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Original Articles

CEPHALOMETRICS FOR YOU AND ME

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IT IS significant, and I believe proper, that the majority of the orthodontic articles published recently have referred directly to, or indirectly have made use of, information gained from the use of cephalometers. Of this we can be sure: The cephalometer is here to stay, and those of you who are not using cephalometrics in your everyday clinical practices now must soon bow to its importance, accept the added burden it imposes, and master its mysteries if you are to discharge your full obligation to your patients.

It is my belief that much of the confusion among clinical orthodontists regarding cephalometrics stems from the fact that most of the literature regarding it has been written by and for teachers and research workers. It is my intention to write this article in the only language I know, "shop talk," with the hope that it therefore may be better understood by others like myself who deal directly with patients.

The cephalometer obviously is one of the most important of all of the contributions made so far to the study of growth and development and to the science of orthodontics in general. It is the very foundation on which present-day thinking and knowledge in orthodontics are based. Much credit must go to Dr. Holly B. Broadbent for the development of the cephalometer and to Drs. Brodie, Downs, Wylie, Thompson, Margolis, Higley, Adams, Reidel, Graber, and others for the development of the technique of its use and for systems of assessment that have made it useful.

It is apparent that the cephalometer has not been promptly accepted, nor generally used by clinical orthodontists. It has been claimed by many that it is a tool of the research laboratory and that the difficulties and expense of its use in clinical practice are not justified. Many have argued that the information

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gained from cephalometric films, when used with present methods of assessing them, does not contribute sufficient information to change, or influence, their plans of treatment. Much of their discouragement stems from the mistaken statements of some who, in writing of the cephalometer, have claimed accuracies that do not exist or assumed direct benefits that were not easy to discern. No one should expect to get satisfaction or benefit from the use of the cephalometer until he has firmly in mind the fact that findings from cephalometric x-ray pictures are, for the most part, merely circumstantial evidence which must be accepted as such and coordinated with other evidence before it becomes useful.

In the past I, too, had misgivings as to the practicability of cephalometrics for the clinical orthodontist, but, having been through all of these phases of doubt, apprehension, and experimentation, I now can say that, even though I cannot read from cephalometric pictures direct answers to all of my problems, I do not feel adequate in analyzing a case as to what its treatment should be and, of equal importance, what it has been unless I have cephalometric records before me. They are used with all cases in our practice and we regard them as being much more important for diagnostic purposes than models.

Experience in analyzing cephalometric x-ray pictures of patients being treated in our office, and particularly in attempting to convey the information that we find in them to parents, has developed in my mind some opinions regarding methods of analysis for the use of clinical orthodontists that I feel and hope may be useful to others. Much of this assessment method is made up of ideas of others. The most important of these comes from Drs. Downs, Wylie, Reidel, Thompson, Margolis, and others. I have taken ideas from these men and their ideas have engendered within me other ideas which we think are more direct and more useful for our purpose. I make no claim that they should replace other methods, but I do believe that for the purpose of the clinical orthodontist, they are direct and useful. We know that they are more easily understood by parents with whom we discuss them.

Anyone working with cephalometrics soon learns that hundreds of measurements and combinations of measurements can be made from cephalometric x-rays. Many of these have value. For each of us the problem is to determine what we want from an x-ray picture for our use, in our practice. In our office, the following measurements and assessments are made. I now shall attempt to justify them.

Our cephalometric x-ray pictures are taken in a cephalometer of standard design, and with an x-ray machine of much more than average power and quality. Our pictures are taken by a man who is a specialist in roentgenography and who has had special training in this special field. The pictures we use are therefore at least of average quality, or above it.

Very early in our experience with cephalometrics we encountered the difficulties of accurately locating certain important anatomic structures. Outstanding among these is that of distinguishing between identical structures on the right and left sides of the head. The literature on the subject would indicate that all that is thought to be necessary in such a case is to take cognizance of

the diverging rays from the target of the tube, and to remember the fact that the side of the head closest to the tube is magnified less than the side farther away from the tube. It is assumed that the structures upon the side nearest to the tube will be shown on the film closest to the point where the central rays strike the film. This method is often used to identify teeth as to whether they are of the right side or the left side. It seems to me that such a determination is largely guesswork, for, as we all know, positions of teeth in opposite sides of the same jaw are rarely entirely uniform. That is true also of the teeth of the same side of opposing jaws. Then, too, for lack of positive knowledge, it is taken for granted that the right and the left ear holes occupy symmetrically opposite positions in the head and that the superposition of the right and left porion points will supply a true profile picture. In our experience this is not true. Very obviously, such structures as the porion points on the bony auricular canals, and in many cases the infraorbital points, are difficult to locate accurately. It is also difficult to determine the right one from the left one. We must recognize also that as the head is rotated, all structures not located in the median plane of the head change positions rapidly, the structures of the opposite sides of the head moving in opposite directions to each other.

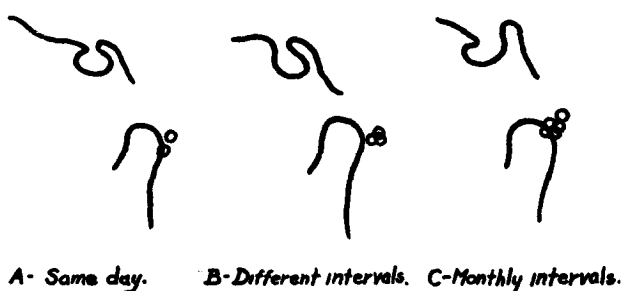


Fig. 1.—Demonstration of movement of the patient's head on the ear posts during the taking of cephalometric x-ray pictures.

Our literature gives evidence of the struggles among our research workers to find anatomic points, or lines, for superposition from which to determine differences and changes between moving parts, and we note with interest that nearly all of these seek points and lines located in the median plane of the head for this purpose.

Working with cephalometrics discloses the difficulty of accurately locating the porion points. This difficulty can be explained on the basis of the fact that porion is a point upon the external exit of the bony auditory canal. This point is covered by soft tissue intervening between the ear posts and this porion point. Tracings are not made from the porion point itself, but from the top of the ear posts which approximates it in position. As proof that patients can and do move in relationship to the ear posts when pictures are taken under the circumstances that I have mentioned, we offer the following evidence.

The tracings of the first two cases (Fig. 1, *A* and *B*) typical of many in our files, are of patients of whom several cephalometric x-ray films of each had been

made within a matter of minutes of each other. These films were routine pictures taken for our office, one being the regular cephalometric profile x-ray picture with the teeth in occlusion, and the other being the same except with the mandible in rest position. In these instances, the patient was not removed from the head holder, nor were the adjustments changed. The usual precaution of having the ear posts properly inserted in the ears and some of the patient's weight settled evenly on the ear posts were observed. By superimposing the pictures on cranial landmarks located in the median plane of the head of the patient, porion points were seen to move in relationship to each other as shown. As a result of this movement the Frankfort plane varied as seen in Fig. 1.

I, who know more of the technique of having x-ray pictures taken than does the average orthodontic patient, was placed in the cephalometer six times over a period of six months. I am sure that I have passed my growth period. These pictures (Fig. 1, C) were not taken to test the accuracy of locating the porion points, but instead to determine whether or not, as evidenced by cephalometric x-rays, the rest position of my mandible would remain constant throughout the period. When these films were superimposed on the cranial outline, and also on some distinctive and easy to recognize fillings in my maxillary teeth, a picture of the ear posts for five of the films varied as shown in Fig. 1, C.

It is understandable that the Frankfort plane would be chosen as a base line for cephalometric appraisal. It was a logical choice because it conformed to the traditional methods established by anthropologists. It seems probable that anthropologists used it originally because the porion points and the infra-orbital points were visible and therefore were available to them from the outside of a dry skull. Points S and N would not have been available to them without opening the skull, or using an x-ray picture of it. In orthodontics we are not dealing with dry skulls and the porion points and the orbitals, not being directly visible to us, are not accurate for our use. Points S and N are clearly visible in the x-ray pictures and can be located easily and accurately. It is of special importance to note that these points are located in the midsagittal plane of the head and, therefore, that they are moved a minimum amount whenever the head deviates from the true profile position.

A true profile picture, however, is unfortunately rarely attained, for accuracy with our present methods of mounting heads in cephalometers must as yet be a matter of degree, varying because of reasons already mentioned and also varying in proportion to the difference of location of right and left auricular canals to the sagittal plane, and to each other. True accuracy also varies to the degree that the patient has moved his head from an even mounting on the ear posts of the cephalometer.

Because the points S and N are both located in hard, nonyielding tissue, are directly and easily visible in a profile x-ray picture, and particularly because they are located in the midsagittal plane and therefore are displaced to a minimum degree by movement of the head, we have chosen the line SN as a reference line for all of the assessment measurements for which such a line is necessary. If it should be argued that this line is outside the face and therefore

is less useful as a line from which to judge facial proportions, I would answer that in this respect it has virtue and advantage because it is used only as a common reference line and is equally independent of facial structures. Things referring to the same thing have reference to each other.

Having determined a base line for our measurements, the question now arises as to what use we want to make of it. What do we want to learn, and what will we be required to explain to the parents of our patients regarding this knowledge?

One of the first questions is likely to be, "Does Willie have a good chin, and if not, what are you going to be able to do about it?" An equally important question may be, "What have you done about it?" A question in its simplest form will be, "Is Willie's chin forward or backward in relation to other structures of his head?" "Forward or backward to what structures?" The answer I want is, "Forward or backward to those structures that will effect his facial appearance and the impression he will make on the people about him."

To accomplish this, it seems to me that the method of Richard Reidel best serves our purpose, that method being the employment of the angles SNA and SNB (Fig. 2).

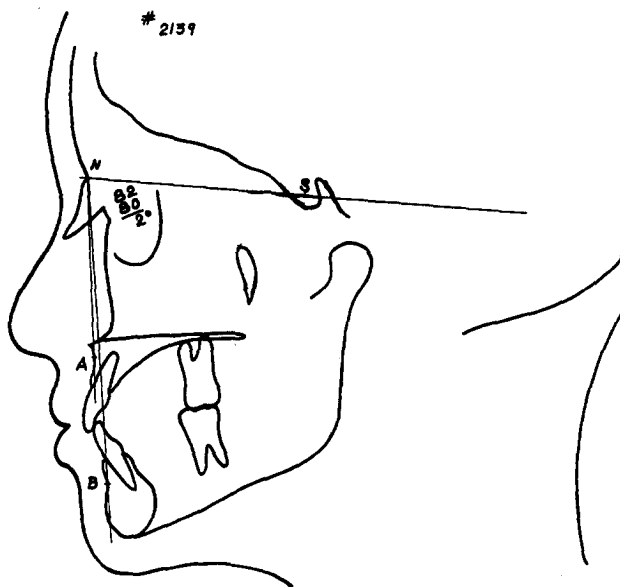


Fig. 2.—Jaw relationships, employing angles SNA and SNB.

To facilitate easy reading and to demonstrate our findings to others more easily, we use red for all lines having to do with the teeth of the maxillary arch, and green for those of the mandibular arch. For those relating to the mandible, brown is used. All other lines are in black.

I am interested in, but not greatly concerned about, the angle SNA because it merely shows whether the face protrudes or retrudes below the skull. I am greatly interested, however, in the difference of the angles SNA and SNB,

which in reality is the angle ANB, because the lines NA and NB are related to the same thing and the difference in their relationship gives a direct reading of the relationship of Willie's chin to other structures of his face. It is Willie's chin and not his sella turcica that interests his mother.

Our efforts have been to simplify tracings and to use methods that give direct readings in the areas to be judged. As an equivalent example, I might show to Willie's mother my fountain pen held in my left hand and a one-foot ruler held in my right hand. I might say, "Look, here is five inches indicated on this ruler in my right hand, and it looks to me as if that pen in my left hand is about five inches long," and I might convince her. A better method would be to lay the pen on the ruler and say, "Look, you can see by the ruler that this pen is five inches long." By this visual method I can show to her that a chin, which is on the average 2 degrees distal to the maxillary structures as evidenced by the angle ANB is in Willie's case perhaps 1, 2, 3 or 4 degrees mesial or distal to that of an average chin (Fig. 2).

Many attempts have been made in recent years to orient teeth, particularly the lower central incisors, to what has been referred to as "its relationship to basal bone," attention having been centered principally upon the central incisors. Its axial inclination has often been mentioned as related to the "mandibular plane." Our observation has been that the so-called mandibular plane as used has been a variable line, for there can be no such thing as a straight line parallel to the lower border of the mandible, for the lower border of the mandible is a curved line, not a straight one. There has been great variance in judgment of what the mean of this curved line is. It seems to me that the angulation of the lower central incisor to such a line is as much an appraisal of the length of the ramus as it is of the backward or forward inclination of this lower central incisor. Unless a conciliation of the rules relating the lower central incisor to the mandibular plane of a deformed mandible is made by some such method as Tweed has recently devised, it seems to us that this measurement has little value. We contend that the method we use to locate the upper and lower teeth in the denture is more direct and more important than those that have been used in the past.

By our method the upper central incisor (1) should lie on the line NA in such a way that the most mesially placed point of its crown is 4 mm. in front of the line NA and its axial inclination is at 22 degrees to the line NA (Fig. 3). We prefer the use of this line to that of facial plane because it is established by two fixed points, one of them on the maxillae and in juxtaposition to the tooth in question. In contrast, the facial plane is dependent upon a changeable moving part, the chin point pogonion. It will be noted that we orient this incisor to the line NA as to both location and angulation, both measurements being vital to us for diagnosis and for comparison to tracings made at a later date. In an attempt to relate all things to the same thing, and thus to each other, we began by recording the axial inclination of the upper central to the line SN, but from experience we found that, like all other measurements which are far removed from the points of their usefulness, this measurement has

little meaning to us or to others, and so we have ceased to use it. Much valuable information may be quickly obtained by observing where the line representing the axial inclination passes in relationship to the orbit. It normally intersects the orbit near its lowest point.

Fig. 3.

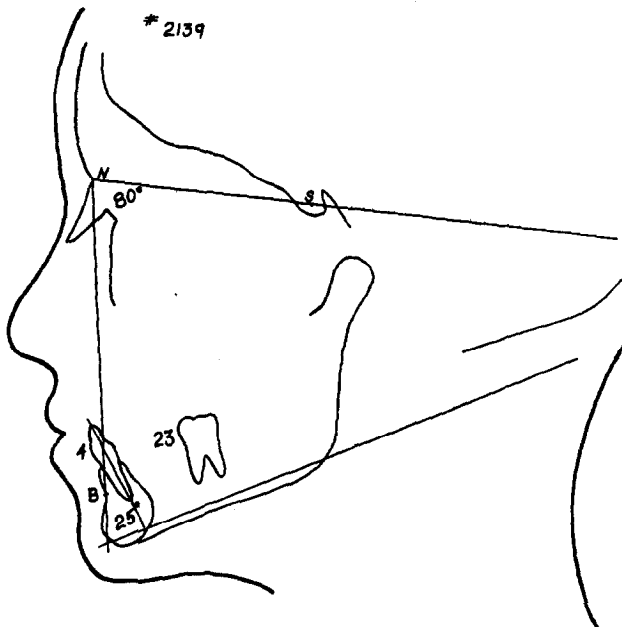
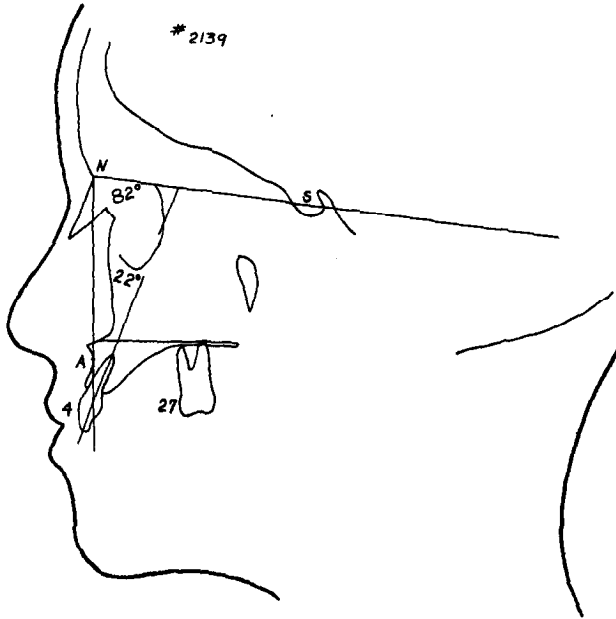


Fig. 4.

Fig. 3.—Orienting maxillary teeth.

Fig. 4.—Orienting mandibular teeth.

We also measure the upper molar ($\bar{6}$) to the line NA (Fig. 3) by measuring from the most mesial point on its crown to the line NA. A standard for this measurement is useless because of the number of teeth intervening and the variations in their size. This measurement is useful at a later date in determining whether or not the molar has moved forward or backward in relationship to this line.

By the same method that applied to the upper central incisor we relate the lower central incisor ($\bar{1}$) to the line NB (Fig. 4), our standard being that the most mesial point on the crown is 4 mm. in front of the line NB and the axial inclination of the tooth is at 25 degrees to the line NB. We also record the measurement, lower first molar ($\bar{6}$) to NB, for future reference. It seems to us quite as important to locate the lower incisors as to both location and angulation as is true of the upper incisors. The line NB is dependent upon a point (B) on the mandible close to the lower incisor, and serves an equivalent purpose to the line NA for the upper incisor. This method of orienting both anterior and posterior teeth to a line intimately associated with their basal bones is both effective and valuable.

We believe that the location and angulation of these teeth to these respective lines is of more importance to us for our appraisal of cases than were former measurements or systems that have been available, and it is certain that this visual method is not only easy to describe to the parents of our patients, but that it is very effective as well.

Because the measurement of the axial inclination of the lower central incisor to the mandibular plane is well established and often discussed, we continue to record it (Fig. 5), but we have come to value it principally as part of the assessment of the warpage of the lower part of the face, and we feel that its inclination to the face is largely determined by the degree of underdevelopment of the condylar growth centers.

The angle upper incisor to lower incisor ($\bar{1}$ to $\bar{1}$) (Downs), as shown in Fig. 5, continues to have value as a supplementary method of appraisal of the angulations of these teeth to each other and to the face. This measurement indicates the total variation from normal of these teeth to each other. The angle of each to its respective lines NA and NB shows where the deviation lies.

A cephalometric survey of a case would be incomplete without an appraisal of the location of the teeth in occlusion to the face and skull. We therefore measure the angle of the occlusal plane to SN (principle of Downs) as shown in Fig. 6.

One of the most important determinations to be made from cephalometric tracings is the degree of warpage, or malformation of the mandible itself, and perhaps the surfaces with which it articulates. For this purpose the angle GoGn to SN (Fig. 6) is somewhat useful, but not fully adequate. Here lies a great opportunity for someone to devise still better methods of appraising maldevelopments in this important area. Drs. Wylie and Johnson deserve credit for the work they have done on it.

It will have been noticed that the line GoGn has been taken as representing the body of the mandible (Reidel). This has been done because of the confusion among orthodontists in the matter of determining what line represents the

Fig. 5.

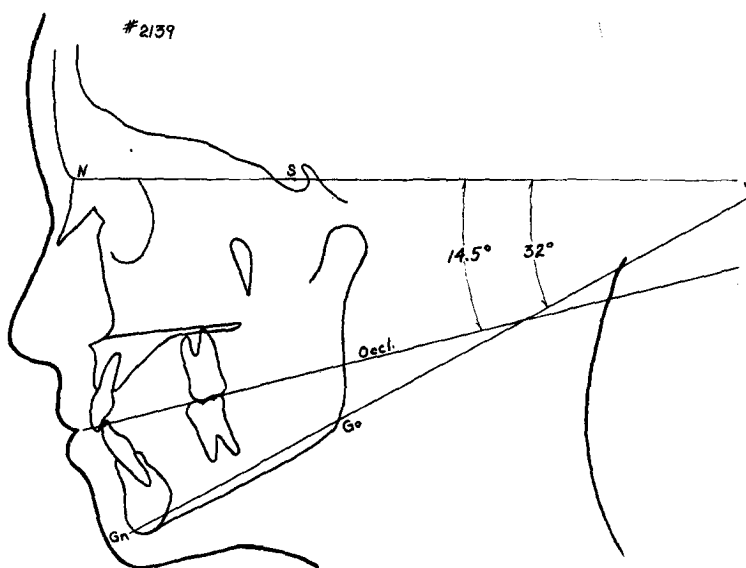
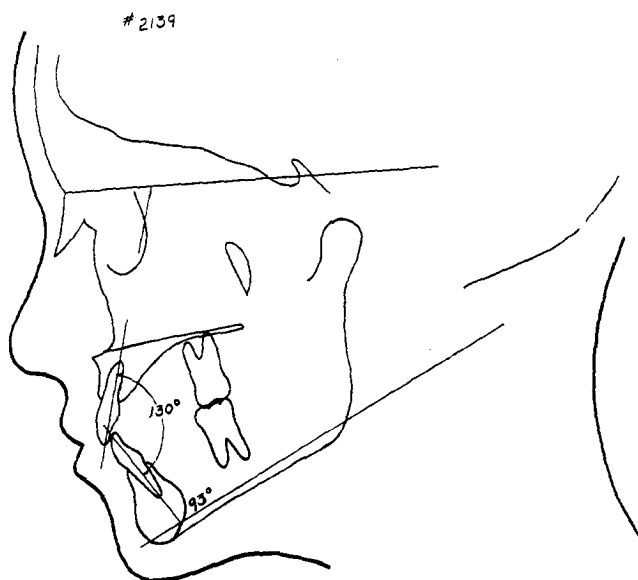


Fig. 6.

Fig. 5.—Axial inclinations.
Fig. 6.—Denture orientation.

center of the condyle establish point C. On this same tracing, by means of a dotted line, also draw the mandible in its rest position. Call this Tracing 1.

Over Tracing 1, place another piece of tracing paper and on it trace the mandible in a closed position. Call this Tracing 2. Pierce both Tracing 2 and Tracing 1 at point C with the sharp point of a pin. Also pierce both tracings at the chin point Gn. Now shift Tracing 2 so that the mandibular image on it corresponds to the image of the mandible at rest position on Tracing 1. Pass the pin through the hole at point C of Tracing 2 and thus establish the point C' on Tracing 1. Also pass the pin through the hole of point Gn, Tracing 2, and establish point Gn' on Tracing 1. Now discard Tracing 2. On Tracing 1, project a line from C' through C to SN. The distance C' to C represents the distance the condyle moved from closed position to the position of rest. The angle C' C SN represents the direction of movement. We may say, then, that the condyle has moved so many millimeters at so many degrees to SN. In like manner, project a line from Gn' through Gn to SN. The distance Gn' to Gn represents the distance the chin point has moved. This distance is often referred to as the freeway space, or occlusal clearance. The angle Gn' Gn SN represents the direction of opening. We may say, therefore, that the chin point has opened so many millimeters at so many degrees to SN.

It will be noted that the mandible does not necessarily open vertically. It opens on a curve and this curve may be on either side of the vertical. This opening varies a great deal in different individuals and it often varies considerably during treatment. Even though we have not as yet established standards for these mandibular excursions, we are developing visual ones. We believe that the appraisal of these conditions is important and will receive increasing attention in the future.

We are well aware that there is an almost unlimited number of other measurements that could be made from cephalometric x-ray pictures, but we have restricted the number to these that you have just seen. We can honestly say that every one of those shown is used in our practice because we feel that there is a need for each of them.

Our reason for presenting this method to you is to share with others a method that in our hands has been satisfactory. We have found that with it the parents of our patients can be made to understand much more easily many of the problems involved. This is true because the tracings made by this method need but a minimum number of lines for the purpose they serve and because each of the various lines may be easily identified by its individual color, and finally because the readings and measurements are close to the areas to be judged.

This method does show simply and graphically some of the important points to be considered in case analysis. An example of its usefulness is shown in the following case (No. 2248).

This case (Fig. 8) appears to be typical of those showing a Class III tendency such as have often had compromised treatment by bringing the maxillary teeth forward. Let us see what our cephalometric appraisal of this case tells us.

The angle SNA (Fig. 9) should, according to the average, be 82 degrees, and it is 86 degrees. This means that point A on the maxillae is 4 degrees anteriorly placed according to our standards. Clearly then, this is not a case of marked underdevelopment of the maxillae. Let us look at the mandible. The angle SNB should be 80 degrees and it is 84 degrees, a difference of 4 degrees, and the error is in the same direction as the error of point A. Both are easily attributable to patient-type. This patient does not have a Class III face.

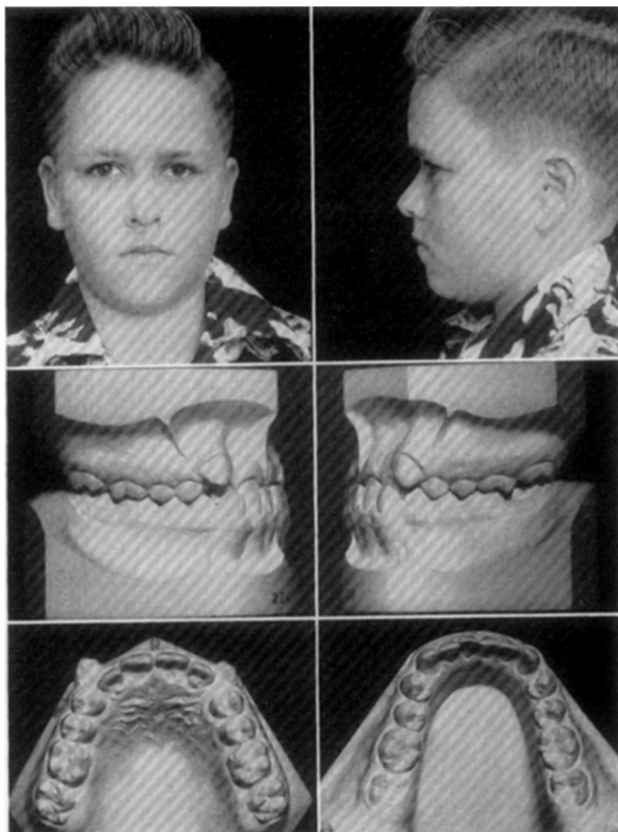
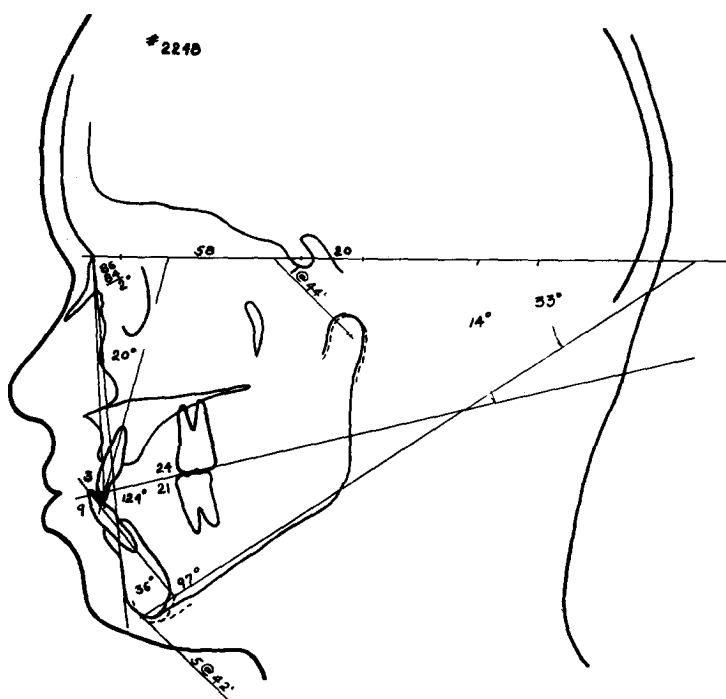


Fig. 8.—Case 2248. Note resemblance to Class III malocclusion.

What is the relationship of the mandible to maxillae as shown by the angles SNA and SNB (in reality the angle ANB)? This difference should be 2 degrees, and it is 2 degrees. The bony bases appear to be good. The angle GoGn SN is 33 degrees, being within 1 degree of what it should be (32 degrees), which reinforces this conclusion.

Let us now see how the denture is placed in its bony framework. The occlusal plane to SN should be $14\frac{1}{2}$ degrees and it is 4 degrees. The denture is well placed in the head. Obviously the malocclusion is created by the teeth themselves, but where?



Name #2248 Date _____ Age 13.3

Cephalometric Appraisal

	Average	5-9-52	
S N A (angle)	82	86	
S N B (angle)	80	84	
Difference	2	2	
GoGn SN (angle)	32	33	
CC' SN (angle)		1 @ 44	
GnGn' SN (angle)		5 @ 42	
S to E (mm)		20	
S to L (mm)		58	
Occl to S N (angle)	14.5	14	
I to I (angle)	130	124	
I to NA (mm)	4	3	
I to NA (angle)	22	20	
I to NB (mm)	4	9	
I to NB (angle)	25	36	
I to GoGn (angle)	93	97	
I to NA (mm)	27	24	
I to NB (mm)	23	21	
Existing & Desired Arch Length Diff.		22.5 - 2.5	

Fig. 9.—Case 2248. Cephalometric tracing and measurements.

Let us look at the upper incisors. According to our standards, the crown should be 4 mm. anterior to NA, and we find it to be 3 mm. anterior to it. That means that we may bring the upper central incisor forward 1 mm., but that would not do much in the way of correcting the posterior relationship of the upper incisors to the lower ones. How about the angulation of this upper incisor? Its angulation is 20 degrees to the line NA, and this measurement should be 22 degrees. Now let us look at the lower incisors. Here we find the culprits. These incisors should be 4 mm. in front of the line NB, and they are 9 mm. in front of it. Are they bodily forward, or are they tipped forward? Let us look. The axial inclination of these teeth should be registered at 25 degrees to the line NB, and it is shown on the tracing as 36 degrees. It should be registered at 93 degrees to the mandibular plane (GoGn), and this measurement is shown as 97 degrees. According to both measurements, the tooth is badly tipped forward.

Very obviously these teeth are badly misplaced, and to have followed the time-honored method of treatment in cases such as this, by moving the already fairly well-placed upper teeth forward in order to properly relate them to the misplaced lower teeth would have been a tragedy.

The correct treatment has now become obvious. The case presents "blocked-out" canine teeth in the maxillae, and the mandibular teeth are in a very much too far forward position, so there is just one answer: the extraction of four first premolars. We then can position the upper canines and move the lower teeth distally to a normal relationship with the upper ones by utilizing the spaces of the extracted premolars, and the treatment of the case has thus become relatively simple.

As evidence of the usefulness of this system of measurements for comparative purposes, we submit the following case reports and explanations of the methods we use to compare tracings. The before-treatment and after-treatment photographs and models of Case 2059 are shown in Fig. 10. Fig. 11 shows a cephalometric tracing representing the case before treatment. Fig. 12 represents it after treatment, and Fig. 13 shows the tracing of the case after twelve months of retention. In Fig. 14 is a chart of the measurements from these three tracings. Fig. 15 shows the before-treatment and after-treatment tracings superimposed on the line SN, registered at N. Fig. 16 shows the same tracings superimposed on the maxillae, on the symphysis of the mandibles, on the condyles of the mandibles, and on the lines SN, registered at S. Fig. 17 is a superposition of the after-treatment tracings and the after-retention tracings. Fig. 18 shows a comparison of the tracings of the case before treatment was started and after it had nineteen months of treatment and twelve months of retention.

This case was selected because it presents many of the troublesome and bewildering problems encountered in the treatment of malocclusions (Fig. 11). It has a mandibular angle (GoGn-SN) or 37 degrees instead of the average of 32 degrees. The difference of the angles SNA and SNB is 7 degrees instead of 2 degrees, meaning that the lower jaw is approximately 5 degrees distally placed to normal. The condyle, instead of rotating on an axis in or near the

condyle, moves 7 mm. downward and forward at 135 degrees to the line SN, when opening from closed position to rest position.

The literature is full of confusion concerning this type of jaw closure, some believing that in a case such as this the condyle is closed distally to its

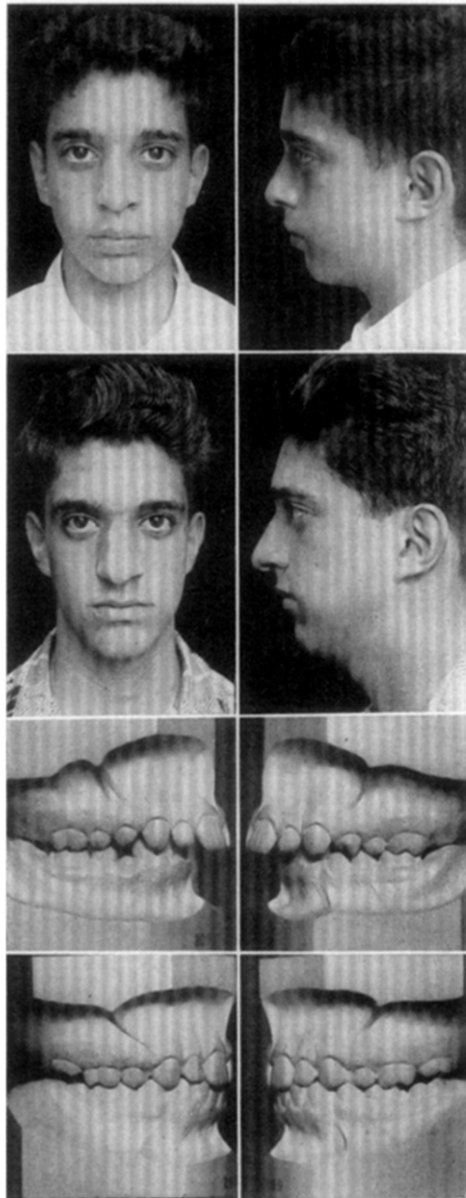


Fig. 10.—Case 2059. Photographs taken before and after treatment.

normal position because of cuspal interference, and therefore they refer to it as “a bite of convenience.” In this case, the distance SE is relatively large and the distance LS is relatively small, which might indicate the presence of such

Fig. 11.

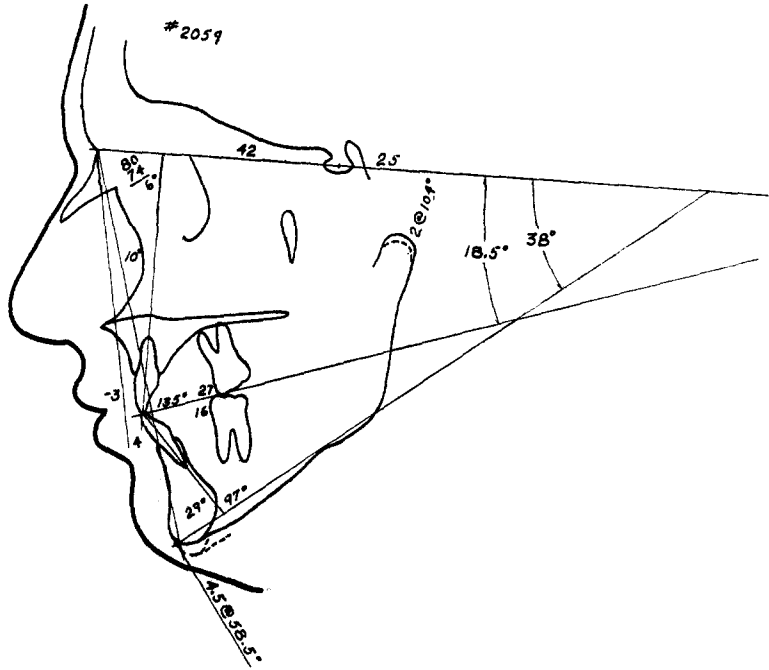
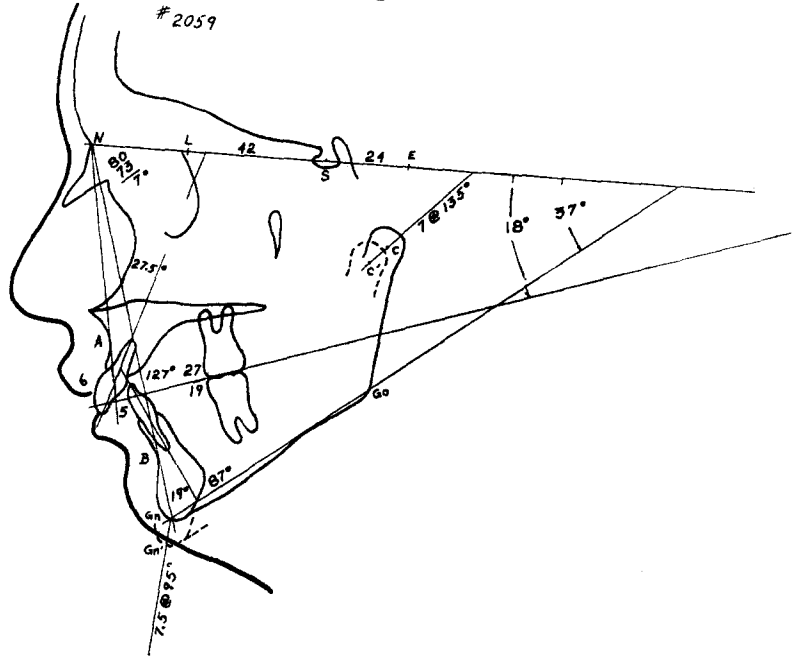


Fig. 12.

Fig. 11.—Tracing of Case 2059 before treatment.
Fig. 12.—Tracing of Case 2059 after treatment.

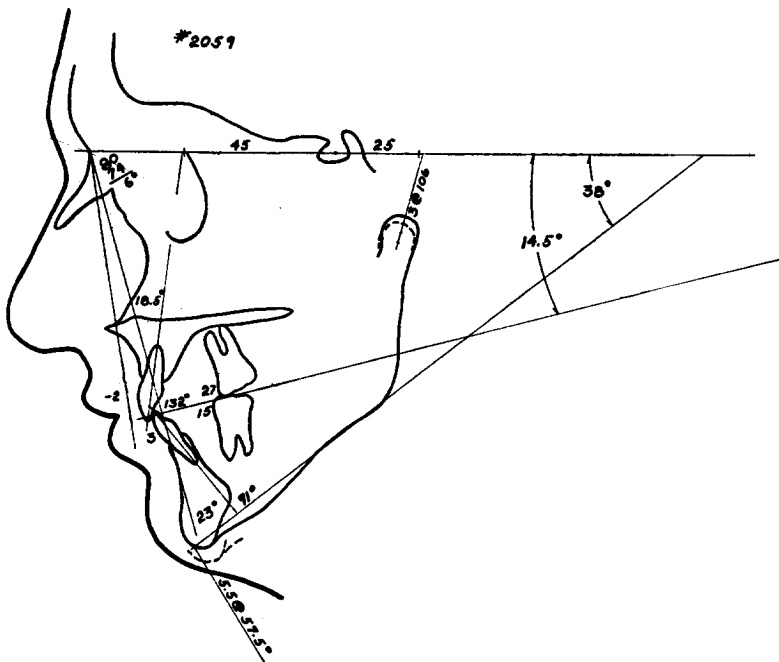


Fig. 13.—Tracing of Case 2059 after retention.

Name #2059 Date _____ Age 13:1

Cephalometric Appraisal

	Average	9-5-50	6-5-52	1-28-53
S N A (angle)	82	80	80	80
S N B (angle)	80	73	74	74
Difference	2	7	6	6
GoGn SN (angle)	32	37	38	38
CC' SN (angle)		7° @ 135	2° @ 104	3° @ 106
GnGn' SN (angle)		7.5° @ 105	4.5° @ 58.5	5.5° @ 67.5
S to E (mm)		24	25	25
S to L (mm)		42	42	45
Ocul to S N (angle)	14.5	18	18.5	14.5
I to I (angle)	130	127	135	132
I to NA (mm)	4	6	-3	-2
I to NA (angle)	22	27.5	10	18.5
I to NB (mm)	4	5	4	3
I to NB (angle)	25	19	29	23
I to GoGn (angle)	93	87	97	91
I to NA (mm)	27	27	27	27
I to NB (mm)	23	19	16	15
Existing & Desired Arch Length Diff.		6.5 -1.5		

Fig. 14.—Case 2059. Chart showing measurements taken from tracings shown in Figs. 11, 12, and 13.

a condition. The over-all distance LE is evidence of a relatively small mandible. The angle SNB by our standards should be 80 degrees, it is 73 degrees—more evidence of a small mandible and its distal placement.

Now let us consider the method of comparing tracings. The landmarks most often used for superimposing on the maxillae for the purpose of measuring the movements of the maxillary teeth are the upper and lower surfaces, and the anterior and posterior terminal ends of the palate. The superior surface of the palate is extremely difficult to trace accurately, as evidenced by the great variance we see in the tracings of this structure, and therefore it is of little value. There is ample evidence that the curve of the lingual surface of the palate is modified as a result of orthodontic treatment, thus ruling it out except as supplementary evidence. X-ray pictures of the anterior nasal spine are largely influenced by the manner in which they are taken. The posterior terminus of the palate is a growth center and changes rapidly during the growing years. We believe that our method contributes to the possibilities of superimposing these structures more accurately and more usefully than has been possible in the past.

All changes in the positions of anatomic parts must be expressed in terms of their relationship to something else. If we desire to record changes due to orthodontic treatment alone, we must offset, or at least minimize, the records of the changes that are due to growth in the areas we wish to judge. To do this we must superimpose on those certain structures from which we want to measure, and observe how the structures to be judged vary in relationship to these superimposed structures and to each other. For example, if we are to judge whether or not we have moved teeth in the maxillae, we must superimpose on the maxillae and let the growth changes be recorded elsewhere. If we want to judge how much the teeth have moved in the mandible, then we must superimpose upon the mandible and upon that portion of it which will serve our purpose. But how are we to superimpose maxillae or mandibles that have been growing and no longer fit each other? It is obvious that we need additional information to supplement that which is available in these bones themselves, for they are no longer identical in size or shape. Let us now see whether or not this system of measurements is helpful to this end.

We are primarily interested in changes that have occurred in the face, so we will diminish evidence of growth changes in the facial area by superimposing upon the lines SN at N (Fig. 15), thus causing the lines NA to superimpose. The record of the anterior-posterior growth changes thus will be expressed elsewhere. Changes in both growth and tooth movement may now be observed throughout the denture as judged from the lines SN and NA. By this superposition we also can judge visually and graphically any relative changes in the position of the mandible in its relation to the maxillae. The anteroposterior relationship is expressed by the angle ANB. We are going to come back to the changes in the mandible later, by another method.

Let us now also minimize the evidence of vertical growth changes in the region of the maxillae by raising the second tracing vertically along the line

NA, thereby keeping the lines SN of both drawings parallel until, by the greatest amount of evidence in the region of the maxillae, the structures of the first and second drawings of the maxillae are superimposed (Fig. 16). The movement of the maxillary teeth in the maxillae can now be assessed. To judge the movement of the mandibular teeth in the mandible, we know of no better way than to superimpose on the cross section of the symphysis, keeping the lower borders of the mandibles parallel (Fig. 16). In order to assess any changes in the location of the mandible and its relationship to the other structures of the head, let us superimpose the line SN, registered at S (Fig. 16). By this

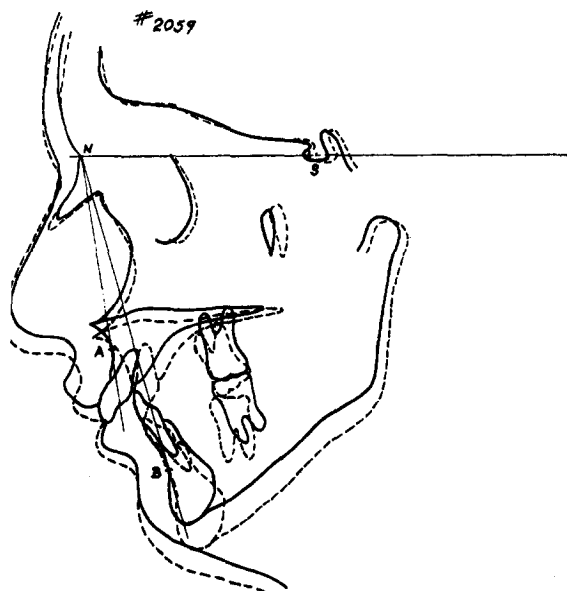


Fig. 15.

Fig. 15.—Tracings of Case 2059 before and after treatment superimposed on SN registered at N.

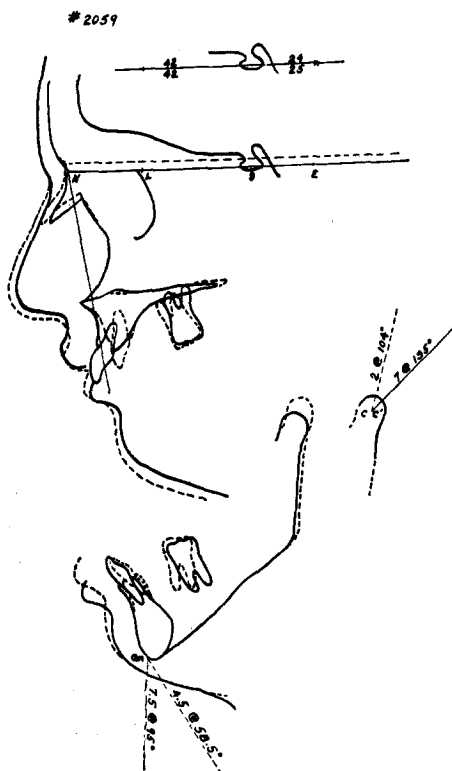


Fig. 16.

Fig. 16.—Tracings of Case 2059 before and after treatment superimposed on maxillae, symphysis, condyle, and SN at S.

method, evidence of growth changes will be minimized in this region and the points E representing the projections of the most distal points on the condyles will be registered in relationship to each other along the lines SN. In like manner, the points L, being projections of the most anterior points of the bodies of the mandibles (pogonion), will be represented along the line SN, and can be compared.

Distances between the points L and E of the respective drawings will represent the anterior-posterior lengths of the mandibles parallel to the line

SN, which is roughly the anterior-posterior direction. Let it be noted that this measurement does not necessarily represent the change in the length of the body, for the mandible does not necessarily lie parallel to the line SN, and as the bite is opened this measurement is effected. Its measurement in this direction is dependent upon its degree of parallelism to the line. It does represent the thing that we are interested in, mainly "Has Willie's chin come forward, or has it gone backward?"

By superimposing the mandibles at the symphysis (Fig. 16), the lines representing the motion of the chin point can be compared. Comparisons of the difference in motion in the condyles can be made in the same manner by superimposing the condyles (Fig. 16). Let us now apply these principles to the tracings of this case and see what they tell us.

By looking at the before-treatment tracing (Fig. 11), we learn that the upper central incisor is 6 mm. in front of the line NA instead of being 4 mm. in front of it, as it should be. The axial inclination is $27\frac{1}{2}$ degrees to NA instead of being 22 degrees, thus showing that it is tipped forward.

Let us look at the lower incisor. It should be 4 mm. in front of the line NB, and it is 5 mm. in front of it, being only 1 mm. too far anterior to this line. Its inclination to the line NB is 19 degrees, and it is entitled to 25 degrees. It is at 87 degrees to the GoGn plane instead of a normal of 93 degrees, and therefore, by both standards, it is tipped back 6 degrees.

The plane of occlusion is at 18 degrees to the line SN instead of $14\frac{1}{2}$ degrees. Upon opening to rest position, the gnathion point moves $7\frac{1}{2}$ mm. at 95 degrees to SN. Instead of rotating on a point in or near the condyle, the condyle moves from rest position upward and backward to a position of closure which might be claimed to be an abnormally distal position or a "bite of convenience." This is the type of case of which it has been correctly stated that an ideal result can never be achieved because the basic framework for an ideal result is absent, and probably cannot be provided by orthodontic means. Because the mandibular dental arch is crowded, lacking 5 mm. of desired arch length, and because to pull forward against it with intermaxillary ligatures would have complicated this crowding further, we chose to extract four first premolars, accept the mandibular position close to where it was, and retract the maxillary teeth to a harmonious relationship with the lower teeth. In the light of changing thought and treatment philosophy in our office during the last several years, we now might have attempted treatment of this case without extraction by using occipital anchorage exclusively.

The tracings (Figs. 7 to 11) will give evidence of what was accomplished. In all of these drawings, the angle SNA and the line NA are transferred from the first drawing to subsequent drawings. Let it now be stressed that point A on the maxillae is not a constant point. It changes not only as a result of normal growth but also as a result of orthodontic treatment. For this reason we use the angle S N A as established on the first tracing for all subsequent tracings. It is the yardstick by which all tracings for this particular case will be assessed.

Let us now compare the tracings of this case. Specifically, what do we want to know about it? The most important questions are, "What changes have taken place in the relationships of the lower jaw to upper jaw, what changes have occurred in the jaws themselves, what movement of the maxillary teeth has taken place in the maxillae, and what movement has there been of the mandibular teeth in the mandible? Equally important, what change has there been in the functional movements of the mandible?" I challenge you to find answers to these questions in a plaster model.

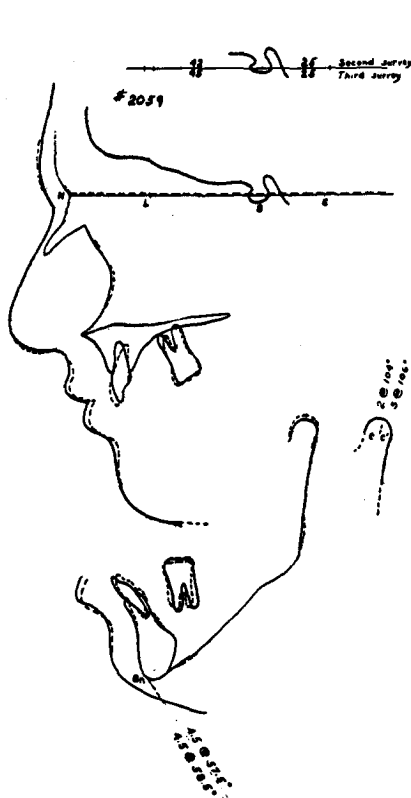


Fig. 17.

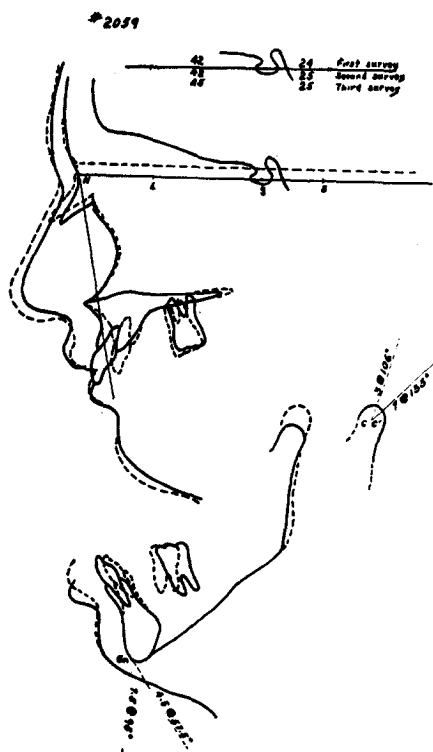


Fig. 18.

Fig. 17.—Tracings of Case 2059 after treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

Fig. 18.—Tracings of Case 2059 before treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

Let us see first what has happened to the chin during treatment (Figs. 11 and 12). The difference of the angles SNA and SNB is 6 degrees, having been reduced 1 degree, meaning the chin has come forward 1 degree, which certainly is not very much. The lower molar, which was 19 mm. behind the line NB, is now 16 mm. behind it. It has come forward 3 mm. The lower incisor, which was 5 mm. ahead of the line NB, has come backward 1 mm. to the desired position of 4 mm. Its inclination is forward 4 degrees of its desired position.

Let us look at the upper jaw. The molar was 27 mm. back of the line NA, and it is still 27 mm. It has been held in its original position. The incisors were 6 mm. ahead of NA, and they are now 3 mm. distal of it. The tooth, therefore, has been moved distally 9 mm., and our diagnostic aim apparently has been well accomplished.

Now let us quickly look at some other things that are interesting. The occlusal plane was 19 degrees, and it is now $18\frac{1}{2}$ degrees, having been held almost constant. GoGn to SN has increased 1 degree. This is due to opening of the bite.

Let us see what has happened to the position of the mandible. The distal point of the condyle projected to the line SN (point E) is now 25 mm. from S, instead of 24 mm. The condylar head has gone back 1 mm. The chin point projected to the line SN is still 42 mm. from S; the over-all length LE has increased 1 mm. only. The mandible undoubtedly has grown, but it also has opened, and the chin point has remained almost constant in an anterior-posterior direction.

Let us see what has happened to the motion of the mandible. The condyle now opens to rest position by moving 2 mm. at 104 degrees to the line SN instead of 7 mm. at 135 degrees, a very much more normal motion. The chin point now moves downward and backward $4\frac{1}{2}$ mm. at $58\frac{1}{2}$ degrees to SN, obviously a much more normal movement.

Make the same comparisons of the tracings after treatment (Fig. 12) to those representing the case after twelve months of retention (Fig. 13). The lower incisor has corrected itself to very close to a normal position. The other teeth that were tipped too far have done much to right themselves. The plane of occlusion not only has recovered its original position, but it has flattened down to a completely normal relationship to the line SN. The mandible has put on a growth spurt of 3 mm. The condyle has moved forward 1 mm. The chin point has come forward 3 mm. It may be wishful thinking, but I believe that normal function is rapidly contributing to the recovery of the malformed framework.

To many of you who continue to say, "Why use a cephalometer? Its use would not alter my clinical treatment," we submit evidence of Case 2171 (Figs. 19 to 27), which was treated by the time-honored method of using intermaxillary elastics to correct the Class II relationship. Every possible attempt was made to provide sufficient anchorage in the anchor teeth and to move those teeth which we desired to move. By means of the methods of assessment just outlined, it will be seen that the upper molars have moved distally 4 mm. The upper incisor has been moved 8 mm. and has been erected $19\frac{1}{2}$ degrees. The price in anchorage paid for this distal movement of the upper teeth was the forward movement of the lower molar 3 mm. and of the lower incisor 4 mm., and a forward tipping of the lower incisor 13 degrees. This means that this lower tooth is 4 mm. in front of its normal position, and 19 degrees forward of its normal axial inclination. The plane of occlusion has paid a heavy price, having been tipped an additional 11 degrees from normal.

Examine Figs. 22 and 23 and be grateful to the Supreme Benefactor who does His best to take care of all of us, even the orthodontist. In this picture,

taken after the retention period, the lower incisor has recovered 9 degrees from its bad axial inclination and 3 mm. of its forward position to a correct position. The position and motion of the mandible have been very nearly normalized, and



Fig. 19.—Case 2171. Photographs taken before and after treatment.

even though the ANB angle is still 7 degrees instead of being 2 degrees, as we might wish it, I believe that the treatment has been satisfactory under the circumstances.

We wish to point out that the cephalometric appraisal of this case has shown clearly and impressively the price in anchorage that intramaxillary pull

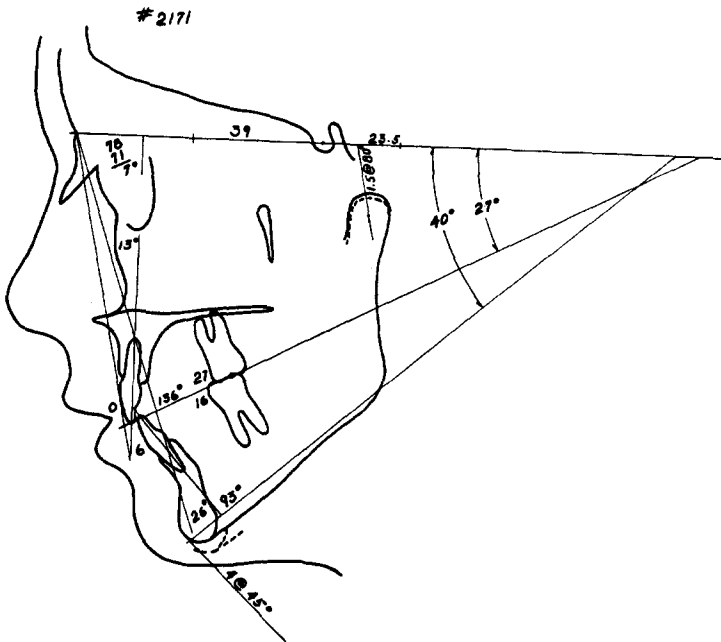


Fig. 22.—Tracing of Case 2171 after retention.

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Cephalometric Appraisal

	Average	8-9-50	1-23-52	2-7-53
S N A (angle)	82	78	78	78
S N B (angle)	80	71	71	71
Difference	2	7	7	7
GoGn SN (angle)	32	37	39	40
CC' SN (angle)		35 @ 113		15 @ 80
GnGn' SN (angle)		7 @ 58		4 @ 45
S to E (mm)		23	23.5	23.5
S to L (mm)		39.5	38	39
Ocul to S N (angle)	14.5	18	29	27
I to I (angle)	130	118	125	136
I to NA (mm)	4	8	0	0
I to NA (angle)	22	32.5	13	13
I to NB (mm)	4	5	9	6
I to NB (angle)	25	22	35	26
I to GoGn (angle)	93	93	104	93
S to NA (mm)	27	26	30	27
S to NB (mm)	23	20	17	16
Existing & Desired Arch Length Diff.		67 67 0		

Fig. 23.—Case 2171. Chart showing measurements taken from tracings shown in Figs. 21, 22, and 23.

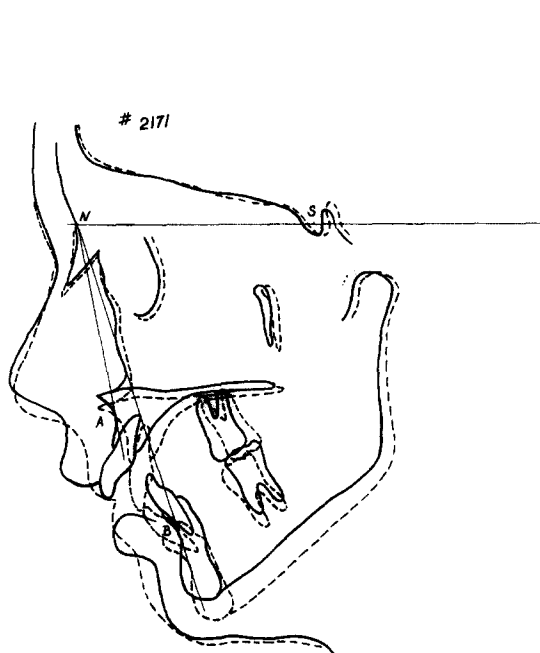


Fig. 24.

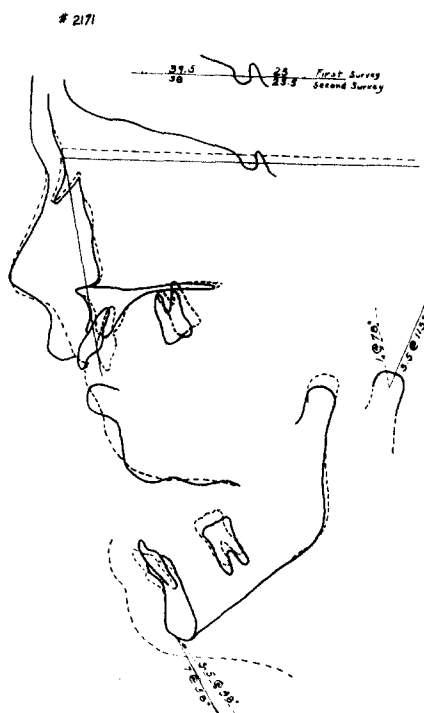


Fig. 25.

Fig. 24.—Tracings of Case 2171 before and after treatment superimposed on SN registered at N.

Fig. 25.—Tracings of Case 2171 before and after treatment superimposed on maxillae, symphysis, condyle, and SN at S.

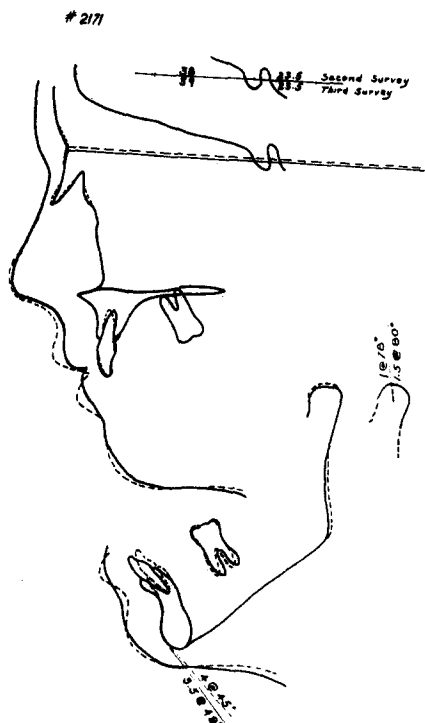


Fig. 26.

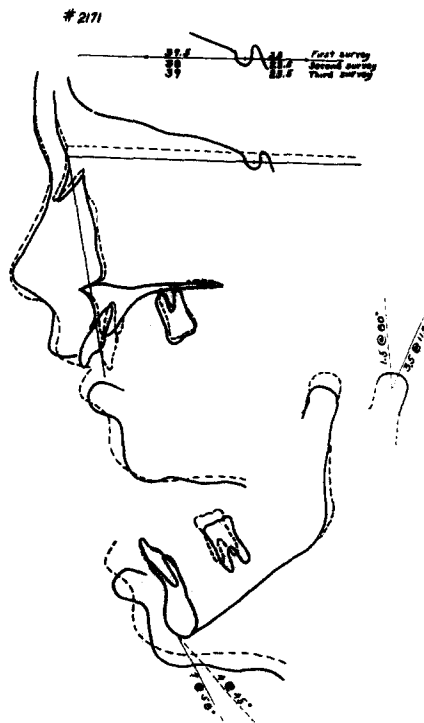


Fig. 27.

Fig. 26.—Tracings of Case 2171 after treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

Fig. 27.—Tracings of Case 2171 before treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

exacts from the anchor teeth. Examples such as these do crystallize the thinking of those orthodontists who use the cephalometer. I am sure that it does contribute to their diagnostic judgment.

As previously stated, we have chosen from those methods of cephalometric assessment that were available measurements that we feel are useful for our needs. To these we have added others that have been useful to us. To have attempted to give complete individual credit for the established methods would have been a Herculean task, and a dangerous one because as is the case of most progress, many of these ideas did not come spontaneously from a single mind, but were evolved by the thinking of others.

Our method is not proposed to replace any that have already been suggested. It is reported because it serves us well and because of our belief that tracings made in this way are simpler and less confusing, particularly to parents and to others who may view them.

The cephalometer is here to stay as a tool of the clinical orthodontist. It is our hope that the suggestions made in this article will help to convince others of the importance of the cephalometer and of its potentialities as a diagnostic instrument.

I wish to express my appreciation to Dr. Fred J. Angel for his valuable assistance in preparing the illustrations for this article.

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