A Consideration of the Anchorage Problem*

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SUCCESSFUL orthodontic management is dependent upon a definite plan formulated from careful case analysis. Some of our failures are due to incorrect analysis. Others may be traced to inability to carry out a plan, but often they are the result of lost or insufficient anchorage. Thus anchorage is one of the major problems in Orthodontia and is worthy of careful study. One would expect to find a great deal of literature on such an important subject but this is not the case. Very little is available even in the text books, which are for the most part concerned with classification. Here, as elsewhere in early Orthodontia, the mechanical concept seems to predominate.

Simple anchorage is defined as that form of anchorage where the attachment is such that upon the application of force the tooth is permitted to tip, while in *stationary anchorage* the attachment is rigid and causes the tooth to move bodily, if it moves at all. These are the two general classes of intra-oral anchorage from which all other types arise, such as, simple single, simple compound, single stationary, compound stationary, etc. The mechanical concept is apparent from this description but in present day Orthodontia we cannot divorce the mechanical from the biological. Every biological problem may be interpreted mechanically and every mechanical problem has its biological modification. Nowhere is this more apparent than in the problem of anchorage where perfect mechanics, viewed from an engineering standpoint, finds its true value deep in the roots of biological science. We cannot consider the subject as an entity in itself. The interdependence of individual factors creates a very complex situation through these interacting relationships and influences. When one seeks to review any particular subject he is soon confronted with the fact that each field is influenced by others, which, at first glance, do not seem even remotely connected with it.

In the study of anchorage it is soon found that bone is a fundamental consideration, for any force applied to the teeth eventually comes to rest in this substance. It is trite to review the history of the development of our knowledge pertaining to bone, for that is well known. It should be noted, however, that in the early days bone did not enter into the orthodontist's reckoning which probably explains the mechanical concept. It was not until Dr. Angle declared bone to be fundamental in his historic paper entitled, "Bone Growing,"[1] that it received any serious consideration. In scientific circles it had long been realized that bone was not a static material; on the contrary, it was known to be one of the most active of the body tissues. It stands ready and eager to adjust any force directed upon it which tends to overthrow its equilibrium. The work of Hunter, Haller, Tomes, DeMorgan, Wolff and others

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had revealed its mechanism and then Oppenheim, in his classic experiments with which you are all familiar, made direct application to Orthodontia. Anyone familiar with this work and the mechanism of bone change or who has examined histological material prepared from tissues around a moving tooth must be conscious of the changes which occur in bone upon the application of pressure. It must be realized that such changes weaken the resistance to force which means weakened anchorage. Bone is so quick to respond that even the placing of a ligature for separation is followed by alterations in the structure of the surrounding bone, which is weakened in proportion to the magnitude of the force and the duration of its operation.

From the above it should be apparent that true anchorage is not available within the mouth. We have at our command only different degrees of resistance. These differences are determined, first, by the form and area of the root surfaces. A tooth is suspended in its alveolus by the peridental membrane fibers and it resists movement through a tensing of these fibers. The greater the surface area on the tension side of the root, the greater the number of fibers resisting the force—hence the greater the available resistance. The second difference is the nature of the surrounding bone. It is common clinical knowledge that any tooth will move more readily in some directions than in others and that some teeth are more resistant to any movement than are others. For example, mandibular teeth are more resistant than those of the maxilla with the possible exception of the incisors; however, we have various means of manipulation at our command so that we may increase or decrease available resistance, which brings us to the correlation of mechanics with biology.

As explained above, in simple anchorage force is applied by means of a hinge attachment which permits the tooth to tip. With such a mechanical attachment a stimulus is applied through a small group of fibers to the crest of the alveolar wall which leads to a rapid transformation of the bone at this point. Upon continued application transformation progresses from the crest to the apex, and in time all of the bone of the socket wall is transformed into osteoid, a less resistant tissue. In so-called stationary anchorage, the attachment is rigid so that upon the application of pressure a stimulus is applied through all of the peridental fibers on the pressure side of the root from the alveolar crest to the root apex. The same bone transformation is in progress but because of the increase in the number of fibers more resistance is offered and bone reaction progresses more slowly. It should be remembered, in effecting stationary anchorage, that unless force control is such that the maximum number of fibers are enlisted all of the available anchorage is not obtained and, thus, simple anchorage or a modification thereof is in effect. This means that to effect stationary anchorage no realignment of the tooth axis is permissible, which gives rise to what in mechanics is termed a "passive adjustment." Because bone reaction is in progress from the moment force is applied, followed by the formation of osteoid tissue in either simple or stationary anchorage, it becomes necessary from the start to think in terms of tissue and tissue reaction. In the final analysis the difference between simple and stationary anchorage is but a difference in the speed of tissue reaction effected by mechanism manipulation. There are factors which contribute to resistance other than that offered by the tissues themselves and the mechanical attachment. This I shall discuss later.

In further discussion of the anchorage problem let us turn to specific cases. Fig. 1 is a schematic drawing involving the problem of moving the incisor teeth forward and to the right to open space for an unerupted upper left cuspid. When the ideal arch is placed, teeth in the right buccal segment will occupy their correct locations on the arch wire, but all remaining teeth will be out of position in relation to it. By placing a spur on the arch between the first and second bicuspid and ligating it to the first bicuspid bracket, the left buccal segment is tied up in a unit of stationary anchorage, provided, of course, that the molar tube and brackets lie in the same plane and the arch passively adjusted. Any effort to obtain alignment of these teeth sufficient to permit bracket engagement speeds up tissue reaction and weakens anchorage, since the undisturbed tooth represents maximum resistance. To effect movement of the incisors to the right a spur is soldered between the left central and lateral incisors and the lateral bracket tied to it. This spur will be carried to the right with each adjustment. As the arch moves forward, the remaining incisors will be carried with it from force acting through the contacts.

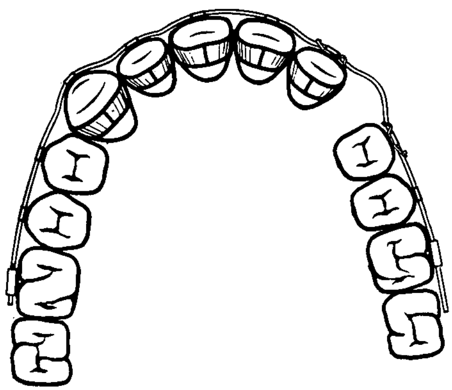

Fig. 1.—Moving incisors forward and to the right to open space for an upper left cuspid.

Analyzing the anchorage when all brackets engage the arch wire, we have compound stationary anchorage in both segments. While it is impossible to determine the relative resistance of the two segments we have reason to believe, from clinical experience, that the desired forward movement of the incisors will be accomplished. It would seem that resistance would be about equal from a standpoint of root area; however, there is another factor which must be considered. As the incisors move forward they move away from occlusion and the only resistance, other than that offered by the tissues, is the backward pull of labial musculature, which is negligible in most cases. The molar and bicuspids, on the other hand, are under the influence of occlusion—a factor which adds materially to resistance. It will be seen that with every closure of the mandible these teeth receive a forward thrust which helps to counteract the backward push from the incisors. This, together with the presence of a second molar, increases the resistance of the buccal segment. If, in this case, the molars and bicuspids were in an end-to-end relation, occlusal resistance would be lost, resulting in lowered resistance of the buccal segment. This factor of occlusal resistance should not be overlooked, for in calculating anchorage it often becomes a means of adding resistance where it is needed.

To cite a specific example, I think it is generally agreed that distal movement of lower molars is the most difficult movement to accomplish because of root area and bone density. It often becomes necessary to move these molars back to open space for an unerupted second bicuspid. In a case with a deep overbite it is expedient to move the maxillary incisors forward only sufficiently to place the lower appliance, then to stop this disturbance of occlusal anchorage while distal movement of the molars is in progress, thereby taking advantage of the occlusal resistance offered by the maxillary incisors to forward movement of the mandibular incisor segment. In this connection, you will recall that in the day of E arch and lingual arch mechanics it was customary, in cases of lingually locked maxillary teeth or labially or buccally locked mandibular teeth, to employ a bite plate for the purpose of holding the teeth out of occlusion. Fundamentally this was a method of changing anchorage ratios by eliminating occlusal resistance.

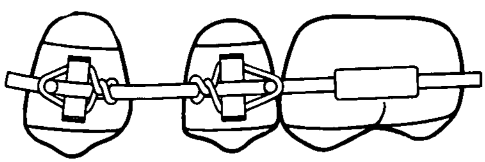

Fig. 2.—Moving the incisor segment forward to open space for a first bicuspid.

In addition to mesial and distal, buccal and lingual resistance, occlusion is also effective in a vertical dimension. This may be best explained from a typical Class II mandibular arch with its excessive curve of Spee. With the teeth banded in the customary manner, when the arch is inserted in the molar tube it will lie gingival to the incisor brackets. When sprung occlusally and made to engage these brackets a depressing force will act on the six anterior teeth while an elevating force will be operating upon the bicuspids when the arch is tied down to their brackets. Since tissue resistance is greater to depression than to elevating force, one would expect the leveling off of the mandibular arch to be accomplished by an elevation of the bicuspids. However, the force of occlusion adds resistance to the bicuspids and depression of the incisors results.

In the next case the problem is the same except that localization of space for a first bicuspid is required, Fig. 2. Here anchorage ratios have changed. A cuspid has been added to the anterior segment and a bicuspid removed from the buccal segment. The greatest tissue resistance is contained in the anterior segment which must be broken down by mechanical manipulation or by addition of resistance to the buccal segment. A passive arch adjustment in the brackets will enlist all of the peridental membrane fibers on the tension side of the molar and bicuspid. By keeping the arch forward of the incisors and ligating to the bracket wings on these teeth, the crest fibers will be tensed, resulting in lowered resistance and a more rapid breaking down of the tissues. Resistance ratios may be further changed by leaving the cuspid free until the incisor resistance has been broken down—the principle being, that anchor teeth should be disturbed as little as possible when the intention is to break up the resistance of the incisors. A third method is to increase the buccal segment resistance which may be done by the addition of intermaxillary elastics.

In comparatively rare cases where we wish to provide space for a second

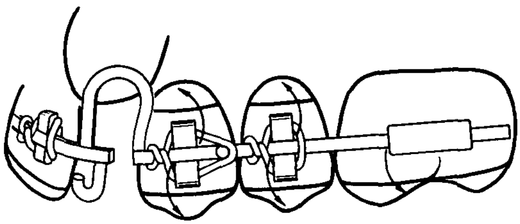

Fig. 3.—Using the incisors together with intermaxillary anchorage to move a buccal segment distally.

bicuspid by moving forward the teeth anterior to it, anchorage becomes a great problem because there is such a tremendous difference in resistance ratios. Tissue resistance of the molar, plus intermaxillary anchorage, is all of the resistance we have available so that arch manipulation must be such that the molar is not overloaded. We must resort to the same plan as previously followed.

So far our problems have all been concerned with anchorage in cases with the molar constant. Now we turn to cases with the incisors constant and the molars and bicuspids forward. With the edgewise arch mechanism three methods are available to effect the desired distal movement. While the choice seems to depend on personal favor, it appears to the writer that the choice of method should be made upon a basis of anchorage. Regardless of this, the incisors may be banded and used for anchorage by breaking the ideal arch with a loop at the cuspid, Fig. 3. With a spur on the arch distal to the first bicuspid, the loop is constricted by tying forward to the first bicuspid bracket. As the power thus stored in the loop is released, distal movement of the buccal teeth is effected. Of course, it is necessary to reinforce the incisor element with intermaxillary anchorage, as the greatest tissue resistance is contained in the molar segment. When the arch engages all brackets it might be reasoned that the anchorage would be reinforced stationary. This would be the case if the loop, when constricted, released its force in a direction perpendicular to the long axis of the teeth, thus tensing all peridental fibers on the tension side of the roots. However, because the loop is soldered when constricted, the arch ends are thrown into different planes which results in a variety of forces. On the teeth adjacent to the loop there is a depressing force, while at the arch extremities there is an elevating force. As the loop opens these forces are reversed. The result is that at no time are all the fibers tensed, rather, first one group, then another, which in effect is a modification of simple anchorage. This is desirable action on the molar segment for here we wish rapid tissue reaction to effect movement. It is undesirable action on the incisors, and even though they offer a source of resistance to the desired movement they are unnecessarily disturbed.

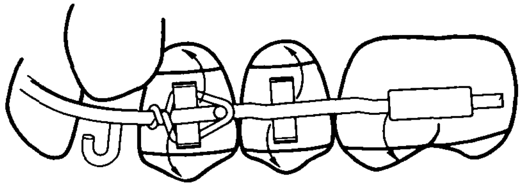

Fig. 4.—Using a continuous arch with second order bends and intermaxillary anchorage to move a buccal segment distally.

The second method, Fig. 4, consists of the use of second order bends combined with intermaxillary anchorage. With this method the incisors are not banded. A spur is placed on the arch wire distal to the first bicuspid for the purpose of preventing the arch from sliding through the brackets. At each adjustment the arch is tied forward, allowing approximately $\frac{1}{16}$ of an inch clearance between the arch wire and the labial surface of the incisor teeth, which we do not wish to move. The principle here is that the effectiveness of the second order bend depends upon the physiological reaction produced by this force. The generally accepted principle is that of a lever working upon a tooth in a gingival or occlusal direction, causing the tooth to tip. This, in itself, is simple anchorage and, working alone, would cause a forward root movement as a result of the fulcrum being established at the bracket with tension of fibers first at the apex. However, when the elastic is added we have a reinforced simple anchorage. Because the arch containing the second order bends receives a backward force, the crest fibers are tensed with a consequent relaxing of the apical fibers and the tooth tips with the apex as a fulcrum. This would seem to be a complicated adjustment but in reality it is not. It is only necessary to remember that the force must be gentle in order that the initial reaction takes place at the alveolar border with a minimum disturbance at the apex. If too great a force is exerted, either by severe bends in the arch wire or too strong elastics, the tooth will be jammed against the distal crest creating a new fulcrum, and again tensing the apical fibers. Since in this problem we wish to tip the molar and bicuspids distal with their apices as a center of rotation, the need for careful thinking regarding force application becomes apparent.

The third method, Fig. V, of effecting the distal movement of these teeth involves the use of the same principle as that just described, the only difference being that the anterior section of the arch is eliminated. The method has not proved popular in spite of the fact that it is very effective, simple and of great comfort to the patient, especially in those cases where a cuspid has erupted labially. I believe that the failures reported may easily be explained. It must be remembered that with the elimination of the anterior section of the arch wire, buccolingual control has been lost—control that is very necessary in second order movement. The only substitute for metal arch control is occlusal resistance, which is present in cases with high cusps and a positive bucco-lingual lock. It is the opinion of the writer that failures have occurred where this control has been absent, for certainly this is the only loss occasioned by the elimination of the anterior arch section.

The next problem to be considered occurs in cases where first bicuspid space has been closed by forward drift of the molar and second bicuspid, Fig. VI. Here the cuspid is considered as being part of the anterior segment and the first bicuspid is missing from the buccal segment. Anchorage ratios have changed and now the resistance to movement is about equally divided between the two segments. Treatment consists in banding all teeth and breaking the ideal arch with a loop at the first bicuspid space. The loop is constricted

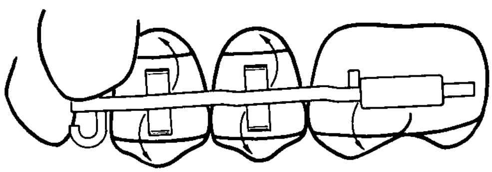

Fig. 5.—Sectional arch with second order bends and intermaxillary anchorage to move a buccal segment distally.

as shown and the molar is carried distally without any attempt being made to carry the second bicuspid with it until distal molar movement is well in progress. The second bicuspid is then carried back by throwing a ligature around the distal of the molar tube and forward to the second bicuspid bracket.

We come now to cases where space has been closed, not by backward movement of incisors, nor forward movement of the buccal teeth, but by a combination of these two movements. Anchorage difficulties are reduced in these cases because reciprocal anchorage may be employed between the two segments. We may have but little concern as to which segment moves up until one or the other reaches its desired cranial relation. At this point the segment which has reached its desired position is stabilized by the addition of intermaxillary anchorage as indicated.

Another anchorage problem which I should like to discuss is the problem of lingual occlusion of a buccal segment. This type requires the use of torque force in its treatment. Here, as in all other treatment, it must be remembered that to every action there is an opposite and equal reaction which must be considered. If a molar arch segment is torqued for buccal crown movement and slipped into the molar tube, the second bicuspid lying in the same plane of space would receive an equal and opposite twist, which we do not desire. To overcome this, buccal torque is placed in the arch controlling this tooth which throws the load on the next tooth forward, the first bicuspid. Thus we go forward step by step to the cuspid, each tooth being torqued in the same direction. But to obtain movement of an entire buccal segment, the torque bend must be increased on each tooth as we come forward. Torque, like second order, operates only in a straight line, and as we round the corner at the cuspid, the twist force in the buccal segment becomes a straight depressing force on the incisors and these teeth become the resisting base.

Another point to be remembered is that the mechanics of torque force cause teeth to tip with the axis at the apex of the tooth root, provided the arch is permitted to travel buccally with the teeth. If the arch is prevented from moving, a root movement occurs in a lingual direction. It thus follows that if a buccal crown movement of an entire segment of the dental arch is desired, it is imperative that expansion be placed in the arch in this area. To further assist the arch to travel in a buccal direction criss-cross intermaxillary elastics are employed, attached to a spur on the lingual surface of the molar band and extending to a spur soldered on the gingival surface of the arch wire of the opposing jew mesial to the molar tube.

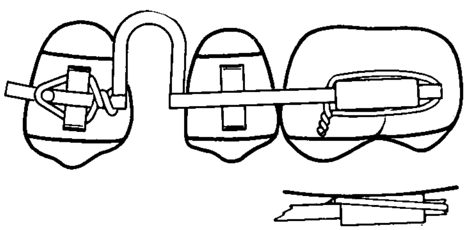

Fig. 6.—Moving a molar and second bicuspid distally to open space for a first bicuspid.

In this discussion of the anchorage problem, I have considered only the anterior and one buccal segment. To do otherwise would only lead to confusion, for the possibilities of malocclusion are unlimited. What applies to these two segments applies to the other four and they may be analyzed and treated in a like manner.

Summary

1. Anchorage is a major problem in Orthodontia.
2. Anchorage is a biological problem, with bone a fundamental consideration.
3. The undisturbed tooth represents maximum resistance.
4. True anchorage is not available within the mouth and it is, therefore, resistance ratios which must be calculated.
5. Resistance may be increased or decreased by mechanical manipulation. Rigid attachments enlist maximum resistance, hinge attachments least resistance.

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