The Rotation Of The Mandible Resulting From Growth: Its Implications In Orthodontic Treatment

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An intensive study of the growth of the human head will inevitably lead to the realization that it involves the most complicated anatomical complex in all creation. The interrelationships are infinite and the causes and effects of these relationships are almost imponderable. The more our knowledge increases the more our ignorance unfolds. The vast stretches of the unanswered and the unfinished still outstrip our collective comprehension. It is little wonder that the allied forces of medical science are making such slow progress in gaining an understanding of the growth of the jaws.

The rotation of the mandible resulting from an inharmony between vertical growth and anteroposterior or horizontal growth has important implications in orthodontic treatment (Figs. 1, 2 and 3). It is well-recognized that the mandible rotates both clockwise and counterclockwise as the growth processes unfold. This is particularly true during the pubertal growth acceleration. Now, how does this rotation affect orthodontic treatment? *Clockwise rotation* (as viewed from the patient's right side) is a result of excessive vertical growth as it relates to horizontal growth, and tends to cause a reduction of vertical overbite. *Counterclockwise rotation* is a result of a deficiency in vertical growth as related to horizontal growth, and tends to cause an increase of the vertical overbite. Rotation of the mandible involves primarily the *vertical* growth of the dentocephalic complex. It is this growth on which we would like to focus your attention. Documented evidence will be presented in this study to corroborate the validity of this thesis.

Read at the biennial meeting of the Edward H. Angle Society of Orthodontia, Phoenix, Arizona, October 1963.

For our purpose here we are dealing only with growth increments which cause positional changes of the chin. Some of these increments cause the chin to move vertically while others cause it to move anteroposteriorly. To those increments which cause the chin to move vertically we apply the term, "vertical growth"; to the one increment, namely the condyles, which causes the chin to move forward we apply the term "horizontal growth". Vertical and horizontal growth are opposing forces competing for the control of the chin. The resultant of their effect is usually a downward and forward direction.

PURPOSE

This study was initiated for the purpose of documenting the growth changes which produce rotation of the mandible. We hoped to identify the specific increments of growth responsible for this phenomenon and wished to point out that it is the relationship of increments one to another which is so important and which results in changes in proportion. A comprehensive documentation and a sound interpretation of these facts should be a worthwhile contribution toward better treatment procedures.

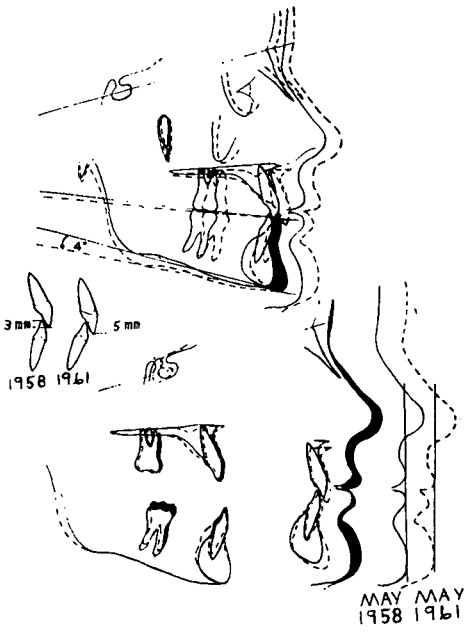


Fig. 1 Showing the growth of a female, age 11 to 14 years, in which the condyles grew out of proportion to vertical molar growth. This resulted in a 4° rotation and marked forward swing of the mandible, a 2 mm increase in vertical overbite, and an adverse effect on the facial profile. (From the U. of Texas growth study)

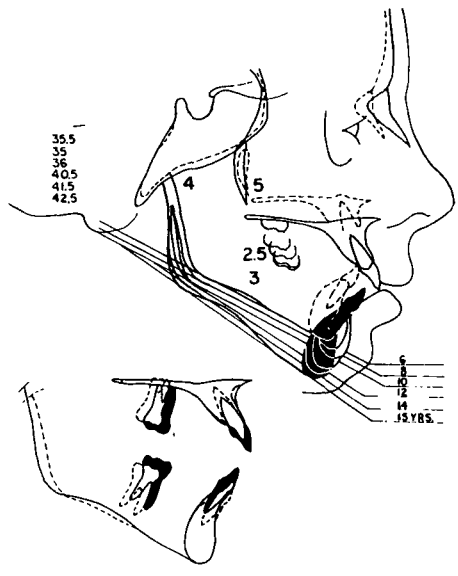


Fig. 2 Here is a growth study from the files of U. of Mich. From age 6 to 10 years the chin grew downward and forward and the mandibular plane moved downward in a parallel manner. At age 10 the condyles almost completely ceased growing. Then the chin moved downward and backward, and the mandibular plane became 7° steeper (35.5° to 42.5°). The posterior growth analysis showed that the condyles grew 4 mm while vertical growth in the molar area was 10.5 mm (5+2. 5+3).

The mandibular first molars moved backward about 3 mm; thus, it would have been impossible to have corrected a Class II condition under these circumstances.

Preliminary Discussion of the Growth of the Jaws

While many investigators have observed changes in the angulation of the mandibular plane, apparently the importance of relating these changes to overbite has not been fully recognized.

If the condylar growth is greater than vertical growth in the molar area, the mandible rotates counterclockwise and results in more horizontal change of the chin and less increase in anterior facial height. Extremes of this condition cause closed bites (Fig. 1). Conversely, if vertical growth in the molar region is greater than that at the condyles, the mandible rotates clockwise resulting in more anterior facial height and less horizontal change of the chin. Extremes of this condition cause open bites (Fig. 2).

We know that growth at the mandibular condyles produces a forward component of the chin, not a downward, nor a downward and forward component. It is only when the vertical increments of facial growth begin to assert their influence on condylar growth through occlusal contact that a downward and forward direction of the chin is produced. Thus, it can be said that condylar growth is pitted against the combined vertical elements of growth. The final vector of growth of the chin is a resultant of the struggle between horizontal growth and vertical

growth, in other words, between condylar growth and vertical growth of molars.

What are these vertical "elements" of growth? Specifically where are the increments which produce an increase in facial height? They are as follows: (Fig. 3) (1) growth at nasion and in the corpus of the maxilla which produces an increase in the distance from nasion to anterior nasal spine and causes the maxillary molars and posterior nasal spine to move away from the sella-nasion plane, (2) growth of the maxillary posterior alveolar processes causing the molar teeth to move away from the palatal plane, and (3) growth at the mandibular posterior alveolar processes causing the molar teeth to move occlusally.

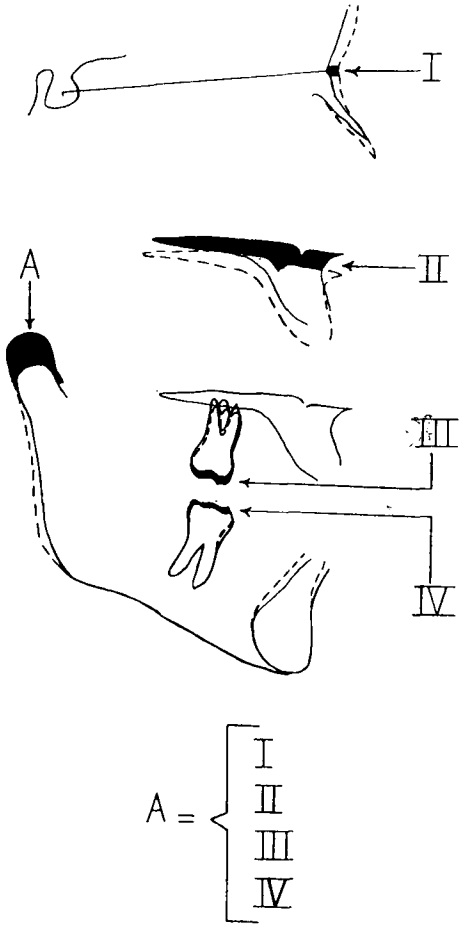


Fig. 3 In harmonious facial growth there is balance between increment A and increments I, II, III, and IV.

The vertical growth of the anterior alveolar processes does not seem to have an appreciable effect on facial height. It is merely expressed in varying degrees of overbite.

The dorsal migration of the glenoid fossa is a very real factor in many cases and tends to cancel out the growth of the condyles; thus, in a sense it is arrayed on the side of vertical growth. Surface additions of bone at pogonion usually have an insignificant effect, but occasionally we do see quite appreciable apposition in this area.

Clockwise rotation of the mandible is a result of more posterior vertical growth than condylar growth, the point of rotation being the condyles. We know that when vertical growth exceeds horizontal growth, (condylar growth) pogonion cannot keep pace with the forward growth of the upper face and the mandibular plane must become steeper (Fig. 2). What effect does this type of growth have upon treatment? Obviously this condition would not help reduce the ANB angle, and it would not aid in correction of a Class II molar relation. However, it would tend to help correct the vertical overbite of the incisors. Many such growth patterns actually do reduce the vertical overbite, perhaps the majority do not. There is ample evidence to show that a predominance of vertical growth of the face facilitates the correction and retention of vertical overbite.

Counterclockwise rotation of the mandible is a result of more condylar growth than combined vertical growth. This type of rotation is nearly always accompanied by a forward movement of pogonion and an increase in the

facial angle. The point of rotation is the most *distal* mandibular molar in occlusal contact. This "flattening" of the mandibular plane tends to increase the vertical overbite and renders vertical overbite correction and retention more difficult (Fig. 1).

The size of the gonion angle has an important influence upon the number of degrees of resultant counterclockwise rotation. The smaller the gonion angle, the greater rotation is produced for each mm of forward movement of pogonion. When this angle is extremely small it is almost a physical impossibility for the chin to move forward without a "flattening" of the mandibular plane. By the same token, when the corpus of the mandible undergoes excessive rotation, we may expect the chin to move forward markedly.

An obtuse gonion angle may compensate for a short corpus. Moreover, it may also compensate for a short ramus. In other words, the correct gonion angle helps to compensate for inharmonies of facial proportions. This angle has a correlation coefficient of .74 with the OM angle and .61 with the SN-MP angle (where significance starts at .27). Thus, it could be said that these three angles represent a closely interrelated anatomical complex.

More knowledge is needed regarding the behavior of the gonion angle. We do not have sufficient information about the changes that this angle undergoes during the growing period and we do not fully understand the significance of these changes. We need to know whether or not t r e a t m e n t causes changes in this region. Obviously, when the gonion angle becomes more acute the mandibular plane tends to become flatter, and when this angle becomes more obtuse the mandible tends to become steeper. In a growth study of sixty-two individuals the gonion angle changed an average of .5 of a degree in the direction of acuteness. In a growth study of a group of fifty treated cases the average change was an increase of 1.5 degrees. This suggests that treatment causes this angle to become more obtuse.

The recent work of Björk[2] has a definite relationship to this subject. By the use of metal implants he has shown that the inclination of the inferior border of the mandible may change considerably by resorption at the gonial region and deposition in the region of the symphysis. Thus, the extremities of the inferior border of the corpus undergo changes while the central portion, in the region of the first molar, apparently changes very little. Since vertical measurements are made at the site of the first molar tooth, they are not appreciably affected by these changes.

The degree of facial divergence (measured by the angle SN-Mandibular Plane) also has a significant bearing on mandibular rotation. The larger the SN-MP angle, the more the mandible tends to become steeper and the more the chin moves backward. The smaller the angle, the greater the tendency of the mandible to become flatter and the chin to grow forward.

Mechanism of Growth

In Figure 4 is shown an edentulous individual. Three cephalograms were taken — one in centric occlusion with the dentures in place, one in a position of overclosure with dentures removed and one with a block of wax between the dentures.

You will note that as the molar height increases the chin swings downward and backward, the mandibular plane becomes steeper, the gonial angle moves posteriorly and the facial angle decreases. Thus, by varying the molar height we were able to change the facial angle fourteen degrees and the inclination of the ramus eleven degrees.

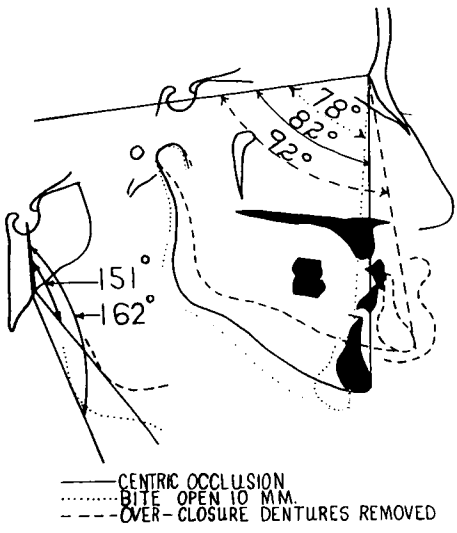


Fig. 4 An edentulous individual showing variation in the facial angle caused by changing the molar height.

It will readily be seen that molar height not only controls the vertical position of the chin, but also to a considerable extent the anteroposterior position. These principles have a very definite application to the treatment of Class II malocclusions. Obviously too much vertical growth of the molar teeth would prevent the forward positioning of the chin and thereby render Class II correction very difficult.

In Figure 3 we have tried to illustrate the mechanism of the growth of the jaws. These five growth increments are the principal ones with which the orthodontist is concerned. The relationships of these increments control the behavior of the mandible. They determine whether pogonion shall move downward and forward or downward and backward and whether a Class II condition will be easy or difficult to correct.

When pogonion and nasion grow forward at an equal rate, increment A will equal the sum of increments I, II, III, and IV. In other words, growth at the condyles must equal the anteroposterior growth at nasion, plus the vertical growth of the corpus of the maxilla, plus the vertical growth of the maxillary alveolar process, plus the vertical growth of the mandibular alveolar process. Then it may be said that the horizontal growth at the condyles is pitted against combined vertical growth. Growth at the condyles is trying to carry the chin forward and combined vertical growth in the molar area is trying to carry the chin downward. The result is usually downward and forward; however, it may be downward and backward as we shall see.

When growth at A exceeds I, II, III, and IV, the mandibular plane becomes flatter and pogonion moves forward more than nasion. When the sum of I, II, III, and IV appreciably exceeds A, pogonion will usually move backward with relation to nasion and the mandibular plane will become steeper. When growth at A equals the sum of II, III, and IV the mandibular plane moves down in a parallel manner. However, excessive mesial movement of the molar teeth causes difficulty in measuring vertical increments.

The ratio between horizontal and vertical growth increments is called the *posterior growth analysis.* It is an aid in explaining the postural behavior of the mandible (Fig. 2). Please bear in mind that it is the relationship of these increments one to another which controls the forward growth and the rotation of the mandible.

You will note that the anterior teeth are absent. This is because these teeth do not have an appreciable effect on anterior facial height. The posterior teeth literally force the jaws apart, thereby increasing anterior facial height. The vertical growth of the incisor teeth is expressed in varying amounts of overbite.

Now what is the clinical application?

All investigators are agreed that orthodontic treatment does not stimulate growth at the mandibular condyles. If this is true we have only the vertical increments that we may possibly change to serve our purposes. If we can inhibit vertical growth it will have the same effect as stimulating growth at the condyles. We are quite sure that we can stimulate the vertical growth of the alveolar processes, and we think we can inhibit this growth. If vertical growth is deficient we try to *stimulate* it, and if vertical growth is excessive we try to *inhibit* it. The question now arises — how do we tell when vertical growth has been deficient and when it has been excessive? There are certain rather well-defined guide posts which we may learn to recognize (Fig. 5).

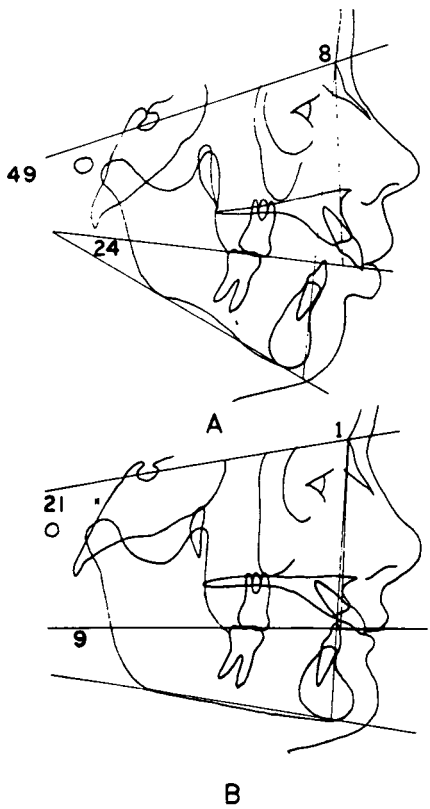


Fig. 5 Showing two opposite facial types. A, A hyperdivergent individual in which vertical growth is excessive and/or condylar growth is deficient. B, A hypodivergent type where vertical growth is deficient.

The Growth of the Mandible

The mandible should not be considered as a single growth entity, but rather as four entities: (1) growth of the condyle and ramus; (2) of the corpus; (3) of the posterior alveolar process; and (4) of the anterior alveolar process (Fig. 6).

This unique bone grows in many different ways. It may grow quite uniformly in all directions or any one of its aspects may grow out of proportion to the rest of the bone. The condyles may grow rapidly while the corpus grows very little or none. The corpus

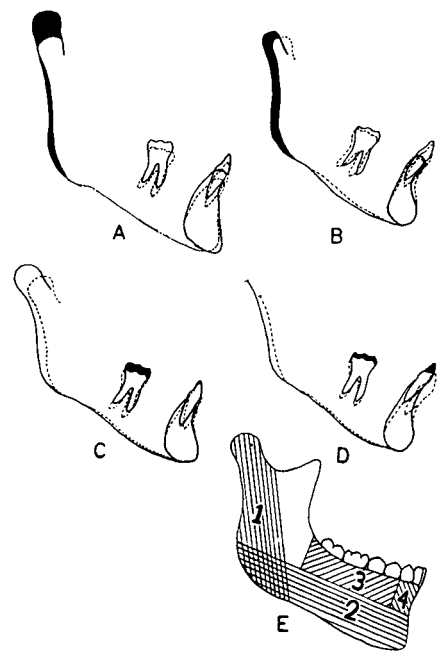


Fig. 6 Showing different types of mandibular growth. A, Much condylar growth but very little growth of corpus. B, Good corpus growth but almost no condylar growth. C, Molar grew vertically much more than incisor. D, Incisor grew more than molar. E, Arbitrary segments of mandible.

may increase considerably in length while the condyles may exhibit little or no growth. The vertical growth of the anterior alveolar process may exceed that of the posterior process. The converse also may be true. The condyles may grow out of proportion to the posterior alveolar processes and vice versa. All of these patterns have an effect upon vertical overbite and overjet.

It has been said that the growth of the mandible is the principal determining factor of facial morphology. However, it is not the growth of the mandible per se which primarily determines its posture but instead the vertical growth of the maxilla. Once this concept is understood it can be applied clinically to much advantage.

Material

Growth was studied on sixty-two patients. On twenty-nine of these the growth period used was from 11 to 14 years. The other thirty-three subjects were studied from approximately 8 to 11 years.

Fifty treated patients were selected and the period studied was approximately 11 to 14 years. Treatment was carried out during this three year period. The average treatment time was about 18 months. All patients were treated without removing dental units and all were of medium or average facial proportions.

Sixty-two measurements were made on each individual. Means and standard deviations were calculated on these measurements. Four thousand correlations coefficients and many "t" tests were run on the data. Only a small part of the total information is used here.

Three hundred and seven treated patients were selected and divided into three groups according to type (Fig. 7). These groups were studied with a view to determining their differences in reaction to treatment, as revealed by changes in the SN-MP angle.

SN TO MANDIBULAR PLANE ANGLE CHANGES

GROUP	TYPE OF TREATMENT		SN-MP	% OF SUBJECTS SHOWING CHANGE		
	EXT.	NON-EXT.		DECREASED	INCREASED	NO CHANGE
UNTREATED		62	33° AV.	74%	10%	16%
TREATED	134	52	29°-35°	44%	50%	6%
TREATED	42	34	27° & BELOW	71%	24%	5%
TREATED	37	8	40° & ABOVE	40%	42%	18%

Figure 7

Method

In order to determine the cause of mandibular rotation it was necessary to measure total vertical growth in the region of the first molar teeth, and relate this growth to that at the mandibular condyles.

To measure the *effective* growth of the condyles over a period of time we punch pin holes through both tracings at the approximate site of the head of the condyle. By superimposing on the mandibular plane, registering on the lingual cortical plate of the symphysis, and measuring between the two pin holes, we can determine the increase in the length of the mandible as well as the vertical and horizontal components of this growth. This method automatically eliminates any error in measuring the condyles and glenoid fossae. After all, we are not so much interested in the actual growth as in the *effect* that this growth has on the position of the chin.

The vertical growth of the body of the maxilla is measured from the Frankfort plane to the palatal plane along a line perpendicular to the Frankfort plane through the distobuccal cusp of the maxillary first molar. The vertical growth of the maxillary alveolar process is measured from the palatal plane to the occlusal plane by a perpendicular to the Frankfort plane through the

distobuccal of the first molar. The vertical growth of the mandibular alveolar process is measured from the occlusal plane at the site of the distobuccal cusp of the first molar. The second measurement was taken at the same anteroposterior site as the first. This growth is difficult to measure accurately if there is marked forward growth of the mandible or marked mesial drift of the molar teeth.

Findings and Their Implications

The average *effective* condyle growth in the untreated sample was 7.2 mm; in the treated group it was 6.7 mm. The average total vertical growth was 6.3 mm in the untreated cases, while in the treated individuals it was 7.1 mm. Since both untreated and treated groups had almost identical average growth of the condyles, it was thought that they could be compared, giving an opportunity to see differences in the behavior of the chin.

Of the 6.3 mm of total vertical growth in the untreated group, 73% (4.6 mm.) was in the maxilla and 27% (1.7 mm) in the mandible. Two and six-tenths mm of the maxillary growth was in the body of the maxilla and 2.0 mm in the alveolar process. Of the total vertical growth in the treated group, 4.8 mm or 68% was contributed by the maxilla, and 2.3 mm or 32% by the mandible. The maxillary growth in this group was made up of 2.4 mm in the body and 2.4 mm in the alveolar process.

Thus, it may be seen that the maxilla is responsible for about 70% of total vertical growth and therefore has an important effect on the "tilt" of the mandible. In the treated cases the amount and distribution of vertical growth was different from that of the nontreated cases. This difference was an increase principally in the mandibular alveolar process. This increase was found to be significant at the 5% level with a "t" test reading of 2.35.

CORRELATION COEFFICIENTS

VARIABLE	Y AXIS (NS-Gn)	Y AXIS FRANK-FORT	X-Y AXIS	OM	SN-MP
% DEPTH TO ANTERIOR VERTICAL HEIGHT	-.64	-.49	-.78	-.56	-.63
% RAMUS TO ANTERIOR VERTICAL HEIGHT	-.07	-.10	-.20	-.60	-.79
% RAMUS TO ANTERIOR DENTAL HEIGHT	-.25	-.10	-.15	-.65	-.78
SIGNIFICANCE 5% LEVEL--.27 1% LEVEL--.35					

Figure 8

Growth of anterior vertical height was found to have a correlation coefficient of .92 with growth of total vertical height in the molar region. This is an extremely high reading indicating that there is a very high degree of association between vertical height and molar height, and suggests a cause and effect relationship.

In a random sample of fifty individuals taken from a group of four hundred malocclusions, correlation coefficients were calculated on the Y-axis at SN, the Y axis at Frankfort, and the X-Y axis. The results may be found in Fig. 8. It can be seen that the relationship of facial height to depth has a high correlation (—.64, —.49, and —.78 respectively) with all of these axes. Obviously, this would be true just as the diagonal of a rectangle varies as does the length of the sides. However, when we correlate these axes with lower face proportions, we find very low readings. Thus, it would appear that the Y-axis and the X-Y-axis are not closely associated with the morphology of the lower face, whereas both the SN-MP and OM angles are.

Price[9] made a study of twenty-five high angle cases (average 43.98 degrees SN-MP angle) treated by several orthodontists by conventional treatment procedures. In this study he found that 64% of the patients had an increase in the SN-MP angle. This increase varied

from 1 to 7.5 degrees. It will be noted in Figure 7 that in forty-five high angle cases only 42% showed an increase in the SN-MP angle. These cases were treated by the author taking advantage of only a part of the principles of treatment expressed in this study. This suggests that the precepts are sound. It also suggests that treatment procedures should be varied when the SN-MP plane varies appreciably.

The Y Axis

There exists at the present time considerable difference of opinion regarding the importance of the Y axis. Some feel that it is undesirable to increase the Y axis with treatment; however, a careful study of the facts do not confirm this opinion. It must be remembered that the Y axis angle increases on an average from 8 to 15 years of age. Also it must be remembered that the average is made up of extremes in both directions. It can be said that most of these extremes represent normal growth for these individuals.

If faces were square, that is, if depth and height were equal, and if faces normally grew equally in vertical and horizontal directions, then normal growth would in fact be down the Y-axis. However, we know that faces are not square but that depth is from 66 to 85% of height. Also we know anterior facial height increases from two to three times as much as facial depth. Figure 9 shows that the Y axis can only open when the face grows more vertically than horizontally. It illustrates why this angle does and should become more obtuse. The more vertical

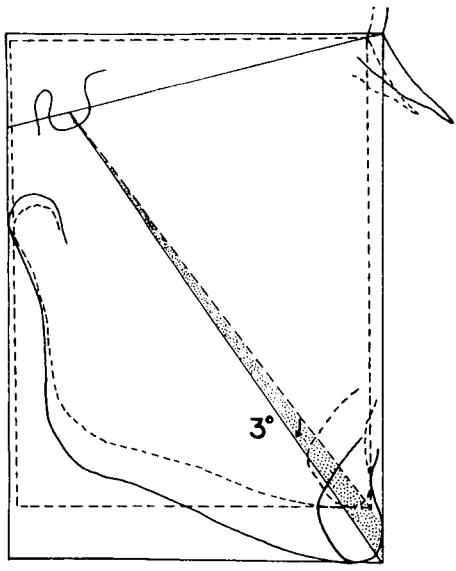


Fig. 9 Here is shown a treated case in which the Y-axis increased three degrees. This was a very favorable growth reaction from every standpoint (aesthetics, function, overbite, and stability). Increase in anterior facial height was four times greater than increase in facial depth. Condylar growth was ample to balance vertical growth and to keep the mandibular plane parallel to its original inclination.

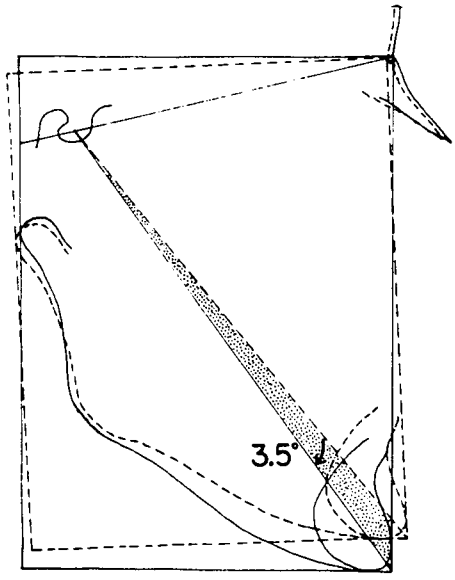


Fig. 10 This 3.5° increase in the Y-axis was a very unfavorable growth reaction. There was very little increase in S-Gn distance, pogonion went downward and backward and the mandibular plane became 7° steeper. The cause of this was primarily a marked deficiency in condylar growth.

growth exceeds horizontal growth, the more the Y axis must drop posteriorly. If during treatment vertical growth far exceeds horizontal growth, the Y-axis must move backward just as it would do if the individual were not being treated orthodontically (Fig. 10).

Perhaps the most desirable behavior of the Y axis from the standpoint of vertical overbite correction is a backward swing, provided there is enough condylar growth to keep the mandibular plane parallel and enable the mandible to keep pace with the forward growth of the maxilla.

While it is important to note and record the anatomical changes which cause the Y axis to change, I do not feel that it is necessary to actually record the Y axis. There are other places at which these changes can be recorded more meaningfully. The Y axis angle merely tells us where the chin is situated with relation to the cranium, but does not tell us by what route it traveled to arrive there. It does not tell us whether we have a square or an obtuse gonial angle. An increase in the Y-axis angle may accompany normal growth as well as abnormal growth.

The Freeway Space

Documented studies of the freeway space were not made in these investigations; however, we have made many observations of the behavior of teeth as related to this space. Usually molar teeth associated with large freeway spaces are very difficult to move occlusally; in the case of small spaces molars are often found to readily move occlusally thereby eliminating most or all of this space. These observations are not consistent with the popular belief that the freeway space is a dictatorial factor in vertical molar position. One encounters on every hand the belief that molars frequently are depressed into the bone by muscle pressure subsequent to treatment and that this is accompanied by a decrease in the lower face height (ANS to menton). In hundreds of cases observed, the author has never seen more than a very slight reduction in ANS-menton height and that was in the first few days following band removal. It can be said that molars almost never are intruded into the bone subsequent to treatment. Thus, if molars can be induced to move occlusally, they will remain at that attained level in almost all instances.

The Behavior of the Occlusal Plane During Mandibular Rotation

In discussing the plane of occlusion one is involved in an area in which it is difficult to communicate. Caution must be exercised lest we refer to this plane as though it were a tangible entity. It is not an anatomical part but a boundary between two parts. To be most accurate we really need two occlusal planes — one for the maxillary teeth and one for the mandibular teeth. However, this would perhaps be too complicated and impractical.

It is not enough to speak of the occlusal plane as having tipped a given number of degrees in a given direction; we should qualify this by saying that a given segment of teeth moved a given number of mm vertically to cause this change. If we will always relate posterior and anterior segments of teeth to their respective bases, we will not become confused about occlusal plane changes. Our real interest is in just which dental units have undergone vertical changes to produce a tipping of the occlusal plane, just which segments moved to produce bite opening.

We must not think of posttreatment occlusal plane changes as a rebounding reaction, as though something returns to where it once was. This seldom if ever happens, but depressed incisors

in some cases do subsequently extrude. The same kind of growth which causes this plane to flatten before treatment also causes it to flatten after treatment. In a high percentage of cases the occlusal plane does not change subsequent to treatment unless there is posttreatment growth (Figs. 11 and 12).

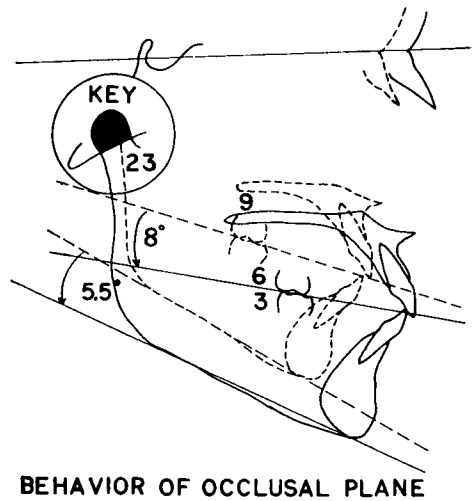
Relating the occlusal plane to the palatal plane is not meaningful because the palatal plane frequently changes with relation to SN. It is possible to have a change in the palatal plane which in no way affects the vertical dimension of the dental area, for example, a downward tipping on only the anterior end of the palatal plane. Hence, such a change may not have any significance so far as facial height is concerned. It is the vertical changes in the molar area with which we primarily are concerned.

The inclination of the plane of occlusion seems to reflect Nature's attempt to compensate for inharmonies of growth. The vertical growth of the anterior alveolar processes seems to try to compensate for the inharmonies between posterior alveolar growth and ramus growth.

Facial Types

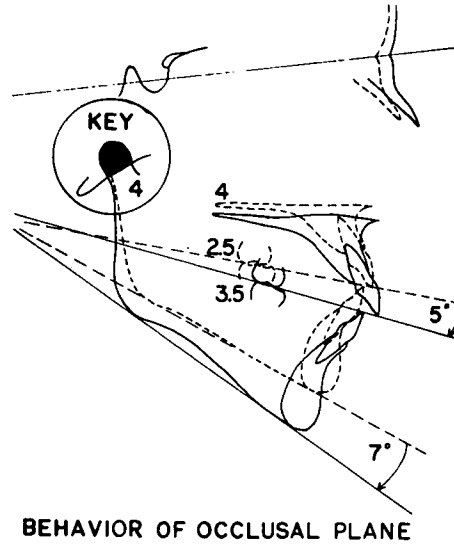
It is important that the profession agree upon the one most important criterion for selecting facial types (Fig. 5). Why is this so important? Because types of facial morphology are identified with specific types of malocclusions, a syndrome of dentofacial symptoms. We know that the face grows from two to three times as much vertically as anteroposteriorly; it seems logical to use such growth as the basis for facial typing.

Angles formed by predominantly horizontal planes are our best registration of vertical variations. The angle SN-MP should be our angle of choice for identifying types. The terms "hyper-



BEHAVIOR OF OCCLUSAL PLANE

Fig. 11 This illustrates that condylar growth (as related to vertical growth) is the key to changes of the occlusal plane. The posterior growth analysis shows that the condyles grew 23 mm and the vertical growth in the molar area was 18 mm (9+6+3). The result was an 8° change of the occlusal plane. (From the growth study of the U. of Mich.)



BEHAVIOR OF OCCLUSAL PLANE

Fig. 12 Again showing that condylar growth when related to vertical growth is the key to the behavior of the occlusal plane. Poor condylar growth (4 mm) could not keep pace with 10 mm of vertical growth (4+2. 5+3. 5). The result was a 5° change of the occlusal plane. (From the U. of Mich. growth study.)

divergence" and "hypodivergence" express the two extremes of the term "facial divergence". The terms "brachycephalic" and "dolichocephalic" are of little value since they refer primarily to cranial proportions and to the relationship of width to length. The orthodontist is principally concerned with facial depth to height ratios. The terms "retrognathic" and "prognathic" are based on the wrong dimension of the face to be most meaningful. They are low and high facial angle readings and as such are measures of facial depth, nothing more. However, the term *facial divergence* in a very real way takes into account depth as well as height.

Discussion

The eternal search continues for the answer to the two most perplexing questions in orthodontics. They are: (1) why are Class I and Class II so much alike in basic jaw structure, and (2) why does orthodontic treatment retard the normal forward positioning of the chin?

Through the years many investigators have futilely pondered these questions; yet they have never explored the vertical dimension of the posterior aspect of the face. Here the secrets are to be found. For the most part the first question remains almost completely unanswered. As for the second question, the efforts to explain this phenomenon are somewhat inadequate.

In 1962 Maj and Luzi[8] stated, "Since it is not possible at present to pin point the predominant factor in skeletal disharmony for the individual case, no useful conclusions can be drawn from the cephalometric analysis as far as treatment planning and prognosis are concerned."

An understanding of the *mechanism* of growth as described by this study is sufficient to completely explain why treatment retards the normal forward positioning of the mandible. The same principles also fill in the "missing link" in the quest for the answer to why Class I and II malocclusions are so much alike in basic osseous structure. When the first molar teeth erupt to an end-to-end cuspal relationship, a little variation in vertical height can make the difference between Class I and Class II interdigitation. As little as two mm reduction in molar height could at this point result in a Class I molar relationship without any mesial or distal movement of the molars, without any increase in the length of the mandible, and without any forward movement of the condyle in the glenoid fossa.

In a study of sixty-two untreated and fifty treated cases Creekmore[4] compared forward movement of the chin. The former group had an average SN-MP angle of 34 degrees and the latter 31.5 degrees. In the untreated group pogonion moved forward an average of 3.48 mm, while in the treated group this reading was 2.49 mm. Again this shows that treatment retards the forward positioning of the chin. The cause of this difference was a difference in the amount of vertical development of the molar area (see findings).

A number of investigators have found that there is little or no difference between mandibular length in Class I and II malocclusions. In a comparison of retrognathia and prognathia Björk[1] states that, "a comparison between the two extreme percentiles indicates that the mean length of the lower jaw is practically the same in both." In discussing Class II, Division 1 malocclusions, Maj and Luzi[8] state, "in most instances, the component parts (maxilla and mandible) are normal by themselves but their association results in a disharmony." They further say, "No significant variations in shape and total length of the mandible have been demonstrated."

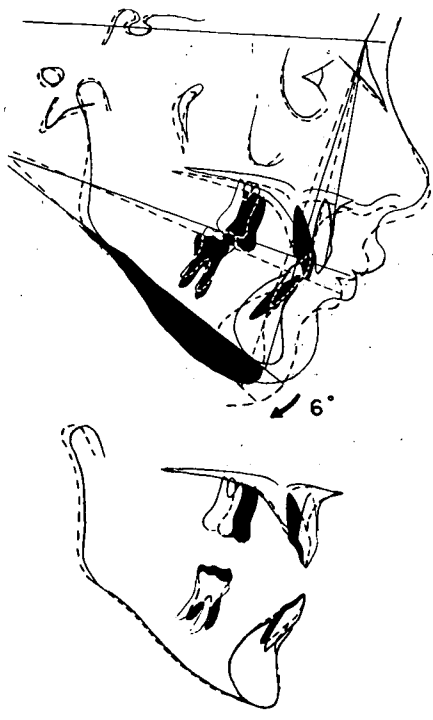


Fig. 13 This is a treated case in which there was no appreciable condylar growth, necessitating the removal of two maxillary bicuspids. In four years of posttreatment observation there was *no* reduction of the SN-MP angle.

Thus, it can be said that most Class II cases have had average horizontal growth. Their principal shortcoming is that they have had too much vertical growth. Herein lies the crux of the orthodontic problem, namely, the *relation* of vertical to horizontal growth. The difficulty is in the fact that the vertical component of growth limits the horizontal component. This in turn prevents the forward movement of the chin.

Thus, we must not think of the growth of the jaws merely as a concentric enlargement of the face, but as definite amounts of growth in millimeters occurring in specific areas resulting in specific effects on overbite and overjet.

The implications in the literature are that when the mandibular plane becomes steeper as a result of treatment it subsequently returns to its original position. Just how this happens is not stated but it is implied that this occurs much as a rotated tooth returns to its original position. Reidel[12] wrote, "If it is noted at the completion of orthodontic treatment that the mandibular plane has increased, it can be expected to return to its former angulation or less" (Fig. 13).

It is important that we understand the cause of this mandibular rotational change. If growth has ceased to be active the mandible will permanently remain at the steeper inclination caused by treatment. If, subsequent to treatment, the condyles grow faster than total vertical growth then the mandibular plane will flatten accordingly. Not just *any* growth but growth at the condyles causes the mandible to return to its original inclination. Fortunately for the orthodontist the mandibular condyles usually are the last portion of the facial complex to stop growing, particularly in males.

As Holdaway[6] pointed out, the mandibular incisor must be harmonized with line NB, always taking into consideration the size of the effective symphysis (Figs. 14, 15, and 16). As the mandible rotates counterclockwise the mandibular incisors move posteriorly in relation to a vertical plane and the incisor-effective symphysis r a t i o is changed in favor of the symphysis. The more posteriorly the incisors are situated on the mandible, the greater this ratio changes for each degree of rotation. It is extremely important to keep these considerations in mind as we try to reach a judgment regarding the future position of the mandibular incisors.

There is a good possibility that one day we will find that the posterior alveolar process of the mandible should

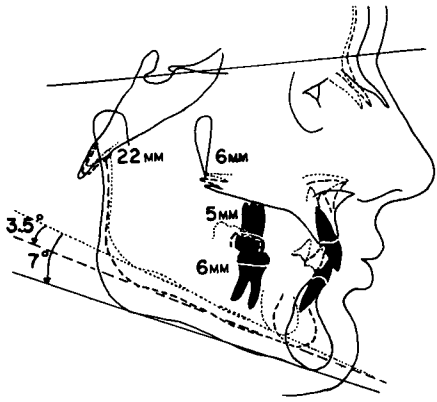


Fig. 14 Here the posterior growth analysis shows a ratio of 22 mm to 17 mm. This accounts for the marked forward positioning of the chin.

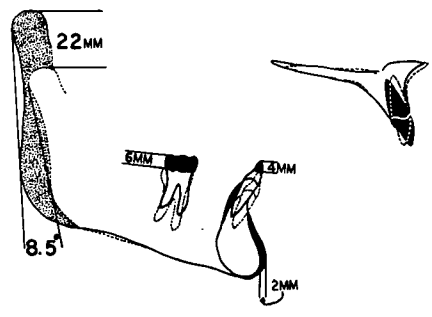


Fig. 15 Same case shown in Figure 14. Note 2 mm of appositional growth at pogonion.

be induced to make a greater contribution to bite corrections. It seems likely that in the future a systematic approach to the application of differential inhibition and stimulation of vertical growth will play an important role in orthodontic therapy.

Treatment

The results of eight years of intensive investigations have led to improved treatment procedures. This consists fundamentally of first typing patients according to basic facial morphology.

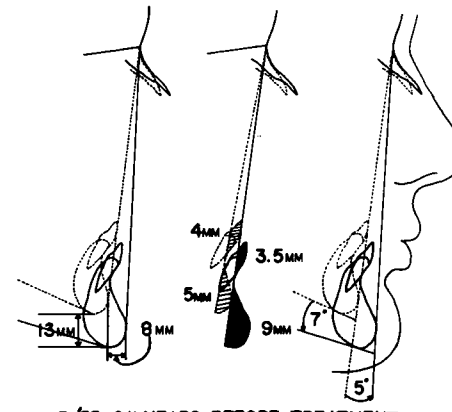


Fig. 16 Same case shown in Figure 14. Note that the incisor — effective symphysis ratio changed from 5-4 to 3.5-9. Only 2 mm of this 9 were due to apposition growth and the rest due primarily to the rotation of the mandible. (Some of this ratio change was due to a change in point B.)

This is done with a view to forming good judgment regarding possible response to treatment.

In order to take advantage of these new concepts in treatment it was necessary to design headgears to apply forces in desired directions. At the suggestion of my associate, Dr. Tom Creekmore, we designed a high pull face-bow for extraoral anchorage. The outer bow is terminated at the site of the maxillary first molar teeth to prevent their tipping. Elastic traction is then applied in an upward and backward direction to a conventional type high-pull headgear. This upward and backward directional force is applied for the purpose of inhibiting the downward growth of the maxillary alveolar process and possibly the body of the maxilla. This type of traction is used primarily on open-bite cases and individuals with high SN-MP angles.

When facial morphology indicates that vertical growth has been excessive or that condylar growth has been deficient, we try to inhibit the downward

growth of the maxillary molars. When it has been determined that vertical growth is deficient, resulting in a deep overbite, we try to stimulate the vertical growth of the alveolar processes with Class II elastics and/or the conventional face-bow headgear with cervical traction.

Summary

1. Variation in growth at the condyles and at the molar area is responsible for the rotation of the corpus of the mandible.
2. Clockwise rotation, viewed from the patient's right side, is a result of more vertical growth at the molar area than at the mandibular condyles. Extremes of this condition cause open bites.
3. Counterclockwise rotation is a result of more condylar growth than vertical growth at the molars. Extremes of this condition cause closed bites.
4. The size of the gonion angle affects the amount of rotation.
5. The degree of facial divergence has an effect upon the degree of rotation of the mandible.
6. The facial angle is influenced by vertical as well as horizontal growth.
7. The orthodontic profession needs to decide just which criterion is most important as a basis for facial type.
8. The posterior growth analysis was presented as a method of analyzing the growth of the posterior aspect of the face.

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