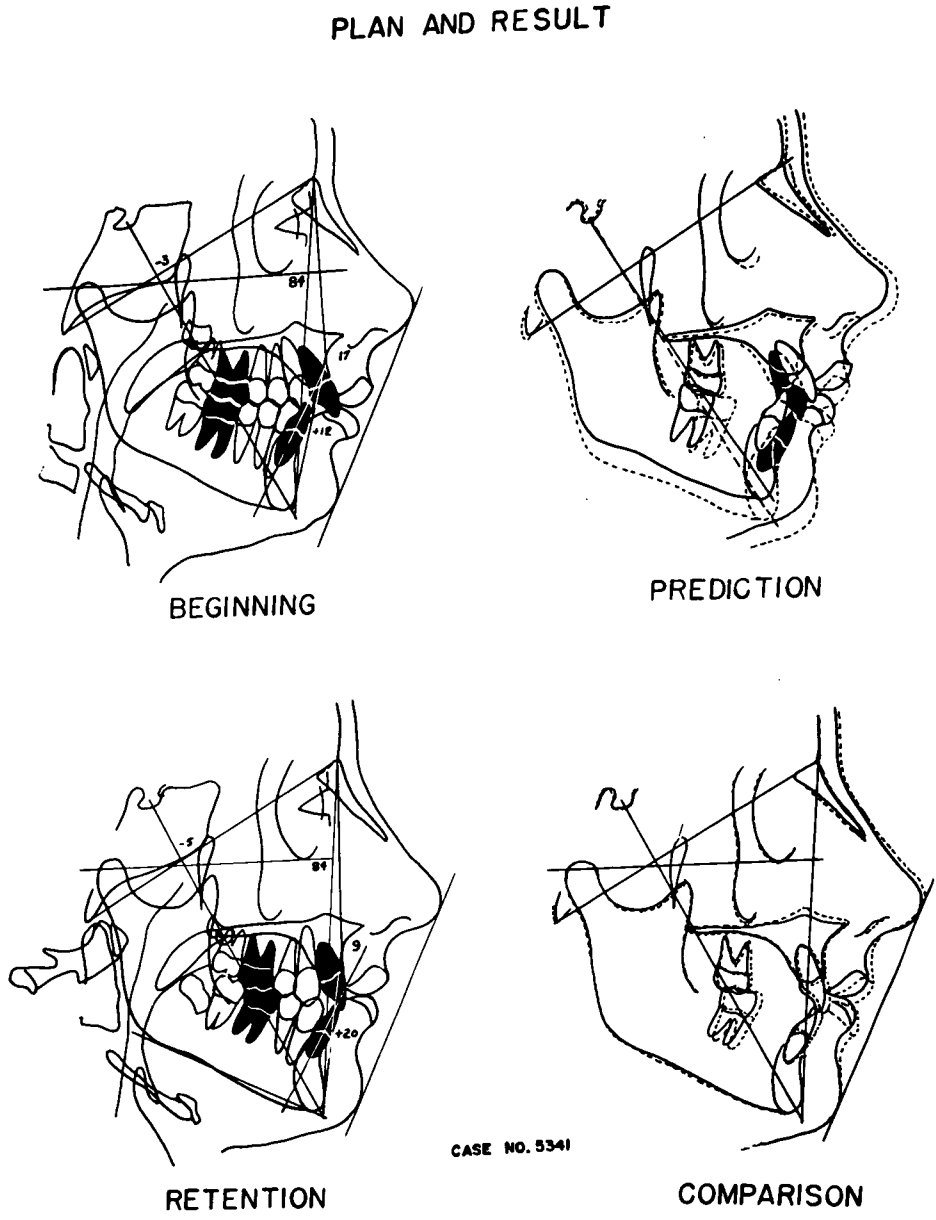


Fig. 4 The "growth estimation treatment plan" applied to a Class II Div. 1 patient with crowding in both arches and treated with extraction of lower first and upper second bicuspids. The growth prediction is seen in the upper right. Figures 5, 6 and 7 outline the steps in arriving at this estimation. Note the accuracy of the growth plan in the comparison tracings. (Lower right) Note how closely the case approaches the "ideal" in denture and lip balance and facial harmony.

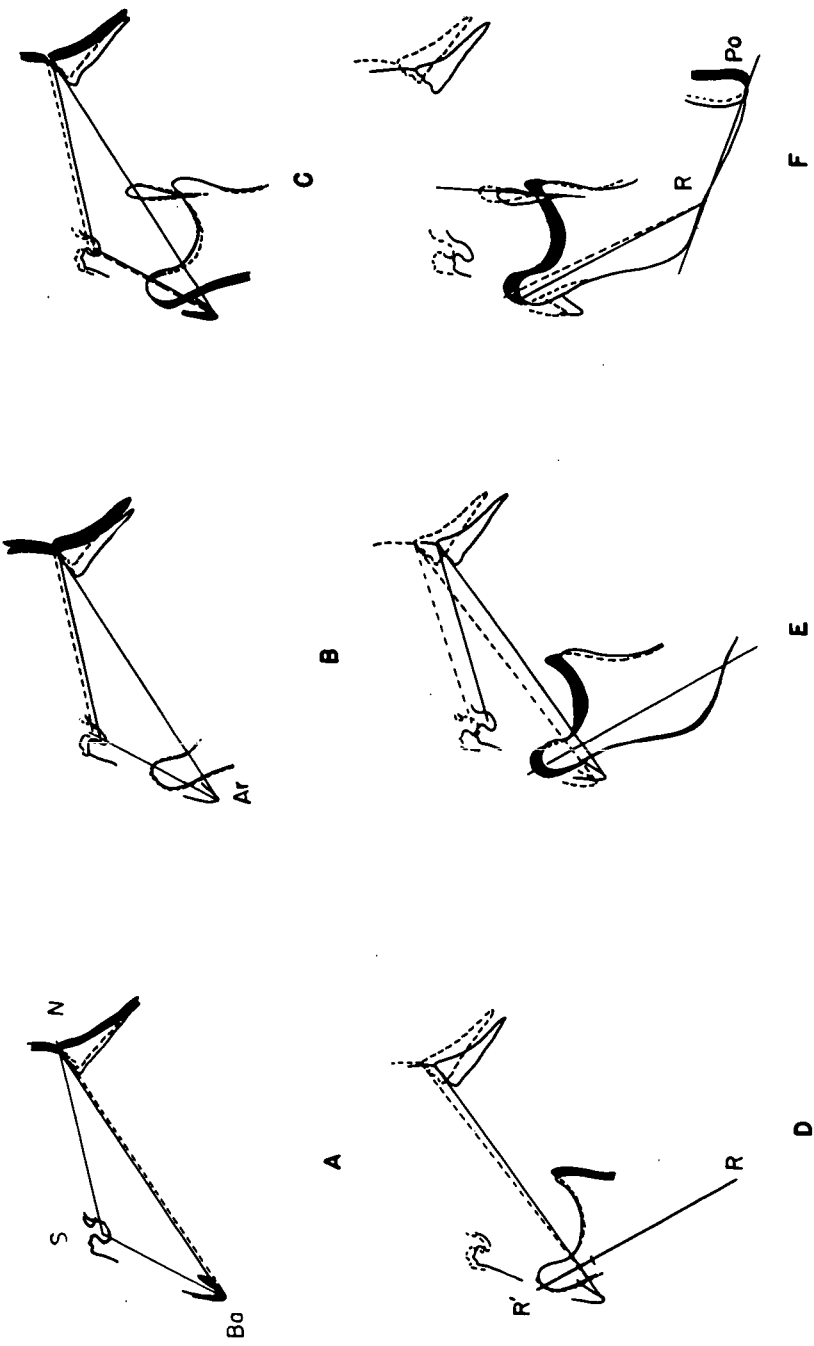


Fig. 5 Steps in estimating the behavior of the cranial base and mandible during treatment. A. Increases in SN and SBa projected and new BaN constructed. B. Location of the condyle is selected. C. Pterygo-maxillary fissure and coronoid process are oriented. D. The condyle axis (RR′ plane) is selected. Degree of bite opening is evaluated and amount of condyle growth is predicted. E. Growth is added to the mandible. Form of the ramus and processes outlined. F. Changes in relation of the body to the ramus are forecast and increases from the condyle axis (point R) to the symphysis are estimated.

and Ba for purposes of this analysis. Employing point sella as a starting point, the average expectancy for increase along SN is plotted. During vigorous growth, as in pubertal spurts, 1 mm. per year can be expected.[1,2] In some children in the mixed dentition stage .5 to .7 mm. per year will be observed while many 13 year old females will demonstrate very little change.

The expected changes between sella and basion are next plotted. The change in length of SBa is about three fourths as much as anticipated on SN. It should be mentioned that certain clues are suspected within the spheno-occipital synchondrosis for this behavior. Wide open sutures are thought to be yet active while closed sutures are not growing. A great deal of variation in closure probably exists at age twelve between sexes. Our knowledge of this area is incomplete. It should also be mentioned that in long term planning the expectation should include possible changes in the angulation of NSBa although the average does not change.[1,2] Following the plotting of estimated SN and SBa behaviors, points Ba and N are connected to establish the expected basion-nasion plane and conclude the formation of the new basi-cranium.

The next step consists of predetermining the behavior of the condyle (Fig. 5). Previous studies have indicated that the condylar position during orthodontic treatment of Class II malocclusions remained the same in about 60% of the cases.[4] During growth, the downward and backward movement of articulare and basion are thought to be parallel after age six. Changes in the location of the temporal bone and hence the glenoid fossae are presumed by associating joint behavior with changes in point basion. In addition, condylar positional changes within the fossae are equally important considerations. As stated previously one of four Class II cases, during treatment, showed posterior movements of the condyles. Such incidences produce a noticeable effect on behavior of the chin during treatment. Superposing BaN and registering Ba will reveal the prospective condylar position relative to basion after the above factors have been considered.

Following the construction of the new basi-cranium and condylar location, the pterygomaxillary fissure is outlined (Fig. 5). The findings of Brodie[5] are utilized in order to make this transformation. Superimposing of SN and registering at S shows a slight downward dropping of this fissure of about 1 mm. during the usual case. The location of PTM is important to the evaluation of the maxillary growth and to help establish the future position of the coronoid process. The tip of the coronoid is usually, but not always, located about 3 mm. forward of the pterygomaxillary fissure at both the start and completion of orthodontic treatment unless dramatic rotation of the mandible is experienced, i.e., bite opening. Behavior of this point was observed from laminagraph sections.

Following the construction of the condyle and the coronoid process, the RR′ plane or condylar axis is constructed (Fig. 5). This axis is determined on the initial tracing by connecting a point in the center of the neck of the condyle at the level of articulare with a point at the deepest curvature of the depression on the body of the mandible anterior to the gonial angle, or at the antegonial depression. It usually expresses the long axis of the condylar head and neck.

The observation of antegonial area is not new. Engel and Brodie[6] noted severe notching of the mandible in this area in condylar growth arrest cases. Broadbent[7] has hinted that a great deal of significance might be found in growth of the mandible at about this junction

between the ramus and the body of the mandible. This is possibly a great adjustment zone, particularly as resorption of the medial and anterior aspect of the ramus makes way for the developing molars during growth.

Interpretation of the character of muscle in the particular case is necessary at this time. This consideration sheds light on the possible effects of bite opening as a consequence of rotation of the mandible during treatment. Muscle patterns are often correlated with specific types of morphologic patterns. Cases with high mandibular plane angles, small gonial prominences, thin rami and short condyle heads frequently display excessive opening during treatment.[1] On the other hand, cases possessing acute gonial angles, well-developed bodies, thick rami and well-formed condyle heads will resist bite opening rather dramatically. Treatment, if slow in this type, will usually result in depression of teeth in correction of overbite rather than rotation of the mandible and lengthening of the face. During treatment with Class II intermaxillary elastics in "weak mandible" severe overbite cases, the relationship of the condyle axis to basion-nasion plane will open about 1 degree or more. In prolonged head gear cases, rotation of the mandible is even greater. Greater knowledge is needed in this regard; however, the condyle axis can be sensibly estimated based on present information.

A contemplation of the important factor of the amount of growth of the condyle is next in sequence. This is estimated on the condyle axis that has been constructed and is measured off the condyle axis at the point it crosses BaN. During treatment of the average case at age seven to nine years, both sexes usually exhibit approximately two mm. of growth per year in the lengthening of the condylar axis. During puberty, slightly greater increases in this line are observed, particularly in males, at which time three and sometimes four mm. per year may be expected. Many females after puberty display very little growth. A consideration of the physical type and endocrine pattern of the individual patient, together with his hereditary disposition offers assistance in this prognosis. In the entire scope of facial estimation, this factor, the amount of growth of the mandible, seems to be the most difficult aspect to predetermine accurately.

The assessment of condylar growth permits the construction of the posterior border, gonial angle, sigmoid notch and the anterior border of the ramus. This yields the projected rough form of the mandible with the exception of the body and symphysis.

As a start to estimation of the remainder of the mandible the possible changes in the angulation of mandibular planes to the condylar axis are ascertained (Fig. 5). In Class II cases the average angle formed by the mandibular plane with the condylar axis was observed to change very little; however, a tendency for forward inclinations was suggested.[4] In excellent facial patterns a definite forward tendency of one degree or more was noted. In certain cases, the mandibular plane-condylar axis angle becomes greater, in others it closes rather markedly.

Changes in the form of the ramus and the condyloid and coronoid processes give clues to the behavior of the gonial angle and body, i.e., increases in depth of the ramus tend to develop more acute gonial angles and vice versa. The procedure is simply to rotate the mandibular plane of the original tracing at its intersection of the condyle axis until the change agrees with the estimate of change for that case. Once the direction of effective growth of the condyle has been determined, a line is constructed for the mandibular plane. It

should be remembered that a forward direction of condylar growth is consistent with lower mandibular plane angles, while backward condylar inclinations usually result in higher mandibular plane angles.

A determination of increases in length of the body of the mandible from the intersection of the condylar axis to the symphysis is the next step (Fig. 5). Lengthening of the body on the average is slightly greater than lengthening of the SN line, i.e., about 1.5 mm. per year during active growth. Cases with acute gonial angles and well-formed mandibles will show this dimension sometimes to increase more than 1.5 mm. per year. The lengthened dimension of the body of the mandible is estimated and the changes in the position of the symphysis during treatment are plotted. The facial plane and the Y axis can now be constructed and the superpositioning on the basion-nasion plane will indicate the direction and magnitude of growth of the mandible (Fig. 6).

Changes in the position of the maxilla are approached in three ways but an application of the findings of Lande[8] is used for the total tendencies. However, the basion-nasion plane is superimposed and registered on N rather than SN or the Frankfort plane. First, in order to predict vertical changes, the facial planes are superimposed and registered on N. About sixty percent of the total facial height increase is credited to the denture area. Therefore, about forty percent of total facial increase is allotted to the upper face, which locates the level of the anterior nasal spine (Fig. 6). An estimate of treatment effects on facial height alters this prediction, however. In conditions in which it is planned to employ intermaxillary elastics and cervical anchorage over a long period of time, Watson[9] showed showed that a slight tipping down of the palatal plane is to be expected.

Secondly, the horizontal position of the maxilla is postulated from the tendency of SNA to remain constant to BaN. Therefore, point A is dropped parallel with the beginning line NA. In cases needing a great amount of bodily retraction of the upper incisor and the upper arch, point A will be moved back as much as three to five degrees depending upon the amount of retraction necessary or thought possible for that individual (Fig. 6).

In cases exhibiting bizarre facial patterns, a second check on the behavior of the maxilla is sometimes used to help predict the strongest tendency and evaluate the case. This is a good adjunct in cleft palate cases. A point on the most superior curvature of the glenoid fossa (K) is selected as a cranial reference point. The anterior end of the zygomatico-frontal suture (Z) and a point at the most inferior curvature of the key ridge (J) represent landmarks for zygomatico-maxillary relationships (Fig. 6). A triangle is constructed connecting these three points. In the average Class II case, the distance from point K to Z increases 2 mm. during treatment, while that of K to J increases only 1.5 mm. Therefore, some indication of the relative position of the jugal process can be visualized, but this needs further investigation in light of more recent treatment techniques.

Total palatal behavior can be checked by the fact that the posterior nasal spine drops parallel to the pterygomaxillary fissure under usual conditions. However, the palatal plane is tipped in some cases receiving strong traction to the maxillary teeth in either direction (Fig. 6). Here again, relations of the cranial base give indications of its relative behavior.

With the construction and positioning of the maxilla in the face, the bony framework is completed. It should be remembered that facial variation in

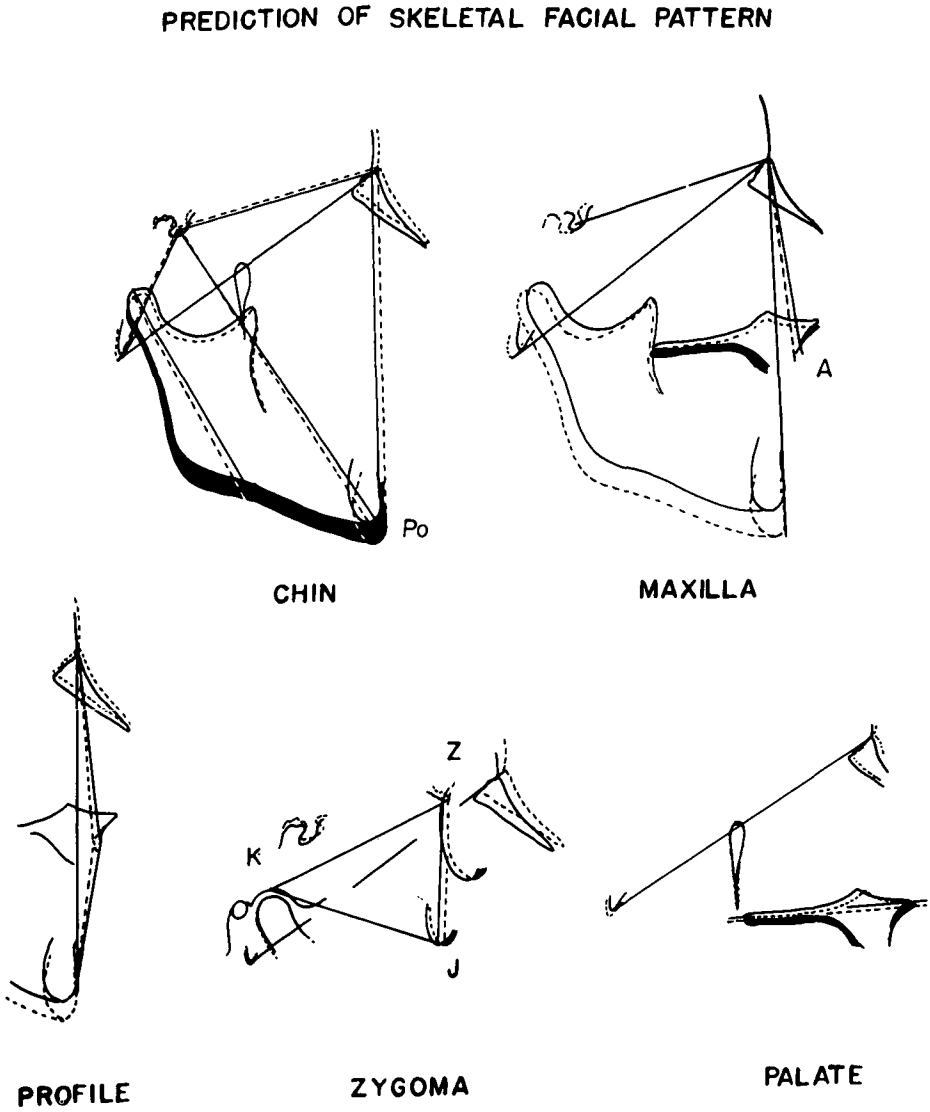


Fig. 6 Estimation of the bony facial pattern. A. The composite of all factors covered in Fig. 5 yields the predicted behavior of the Y axis and facial plane and location of the chin. B. The vertical relationship of the maxilla is estimated by proportioning total vertical growth. C. Future facial convexity is determined by predicted behavior of point A. D. Zygomatico-maxillary temporal relations are anticipated. E. Descent of the palate is forecast.

height, depth and breadth are to be expected, together with profiles that exhibit convexity or concavity in different degrees. The skeleton or the bony frame of reference for the denture is not alike in all cases. It becomes an architectural problem to plan the relationship of the denture for each case.

Planning the Arrangement of Teeth and Determining Anchorage Values

The arrangement of teeth is planned from the occlusal plane (Fig. 7a). During normal growth the cant of the oc-

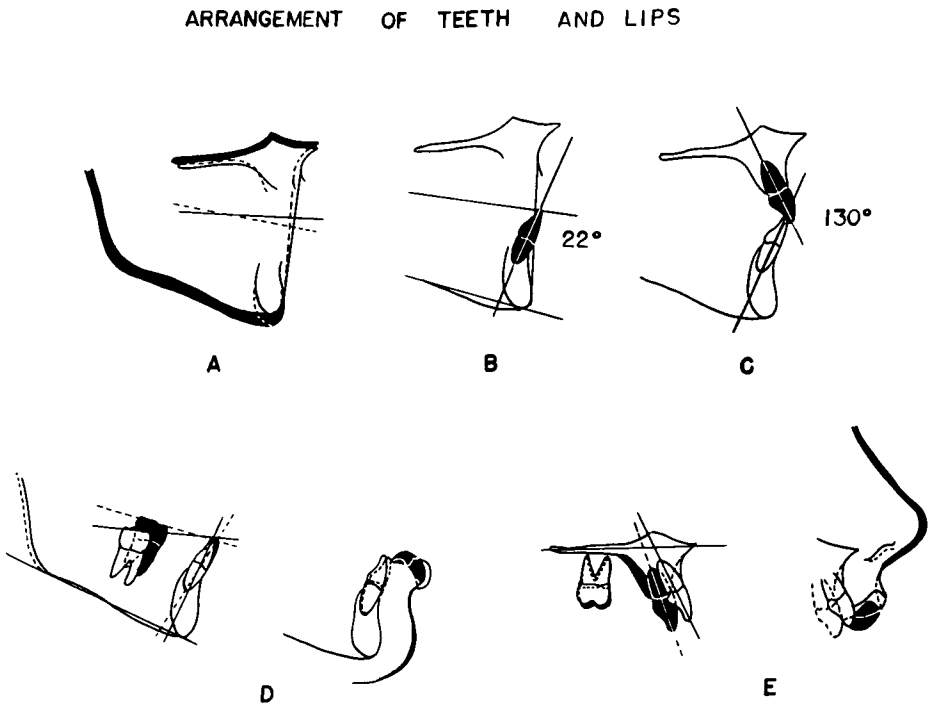


Fig. 7 Method for arranging the teeth for ideal relationship. A. Palatal and mandibular planes are bisected and the occlusal plane is tilted in respect for the conceived changes brought about by intermaxillary traction. The new APo is established for reference for the teeth. B. The lower incisor is arranged at 22° 1 mm. forward of the APo plane. C. The upper incisor is oriented at 130° to the lower incisor. D. Molar anchorage value is determined and the behavior of the lower lip is predicted. E. Reaction of the upper arch is estimated and selection of the teeth to be removed in this instance can be made.. Growth of the nose and changes in the lip can be estimated. The complete planning is seen in Fig. 4.

clusal plane will decrease, i.e., it will drop faster in the back than in front. Cervical elastic traction applied at the maxillary molars will be in accordance with this tendency. The application of intermaxillary Class II elastic works in a reverse direction and tends to rotate the plane an average of 3° from the mandibular plane. This action elevates the lower first molar an average of 2.5 mm. while the anterior teeth elevate more slowly, are held in place vertically or are depressed, depending upon growth factors and anchorage values. Simply bisecting the height increase of the lower face and assuming changes in one way or another depending upon the avenues of treatment provides a base line for the arrangement of the teeth.

Once the occlusal plane is established, the new point A-pogonion plane is erected and the lower incisor is placed one mm. forward to it and at a 22° inclination by using the original tracing as a template (Fig. 7b). The upper incisor is arranged ideally at 130 degrees to the lower incisor (Fig. 7c). *If conditions of the lips or the tongue contraindicate such movement or the amount of trauma thought to accompany this arrangement be too great, some compromise from the ideal position of the teeth must be made at this time.* At any rate, the relationship of the incisors should be made to accomplish a functional equilibrium together with esthetic balance and harmony.

Having arranged the incisors to fit the face as indicated from the x-rays, models, photographs, etc., it is time that full consideration of anchorage be made. The forces necessary to arrange the posterior teeth can be determined. Herein various factors that affect anchorage of teeth can be evaluated (Figs. 7d, 7e). Different growth patterns give clues to different types of anchorage behavior. The possibilities of headgear therapy on either or both the upper and the lower arch can be considered. The amount of anchorage offered by teeth in the event of extraction can be envisioned. Anchorage values and their preparation are a separate topic and will not be discussed here.

Speculation on Soft Tissue Behavior

Soft tissues of the face can be modified a great deal by orthodontic therapy. The next procedure is to evaluate the soft tissue changes for esthetic improvement and to determine the indications for myo-therapy. Superpositioning of the palatal planes and registering on ANS has indicated that, on the average, 2 mm. of growth of the nose can be expected during the course of orthodontic treatment (Fig. 7e). In rapidly growing faces this figure will be greater, while in already well-developed, non-growing individuals this figure will be smaller. The profile outline is then constructed to the area below the nose, including the nares, using the palatal plane as a reference. Following this procedure, the changes in the upper lip are determined. In excessively protruding cases, the upper lip may appear to be thin and stretched but as the teeth are retracted a thickening of the lip will occur due to its relaxation. In addition to this, the upper lip actually grows in thickness. Therefore, a two to four mm. increase in thickness of the lip can be expected in severely protruding cases and about a one to two mm. increase in cases wherein the upper incisors are not going to be moved excessively.

Estimation of changes in the lower lip are made by bisecting the overbite and overjet change and drawing in the superior portion of the lower lip at this level (Fig. 7d). Almost the same thickness of lip will be present after treatment. The sub-labial area seems to behave in conformity to the roots of the lower incisor. Therefore, if the roots of the lower incisors are retracted, an increase in sub-labial depression will ensue. If the lower incisors are brought forward, this portion of the lip will be built out. Cases demonstrating active mentalis habits with the soft portion of the chin rolled upward and forward will often be relaxed by treatment and the soft tissue of the chin will come to occupy a normal position. Therefore, it should be constructed accordingly.

This then constitutes the complete procedure for estimating the changes that can be expected in any given case prior to treatment.

Part II

Esthetic Considerations and Treatment Planning

Because an appreciation of tooth position is an integral part of growth estimation and treatment planning, a "prescription" for the arrangement of teeth has been included. However, it could be asked, "What evidence avails to justify the relationship so described?" A search through the literature on esthetics yielded little but personal opinion in this regard. It was agreed that one of the primary objectives of orthodontic treatment is that of esthetic facial balance and harmony. However, "balance" and "harmony" should be more clearly defined.

The word "balance" implies evenness or proper proportion of parts or elements. The word "harmony" denotes a

fitting together or a smoothness; a blending, or that which is pleasant.

In his chapter on facial art, Angle[10] used such terms as harmony or inharmony, beauty or ugliness, and perfection or deformity. He also stated emphatically that the study of orthodontia was indissolubly connected with that of facial art. Angle further inferred that the orthodontist must look toward an ideal. He held that poor results could be prevented by the proper application of sound principles and guides. However, many clinicians will not agree that the facial esthetic results he showed in some cases were the best that can be achieved today. Angle made one point clear that should be considered in the analysis of any profile view and that is, that it is the upper teeth, not the lower, that establish the curve of the lower lip. The dearth of discussion of the chin contour was noted in his writings as greater heed was paid to the upper cuspid area. Severe retrognathic pattern cases were dismissed as rare.

Attempts to establish rules for the attainment of the ideal were made by Simon,[11] who established the orbital plane as a reference line. Later, Tweed[12] concluded that facial esthetics were closely related to the axial inclination of the lower incisors to the mandibular plane. Tweed[13] more recently has correlated the lower incisor to the Frankfort plane. Although many do not agree with Tweed's concept of beauty of a face, he must be given credit for reawakening the profession to the consideration of facial lines, beauty and harmony.

Probably the most recent systematized study of facial esthetics was that of Reidel[14] who obtained soft tissue profile outlines and submitted them to seventy-two orthodontists for esthetic evaluation. It was evident that the profession lacked objective criteria for evaluation of the profile. The nebulous classification of "poor," "fair," or "good" was all that could be gained. Reidel found certain skeletal consistencies with those cases classed as "poor" but offered no suggestions for an improved method of evaluating esthetic balance and harmony of the face. The desire for a method to explain facial improvement was currently noted by Tweed.[13]

Downs' cephalometric analysis,[15] which has gained almost universal acceptance, provides a classification of facial and denture patterns that may be compared with Angle's classification of malocclusion as a contribution to dentistry. His report was based on patients exhibiting normal occlusion together with those with malocclusion, and constitutes an excellent yardstick to evaluate facial types and the relationship of the teeth. However, a cephalometric analysis should include two additional considerations in the author's opinion. One is that the soft tissues of the nose, lips and chin be considered; and secondly that additional information must be gained in order to guide the clinician in treating malocclusion in facial patterns which lie outside the range of those demonstrating harmonious relations. This need was noted by Steiner[16] who has published his recommendations using a slightly different approach than that of Downs. However, neither does Steiner's analysis include a consideration of the soft tissues. The clinical application of both methods are restricted in the sense that both constitute a static analysis of the immediate condition. Neither takes into consideration growth factors that ultimately must be considered in the full application of any treatment planning procedure.

Method of Soft Tissue Determination

The method of arriving at an ideal face must necessarily be purely subjec-

tive. Therefore, a search was made to observe as many photographs from any source as were readily available. Attention was ultimately limited to the parts of the face that were thought to be greatly modified or changed by orthodontic treatment. The conclusion was finally reached that the most convenient points from which the lips could be related were the end of the nose and the chin. A line was drawn between these two points and the lips were measured anterior or posterior to this line. For want of a better name this line was termed the "esthetic plane."

By fortuitous circumstance, three pictures appeared on the covers of leading magazines within a month's time. All were nearly true profile views of the heads of popular starlets in almost life-size. An analysis of these portraits, undoubtedly picked for their close adherence to the prevailing idea of beauty of profile, revealed that the lower lip was approximately two millimeters and the upper lip approximately four mm. posterior to a line from the nose to the chin. It should be mentioned that the majority of still models, as evidenced by some magazines, are selected for a prominent chin and a "hungry look." The animation of movies apparently requires a more prominent denture.

The consideration of the faces in a group of males exhibiting normal relationships of the teeth and again a subjective impression of what was considered to be desirable revealed the lips of the male to be slightly more retracted in relationship to the nose and chin. This is probably because the features of the male are slightly more rugged, the chin is more prominent and the nose somewhat greater in length. A study of the lip relationship in the face of the Appollo bears out this conclusion.

The above has reference to adults; what might determine balance and harmony for children? Previous growth studies are referred to in this regard. The findings of Schaeffer[17] and those of Baum[18] both suggested normal retraction tendencies of the denture area during the growth span. Clinical observation suggested that the lower lip should be on or slightly posterior to the chin-nose line in order to attain pleasing relationship for the age range from seven to twelve. Reidel's work, conducted on children in the mixed dentition age, demonstrated that all cases "poor" in facial balance possessed lips located forward of a line drawn from the nose to the chin. This observation emphasized the reliability of using the line from nose to chin for purposes of reference.

These impressions were gained almost entirely from clinical observation and through the careful evaluation of photographs. Recourse to x-ray analysis is needed to study fully the relationships of tooth and skeletal structures to the soft tissues. A hard and soft tissue tracing is seen in Fig. 3. Thus cephalometric procedure permits the correlation of lip, nose and chin relationships with the teeth.

Relationship of the Anterior Teeth

For a long time the author had shared in the general interest that had been focused on the lower incisor and was aware of the skepticism that prevailed regarding the relationship that the lower incisor tooth bore to reference planes such as the mandibular plane, the Frankfort plane and the orbital plane. However, two important factors continued to attract attention toward this tooth; viz., (1) orthodontic treatment planning most frequently revolved about the relationship of the lower incisor; (2) success or failure often was measured in the degree of stability of correct incisor relationship.

X-ray examination of a small sample of children with normal occlusion and of those with malocclusion in a variety of facial patterns suggested that the lower incisor angulation was related in some manner to a line from point A to pogonion (Fig. 3). This suggested that the lower half of Downs' angle of convexity alone might serve as the point of departure for the evaluation of this tooth in all types of faces. Subsequently, Dr. Downs was kind enough to measure the axial inclination of the lower incisor to the APo plane in his normal sample. The findings indicated an average of 23 degrees, with a range from 16 to 33 degrees. The standard deviation was strikingly low (3 degrees). However, the mere inclination of this tooth was not sufficient for any conclusion because its antero-posterior position also had to be considered. Therefore, a sample of forty esthetically acceptable faces was selected and the inclination and position of the lower incisor to the APo plane was studied. In addition to this, the actual thickness of the upper and lower lip was read from the head films. The conclusions reached were as follows:

A. The ideal lower incisor is inclined 22-23 degrees forward of the APo plane and is located 0-1 mm. anterior to it.

B. Axial inclinations below 16 degrees or above 28 degrees with positions of 3 mm. or more posterior or 4 mm. or more anterior to the point A pogonion plane are undesirable.

C. Interincisor relationship of 130 degrees is advisable in the treated case in order to promote stability and allow for uprighting with later vertical development.

D. Both the upper and lower incisors contribute to facial esthetics depending upon the case.

Typical cases demonstrating severe imbalance of the lips are seen in Fig. 8. The undesirable qualities in each case can be specified by relating the lips to a line connecting the chin and nose. An evaluation of the inclination and location of the incisors will indicate the contribution of the teeth to the total effect. The needs of the individual can readily be determined by placing the lower incisor in proper position (22 degrees to APo at plus 1 mm.) and arranging the upper incisors to it at 130 degrees to 135 degrees. Fig. 8 shows eight distinct types of imbalance of the lips that are commonly seen in orthodontic practice. Note the relationship of the individual lips to a line connecting the chin and nose.

It should be pointed out that normal occlusion of the teeth is not necessarily a criterion for beauty in the face. Cases are sometimes seen in which the teeth are normal, yet the face is not within an accepted esthetic range. However, it should be pointed out that the abandonment of common sense toward the attainment of the ideal is not justified. The amount of tooth movement, damage to tissues, and risk of relapse may contra-indicate an attempt to gain the strict cosmetic ideal. The acceptable range is great enough to permit the majority of cases to be brought within the prescribed limits. A question may be asked regarding functional balance without concomitant balance of the musculature. Again, it is the author's opinion that the orthodontist should recognize such conditions and employ orthopedic measures for muscle correction to permit stability of the case. Tongue and lip exercises have proven of value. Equilibration of occlusion and chewing exercises also should be included in a complete care. Neither poor muscle balance, habits nor even facial type should be a definite obstacle toward attainment of the ideal.

Clinical Application

With that background for esthetic

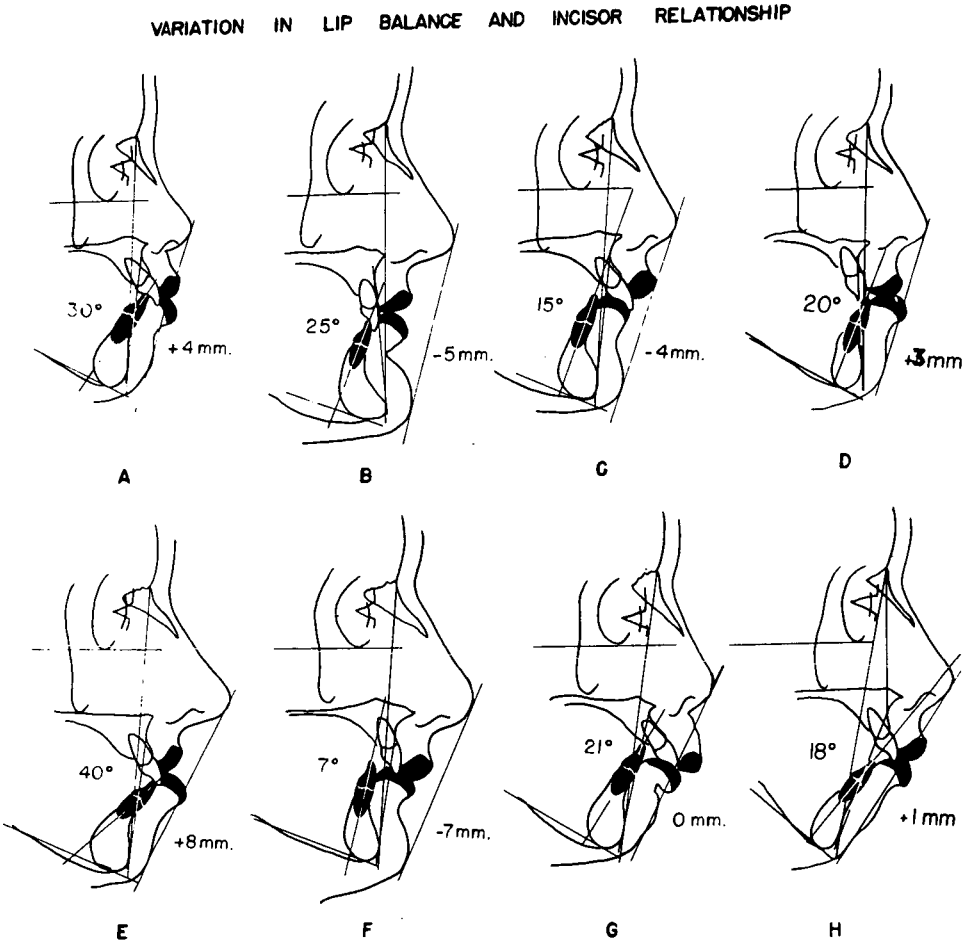


Fig. 8 A variety of cases demonstrating lip imbalance and poor facial harmony. The relationship of the teeth to the lips can be studied. A. A bimaxillary protrusion case—needs 3 mm. and 8° retraction of the lower incisor. B. A bimaxillary retrusion. The entire denture should be located 6 mm. forward. "Button" apparently is present due to mandibular growth and tight buccinator complex that restrains the denture. C. The upper lip is forward and the lower lip is back. The lower incisor should be located 5 mm. forward. D. Poor balance and harmony due to mesial thrust and lingually locked upper incisors. The lower incisor is 2 mm. forward of the ideal. E. A similar lip imbalance is seen in D. This, however, is due to almost 20° and 7 mm. forward relation of the lower incisor. F. Opposite lip imbalance is seen in E but similar to C. For purposes of facial harmony this case needs forward movement of the lower incisor. See Fig. 12 and 13. G. Primarily protrusion of the upper incisor. The lower is almost ideal except supraerupted. This case called for bilateral extraction in both arches. Case C has a similar relationship of teeth on the plaster cast but was treated without extraction. H. High convexity and severe retrognathic pattern. Success in uprighting lower incisor depends upon the ability to retract point A.

and functional consideration let us return to growth estimation and treatment planning as applied clinically.

The reliability of this estimation procedure is tested in the application to the forty-five almost consecutively treated cases exhibited here* and in particular to the first clinical case involving a multitude of orthodontic problems. This case was selected to be representative of typical behavior during space closure and intermaxillary traction. It is a Class II malocclusion in a female aged eleven years in which the analysis calls for the extraction of four bicuspids. The lower first and upper second bicuspids were extracted on the basis of anchorage values, the overbite conditions, tight lips, small mandible and the growth pattern.

The estimation of the growth of the face was accurate to within the width of a pencil line. Slightly greater retraction was found than was desired but the case is still considered to be in pleasing balance from an esthetic standpoint and ideal balance from a functional standpoint.

The analysis of treatment (Fig. 9) indicated that the Y axis opened 2 degrees as estimated. The anchorage values, rotation of the occlusal plane, etc., were almost identical to the treatment plan (Fig. 7). The retraction of the roots of the upper incisors was attained by continuous torque action throughout treatment.

The facial improvement is seen in Fig. 10. The severe sublabial depression has all but disappeared. The upper lip is in balance with the lower lip and the mouth is now in better harmony with the chin. A slightly pointed nose

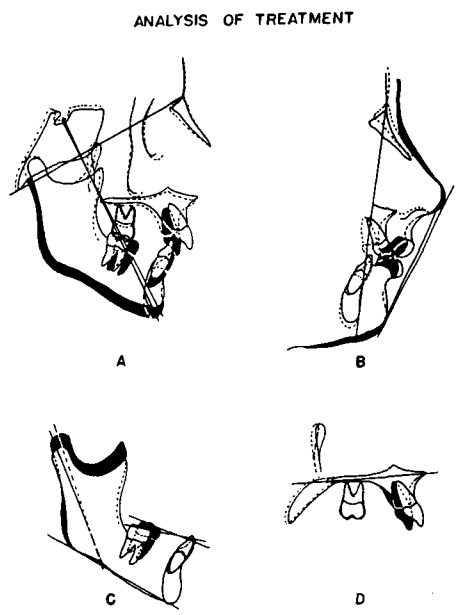


Fig. 9 The analysis of treatment for the estimated case. Note the accuracy of the plan by referring to Figs 4 to 7. A. Note the opening of the Y axis together with vertical facial development. Note point A has been retracted. B. Superpositioning on the facial plane and registering on the palate reveals the changes in lip balance and facial harmony. Retraction of the lip is seen as well as the lower lip being filled out in the sublabial area. Relaxation of the chin has occurred. C. The lower incisor was moved forward in spite of the extraction of the lower first bicuspids. The lower moved forward about one-half its width which is the typical finding in extraction cases. D. The upper molar was held in place while good bodily movement of the upper incisors was accomplished.

detracts from this face giving the impression of slight retraction to the denture area. However, the lower incisor is only 1 mm. posterior to an ideal relationship and the case is thought to be stable.

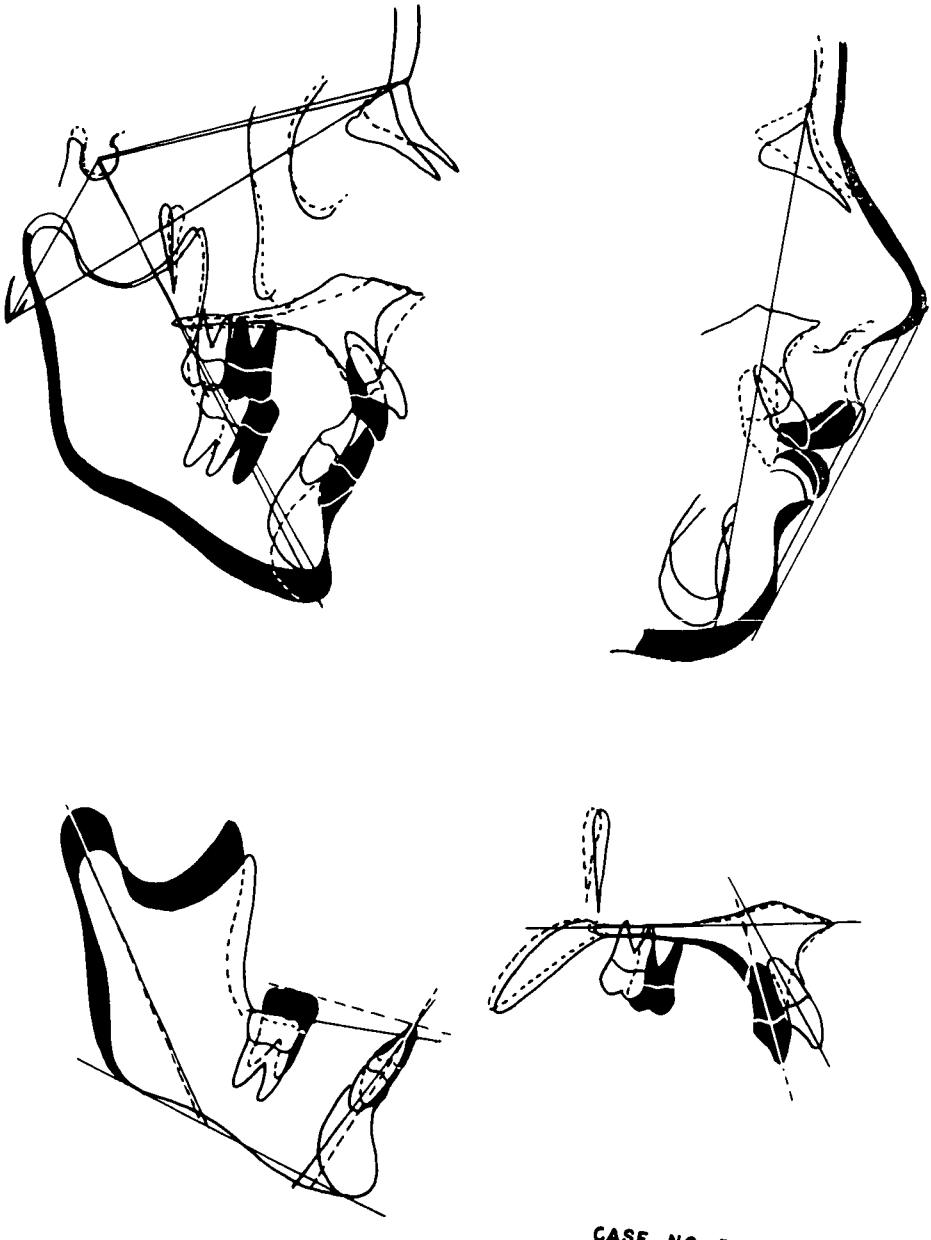
The second case is a boy, aged twelve (Fig. 11), for whom the analysis indicated extraction in the upper arch only. A low facial angle and high facial convexity with maxillary protrusion characterized the case. (This type seen in Fig. 8.) Growth estimation and the treatment plan proved accurate to the

* The models, photographs, intraoral x-rays, head plates and ink tracings of the headplates of the before treatment cases, the planned and estimated cases and the after treatment case, together with the analysis of treatment were all exhibited at this meeting.

Fig. 10 The facial improvement for the case outlined in Figs. 4 through 7. Excellent lip balance is seen and harmony could be improved only with slight forward position of the denture (1 mm. according to ideal). Tight thin lips and a pointed nose limit the esthetic value but the facial lines are good. Note the narrowness of the mouth.

Fig. 11 Note the convexity of the face and the retrognathic pattern. Case was considered in ideal balance from a functional and esthetic standpoint for 14 year old male after treatment.

ANALYSIS OF TREATMENT



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same degree as in the first case. The upper first molars were extracted because of severe caries.

The analysis of treatment (Fig. 12) revealed rapid mandibular growth as expected in a boy at puberty. Opening of the Y axis was seen. Maximum bodily retraction of the upper incisors was accomplished. The lower arch maintain its stability; the incisors were held upright during a period of twelve months of light elastic traction. The case after treatment is considered to be in almost perfect balance for this type of face and age of patient (Fig. 11). The lower incisor is located 1 mm. forward of APo at 20 degrees inclination, and the interincisor angle is 133 degrees.

The lip imbalance of the third case is seen in Fig. 8 and Fig. 13. The skeletal pattern is within normal limits and the upper incisor is almost ideally situated but a severe Class II molar relation is present. A part of the etiology in this case is perhaps tongue and lip habits. The prediction and plan indicated the need for forward movement of the lower arch (Fig. 14).

The treatment consisted of strong intermaxillary elastic traction for a period of thirteen months. No caution was used to maintain mandibular anchorage because forward lower arch movement was desired. The analysis of treatment indicated that forward movement of the chin had occurred as expected. Less growth occurred than was anticipated in a 14 year old male for 20 months period. In spite of all efforts to drag the lower teeth forward, they remained 2 mm. posterior to the ideal position. They were, however, inclined about 3 degrees too far forward. Much greater retraction of the entire upper arch was accomplished than was thought possible. The growth pattern (note no bite opening) together with the strong lower lip were held to account for the tremendous anchorage of the mandibular arch.

The photographs (Fig. 13) show a gratifying result. A critical analysis reveals that still better harmony could be accomplished with the uprighting and forward movement of the lower anteriors, together with greater lingual root torque on the upper incisors. This would place the lower lip slightly more forward toward the esthetic plane and set the upper lip farther back to create better balance and harmony.

Comments

Certain critical observations seem to warrant a short comment. They are:

1. This procedure has been routinely used for four years and has been sensibly accurate in more than ninety percent of the cases.
2. This method of planning suggests that lingual root torque of the upper central incisor should require the utmost attention. (See Fig. 12).
3. In order to satisfy the range of requirements prescribed for lip balance and facial harmony it was found necessary to extract in one

Fig. 12 Analysis of treatment of case seen in Fig. 11. The case was characterized by high convexity and a retrognathic pattern and the prediction called for compromise in the upper arch. The prediction was accurate to within 2 mm. in direction and magnitude of mandibular growth. The case at conclusion was in ideal balance and harmony for this face. Notice the extreme thickening (7 mm.) of the upper lip. Note the great amount of growth experienced and that growth permitted an elevation of the entire occlusal plane. The upper first molars were removed for reasons of decay and the second molar was employed for anchorage. The incisor experienced the maximum bodily retraction. In fact the roots could be palpated on the palatal aspect at the conclusion of the torquing action.

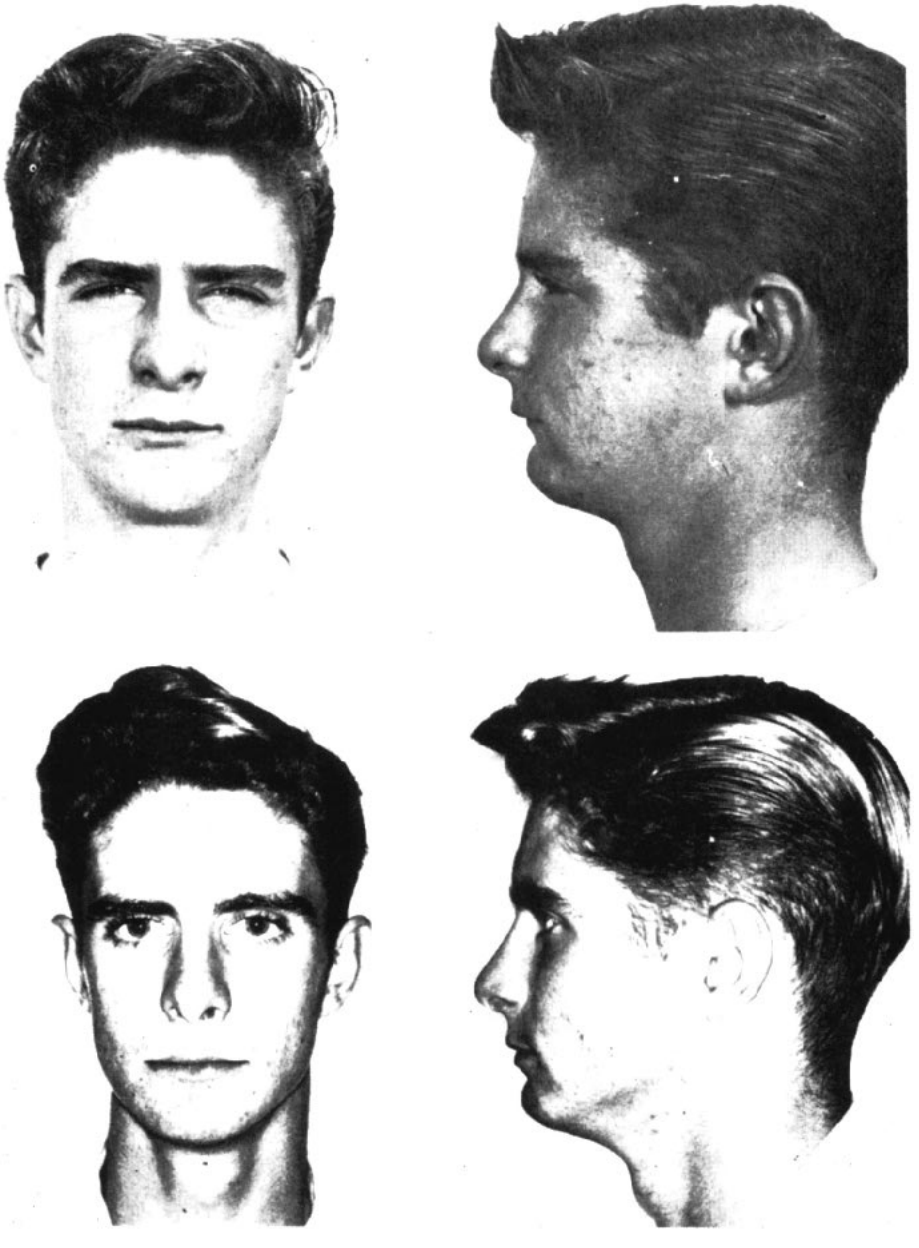

Fig. 13 The rewarding result in facial harmony and lip balance of case analyzed in Fig. 14. Slightly more retraction of the upper lip would still improve esthetics. The patient was placed on lower lip "puffing" exercises after treatment to gain relaxation of a severely tight mentalis muscle.

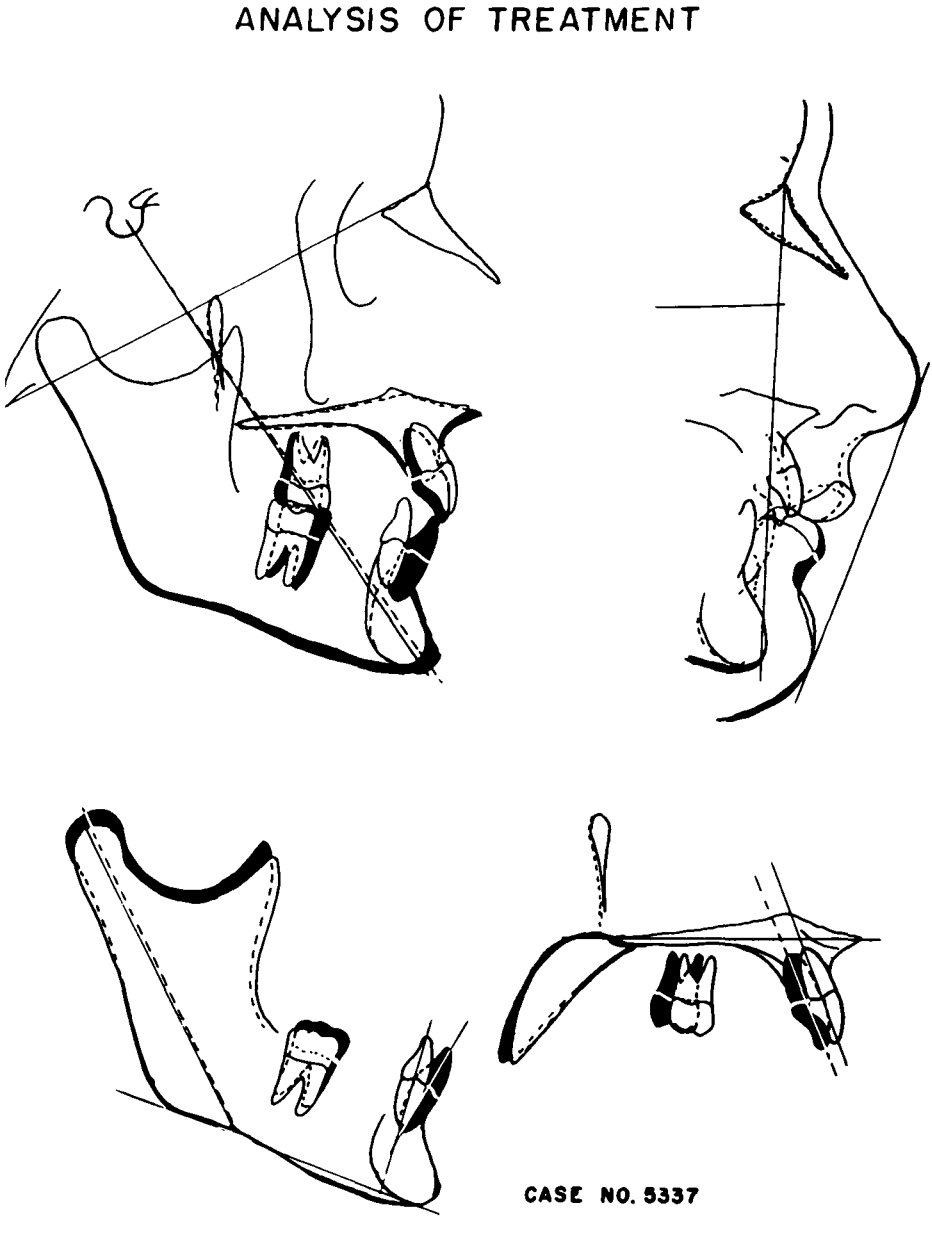

Fig. 14 Analysis of a case diagnosed to need forward movement of the lower arch. Continuous elastics were worn for 13 months. The upper lip was retracted, the lower was built out in the sublabial area and the chin became relaxed. Note that a slight change in the occlusal plane is seen with depression of the lower incisor being accomplished. The lower incisor is tipped forward excessively 2°. The amount of retraction of the upper arch is the most ever observed with intermaxillary elastics. No second order bends were employed and continuous torque was applied to the incisors. Note that the root tip was retracted more than the crown.

or both arches in approximately thirty-five to forty percent of the cases experienced.

4. It is extremely important to have a definite objective. The orthodontist should be wary of the trap of falling into the acceptance of one fixed idea of tooth arrangement for all individuals.

Summary

For purposes of organization and clarity of presentation, this subject was divided into two parts.

The first part dealt with cephalometric procedures and findings, culminating in the application of a single head film for the estimation of growth and treatment changes. Studies employing a combination of cephalometric and laminagraphic technique had revealed several pertinent findings. The main factors held to effect changes in the chin position were located within the temporomandibular complex. That work further suggested that these findings together with other available information could be utilized to predetermine individual growth and treatment behavior.

The basion-nasion plane was employed for reference. In addition the work introduced a new plane termed the "condylar axis". This plane was selected from a point bisecting the condylar neck to a point at the deepest curvature of the antegonial depression.

A specific case was selected to demonstrate the estimation procedure. The steps in the method included the predetermination in the following categories:

A. The cranial base (SN, SBa and BaN)
B. The temporomandibular joint (location of the glenoid fossa, changes in condylar position)
C. The mandible (amount of growth of the condyle, changes in direction of growth of the condyle and changes in the form of the mandibular ramus and body)
D. The effects of treatment on the musculature (bite opening versus muscle patterns)
E. The effects of treatment on the maxilla (changes in point A and tipping of the palatal plane)
F. The effects of intra and extraoral anchorage (anchorage of teeth, tip of the occlusal plane versus growth patterns and musculature)
G. The changes in the soft tissues (lips, nose and chin).

Part two dealt with a study of facial esthetics. A line drawn from the end of the nose and the chin was employed for reference. This was called the "esthetic plane." The upper and lower lips were studied in relation to that plane. Descriptions were made for lip balance and facial harmony in adults and children. It was observed that most orthodontists termed a case "disharmonious" or "imbalanced" when the lips extended forward of this plane.

Recourse to the x-ray film was made in order to determine the tooth relationship consistent with cases exemplifying ideal lip balance and facial harmony. Great significance was placed on the point A-pogonion plane as a reference line. The lower incisor was related in angulation and anteroposterior position to this plane. The author's range of acceptable variation was described. In addition, the undesirable characteristics in unacceptable esthetic conditions were enumerated (Fig. 10). The ideal position was held to be a lower incisor related at 22-23° and 0-1 mm. anterior to the APo plane. The results in three radically different clinical problems were shown in order to demonstrate the application of the method. The technique appeared to be sensibly accurate in more than ninety percent of routine clinical cases to date.

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