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ORIGINAL ARTICLES

Directional forces

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This project was started some time ago by our study club, and we want to emphasize that this is a joint effort by the membership. The club is composed of Gale E. McArthur of Ponca City, Herbert A. Klontz of Oklahoma City, James F. Gramling of Jonesboro, Arkansas, Charles M. Taylor of Abilene, Texas, and the two of us. We became interested in the direction of force application as applied with orthodontic headgear.

Headgear is used in orthodontics to provide a direction to the forces used. A technique without a headgear is like a ship without a rudder. It sails along the path of least resistance, with never a thought to where it is going. We can imagine an individual treatment without headgear but not an entire technique. However, the use of just any headgear will not ensure a stable and successful treatment. In this article we intend to discuss not only the action of the different headgears but also the reaction of the patient. Many of these reactions were concurrent with the advent of the cervical face-bow. These are the things that we generally blame on the patient's lack of cooperation or the patient's growth pattern. Specifically, we are speaking of (1) relapse of Class II cases, (2) lack of facial improvement, (3) difficulty of reducing ANB, (4) upper second molar problems, such as impaction, eruption into buccal crossbite, or extraction of second molars, (5) torque of upper incisors, (6) a "toothy" smile caused by extrusion of upper incisors below the normal posture of the upper lip, and (7) mandibular rotation.

These are the things that indicate what is often called a *Kloehn reaction.* We will refer to it as a *cervical face-bow reaction.* Fig. 1 illustrates the condition. It is neither the best nor the worst, but it does have many features common to the use of the cervical face-bow.

Fig. 1 shows the side view of the models of a Class II, Division 1 case (207).

Read before the Middle Atlantic Society of Orthodontists, Williamsburg, Va., Jan. 15, 1968.

Fig. 1

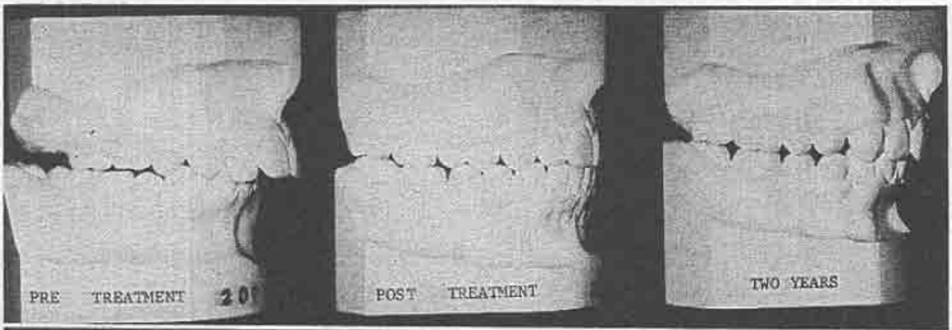


Fig. 2

The occlusal view of the lower models of this case and a tracing of the original head film are shown in Figs. 2 and 3. With a low FMA, this was thought to have a good growth potential. The model analysis showed a good lower arch with mild crowding of the incisors and a small amount of leeway space because of the size discrepancy between the second premolar and the second deciduous molar. In view of the growth potential and the lack of crowding, it was decided to treat this case by (1) correcting the molar relationship with the cervical face-bow and (2) banding the remaining teeth to complete the treatment.

After the face-bow had been worn for 7 months, the molar relation was corrected. Fig. 4 shows the superimposition of the 7-month head film upon the original film. The films were superimposed upon the sella-nasion plane at sella. This reveals that very little growth has occurred. In 7 months nearly all the changes can be attributed to treatment. These changes include a downward tipping of the palatal plane, the occlusal plane, and the mandibular plane. Although point A has been recontoured distally, point B has moved downward and back, resulting in a lack of facial improvement. There is a general downward and backward rotation of the lower face. Maxillary superimposition showed extrusion of the upper denture (Fig. 5). The upper molar was extruded 4 mm. These are undesirable changes which definitely should not be encouraged with treatment. Incisor extrusion makes retraction and torque doubly difficult. Upper molar extrusion makes correction of the molar relationship more difficult, since the lower molar moves distally as the upper molar is extruded. One should not encourage extrusion of the teeth with orthodontic treatment.

The results of 26 months of treatment and growth are shown in Fig. 6. There is a small amount of forward growth of the upper part of the face. The lower face has not moved forward. Point A has been recontoured distally and point B has moved downward. The palatal plane and the mandibular plane have rotated downward and back, with a 3 degree opening of the mandibular plane.

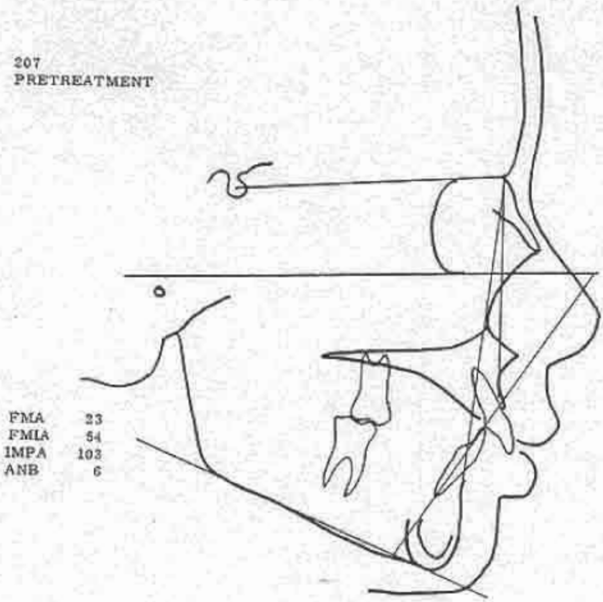


Fig. 3

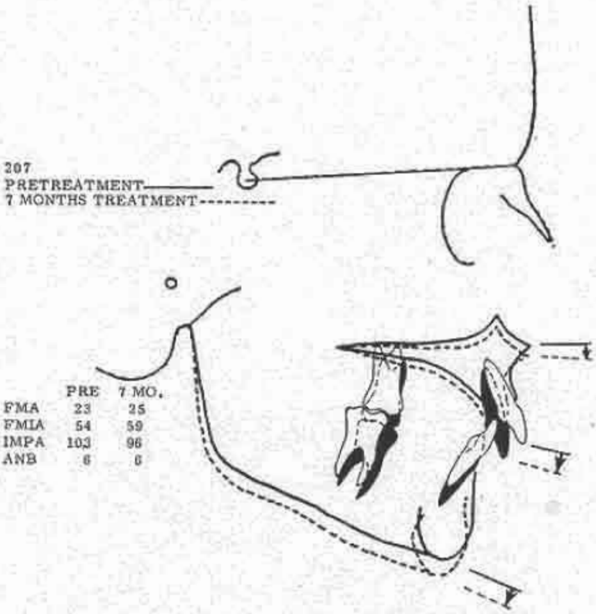


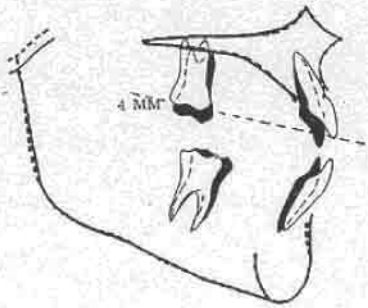
Fig. 4

Superimposition on the palatal plane (Fig. 7) shows that the 4 mm. upper molar extrusion has remained. Although Class II elastics were not used, the lower molar has migrated mesially 3 mm. and the lower incisor is tipped forward slightly.

In reviewing this treatment, it should be noted that the lower part of the face has not come forward, as would be desirable in a Class II case. Another feature is the amount of extrusion of the upper molar. Molar extrusion is undesirable, not only because it results in mandibular rotation but also because

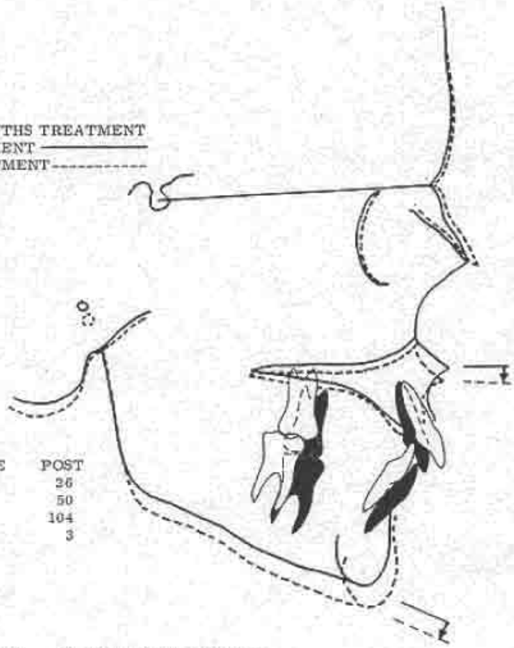
207
PRETREATMENT ————
7MONTHS TREATMENT - - - - -

Fig. 5



207 26 MONTHS TREATMENT
PRETREATMENT ————
POST TREATMENT - - - - - - - - - -

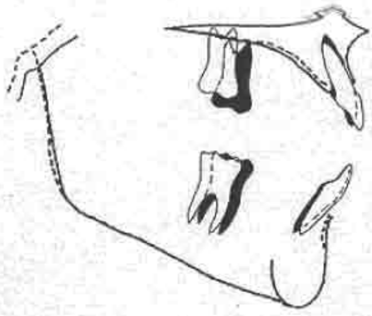
Fig. 6



	PRE	POST
FMA	23	26
FMIA	54	50
IMPA	103	104
ANB	6	3

207 26 MONTHS TREATMENT
PRETREATMENT ————
POST TREATMENT - - - - - - - - - -

Fig. 7



it moves the molar into the freeway space. Even 1 mm. of molar extrusion causes this tooth to encroach upon the freeway space. Teeth should not enter the freeway space, for this results in a premature contact of these teeth upon closure of the mandible. Thompson[4, 5] has defined a premature contact as "a contact of one or more teeth occupying the freeway space." According to him, "These teeth have an abnormal amount of mobility and frequently become sore." Schuyler[3] states: "Malocclusion can cause stretching or tearing of the ligaments surrounding the joint. This is due chiefly to premature contacts of the posterior teeth." All of the available information indicates that extrusion of the molars into the freeway space is an extremely dangerous procedure and that it can result in injury to the teeth or the joint.

Two years after treatment a third set of records were taken, and the results are shown in Figs. 1, 2, 8, and 9. The models show a relapse of the molar rela-

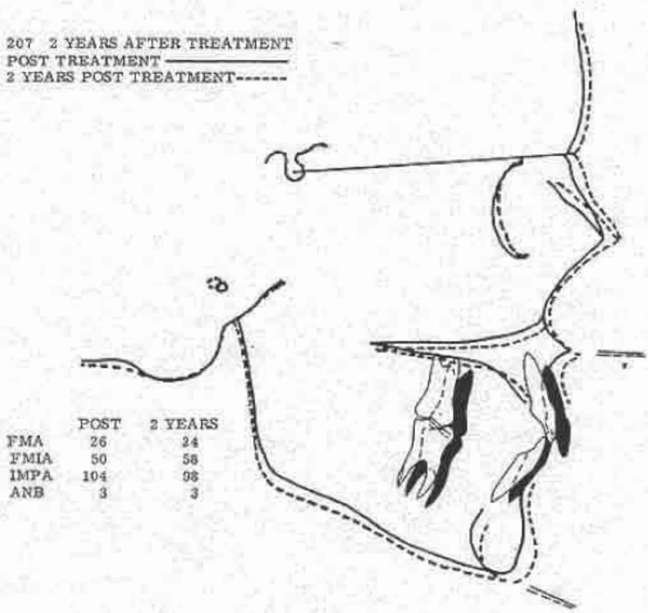


Fig. 8

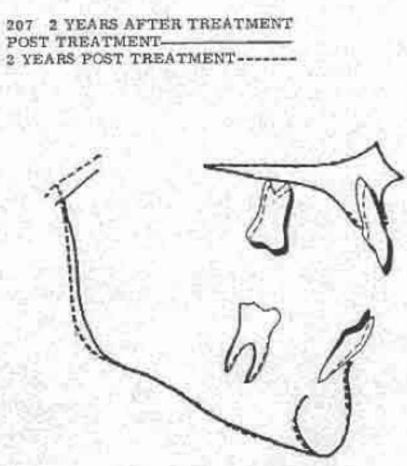


Fig. 9

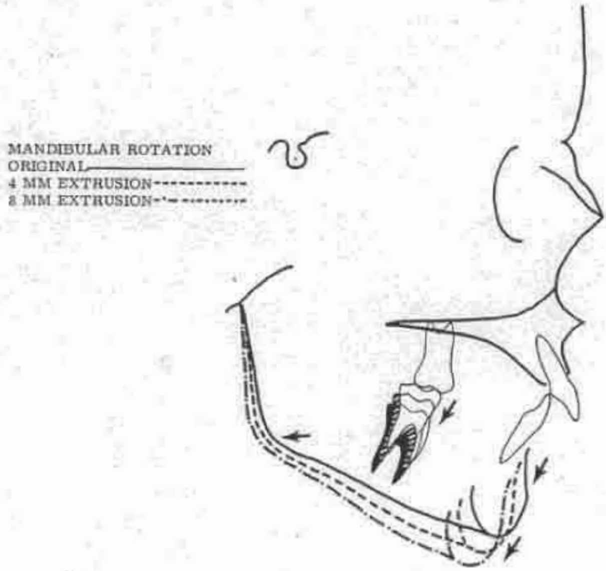


Fig. 10

tion, deepening of the bite, and crowding of the lower anterior teeth. Fig. 8 shows that growth has been predominantly forward for both upper and lower face. Point A and point B have moved forward. The palatal plane and the mandibular plane have closed slightly, with the FMA closing from 26 degrees after treatment to 24 degrees 2 years later. This is opposite to those changes occurring during treatment, as the lower part of the face was rotated downward and back.

Fig. 9 reveals that the upper molar has moved mesially, resulting in a relapse of the molar relation. The lower central incisor has uprighted some 6 degrees, resulting in a crowding of the lower incisors. In reviewing this case, it can be stated that the treatment result was not stable. Also, treatment with the Kloehn cervical face-bow distorted the lower part of the face in a downward and backward direction. Both of these features are common following use of the cervical face-bow and can be even more severe when this appliance is used in medium- and high-angle cases.

When the upper molar is extruded, it results in the mandible swinging open to accommodate the extra length. As the mandible opens, it rotates downward and back. This is called mandibular rotation. The effects of upper molar extrusion and mandibular rotation may be seen in Fig. 10, which shows a tracing of a Class II case, with the mandible opened artificially 4 mm. and 8 mm. about the hinge axis.

These effects are comparable to those of cervical face-bow treatment. The mandible rotates downward and back. Point B and pogonion move downward and back. The lower first molar moves downward and distally, making the molar correction that much more difficult. The gonial angle moves in a posterior direction. As the gonial angle moves posteriorly, it alters or changes the relationship of the muscles of mastication. This may reduce the power of these muscles, thereby allowing further mandibular rotation.

Table I. Mandibular rotation

	Centric	4 mm. extrusion	8 mm. extrusion
FMA	23°	26°	30°
FMIA	57°	54°	50°
IMPA	100°	100°	100°
ANB	6°	8°	9°
$\overline{6}$ distal movement	0	2 mm.	4 mm.

The effects of mandibular rotation are summarized in Table I. Although the lower central incisor has not moved, the FMIA, FMA, and ANB are worsened by mandibular rotation. The lower molar moves distally as the mandible rotates. These effects were measured and may be summarized as follows:

1. For each millimeter of extrusion of the upper first molar there is a 0.75 degree opening of the FMA.
2. For each millimeter of extrusion of the upper first molar, there is a 0.5 degree increase in ANB.
3. For each millimeter of extrusion of the upper first molar, there is 0.5 mm. distal movement of the lower first molar.

These computations were made for one specific case and would not be the same for every case. If the mandible were longer from hinge axis to pogonion, the situation would be less severe. For a shorter mandible, the results would be more severe. However, the trend is the same. Extrusion of the upper molars is equal to downward growth of the maxilla. Downward growth of the maxilla is equivalent to forward growth of the maxilla. It is of the utmost importance that we do not stimulate this downward growth or extrusion of the maxillary teeth with orthodontic force.

Let us give some thought to the desired direction of tooth movement in a Class II case. Which direction should the anterior teeth be moved? By looking at Fig. 11, we can see that the upper incisors should be retracted and intruded. They should not be extruded as they were in the face-bow case. To correct the molar relation, we will need distal movement of the upper molar to the extent of 7 mm., which is the approximate width of a premolar tooth.

If this is not done the lower molar must move mesially 7 mm. Growth will not correct molar relations. We have often heard that cervical traction with the face-bow will retard the growth of the maxilla while the mandible grows forward into a Class I relation. This would be a wonderful idea if it worked. For it to be true, there would have to be at least 7 mm. of growth in the mandible, there must not be any forward growth of the maxilla, and there must not be any downward growth of the maxilla.

In studying head films of face-bow treatment, we just do not find cases that meet these specifications. The fact is that there is rarely more than 5 mm. of horizontal growth of the mandible within a 2-year treatment period. Ricketts[2] found that the average Class II case has 4.5 mm. of condylar growth during

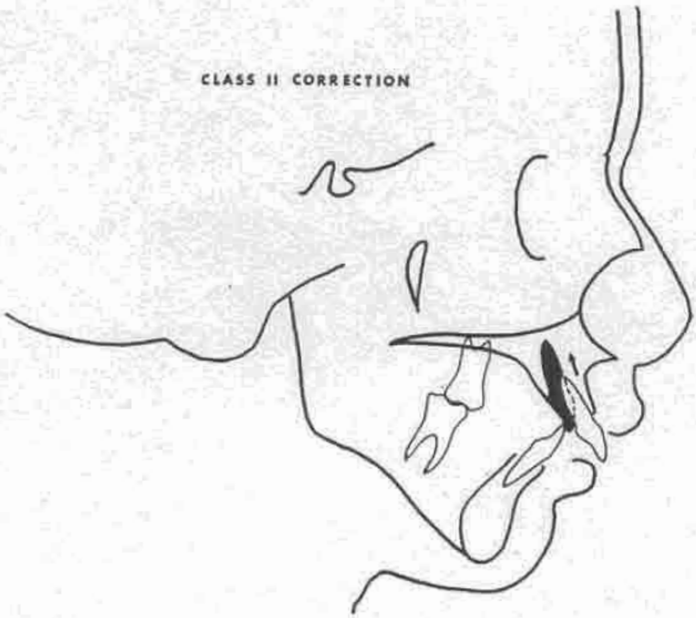


Fig. 11

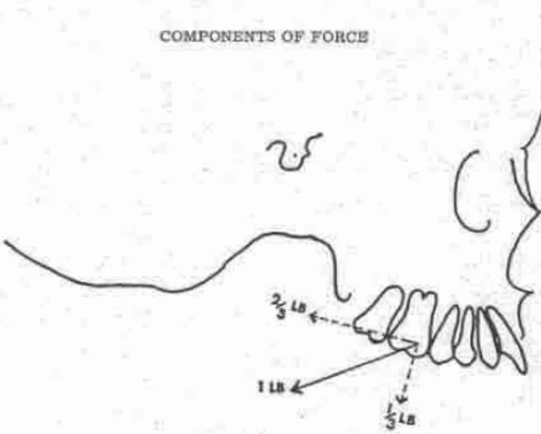


Fig. 12

treatment. Mandibular growth is neutralized by approximately the same amount of downward, forward growth of the maxilla, and the jaw relation remains the same. The only thing that has changed is the dental relationship, and this is due to the movement of teeth in either or both arches. Moving the upper molars distally does not provide longer arch length; it simply transfers the discrepancy from the anterior segment to the posterior segment.

There is some evidence that the cervical face-bow causes a high percentage of downward, backward growth patterns. Moore[1] found, in 1959, that 54 per cent of a treated group grew either downward or backward and that 46 per cent grew forward. This group was treated with the face-bow. In the control group, which had no treatment, 88 per cent grew forward and 12 per cent grew downward. Without the face-bow, 10 per cent of the group had downward growth of the mandible. With the face-bow, half of the group grew downward or backward. If half of the cases treated with the Kloehn face-bow have a downward

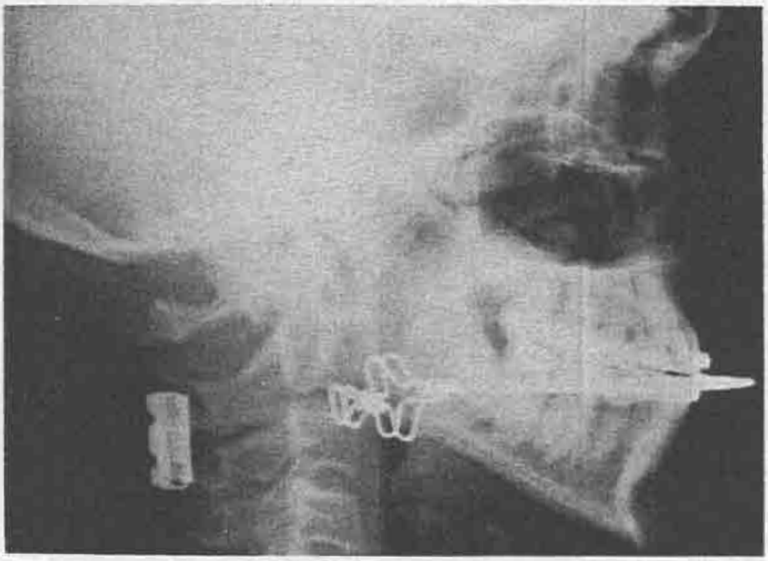


Fig. 13

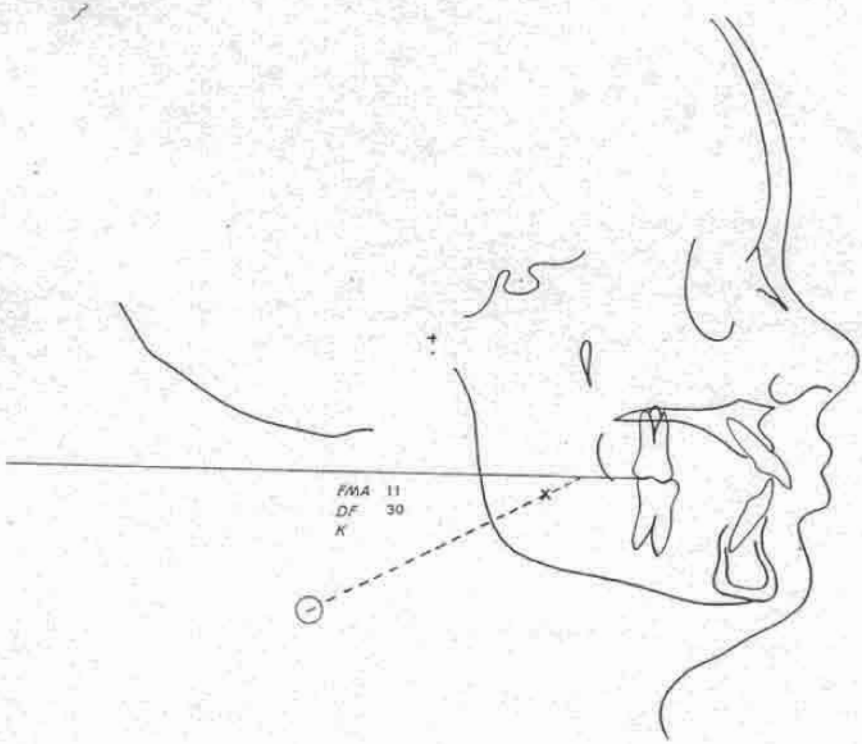
or backward growth direction, then we must question the use of this directional force.

At this point, one has to wonder about the "action" of a device that causes such a profound "reaction" in the patient. A few head films were obtained with the face-bow in place. Fig. 13 shows that the occlusal plane, if extended in a posterior direction, would pass through the first cervical vertebra. On the other hand, note the level of the neck strap. It is at the height of the second and third cervical vertebrae. The neck strap is not as consistent as the occlusal plane, but it is usually between the second and fourth cervical vertebrae. Since the neck strap is below the occlusal plane, it is pulling downward, across the occlusal plane. It was immediately clear that the directional force of the cervical face-bow was dependent upon two factors: (1) the cant of the occlusal plane and (2) the height of the neck strap on the patient. The occlusal plane varies considerably from patient to patient and roughly follows the FMA. A steep FMA will have a fairly steep occlusal plane. The height of the neck strap also varies from patient to patient and is governed by the shape of the back of the neck. Thus, it was found that the directional force has quite a bit of variation, even among patients with the same FMA. Head films were taken of approximately 200 patients with various headgears in place. Tracings of these films were made, and the direction of pull of the headgear was measured to the occlusal plane.

In Fig. 14, the occlusal plane is represented by the solid line and the direction of headgear pull is along the dotted line. The angle between the two is the directional force (DF). In this case, with an FMA of 11, the DF is 30 degrees.

Of the face-bow sample, the FMA ranged from 11 to 43. The directional force ranged from 20 to 37 degrees. From examination of this tracing, it can be seen that the cervical face-bow has a directional force which is at an angle to the plane of occlusion. The directional force is below the plane of occlusion and at approximately 30 degrees.

Fig. 14



The solid arrow shown in Fig. 12 indicates a directional force of 30 degrees and 1 pound of pressure. The directional force may be divided into its components. These are the two dotted arrows. One arrow extends distally and one occlusally. The distal component is ⅔ pound and the occlusal component is ⅓ pound. Therefore, the action of the face-bow is to exert a distal force and an extrusive force on the maxillary molar. Both forces are damaging to the dentition and are the reasons for the reactions discussed earlier. One of these reactions was the tipping of the occlusal plane. As the occlusal plane rotates down and back, the directional force changes. Remember, the directional force (DF) is dependent on the cant of the occlusal plane. Therefore, the action of the Kloehn face-bow is progressively worse with each bit of reaction caused by the device.

The next thing to consider is the action of the cervical face-bow upon the growing patient. For this part of the study, a dry skull was selected and brass wire was placed in the primary growth sutures of the maxilla (Fig. 15). For reference, *Sicher's Oral Anatomy* was used.

A head film was taken and traced and the primary growth sutures were outlined in red (Fig. 16). Starting from the back, the pterygopalatine suture's growth is in a posterior direction. Next the zygomaticomaxillary growth is in a posterior and upward direction. The frontomaxillary growth is posteriorly and up. If the effects of these growth sites are combined it tends to move the maxilla downward and forward in relation to the rest of the skull.

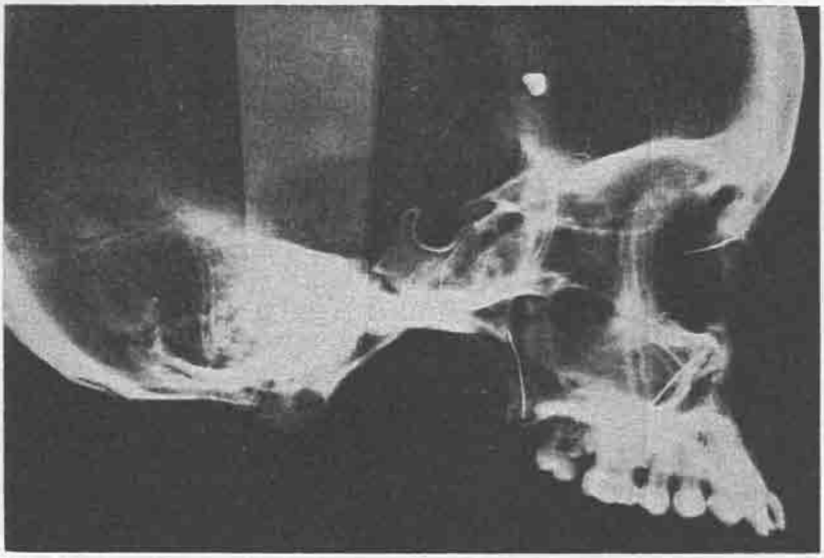


Fig. 15

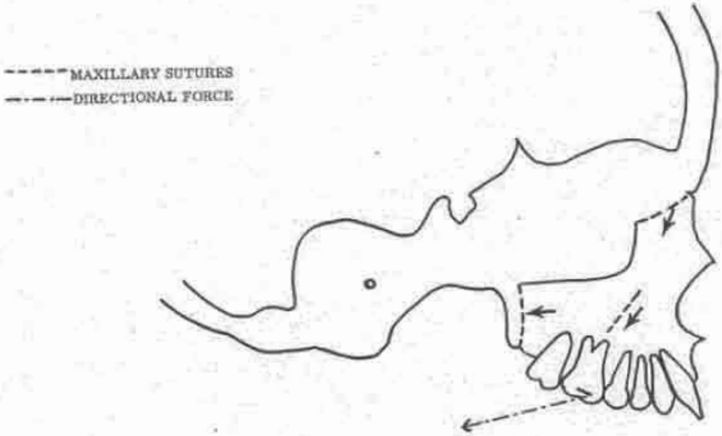
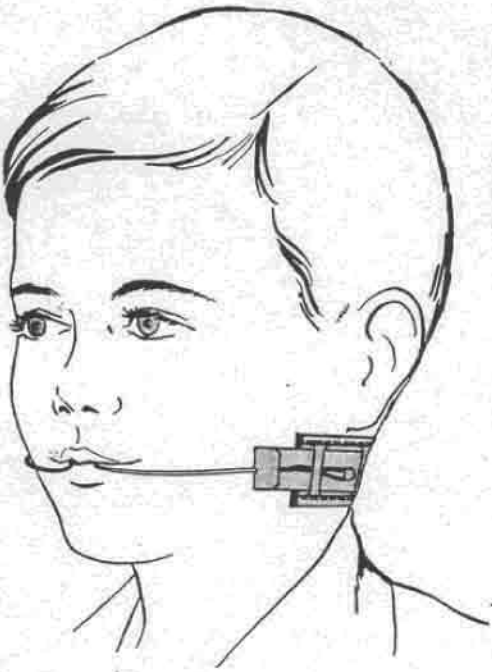


Fig. 16

Let us assume for a moment that a cervical face-bow is placed on a growing patient with a DF of 30 degrees. What effect would this have on the growth sutures? Again, starting from the back, the headgear causes a compression of the pterygopalatine suture. The zygomaticomaxillary suture exhibits a shearing action and the frontomaxillary suture is placed under tension. To put it briefly, the maxillary denture is moving downward and backward. This opposes the forward growth and enhances the downward growth. Thus, the undesirable action of the cervical face-bow may be described as follows: (1) It enhances downward movement of the maxillary denture. (2) It moves the maxillary teeth distally. (3) It causes mandibular rotation.

There is the concept that extraoral traction has some influence on growth direction. If this is true, then the Kloehn face-bow should not be used, as it

Fig. 17



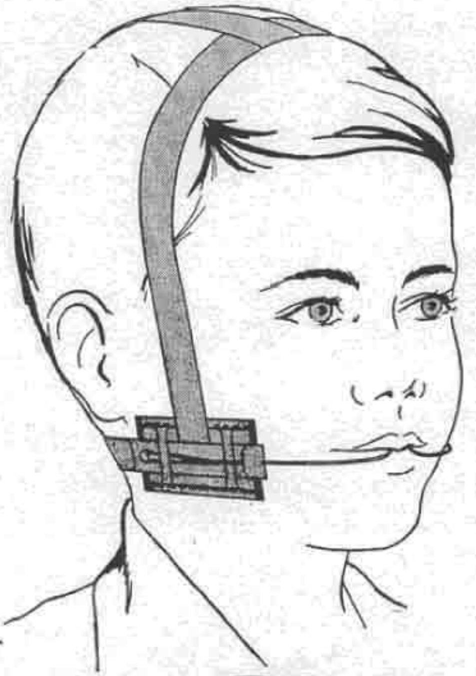


Fig. 18

Fig. 19

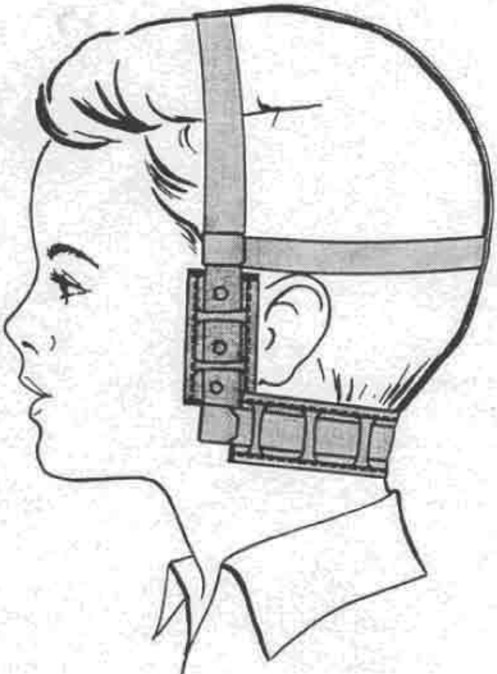


Fig. 20

stimulates downward growth. If the face-bow has no influence on growth, then the device has no value for the growing child.

If the face-bow has no value, this raises a question about the action of the other types of headgear in common use by the orthodontist. Head films were obtained of patients wearing the different types of headgear. Fig. 17 illustrates what we term *cervical headgear,* which is attached to hooks on the arch wire. Several head films were made with the cervical headgear in place. In Fig. 21, note that the level of the neck strap is approximately the same as with the cervical face-bow. Tracings were made and the directional force was measured; the average DF was 25 degrees (Fig. 22). The directional forces in this series have more acute angles than those of the face-bow. This is due to the fact that the headgear is attached to the anterior part of the arch wire. Note that the direction of pull is downward, across the occlusal plane. Although the angles are slightly smaller, the cervical headgear action is very similar to that of the face-bow except for its point of attachment on the dentition.

Moving a little higher, the next headgear is the straight-pull type (Fig. 18), which is similar in construction to the cervical headgear except that it has a strap over the top of the head. This allows the direction of pull to be raised several degrees above the cervical headgear. There is some adjustment possible in the level of the neck strap.

In Fig. 23 the neck strap is at the level of the second cervical vertebra and slightly higher than the two previous types of headgear. Anteriorly, it may be attached to hooks on the arch wire, to the arch wire interproximally, or to sliding jigs. Fig. 24 shows a tracing of the average directional force for the straight-pull headgear.

The DF ranged from a low of 2 degrees to a high of 19 degrees, with an average of 7 degrees. The lower DF's, or those below 10 degrees, have a very good action. They are almost parallel with the occlusal plane. With those DF's above 10 degrees, an effort should be made to adjust the headgear so that the neck strap is as high as possible.

Fig. 19 shows a recent development in orthodontics. Some call it the high-pull headgear; others call it the variable-pull face-bow. The latter term is preferred, as the direction of force may be varied by using different buttons on the headgear.

With the headgear in place (Fig. 25), it may be noted that the direction of pull is upward and posterior at an angle to the plane of occlusion.

The DF in this series ranged from a high of 49 degrees to a low of 29 degrees. If this force were broken down into its components, the DF of 47 degrees would direct half of its force distally and the other half in an intrusive direction. The DF of 29 degrees would direct two-thirds of its force distally and one-third in an intrusive direction. The variable-pull face-bow might have a limited usefulness in a Class II case with an open-bite. The intrusive action would tend to depress the posterior segments, allowing the bite to deepen anteriorly. For the balance of Class II cases, it is contraindicated because intrusion is needed in the anterior rather than the posterior segment.

The last headgear is the high-pull one shown in Fig. 20, the head film of

Fig. 21

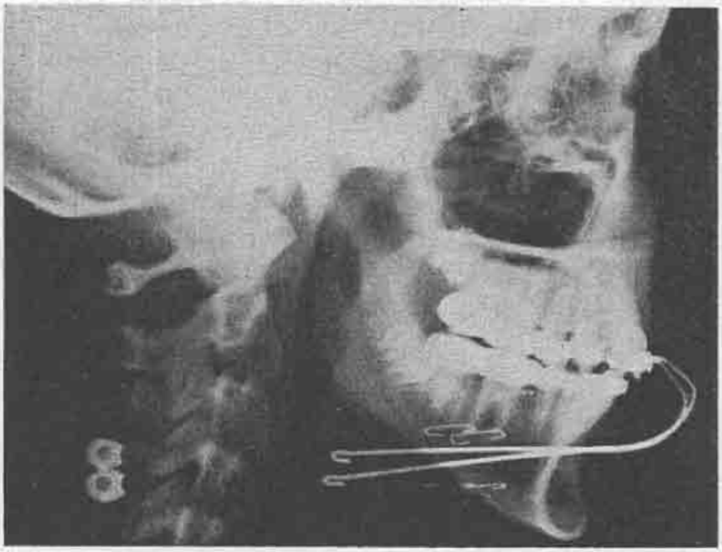
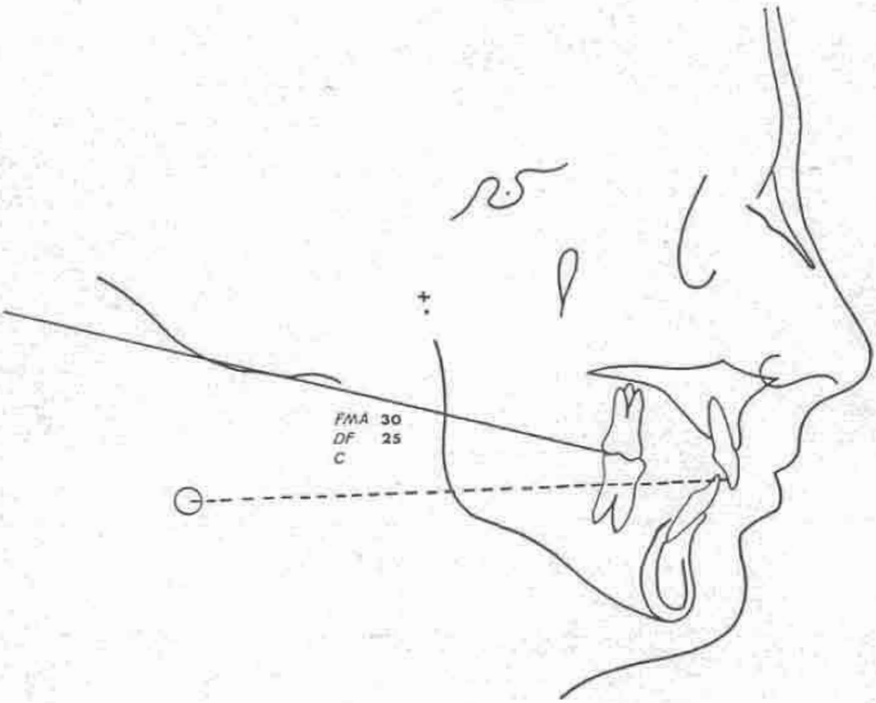


Fig. 22



which is shown in Fig. 26. The high-pull headgear is attached to hooks soldered on the arch wire. The best position for these hooks is just distal to the central incisors and gingival to the arch wire. It may be noted that the direction of pull is upward and back against the upper anterior segment. The action tends to intrude and move this segment distally. The DF in this series ranged from a high of 37 degrees to a low of 30 degrees. The average DF is approximately

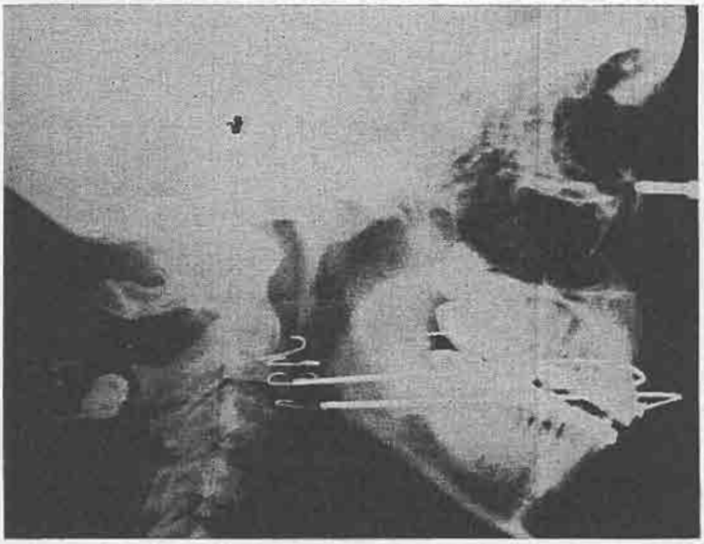


Fig. 23

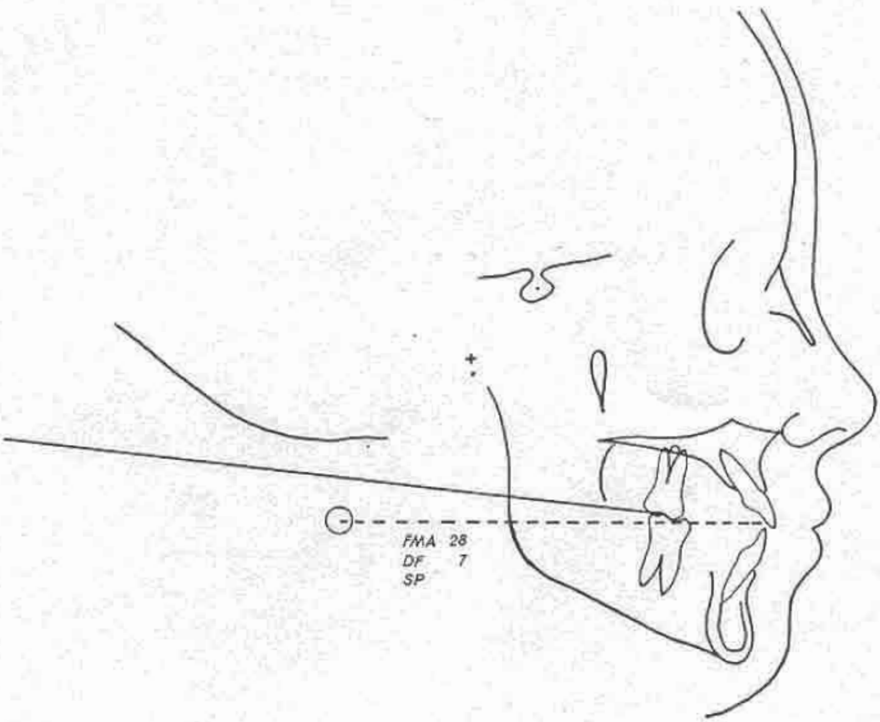


Fig. 24

34 degrees. The component forces would be about one-third intrusive and two-thirds distal. This is an excellent action for a Class II deep-bite case.

If it is necessary for a growing child to wear a headgear for an extended period of time, the high-pull headgear has a better action than any other. (See Fig. 27.) It exhibits good growth control by compression of all three of the primary growth sutures of the maxilla.

Fig. 25

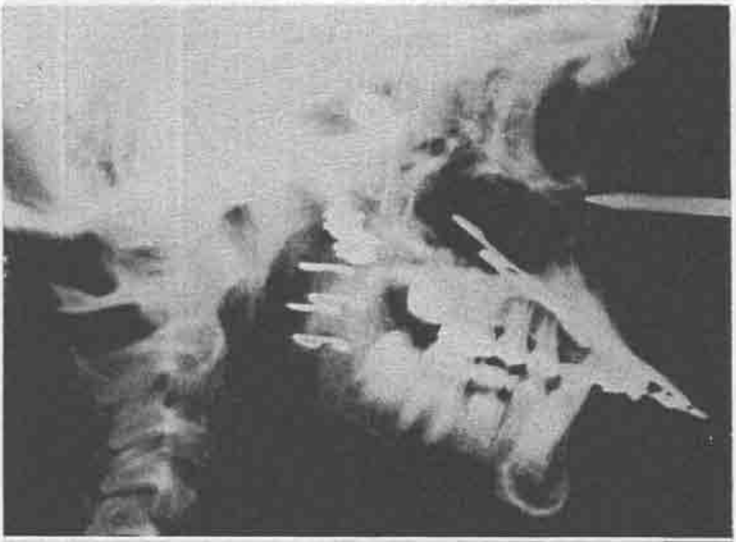


Fig. 26

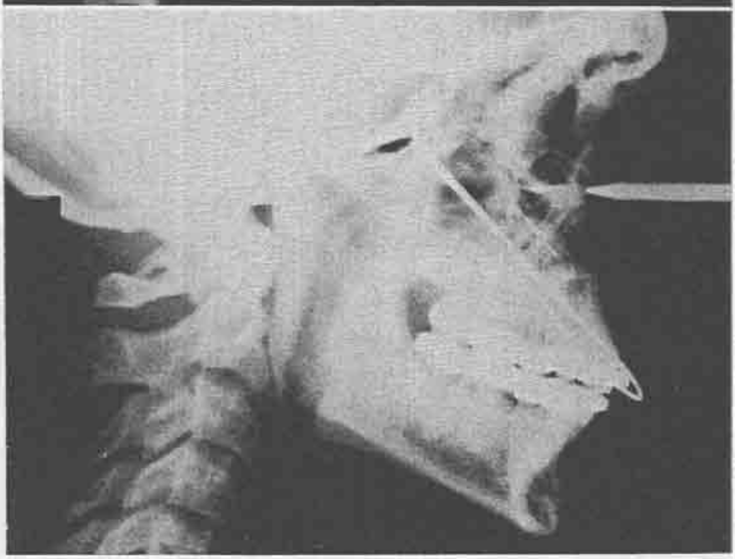
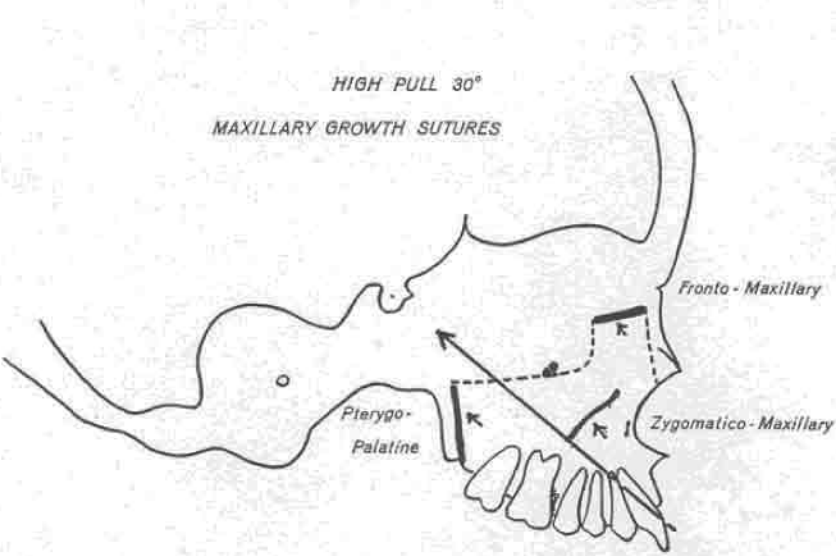


Fig. 27



Conclusions on various forms of headgear

The *cervical face-bow* has a directional force (DF) that is approximately 30 degrees *below* the occlusal plane, and its undersirable effects are in direct proportion to the length of time it is worn. Any utilization of this directional force must be confined to short periods during orthodontic treatment. It should not be used on the growing child for extended periods. Incidentally, we discarded a lot of our problems when we discontinued the use of the Kloehn face-bow.

The *cervical headgear* has a directional force of approximately 25 degrees below the occlusal plane. It is similar to the face-bow in directional force and action. On the maxillary denture it should be used for only short periods of time. Cervical headgear may be very beneficial in Class III cases when the headgear is attached to the lower teeth; when cervical headgear is coupled with Class III elastics, we can expect extrusion of the maxillary posterior teeth and mandibular rotation. This is a beneficial action for Class III cases.

The *straight-pull headgear* has a DF of approximately 5 to 10 degrees. It is effective in the stabilization of the upper denture in anchorage preparation and canine retraction. It can be used for longer periods of time than either the cervical face-bow or the cervical headgear hook-up, but the directional force would be harmful over a full treatment period.

The *variable-pull face-bow* has a directional force which varies with the headgear attachment. It is usually adjusted above the occlusal plane. It can be harmful in that it causes distal movement of the maxillary molars and is recommended for short periods of time only.

The DF of the *high-pull headgear* is approximately 35 degrees above the occlusal plane. It has an intruding, distal action on the upper anterior segment. It is very useful in upper anterior retraction and torque activation, it is absolutely necessary in proper application of Class II mechanics, it is excellent in overbite control, and it has the proper DF for growth control of maxillary growth suture.

Auxiliary forces

Thus far we have discussed the directional forces of headgear, but this study would be incomplete without consideration of the other auxiliary forces, such as intermaxillary elastics.

The directional force of intermaxillary elastics is better understood than that of headgear. However, it is interesting to note in Fig. 28 that with Class III mechanics there is a slight extrusive force on the upper molars and the lower incisors. This is about 10 degrees to the occlusal plane. The balance of the force is distal on the lower denture and mesial on the upper. The extrusive forces in both dentures are nicely balanced by bends in the arch wire. On the upper denture the curve of Spee is increased, which depresses the molars, and on the lower denture the curve of Spee is reversed, which depresses the incisors. Therefore, the extrusive action of the elastic causes little extrusion of the teeth. The mesial force on the upper denture is neutralized by the straight-pull headgear, which is worn 14 hours a day. The distal force on the lower denture

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Fig. 28

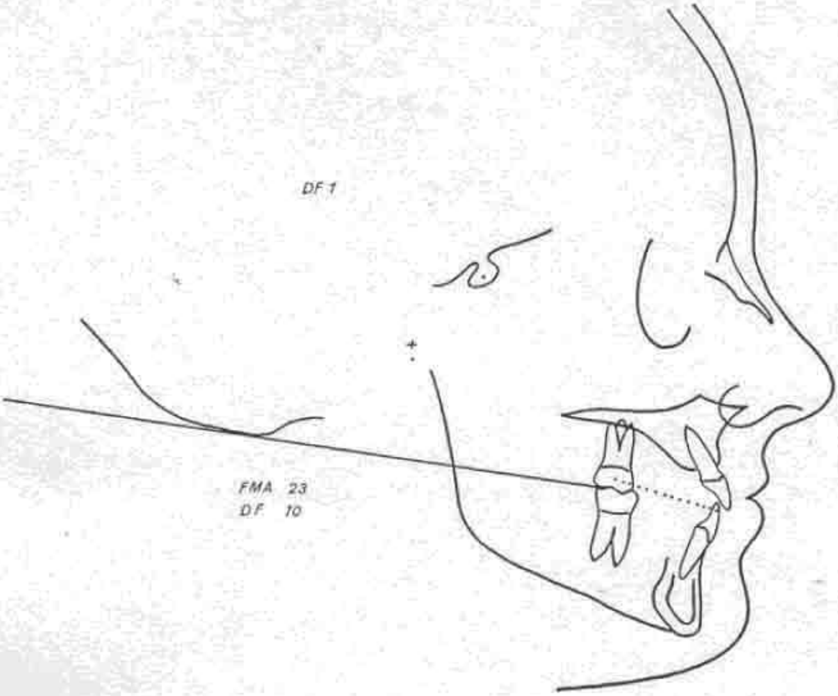
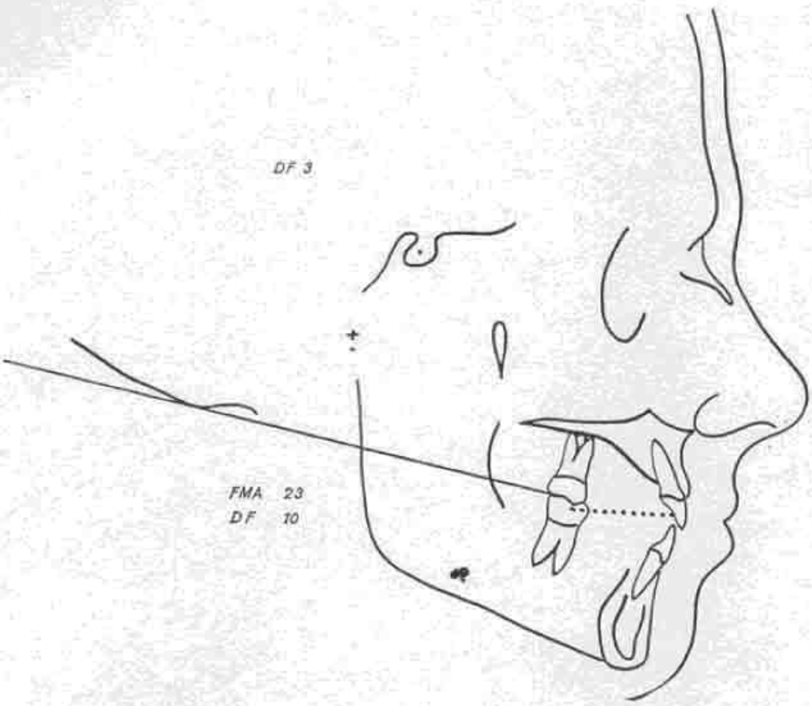


Fig. 29



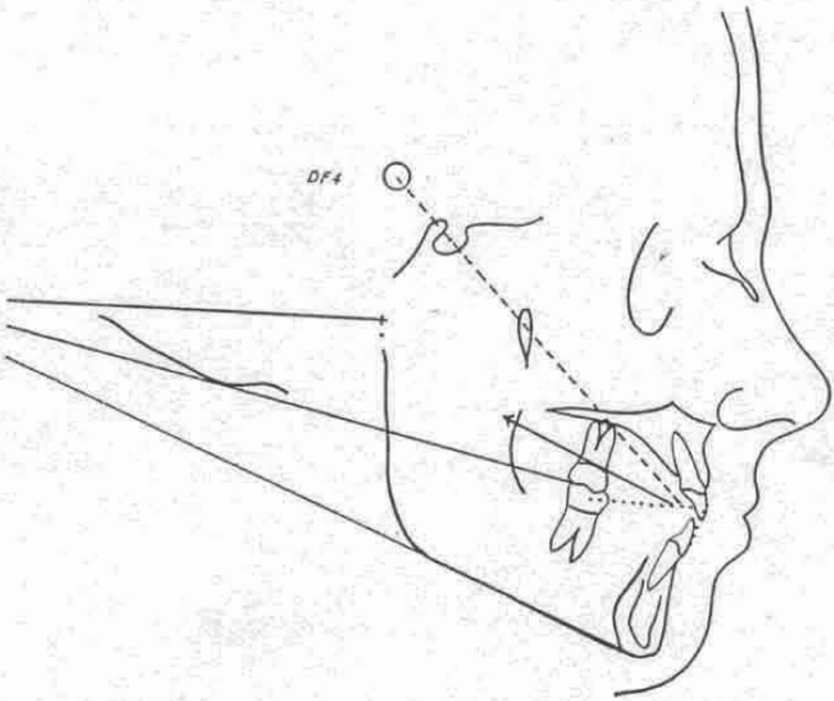


Fig. 30

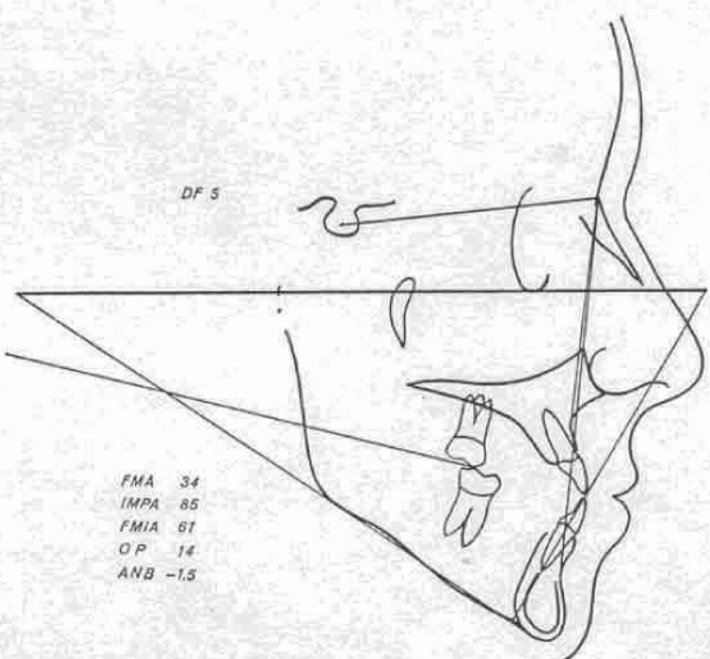


Fig. 31

activates a series of small-spring levers on the arch wire, causing a distal tipping of the teeth in the buccal segments.

Fig. 29 shows that with Class II elastics the action is reversed, with a 10 degree extrusion of upper anterior and lower posterior teeth. The balance of the force is distal on the upper denture and mesial on the lower. On the lower denture the extrusive force is kept under control by means of a stabilizing arch wire and anchorage preparation.

Fig. 30 shows that the extrusive force on the upper denture is balanced by the action of the high-pull headgear. With the headgear worn 14 hours daily, the actual component of force is up and back, which is exactly the directional force needed on the maxillary denture. This is the ideal directional force in Class II cases. Also, we would like to point out that this directional force would be ideal for retarding the downward, forward migration of the maxilla in a growing child. As we studied directional forces, we were amazed to notice how the Tweed mechanics harmonized with the forces of the orthodontic auxiliaries.

The Class II elastics are balanced by the use of Class III elastics, and the extrusive forces are balanced by the intruding forces of the arch wires and the high-pull headgear.

Clinical cases

The theme of this presentation has been directional forces. Let us now consider the effects of directional force application clinically.

To illustrate one clinical use of directional forces and their effect on the dentition, Fig. 31 shows a Class III malocclusion with an AB difference of –1.5 degrees, an FMA of 34 degrees with the lower incisors at 85 degrees, and an FMIA of 61 degrees. The plan of treatment here was to try purposely to rotate the mandible downward and backward by extrusion of the maxillary molars to effect a more normal ANB relationship. To accomplish this adjustment, Class III elastics were used on the maxillary teeth with tip-forward bends and a cervical headgear was placed on the lower arch wire in the anterior region. The cervical headgear holds the mandible open as the Class III elastics extrude the upper posterior teeth. Two years of active treatment accomplished the results shown in Fig. 32.

The AB difference is now 2 degrees (a 3.5 degree increase), the FMA changed from 34 to 38 degrees (4 degrees greater), the IMPA went from 85 to 75 degrees, and the FMIA increased from 61 to 67 degrees. These are interesting figures, but let us now superimpose our head film tracings (Fig. 33) and see where and what occurred.

Superimposition along SN at sella shows the over-all results. Note the downward and backward movement of point B. This was very desirable here but would be disastrous in a Class II malocclusion. Point A came forward slightly, and the vertical height of the face was increased considerably. Note that the maxilla is in almost the same vertical position but that the mandible has swung downward and backward. This is somewhat different from the typical face-bow reaction, which shows the anterior nasal spine dropping downward also.

Superimposition at ANS and along the palatal plane gives us a truer picture

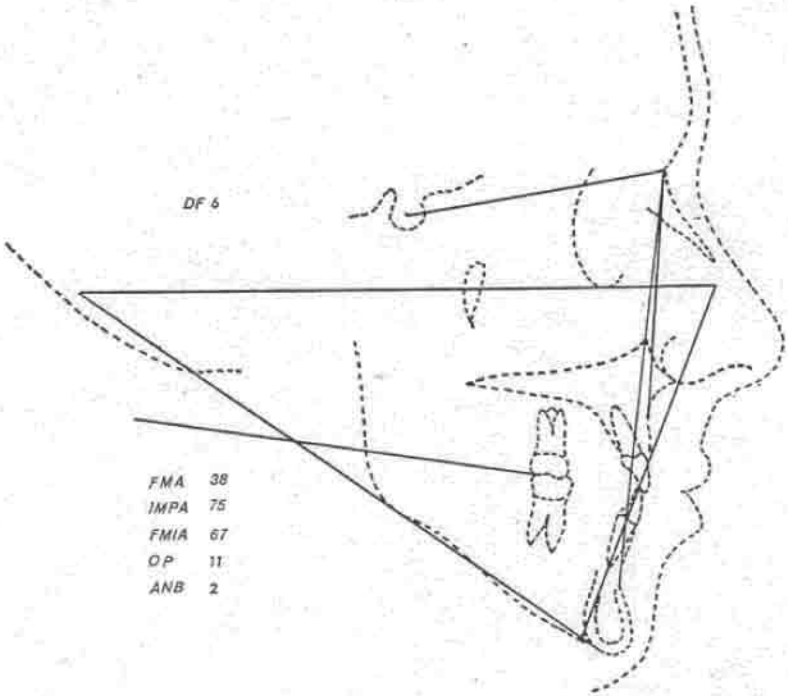


Fig. 32

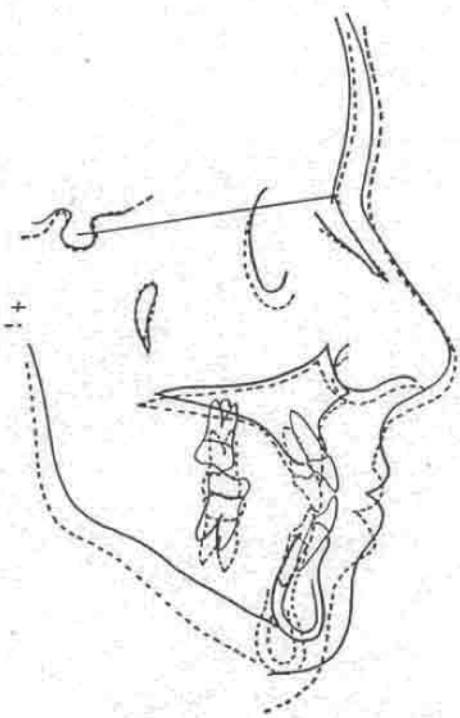


Fig. 33

Fig. 34

of maxillary tooth movement. Fig. 34 shows almost no change in the incisors, but there is almost 5 mm. of molar extrusion along with approximately the same amount of mesial movement of the molar. This was brought about by a combination of Class III elastics and cervical headgear.

Fig. 35 shows, through superimposition at the symphysis and along the lower border of the mandible, that the lower incisors extruded and tipped lingually from the effects of the headgear and Class III elastics. The lower molar uprighted and had some mesial and extrusive movement. The occlusal plane was flattened from 14 to 11 degrees by the extrusion of the lower incisors. These over-all results appear very promising for treatment of Class III malocclusions, but we should temper our prognosis until the permanency of the result can be determined. Our opinion, based on observation and previous experience, is that, in steep FMA cases, molar extrusion and mandibular rotations will be fairly permanent. Our theory is that persons with high FMA angles have a much weaker muscular environment, which is more adaptable to a further steepening of the FM angle.

For the benefit of those who might be considering the light-wire technique, either for its efficiency or for the type of result obtainable, let us now look at a case treated by a well-trained, capable orthodontist using this technique. The tracing shown in Fig. 36 reveals an FMA of 37 degrees, an IMPA of 83 degrees, and an FMIA of 60 degrees, which is a fairly good compensation for such a steep angle. The ANB angle was 6 degrees, and the occlusal plane was 9 degrees. The molar relationship is Class II.

A tracing made at the completion of treatment (Fig. 37) shows that the

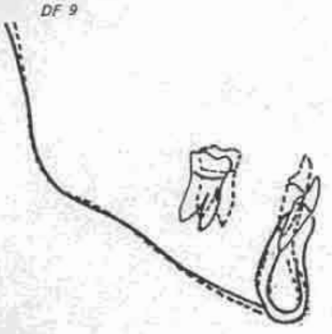


Fig. 35

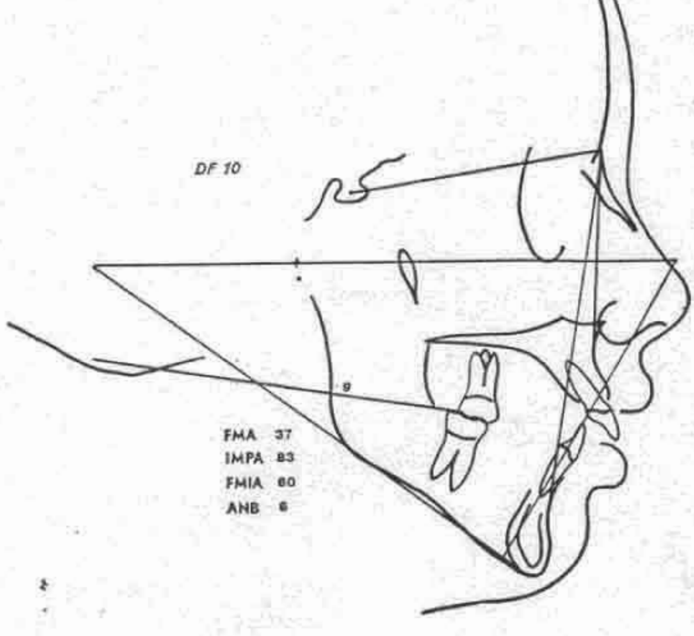


Fig. 36

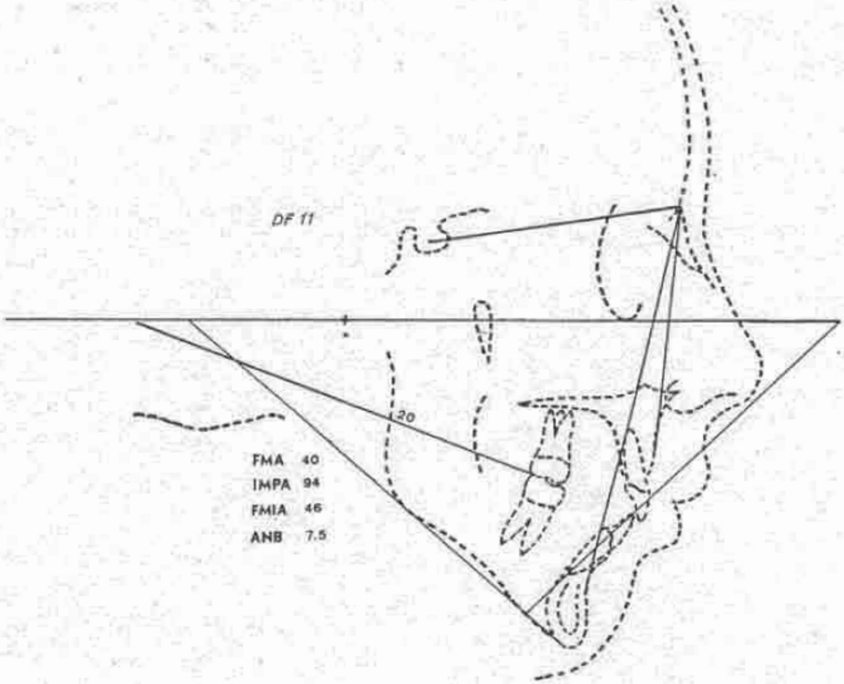


Fig. 37

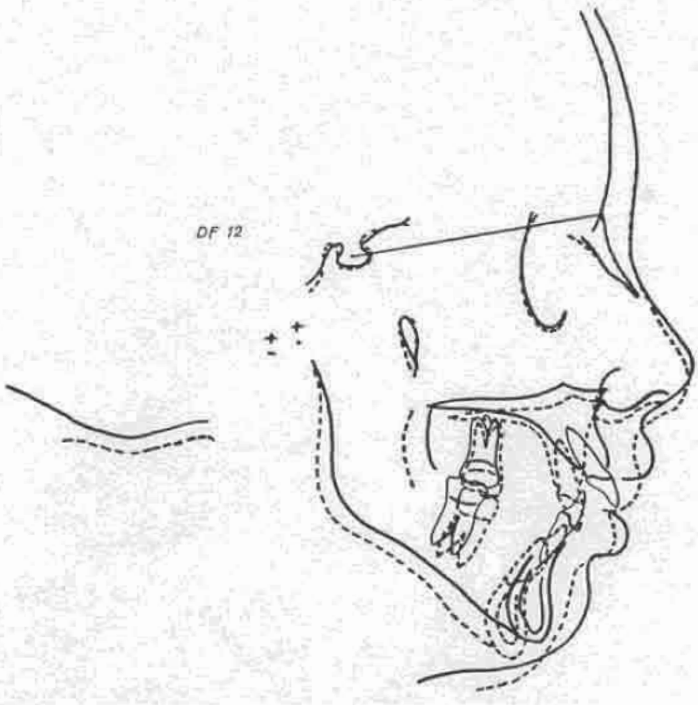


Fig. 38

FMA increased from 37 to 40 degrees. The IMPA increased from 83 to 94 degrees, meaning that the lower incisors were tipped 11 degrees, and the FMIA worsened from 60 to 46 degrees. The ANB angle increased from 6 to 7.5 degrees. The soft-tissue profile became considerably more convex. Note that the occlusal plane has tipped from 9 to 20 degrees, which means that this denture is now oriented completely differently than in the beginning and that every measurement is worse at the finish than at the start of treatment.

Fig. 38, in which the two tracings are superimposed on sella along sella-nasion, shows us that there has been little cranial growth during the 2 years of orthodontic treatment. Note the direction of the mandible; point B is downward and decidedly backward. Note also the recontouring of the anterior part of the maxilla and the tipping of the occlusal plane; these are serious reactions during treatment.

Looking at Fig. 39, in which the maxilla is superimposed at ANS and along the palatal plane, we see that the upper molar is in almost an identical position in both the beginning and finish tracings. The upper incisors have been tipped downward and backward, and point A has been recontoured distally.

In Fig. 40 superimposition of the mandible at the symphysis and along the lower border shows where most of the mandibular rotation came from. The lower incisor has been severely intruded, with the root moved lingually and the crown labially. The lower molar has been extruded so that the bite opening and tipping of the occlusal plane occurred by incisor intrusion and molar extrusion. The molar has moved mesially more than the width of the extracted first premolar. It is very easy to visualize the combination of Class II elastics and light arches. I would seriously caution anyone interested in such a technique to study conscientiously the directional forces at work in a series of cases, for treatment placed this denture completely out of harmony with its muscular environment. In contrast, and to show controlled forces at work, we have carefully selected a Class II malocclusion with similar measurements that was treated by Dr. Tweed.

In Fig. 41 this patient shows an FMA of 36 degrees, within 1 degree of the other youngster, an IMPA of 84 degrees, also within 1 degree, and an FMIA

DF 14

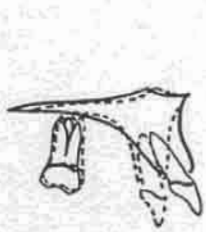


Fig. 39

DF 13

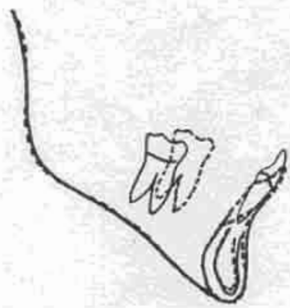


Fig. 40

of 60 degrees, which is identical. The ANB angle was 7.5 degrees, or 1.5 degrees more severe than in the previous patient. The occlusal plane was 15 degrees.

Although the beginning values were very similar and both patients had four first premolars extracted, the similarity between the two cases seems to end there. At the completion of treatment (Fig. 42) Dr. Tweed's patient had an FMA that remained the same 36 degrees, an IMPA of 82 degrees, an FMIA of

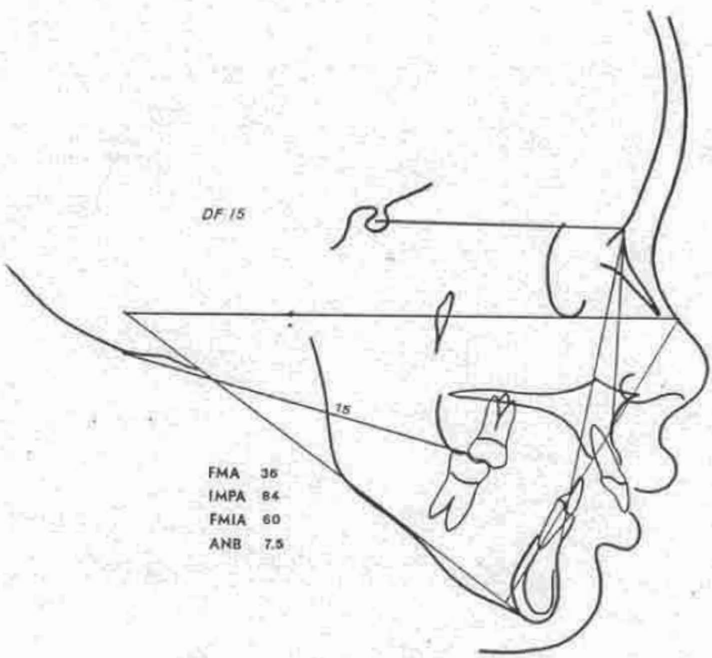


Fig. 41

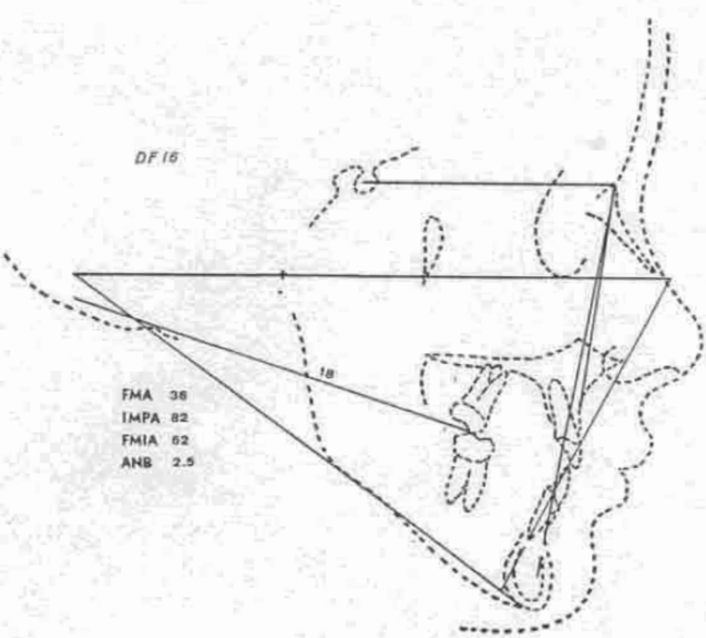


Fig. 42

62 degrees, and, most important, an ANB angle of 2.5 degrees. This is a reduction of 5 degrees. Remember that in the previous case the ANB angle increased 1.5 degrees, from 6 to 7.5 degrees. The occlusal angle is now 18 degrees.

The over-all results of 2 years of treatment and growth can be visualized in Fig. 43, in which tracings are superimposed at S along SN. The soft-tissue outline is markedly improved, with a reduction in the upper lip protrusion and a stronger chin outline. The mandible has dropped mostly downward, but pogonion is slightly advanced. Point B is in an almost identical relationship on beginning and finish. The maxilla shows the result of controlled directional forces. Point A is 6 mm. distal to its original position.

Superimposition on the maxilla at the anterior nasal spine and along the palatal plane shows proper directional forces (Fig. 44). The maxillary incisors

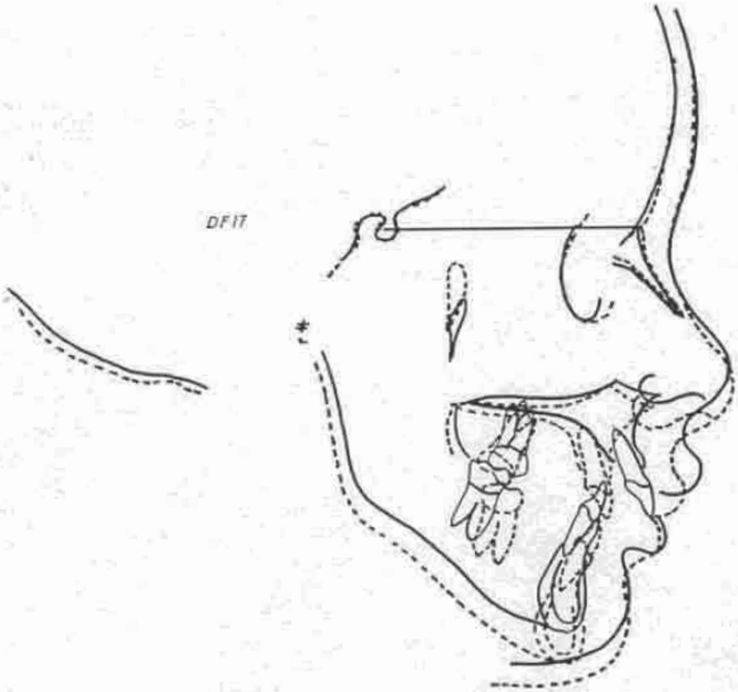


Fig. 43

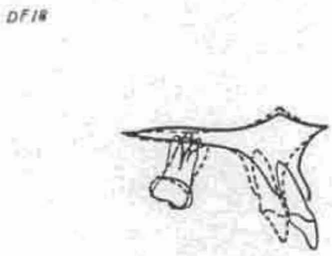


Fig. 44

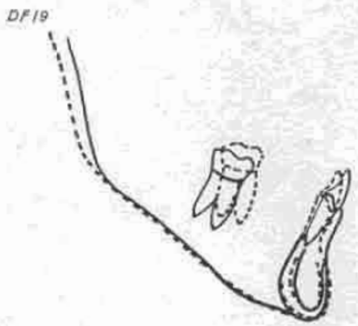


Fig. 45

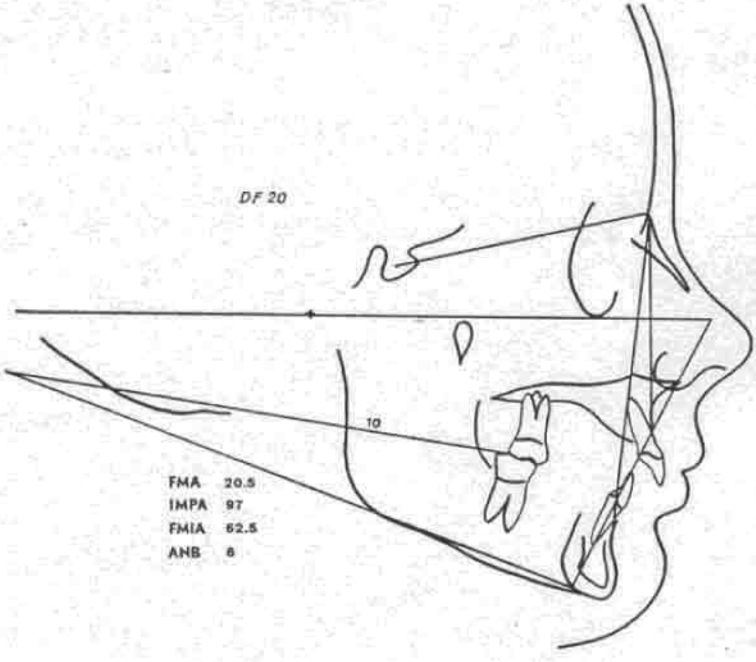

DF 20
10
FMA 20.5
IMPA 97
FMIA 62.5
ANB 6

Fig. 46

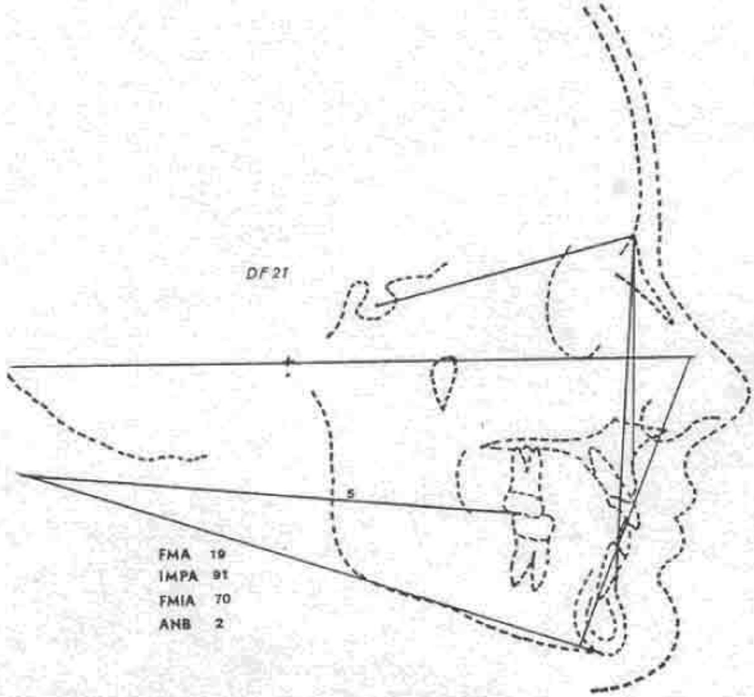

DF 21
5
FMA 19
IMPA 91
FMIA 70
ANB 2

Fig. 47

have been intruded and moved bodily distally. This is quite a difference from the light wire and the Kloehn face-bow, which are characterized by extrusion of the upper anterior teeth. Note the change in point A and the relationship of the maxillary incisor root to the lingual palatal plate. The maxillary molar crown has been tipped somewhat distally. Note the absence of extrusion of this tooth. This is the finest control of a maxillary denture that we have ever studied. It shows the ideal application of the high-pull headgear, Class II elastics, and arch wire mechanics. Superimposition of the mandible at the symphysis and along the lower border (Fig. 45) gives a good evaluation of the mandibular tooth movement and vertical growth in this area. The apices of the lower incisors were maintained nicely, and the crowns were tipped lingually. The lower molars were uprighted, moved mesially about 2 mm., and show some vertical change.

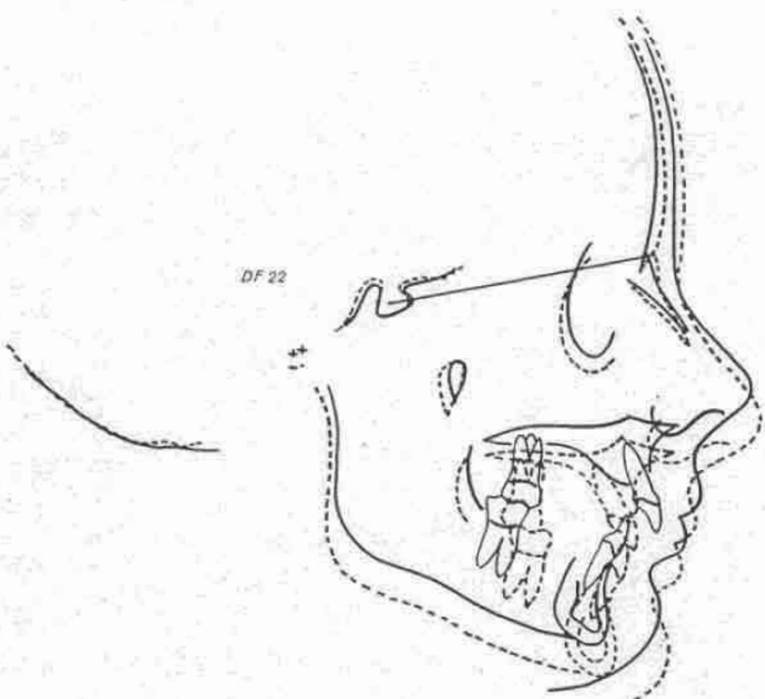


Fig. 48

Fig. 49

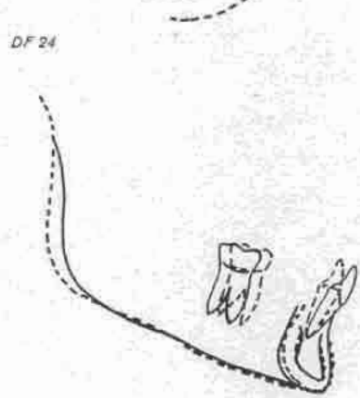


Fig. 50

The over-all study of this difficult case, which was extremely well treated, emphasizes the importance of applying the proper directional forces.

It is most interesting that this case study further substantiates the effectiveness of the treatment procedures used and advocated by Dr. Tweed long before the advent of cephalometric recordings.

Let us now look at the effect of directional forces on a more normal facial pattern.

The patient shown in Fig. 46 had an FMA of 20.5 degrees and was selected for that reason. Fortunately, not all patients with Class II malocclusion have a high FMA. This patient was treated with routine Tweed edgewise mechanics, with emphasis on uprighting the lower incisors and controlling the maxillary denture with the high-pull headgear. Fig. 46 shows the beginning head film with an FMA of 20.5 degrees, an IMPA of 97 degrees, an FMIA of 62.5 degrees, an ANB angle of 6 degrees, and an occlusal plane as related to Frankfort horizontal of 10 degrees.

Fig. 47 shows that at the completion of treatment the FMA has flattened 1.5 degrees to 19 degrees, the lower incisors have been uprighted 6 degrees to 91 degrees, the FMIA has improved from 62.5 to 70 degrees, and the ANB angle has changed from 6 to 2 degrees (a 4 degree reduction). The occlusal plane has been flattened from 10 to 5 degrees. The soft-tissue outline is in much better balance.

Superimposition at S along SN shows us the over-all direction of growth (Fig. 48). The maxilla moved downward, and the chin moved downward and forward. Point A has been retracted, along with the upper incisor. Point B has progressed forward, which is good quality growth for this youngster.

Checking maxillary tooth movement by superimposing on ANS and along the palatal plane in Fig. 49 reveals that there was considerable bodily movement of the upper incisors as well as some intrusion of these teeth. Note the nice recontouring of point A. This is a very important evaluation when one is considering appliance control and proper directional force application. The upper molars moved forward about 2 mm. with almost the same vertical relation at the beginning and finish of treatment.

In Fig. 50 superimposition on the symphysis and along the lower border shows the lower incisor being uprighted with a slight extrusion in this area. Point B has followed the uprighting of the lower incisors. The lower molars have moved forward slightly. Note the lengthening of the mandible, which is now expressed distally. Over-all, this is fine directional force control with good quality growth. It is of the utmost importance that one's directional forces be in complete harmony with the growth being experienced during treatment.

We have presented the concept of directional forces and their application to orthodontics. We have shown a selection of clinical cases, some treated with the application of controlled forces and others with the application of uncontrolled forces. These cases clearly indicate that directional forces have a direct bearing upon treatment results. Orthodontists should carefully analyze the problem and then adapt the directional force to each specific case.

REFERENCES

1. Moore, A. W.: Observations on facial growth and its clinical significance, Am. J. Orthodontics 45: 399, 1959.
2. Ricketts, R. M.: A study of changes in temporomandibular relations associated with the treatment of class II malocclusion, Am. J. Orthodontics 38: 918-933, 1952.
3. Schuyler, C. H.: Fundamental principles in correction of occlusal disharmony, J. Am. Dent. A. 22: 1193, 1935.
4. Thompson, J. R.: Concepts regarding function of the stomatognathic system, J. Am. Dent. A. 48: 626-637, 1954.
5. Thompson, J. R.: Rest position of the mandible and its application to the analysis and correction of malocclusion, Angle Orthodontist 19: 162, 1949.