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Original Articles

THE USE OF CEPHALOMETRICS AS AN AID TO PLANNING AND ASSESSING ORTHODONTIC TREATMENT

REPORT OF A CASE

CECIL C. STEINER, D.D.S., BEVERLY HILLS, CALIF.

A CASE treated by Dr. Howard Lang demonstrates the use of cephalometric evidence in planning and assessing orthodontic treatment (Figs. 1 and 2).

Characteristics.—The patient, a boy, was 12 years 3 months old at the time treatment was started. His childhood was normal and average. In both his mother's and his father's families, varied types of faces and dentures were encountered. Some of these dentures were normal, and some of them were in malocclusion. In general, the inheritance of physical qualities was probably better than average as regards both physical development and health. The boy's father was an accomplished athlete and a physical education director.

The patient had the usual childhood diseases. We do not know of any of them that would have influenced his orthodontic treatment or his need for such treatment. The teeth were free of cavities, and the supporting tissues may be described as being normal.

The lip and cheek muscles lacked normal tissue tone. The marked protrusion of the teeth undoubtedly contributed to the lack of normal functioning of the lips. It also inhibited normal breathing and chewing.

Etiology.—Because of the extreme nature of the malocclusion, and particularly because of the narrowness of the dental arches, it is a temptation to suggest sleeping and/or leaning habits as contributing factors of this malocclusion. Instead, we must report that we do not know the cause, although we strongly suspect heredity as the dominate one.

In planning the treatment, evidence from all possible sources was gathered and used. Cephalometric headplates played an important part in this planning and also in the assessment of the changes that took place during and after the treatment time.

The following instructions will show how cephalometric evidence is used for treatment planning and for assessing the changes that take place as a result

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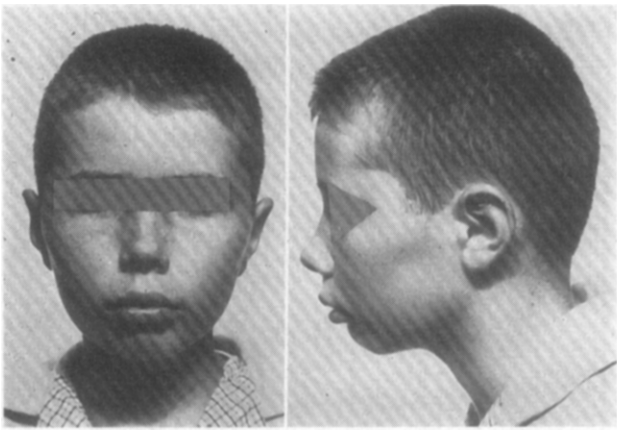


Fig. 1.—Before treatment.

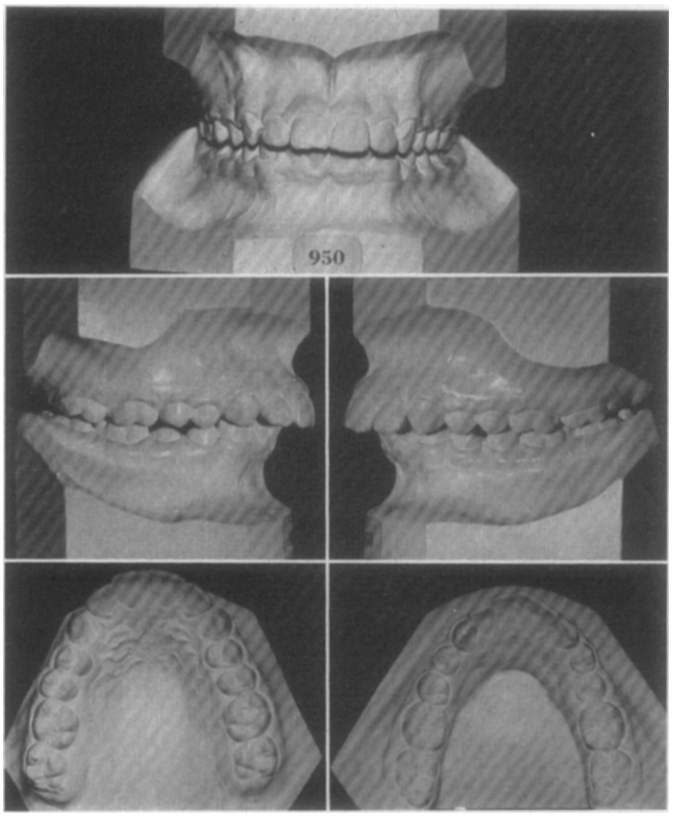


Fig. 2.—Before treatment.

of growth, development, and orthodontic therapy. I will presume that the reader is familiar with my articles entitled "Cephalometrics for You and Me" and "Cephalometrics in Clinical Practice," in which the measurements and methods referred to in the present article are fully described.

VIEWING THE PROBLEM

To view the problem, it is necessary to become familiar with the measurements of our "norm," which we will accept as representing the measurements of a normal average child of average orthodontic age[5] (Fig. 3), and to compare the pertinent measurements of the case at hand with these same measurements of the norm (Fig. 3).

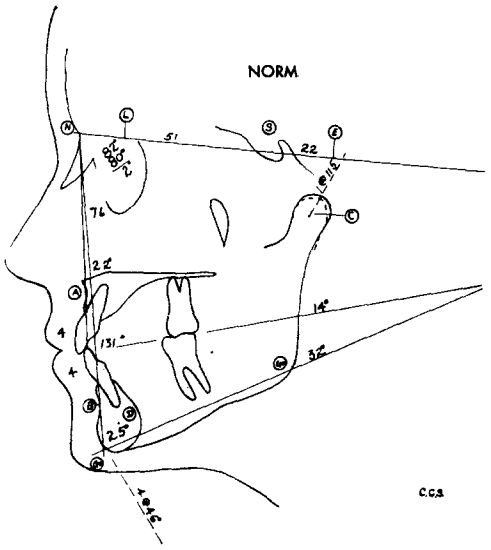


Fig. 3.—Measurements of norm.

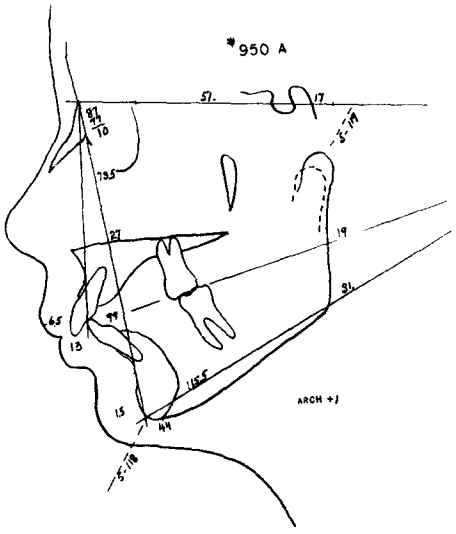


Fig. 4.—Case to be treated.

It will be noted that in the malocclusion shown in Fig. 4 angle ANB is 10 degrees instead of 2 degrees as it is in the norm. The apical base of the mandibular teeth, therefore, is 8 degrees more distally placed in relation to the apical base of the maxillary teeth than is normal.[4] This does not necessarily indicate that the mandibular apical base is distally placed in relation to the head as a whole. It could be that the fault lies with the maxilla. Comparison of angles SNA and SNB with the norm[5] will give some evidence (not conclusive) of which is at fault. Angle SNB is 77 degrees; therefore, it is only 3 degrees short of the norm for it (80 degrees), so the mandible probably is not seriously at fault. Angle SND,[6] which is an assessment of the anteroposterior position of the chin area of the mandible, is 73.5 degrees instead of the norm of 76 degrees. This is corroborative evidence that the chin is short by only about 2.5 degrees. The balance of the error in the apical base relationship is due to a forward positioning of the maxilla. Angle SNA is 87 degrees instead of 82 degrees, which gives further support to this opinion. There is conclusive evidence that there is disharmony in the relationship of the jaws to one another

and that we are dealing with a "distal occlusion," generally referred to as an Angle Class II malocclusion. Examination of the incisors, indicates a Class II, Division 1 malocclusion.

Let us look now at the upper incisor. It measures 6.5 mm. in front of the line NA, instead of 4 mm. as shown on the norm. It is, therefore, 2.5 mm. too far forward. Comparing its angle to that of the norm, we find that it is tipped forward excessively by 5 degrees.

Next let us examine the lower incisor. Here is the key to the severity of this case and to the difficulty of its treatment. The norm for this tooth places it 4 mm. in front of the line NB with its long axis at 25 degrees to this line. This incisor is 13 mm. in front of the line NB and at an angle of 44 degrees. to it. This means that the tooth is 9 mm. too far forward and leaning forward 22 degrees more than is normal for it.

Comparing the measurement Pg-NB (pogonion to the line NB) to the measurement $\overline{1}$-NB (lower incisor to the line NB), Holdaway[3] believes that ideally these two measurements should be equal. In this case Pg-NB measures 1.5 mm. and $\overline{1}$-NB measures 13 mm. There is, therefore, a difference of 11.5 mm. between $\overline{1}$-NB and Pg-NB.

The lower incisor's angulation to the Frankfort plane (Frankfort-mandibular incisor angle of Tweed[7]) is 36 degrees.

By any and all standards, this lower incisor is badly displaced forward of its supporting base, and the case may be said to be one of a severe "double protrusion."

The "mandibular angle" which we read as the angle GoGn-SN (cant of the mandible to the SN plane) is 31 degrees. This is within 1 degree of normal, which indicates good growth in the condylar growth area and a normal ramus height.

Now let us read the measurements SL and SE. Combined, they represent the effective length of the mandible projected onto the line SN. They measure 68 mm., which is only 5 mm. short of the normal average. The measurement SL, at 51 mm., is exactly as it occurs on our normal chart and indicates a relatively normally developed mandible. In this Class II malocclusion case, therefore, the malformation is principally in the maxilla and the maxillary teeth. The lower teeth are placed in a nearly normal mandible, but they are leaning badly forward.

The occlusal plane is canted to the SN line at 19 degrees instead of at 14 degrees. Therefore, it is tipped 5 degrees too much in its relation to this line. This type of error occurs regularly, but in varying degrees, in conjunction with Class II malocclusions. It generally has a relationship to the variations of the mandibular plane (GoGn-SN). Its correction is thought by many orthodontists to be important to the treatment of both Class II and Class III malocclusions. It is of interest that the use of Class II rubber ligatures generally tends to make it worse. Extraoral anchorage, particularly when it is used with the Kloehn type of face-bow, can be made to improve it.

Let us look now at the action of the condyles and of the chin point when the mandible is moved from closed to rest position. Normally, the condyles move for this distance on what is referred to as "the terminal hinge axis." The center of this axis is generally located not in the center of the condyle but in its lower portion, or even in the upper part of the neck of the condyle itself. Normally, point C (center of the condyle) moves downward and forward about 1 mm. at 115 degrees to the line SN. In the malocclusion under consideration here the condyle moves 5 mm. and at 119 degrees to the line SN.

The chin point normally moves from the closed position to the rest position, *downward* and *backward* about 4 mm. and at about 46 degrees to the line SN. In this malocclusion case, the chin moves *downward* and *forward* 5 mm. and at 118 degrees. This has been referred to as the "Sunday bite," but we should bear in mind that cephalometric evidence shows that this abnormal opening is typical of the majority of Class II malocclusions. It changes toward the normal type of opening coincidentally with good treatment of the malocclusion.

As stated before, cephalometric evidence is important, but it must be compared, tempered, and coordinated with evidence found in photographs, models, and particularly in the patient himself. Teeth in the living denture are mounted in the finest articulator ever devised, and there they and the other parts of the denture give diagnostic evidence that cannot be surpassed in importance.

PLANNING TREATMENT

First the information pertinent to the problem is recorded on the diagram marked "problem" on the analysis sheet[6] (Fig. 5). The improvement in angle ANB that will occur during treatment is estimated and the new estimated angle ANB is recorded on the graph at *A* in the portion of the diagram marked "ANB." (See Fig. 6 for location of *A* and record the figure on the analysis sheet shown in Fig. 5 for this and the following measurements.) The positions of the upper and lower central incisors that this new angle ANB dictates are estimated. (To do this, see the "acceptable compromises" in Figs. 5 and 6 and record at *B* and *C*.) Next an estimate is made of what the measurement pogonion to line NB (Pg-NB) will be at the end of treatment.[6] For evidence, one must consider the growth potential, the distance and manner in which the lower incisor is to be moved, the expectancy of the addition of appositional bone, etc. It must be remembered that "them that has, gets" and vice versa. This estimate is recorded at position *D*. The distance of the point Pg from the line NB, having been estimated, now the position of the lower central incisor from the line NB is estimated. Holdaway says[3]: "A I:I ratio between these two measurements is ideal." Therefore, the distances marked at *D* and also at *E* are recorded, so that these two distances will be recorded as being equal. The position of the upper incisor which is marked *F* on the diagram is established as follows (Fig. 7):

$$F = E - (C - B).$$

C, *B*, and *E* are known. Solve for *F*.

$$F = 3 - (5 - 0).$$

$$F = -2.$$

F and *E* now hold the same relative relationship to the lines NA and NB in both the ANB and the Pg diagrams as do *B* and *C*. In this position, *F* is ahead of *E* the same distance that *B* is ahead of *C* in their respective diagrams.

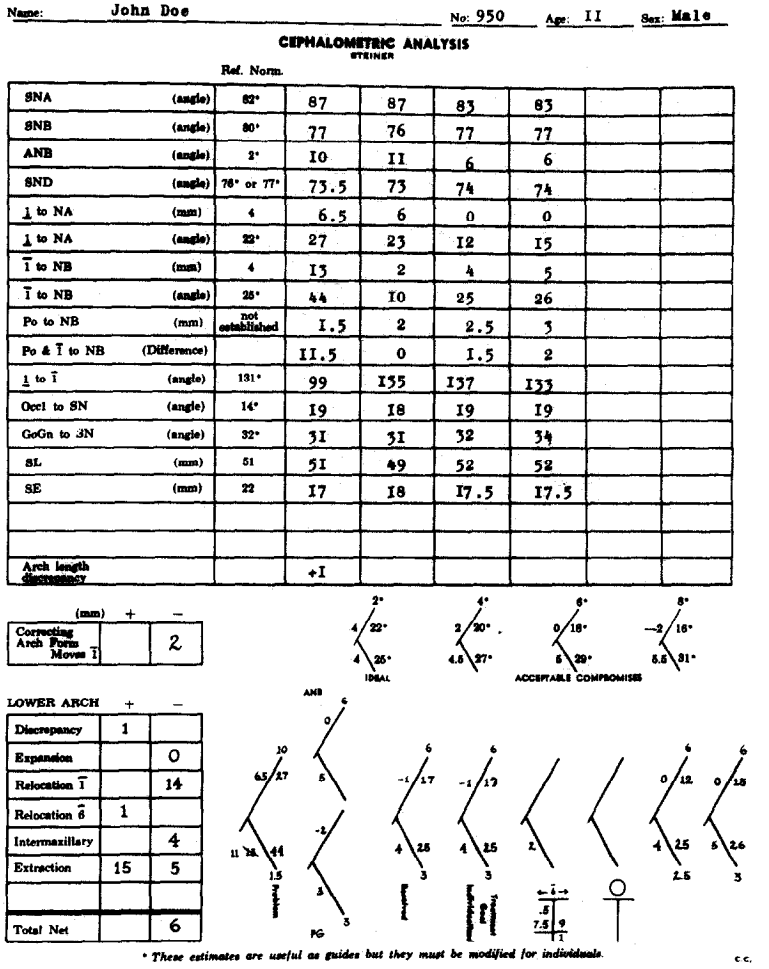
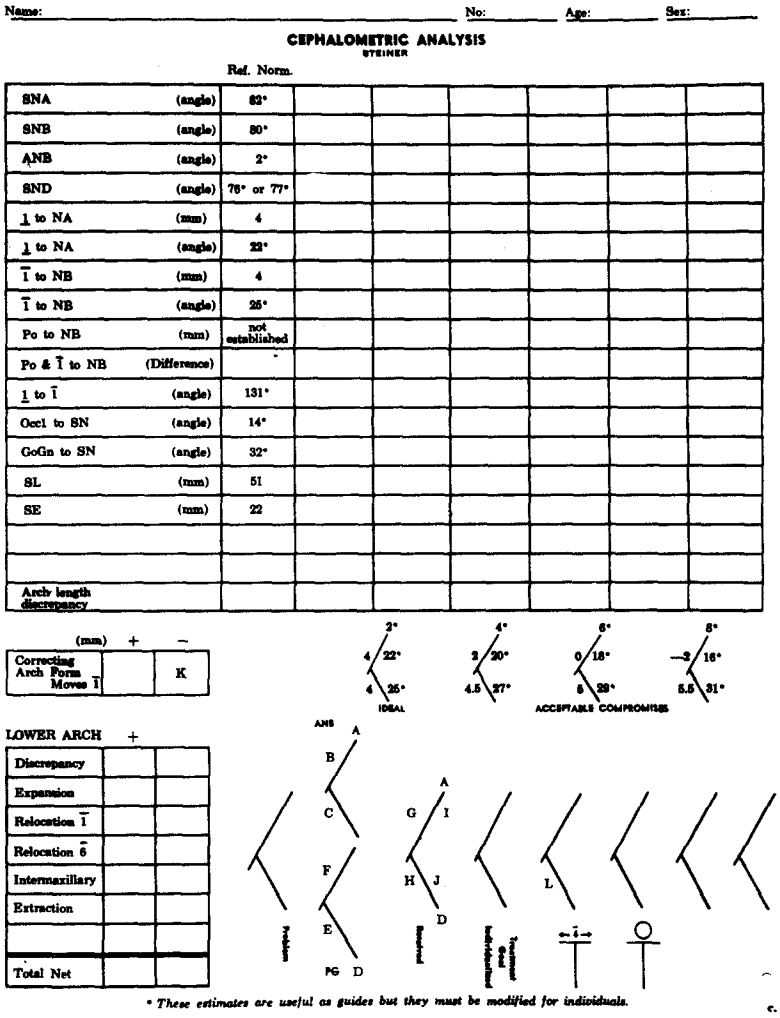


Fig. 5.—See Fig. 6 for letters representing the positions on these charts.

We have now established the positions of the upper and lower incisors, as they are dictated by the angle ANB, as being *B* and *C*. We have established the positions of the upper and lower incisors, as they are dictated by the distance Pg to the line NB, as being *F* and *E*. Both are important. Therefore, both of these diagrams should be resolved into one by establishing the average of them. This is recorded on the diagram labeled "resolved." *A* and *D* are carried over intact. The average between *B* and *F* is estimated as follows: $B + F \div 2 = G$. In like manner, *H* is established by the following formula: $C + E \div 2 = H$.

G represents the distance, in millimeters, of the upper incisor ahead of the NA line. To determine what the angle of this incisor to the line NA should be, one may look at the acceptable compromises. The angle should be established from these diagrams and recorded at *I*.



Name: No: Age: Sex:

CEPHALOMETRIC ANALYSIS
STEINER

		Ref. Norm.						
SNA	(angle)	82°						
SNB	(angle)	80°						
ANB	(angle)	2°						
SND	(angle)	76° or 77°						
1 to NA	(mm)	4						
1 to NA	(angle)	22°						
$\bar{1}$ to NB	(mm)	4						
$\bar{1}$ to NB	(angle)	25°						
Po to NB	(mm)	not established						
Po & $\bar{1}$ to NB	(Difference)	-						
1 to $\bar{1}$	(angle)	131°						
Occl to SN	(angle)	14°						
GoGn to SN	(angle)	32°						
SL	(mm)	51						
SE	(mm)	22						
Arch length discrepancy								

(mm)	+	−
Correcting Arch Form Moves $\bar{1}$		K

LOWER ARCH +

Discrepancy		
Expansion		
Relocation $\bar{1}$		
Relocation $\bar{6}$		
Intermaxillary		
Extraction		
Total Net		

2° 4° 6° 8°
4/22° 2/20° 0/18° −2/16°
4/25° 4.5/27° 6/29° 5.5/31°
IDEAL ACCEPTABLE COMPROMISES

ANS A B C F E PG D
A G I H J D
L

* *These estimates are useful as guides but they must be modified for individuals.*

Fig. 6.—Chart showing positions for numbers.

H represents the distance, in millimeters, of the lower incisor ahead of the line NB. Its angle to the line NB may be determined from the diagrams of "acceptable compromises" and recorded at *J*.

These estimates are useful as guides but they must be modified for individuals. Now, the orthodontist must use his training, his experience, and all the intelligence and skill at his command to individualize these figures and mark these modified estimates on the graph marked "treatment goal individualized." Surely, one set of figures is not applicable to all ages, to all races, and to all

types, or even to all temperaments. For the sake of simplicity, I will say that this particular patient conforms in all ways to the standard from which our average normal standards were derived. Let it be made plain, however, that when there are indications for doing so, we do alter for individual patients figures which have been arrived at by these methods.

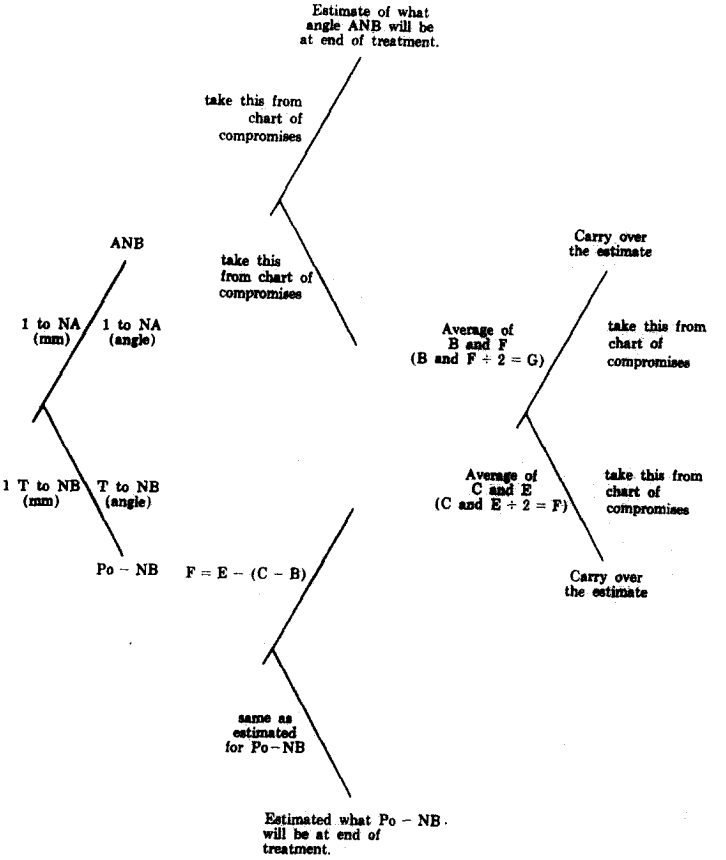


Fig. 7.—See Fig. 6 for letters representing positions on these charts.

HOW TO ACCOMPLISH THE PLANNED TREATMENT

We have made an estimate of what we think should be accomplished. Let us now make some estimates of what the treatment should be.

When the lower central incisor was traced from the headplate, it could or could not have properly represented the true average anteroposterior positions of the other mandibular teeth. It might, for instance, be the only lower tooth that is crowded out of the general arch alignment. In that case, it would be erroneous to say that all the lower teeth are forward of their correct environment to the same degree as this particular tooth. We must first visualize the tooth back in a good alignment with its neighbors before we can use it to judge the positions of the other lower teeth. Therefore, we must make an estimate

of how far forward of the general alignment it is and make a correction in our figures for it. Let us say that we estimate it to be 2 mm. forward of the general alignment. It would then be necessary to imagine it back 2 mm. We would mark 2 on the minus side of the box labeled "correcting arch form moves $\bar{1}$" and, in addition, subtract 2 from the 13 (position of the lower incisor as it was traced), leaving 11. We now cross out the 13 and write 11, this being the position of the incisor when it is visualized in acceptable arch form.

Also, the shape of the arch might not be normal for the case; therefore, the location of the incisor in this abnormal arch form might not truly represent the location of the average positions of the remaining teeth of the arch. In this particular case the arch is narrow and pointed. To visualize the teeth in good arch form, it is necessary to picture mentally the widening of the cuspid areas and the retraction of the central incisors about 2 mm. Therefore, as described in the preceding paragraph and for the same reason, we write 2 in the minus side of the box, cross out the 13, and replace it with 11 (Fig. 5).

Now we look at the box marked "lower arch + and –." The arch length discrepancy of this case is + 1. It should be marked on the plus side, opposite the word "discrepancy." The amount of expansion that can be accomplished and maintained for this particular case is now estimated. We must remember that when the narrow, peaked arch form was changed to a flatter one, the arch was already expanded laterally. I would therefore say that no further expansion can be achieved and would record 0 opposite the word "expansion."

How much will the arch length be decreased by moving the incisors from 11 mm. back to 4 mm.? The answer is 14 mm., for moving the incisors back this 7 mm. shortens the arch length 7 mm. on the left side and also 7 mm. on the right side, for a total of 14 mm. We record this on the minus side opposite "relocation $\bar{1}$."

How much arch length can be gained *and held* by erecting or by bodily moving the lower first molars backward?[2] Let us say that in this case there is no evidence that these teeth have drifted forward of their normal positions. However, the case does present an excessive curve of Spee, and we will estimate that each molar crown will be erected and moved backward 0.5 mm. when the curve of Spee is flattened to what would be considered normal for it. This will gain approximately 0.5 mm. on each side, or 1 mm. for both sides combined. Hence, we mark 1 mm. on the plus side for "relocation $\bar{6}$."

This is a Class II malocclusion. We will arbitrarily estimate that if it is treated in the orthodox manner with intermaxillary rubber bands, and if this is done in a skillful manner, each lower first molar will come forward in the mandible about 2 mm. Considering both sides, this will shorten the arch length 4 mm., so we mark 4 on the minus side opposite "intermaxillary."

Shall we extract? Let us look at the score so far. We have a total of 2 on the plus side and 18 on the minus side. That gives us a net score of minus 16 mm. If we extract, we will create approximately 15 mm. of space in the arch. If we close it by orthodox methods, exclusive of extraoral anchorage we will lose about one-third of this gain by bringing the molars forward.

This means that extracting would give us a net gain of 10 mm. of arch length. Certainly, we need this space, so we will extract. Therefore, we mark 15 on the plus side and 5 on the minus side. (It is possible that we cannot afford the luxury of closing the space in the orthodox manner but must resort to other means to save this expenditure of 5.)

As the matter now stands, even after we have extracted we still have a total net figure of minus 6. That means that, using the orthodox methods of treatment alluded to, we must either be satisfied with finishing the case with the lower incisors 3 mm. too far forward (6 mm. ÷ 2 sides = 3 mm.) or resort to other methods of treating it.

Let us review our figures and see where we might gain or save these 6 mm.

Arch discrepancy: We could strip or cut down the size of the teeth. I would consider that to be out of the question for this case.

Expansion: We could expand the arches. We had decided that this should not be done, however, for the reason that they probably would not stay expanded.

Relocate $\overline{1}$: We could, of course, leave the lower incisors 3 mm. forward of the positions planned for them. That would do it, but we want the lower incisor at 4 mm., not 7 mm.

Relocate $\overline{6}$: That would be a nice way to do it. It would mean moving each lower molar backward 3 mm., and it undoubtedly could be done. The question is: Does the molar belong behind where we found it and, if not, will it stay behind its rightful place? Until we have more evidence to answer this question, let us look elsewhere for an answer to our problem.

Intermaxillary rubber ligatures: Here is a place where we can save 4 mm.—just do not use intermaxillary ligatures but use extraoral anchorage instead and/or "anchorage preparation," which involves the use of extraoral anchorage and Class III ligatures to store anchorage in the mandible in preparation for using the Class II ligatures.

Extraction: We had planned to close the spaces provided by the extractions in the "orthodox" manner, using intraoral anchorage for the purpose. We cannot afford it. We can use intraoral anchorage to close some of it (until we lose 2 mm. of arch length, which means that each molar drifts forward 1 mm.). After that, the anchorage must be developed outside the mouth and either be used directly for the purpose or stored as "anchorage preparation."

ANCHORAGE PREPARATION

Charles H. Tweed, who deserves credit for popularizing the term "anchorage preparation"[7] and for pointing out its benefits, says, in effect: "Anchorage preparation is the placement of the anchorage teeth into such positions of advantage as will best resist pull upon them." Let me add that anchorage preparation

can also be said to be such placement of the anchorage teeth as will result in their being in the desired places for them after they have been used for anchorage. This generally means carrying the anchor teeth back beyond their desired permanent positions far enough to offset what they will lose when used for anchorage.

Let us now determine where the incisor and the molar should be, *before* they are pulled upon for anchorage, in this particular case. We will consider the lower incisor first. We want it to be finally placed 4 mm. in front of the line NB. If it is to be pulled forward 2 mm. by the Class II intermaxillary ligature (loss of anchorage), then it should be prepared for this loss by placing it 2 mm. back of its final position (4 mm. − 2 mm. = 2 mm.). The position of the lower incisor at the time anchorage preparation is completed is 2 mm. We record this at *L* on the diagram provided for this purpose, which can be identified by the $\overline{6}$ and the two arrows (one pointing forward and one pointing backward). The lines above the $\leftarrow 6 \rightarrow$ are for the incisors, and those below it are for the molars.

Let us consider now the anchorage preparation position of *one* lower first molar. Ignoring all else, how far would each molar have to be moved to correct the crowding or the spacing of the teeth anterior to them? The arch length discrepancy of this case is + 1. Therefore, *each* molar conceivably could come forward 0.5 mm. because of this space. This is recorded under the arrow pointing forward. We have envisioned the teeth in good arch form and in contact; if we were to move the incisor from its adjusted original position of 11 mm. to the estimated position in anchorage preparation of 2 mm., how far would the molar have to be moved to stay out of the way? Subtracting 2 mm. from 11 mm., we find that the molar would have to be moved backward 9 mm. This is recorded under the arrow pointing backward. Obviously, this is impractical; therefore, we extract.

Again considering only a single principle, how much room would the extraction of a premolar provide for the molar to move forward? We estimate the width of the average lower first premolar to be 7.5 mm. The answer, therefore, is 7.5 mm., which is recorded under the arrow pointing forward. The net answer to the two columns is 1 mm. on the distal side. This means that at the time the anchorage preparation is complete, and with the premolar space closed, the molar should be 1 mm. distal to its original position.

Let me restate the problem of the molar in terms that may seem simpler. The space provided by the arch discrepancy (0.5 mm. on a side) plus the space provided by extraction of the premolar (7.5 mm. on a side) is 8 mm. The incisor is to be retracted 9 mm. This means that the combined spaces of 8 mm. will provide 8 mm. of the needed space and the other 1 mm. must be provided by moving the molar back that distance. This is its position at the time anchorage preparation is complete. In other words, in this position the molar is placed far enough back of its permanent position to offset what it will lose in position when it is used for anchorage.

RESULTS ACHIEVED

Our goal for the anchorage preparation for this case is shown in Fig. 5. The tracing in Fig. 8 shows the case with the anchorage prepared and ready for Class II intermaxillary rubber band therapy.

Our goal for the treatment of the case at the end of treatment is also shown in Fig. 5 and is captioned "treatment goal individualized." The tracing in Fig. 9 was made at the time the bands were removed. Notice the incisor and molar lines that record where these teeth were formerly located. These lines are described in my article entitled "Cephalometrics in Clinical Practice."[6]

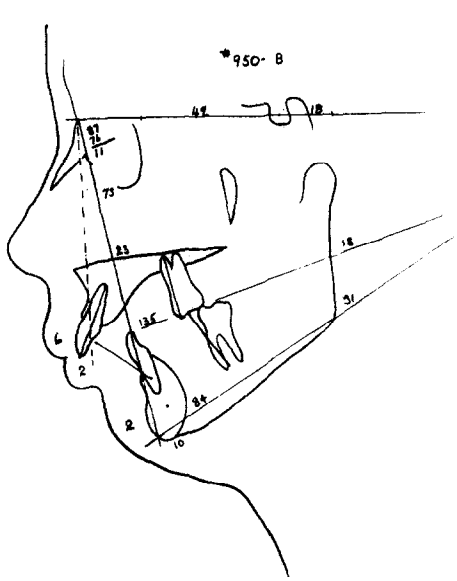


Fig. 8.—The anchorage preparation.

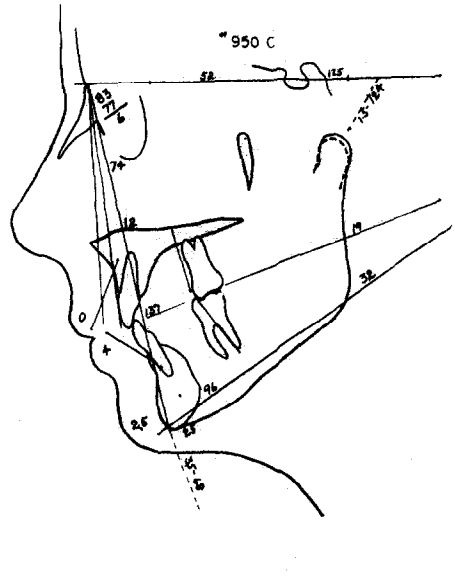


Fig. 9.—At the end of treatment.

The models and the photographs of the case at this time are shown in Figs. 10 and 11. Fig. 12 shows the case one year after treatment and Fig. 13 shows it five years after treatment.

CONCLUSION

The foregoing case was treated some years ago with Angle's edgewise appliance. Full use was made of the principles of anchorage preparation and subsequently of Class II rubber ligature pull.

Treatment consisted of stabilizing the maxillary teeth with the edgewise appliance on the buccal teeth, the use of a palatal plate in an attempt to gain some stability from the palate, and the generous use of a neck strap and a Kloehn type of face-bow with the outer bow aligned high to resist further the displacement of the maxillary teeth.

Against this maxillary anchorage, Class III, rubber ligatures were used to move the mandibular teeth to positions of "anchorage preparation" which, to my mind, means positions of advantage not only to resist rubber pull but

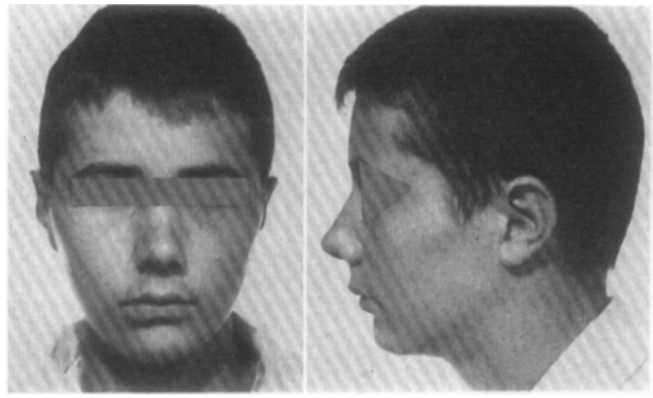


Fig. 10.—After treatment.

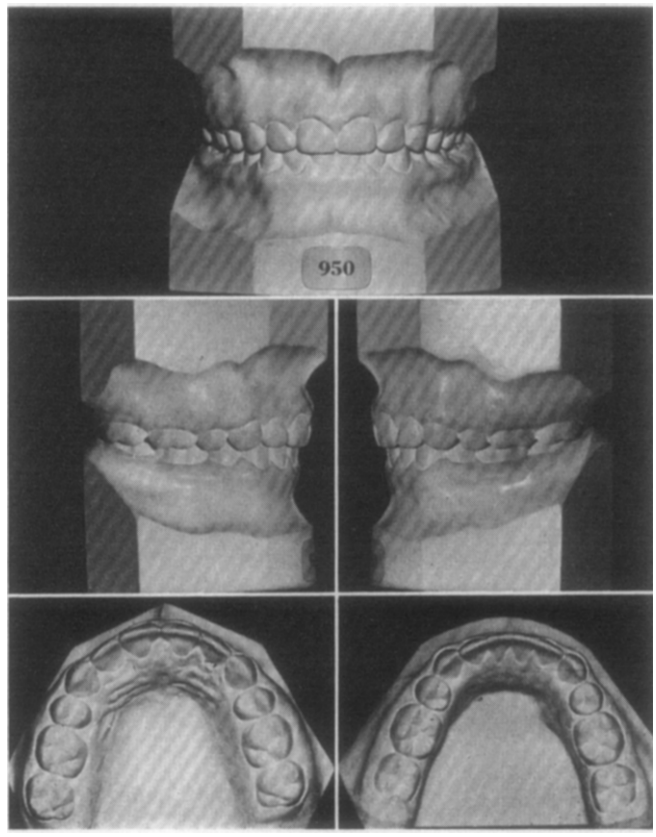


Fig. 11.—After treatment.

also to result in their correct positions after they have been subsequently pulled upon by the Class II rubbers. This means that the mandibular teeth were moved 2 mm. too far distally and then brought forward to their correct positions as a result of wearing the Class II rubber ligatures.

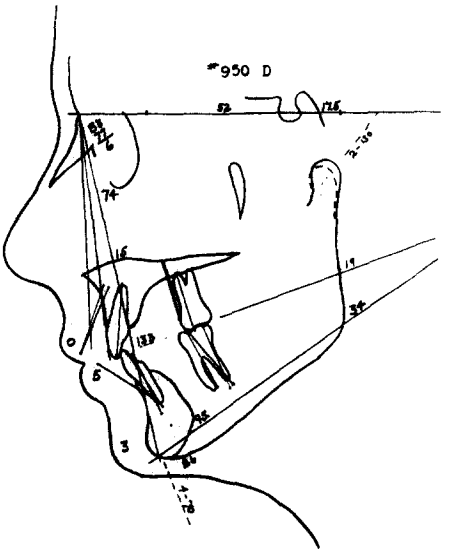


Fig. 12.—One year after treatment.

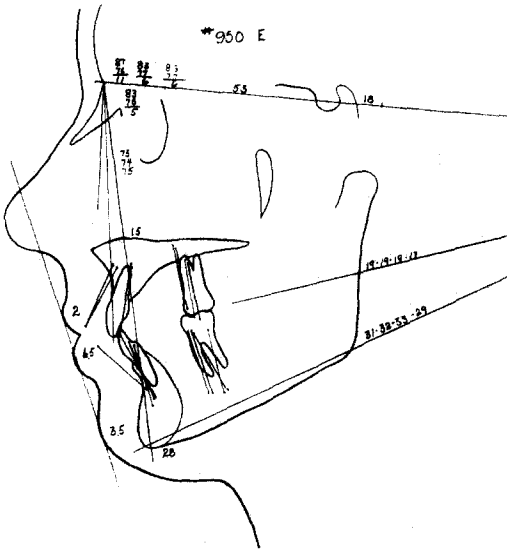


Fig. 13.—Five years after treatment.

In view of evidence seen in cephalometric headplates and from other clinical observations, both Dr. Lang and I believe that it is also possible to treat cases of this type to advantage by positioning the mandibular teeth where they should be by the methods just described and then maintaining them there while the Class II discrepancies are treated by extraoral anchorage. We know of no evidence that mandibles treated in this way show less indication of growth than mandibles that have been subjected to vigorous Class II rubber ligature pull. We definitely do not believe in "jumping the bite." The study of cephalometric headplates is giving proof of the value of some of our orthodontic treatment methods. In some instances it is changing them.

We believe that this method of analysis does assist in treatment planning and in assessing changes that take place naturally and as a result of treatment. For treatment planning, it expresses problems so that they can be easily observed and therefore understood. It helps to make such decisions as when to extract and when not to extract, and it gives an indication of what to extract. It helps to evaluate the results of different types of treatment—for instance, intraoral versus extraoral, stationary versus simple anchorage, and light forces versus heavy ones.

Orthodontics is now going through a period of rapid change. We believe that cephalometrics is an important factor in bringing these changes about, and we hope that this method of using cephalometry is contributing to that end.

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