Tooth Movement with Removable Appliances

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The C. V. Mosby Company
Saint Louis, Missouri
1979

Preface

Many orthodontic textbooks have been written by those who are primarily teachers rather than clinicians. As a result texts, which are in other ways excellent, fail to speak with authority on the practicalities of treatment.

We have set out to produce a book which will serve as a useful chairside guide to the practitioner rather than a comprehensive reference work, limiting ourselves to describing appliances which we have used and found to be effective.

A practical guide must necessarily omit certain subjects. Functional appliances, a study in their own right, have been excluded. Details of patient examination and treatment planning are largely outside the scope of this book, but because appliance design is intimately related to planned tooth movements, emphasis has been placed on space assessment, anchorage control and measurement of progress. We have omitted reference lists and bibliography. So many sources of practical information are not in print but derive from personal communications from our past teachers and our colleagues. We are glad to have this opportunity of thanking them publicly.

Regardless of the number of trained specialists and the popularity of fixed appliances it seems likely that much treatment will be carried out by the interested practitioner rather than the specialist. We believe that removable appliance techniques can make a valuable contribution to the provision of an orthodontic service. They may offer neither the precise tooth movements nor the adaptability of fixed appliances but, used in selected cases, they can provide good results. There is also a wider range of cases in which circumstances may prevent the complex treatment which would be necessary to achieve perfection, but where treatment with a removable appliance may provide a result which pleases the patient and

is acceptable to the orthodontist. Such a result, though falling short of the ideal, can be regarded as a success if it is the fulfilment of a well considered treatment plan efficiently executed.

In order to use any appliance to the best advantage it is essential for the operator to select appropriate cases, to match appliance design to the required tooth movement and to maintain effective control of the clinical treatment. We hope that this book will assist the practitioner in achieving these ends.

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Contents

CHAPTER 1

The Scope of Removable Appliances

A removable appliance is one which, by definition, can be easily removed from the mouth. This must not be thought to imply that such appliances are intended for part-time wear. With the exception of certain functional appliances and retainers, removable appliances will only perform their tasks satisfactorily if they are worn continuously. This means that not only must the patient be enthusiastic and co-operative but that the operator has a duty so to design and construct the appliances that they can be readily tolerated by such a patient.

For this reason it is important that the appliance is not only easy to remove but also easy to insert, that it should stay firmly in the correct position in the mouth and that it should be comfortable to wear. It should be designed to avoid causing pain or unnecessary discomfort and should not be so bulky or complex that it interferes seriously with speech and eating. Only in these circumstances can we reasonably insist upon full-time wear.

The vast majority of removable appliances are used in the upper arch but a small number of useful movements can also be carried out in the lower arch. A keen patient may be prepared to wear an upper and lower appliance at the same time but this constitutes a great bulk in the mouth and is usually not advisable. The main indication for a removable appliance is to provide treatment in the upper arch when the lower is to have:

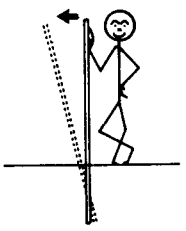
1. no treatment
2. treatment by extractions only
3. treatment with a fixed appliance.

This is an appropriate moment to stress that removable

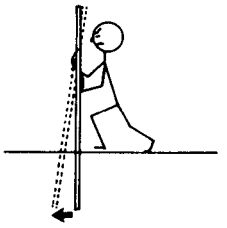
and fixed appliances are not mutually exclusive. The Hawley type of retainer is used by many orthodontists who would class themselves as using only fixed appliances, and it is not uncommon for certain movements to be carried out with a removable appliance during the course of fixed appliance treatment, e.g. the initial retraction of mesially inclined canines.

Similarly the scope of removable appliances may be extended considerably by the use of one or two bands for the attachment of whips, hooks, or extra oral traction.

Despite this it must be stressed that removable appliances do not constitute a 'complete treatment philosophy'. Some tooth movements may be carried out with ease, some with difficulty and others not at all. Obviously the orthodontist can only hope for success if he selects cases which are suitable for treatment with removable appliances, i.e. cases requiring the type of tooth movements which these appliances can carry out.



Tilting movements are readily carried out with light pressures.



Complex movements are difficult to carry out. More control is required.

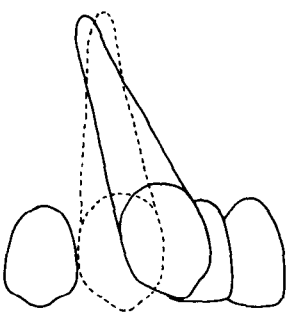
TOOTH MOVEMENT

The histology of tooth movement is beyond the scope of this book but a useful analogy to the behaviour of a tooth may be obtained by comparing it with a post embedded in thick mud. This is obviously not an accurate comparison but it will serve our purpose. If pressure is applied to the post it can be readily tilted in any direction. An ill-defined fulcrum is set up and the embedded end of the post will move in the opposite direction to that in which the pressure is applied. If the post is grasped firmly with both hands the range of possible movements is much greater. It can be rotated, moved bodily, or the embedded base can be moved more than the top. It can also be pushed further into the mud or pulled out.

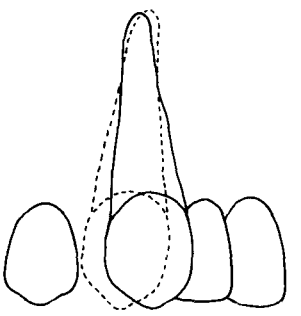
Simple Tilting Movements

A removable appliance most commonly delivers its force through a single point of contact where a spring touches the tooth. Simple tilting movements can be easily carried out and teeth may be tipped mesially, distally, buccally or lingually. As in the analogy of the post the apex will move in the opposite direction. It has traditionally been held that the fulcrum of rotation is about one third of the root length

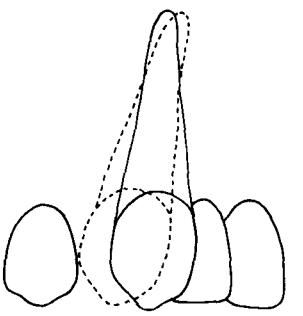
from the apex but it seems probable that it is often much nearer the crown than this. It can be seen that retraction of an inclined tooth which requires uprighting (e.g. a mesially inclined canine which must be retracted) can give a good result. If a tooth which is already at the correct inclination must be moved then some degree of tilting will have to be accepted. If a tooth is already inclined and has to be moved further in the direction of its inclination (e.g. a retroclined canine which has to be further retracted) then a removable appliance is usually unsuitable.



A mesially inclined canine will tilt readily into a good position.



The tilting which results from slight distal movement of an upright canine may be acceptable.



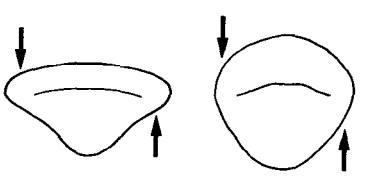
A canine which is already distally inclined would tilt more severely during retraction.

Other Movements

Movements which in the analogy of the stick required the grip of both hands pose greater difficulties. A force couple is required. In theory force can be applied by two wires or by a wire in conjunction with the base plate. Unfortunately the degree of flexibility of the wires necessary to permit insertion and removal of the appliance, and to deliver a light force, usually makes it impossible to keep the force applied constantly in the correct position.

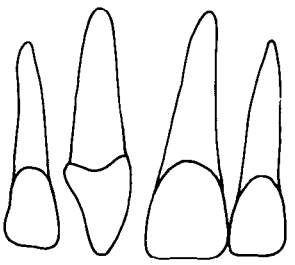
Rotation

It is frequently held that removable appliances cannot correct rotations. This is not strictly true. Central incisors or large lateral incisors can often be corrected if the problem is only a simple rotation of up to about 45°. Multiple rotations, more severe individual rotations, and those in teeth with crowns which are round in cross-section, e.g. premolars and canines, are impossible to correct with a removable appliance alone.

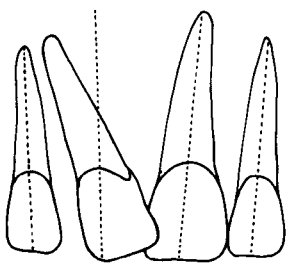


A force couple can be achieved on a flat tooth such as a central incisor. This is impossible on a canine or premolar.

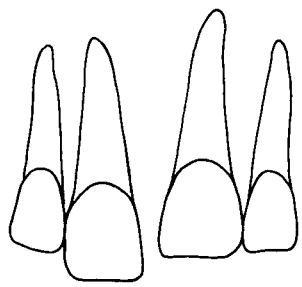
The addition of a band to a single rotated tooth with a whip engaging on to part of the appliance (Chapter 11) will allow the correction of more severe rotations and also of canines and premolars. It is important, however, to check that the problem is simply a rotation. Many rotations have an associated apical malposition which may make the problem impossible without the control offered by full banded appliances. If an attempt is made to treat such a problem with a simple whip and band the tooth will tend to upright over its apex and will probably finish in the wrong position and at the wrong height.



A severe rotation with the apex in a normal position.



In this example the rotation is less severe but is combined with apical displacement.



Treatment by simple means is unsatisfactory.

Intrusive Movements

Deliberate intrusive movement of a single tooth is hardly ever required. It would be technically possible to deliver the force although it would tend to unseat the appliance.

Extrusive Movements

These provide another example of the sort of movement which is impossible by means of a simple removable appliance alone but which can be facilitated by the attachment of a hook, either on a band or directly bonded to the enamel. It may be particularly useful when a tooth has been surgically uncovered following failure to erupt.

Apical and Bodily Movements

Generally speaking these are not possible with removable appliances. Designs have been demonstrated recently which successfully produce such movements but they are limited

to the upper labial segment and depend upon having the teeth already aligned and on the use of enthusiastic headgear. They may be useful in selected cases but are beyond the scope of this book.

Arch Levelling

This is usually not possible with a removable appliance. The chief exception is the use of an anterior bite plane in a growing patient to permit molar extrusion and so flatten out an exaggerated curve of Spee in the lower arch (Chapter 2).

Space Closure

The presence of a rigid base plate makes removable appliances inefficient at generalized space closure and their use for this purpose must usually be limited to carrying out local movements and to cases where overjet reduction is required as a contribution to space closure.

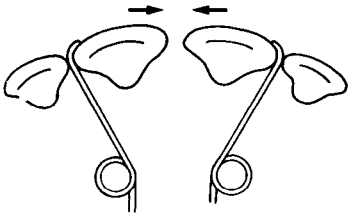
ANCHORAGE

The control of anchorage is an important consideration in tooth movement by any system and removable appliances are no exception.

Anchorage is a concept easy to understand but hard to define and the definitions found in many textbooks are unsatisfactory. Beginners sometimes confuse anchorage with retention (i.e. the mechanism by which an appliance is held in the mouth). Fortunately most orthodontists have at least some idea of what they mean by the word and it is certainly important that anyone carrying out tooth movement should understand the concept and control of anchorage.

Newton's third law of motion states that every force has an equal and opposite reaction. This is of obvious relevance in orthodontics because teeth are moved by the application of force. The reaction to this force will usually fall upon other teeth which are themselves capable of movement.

We consider anchorage to mean the resistance to movement offered by the teeth used to deliver an orthodontic force. Removable appliances rely upon intra-maxillary traction, i.e. anchorage is obtained from within the same arch. In some circumstances anchorage may be reciprocal. This means that the anchorage requirements of two teeth



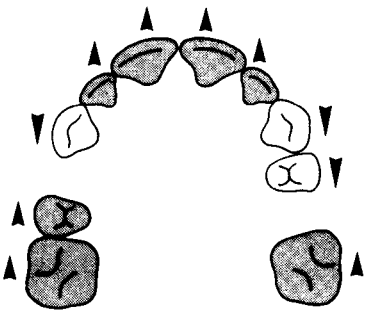
The equal and opposite movements provide an example of true reciprocal anchorage.

or groups of teeth cancel each other out. Examples of this are provided by the approximation of two central incisors or during the closure of excess space by the reduction of an overjet and the forward movement of upper buccal segments.

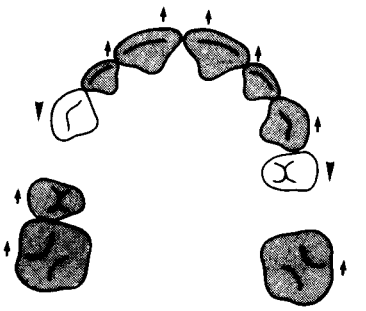
More usually we wish to move certain teeth whilst leaving the rest of the arch unchanged.

The force necessary to carry out a simple tipping movement on a single rooted tooth is usually said to be in the region of 30 to 50 g. There is a threshold of perhaps about 20 g below which movement does not occur.

Our problem is to deliver sufficient force to move the required teeth while ensuring that the reactionary force, when divided among the anchor teeth, is insufficient to cause movement.



The reaction to heavy forces applied simultaneously to too many teeth is likely to produce forward movement of the anchor teeth.



A light force applied to one tooth in each quadrant throws less strain on the anchor teeth and will minimize their forward movement.

Except where very minor tooth movement is being carried out some movement of the anchorage teeth frequently occurs. This is described as anchorage loss. Forward movement of buccal teeth occurs very readily particularly in the upper arch. This is frequently seen when physiological mesial drift occurs after premolar extractions have been carried out, even when appliances have not been used. In cases where space is not critical some anchorage loss may be acceptable. In other cases it may be vital that anchorage loss does not occur.

Anchorage may be conserved in two main ways:

1. Keeping Forces Light

Removable appliances conserve anchorage well because they allow simple tipping movements of the teeth which require

the lightest pressures. The reactionary force can be reduced by limiting the number of teeth moved. Only one buccal tooth per quadrant should be moved in the same direction at any one time and when an overjet is to be reduced the incisors should not be moved palatally while other teeth are being retracted. Nevertheless it is unwise to assume that anchorage loss will be completely avoided merely by the use of light forces.

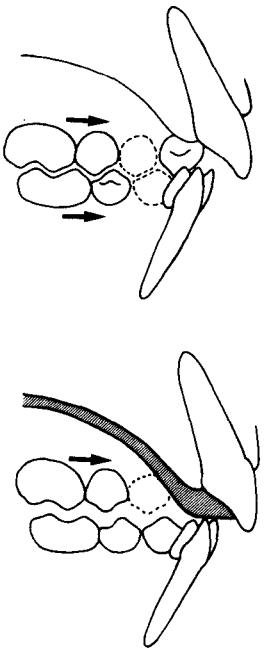
2. Increasing the Resistance of the Anchor Teeth

The Base Plate

The resistance offered by the fit of the base plate against the teeth and mucosa contributes to the good anchorage offered by removable appliances. This may be maximized by keeping the acrylic fitted around as many teeth as possible.

Cuspal Interlock

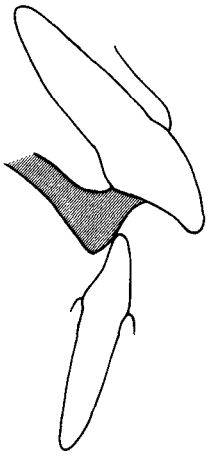
It seems likely that good cuspal interlock with the teeth of the opposing arch will offer added resistance to any anchorage loss. A problem, however, is that extractions in the opposing arch may allow the interlocked teeth to move mesially together. Further, when bite planes of any sort are used, cuspal interlock ceases to be effective.



The helpful effects of cuspal interlock may be eliminated by lower extractions or the use of bite planes.

The Inclined Bite Plane

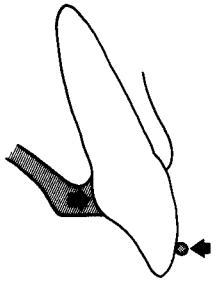
It is often claimed that the addition of an inclined anterior bite plane to an upper removable appliance will reinforce the anchorage by transmitting a distal thrust from the lower incisors when the patient occludes. It seems more likely that it will merely encourage the patient to posture the mandible forwards and in some cases it might cause proclination of the lower incisors. We think that it is wiser to reduce overbites by the use of a flat anterior bite plane and to use more reliable methods of anchorage reinforcement in cases where this is necessary.



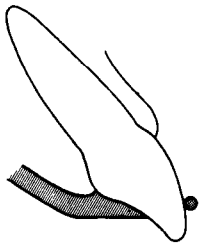
The use of an inclined bite plane makes no worthwhile contribution to anchorage.

The Labial Bow

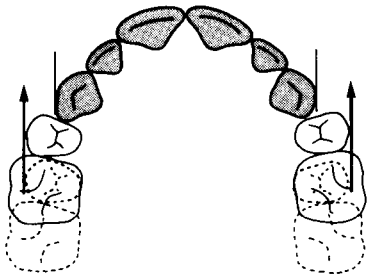
It is held in several textbooks that a labial bow placed incisally on the anterior teeth will prevent their proclination as a result of forward force applied through the acrylic base plate during the retraction of canines. In theory this might seem sensible. The acrylic and the labial wire should set up a



The traditional textbook view claims that the significant vertical separation between the palatal acrylic and the labial wire increases the anchorage value of the incisor teeth by establishing a rotational force couple.



The saggital section of a model demonstrates the minimal vertical separation of wire and acrylic.



Forward movement of the buccal teeth produces prominence of the second premolars unless the arch width is reduced.

force couple which resists the forward tilting of the incisors and permits only their bodily forward movement. The anchorage value of these teeth to the appliance should thus be greatly increased.

In practice there is often very little vertical separation between the acrylic and the labial wire. In addition a long labial bow is too flexible to remain securely in the correct position. A short fitting wire around two or more upper incisors would be more rigid but it seems probable that its main contribution to anchorage would be made by improving retention and holding the appliance in tight contact with the teeth and mucosa.

Intermaxillary Traction

Again this has little practical application in removable appliance treatment. Traction might occasionally be used from a removable appliance, perhaps to support a lower fixed sectional arch, but this would be more for the benefit of the fixed appliance than the removable one.

Extra Oral Traction

This is the surest and most useful method of improving anchorage in a removable appliance. It can be applied in a wide variety of ways which will be dealt with in a later chapter. It is well tolerated and can extend considerably the scope of removable appliance treatment.

Deliberate Loss of Anchorage

Unless good anchorage reinforcement is being employed any major tooth movement will usually involve some slight shift of the anchor teeth. In certain treatments, however, extractions may be necessary but may consequently produce excessive space. In these cases forward movement of the buccal segments is desirable. Removable appliances do not carry this out particularly well because the base plate limits the necessary re-adaptation of the arch shape as space is closed. If anchorage is to be lost intentionally then provision must be made for narrowing the width of the arch to facilitate forward movement of the cheek teeth.

CONCLUSIONS

A removable appliance is less flexible than a fixed appliance; not only physically, in that it has a rigid base plate, but also in its adaptability. It is frequently possible to change the effect of a full banded appliance completely, e.g. by modifying an arch wire or altering elastic traction. By contrast a removable appliance is designed to carry out a small number of pre-determined tasks. Minor alterations may require considerable laboratory or chairside time; major ones may require total reconstruction of the appliance. It is important, therefore, that cases are selected carefully for removable appliance treatment. As with any other orthodontic treatment it is necessary to have a patient who is receiving regular dental care and has a good standard of oral hygiene and a healthy mouth. It is also necessary that a patient is keen to have treatment and is prepared to co-operate in the correct wearing and cleaning of the appliance.

Case Selection for Removable Appliance Therapy

Indications

1. The skeletal pattern should not be far removed from Class I. The increased or reversed overjet should be due mainly to changes in incisor inclination.
2. It should be possible to treat each arch individually. For example, the upper arch might be treated with removable appliances and the lower either with extractions only, no treatment or a simple fixed appliance.
3. Any individually malpositioned teeth should have their apices fairly well in line.
4. Planned extractions should allow tipping movements to correct the malocclusion.
5. Faults of bucco-lingual occlusion should be associated with a mandibular displacement. For example a unilateral crossbite of the posterior teeth.
6. Extractions should provide slight excess space or just sufficient space. Removable appliances are inefficient at space closure.

Contra-indications

1. A noticeable skeletal discrepancy exists.
2. There is a need to correlate treatment in both upper and lower arches. For example anchorage problems requiring

intermaxillary traction and more severe discrepancies in arch width or shape.

3. The presence of apical malpositions, severe or multiple rotations.

4. Bodily movements are required.

5. The presence of vertical discrepancies such as a deep overbite, an open bite or height discrepancies between teeth.

6. Space problems exist, for example severe crowding or excess of space.

In general the points made in this book refer to upper appliances although many are also relevant to lower appliances. Lower removable appliances are dealt with specifically in Chapter 7.

In the following chapters we shall deal with the design and construction of the component parts of removable appliances.

CHAPTER 2

Principles of Design: The Acrylic Component

The body of a removable appliance consists mainly of the base plate which is made of acrylic resin. It can, if necessary, be extended and built up to form bite planes which will have an active influence on tooth position.

THE BASE PLATE

The base plate has two functions. Firstly it acts as a foundation into which the retaining clasps and active components of the appliance, such as springs and screws, are embedded. Secondly it contributes to the anchorage during the course of active tooth movement. It must provide a sufficient thickness of acrylic for the attachment of springs and retentive wirework but otherwise should be kept as thin as will be compatible with strength. The recommended thickness of the base plate is generally quoted as that of one sheet of modelling wax. In practice thicker base plates are often used satisfactorily but it is important that the acrylic should not be grossly thickened or the appliance may be difficult to wear, particularly during the initial adaptation period. The base plate should cover most of the hard palate and, while it may be trimmed away to permit movement or eruption of individual teeth, it should fit closely around the necks of those teeth which are not to be moved. The acrylic usually finishes across the vault of the palate just distal to the first molars.

Construction

The base plate is constructed on the model after completion of the wirework and boxing in of palatal springs. Conventionally heat-cured acrylic resins have been used. The springs

are boxed in with plaster and a wax plate is built up and then flasked and processed in the same manner as for a denture. In recent years there has been a great increase in the use of 'cold cure' acrylic with a resultant economy of laboratory time. When this technique is used palatal springs are waxed rather than plastered in and other springs and clasps are secured in place with a dab of wax applied on the buccal side of the teeth. After the application of a separating medium the base plate is built up by the addition alternately of polymer powder and monomer liquid using a small plastic 'puffer' bottle and a glass dropper, respectively. If the model is tilted during this process the base plate can be built up in sections without unduly increasing the thickness of the appliance in the palatal vault. The model is placed in warm water in a pressure flask for a few minutes and this produces a non-porous acrylic which may be trimmed and finished in the normal manner. Several commercial brands of acrylic are now produced specifically for orthodontic purposes and almost all removable appliances used by the authors are constructed by a 'cold cure' technique. These appliances have proved entirely satisfactory in use. It is probably an advantage to use a transparent acrylic resin as areas of pressure can then be detected with the appliance in the mouth. Apart from the saving in time a particular advantage of this method is that the model can be retrieved intact in most cases. This often proves useful if the appliance has subsequently to be repaired or modified. Any possible distortion of the wirework during flasking and de-flasking is also eliminated.

Anchorage

The base plate makes an important contribution to the preservation of anchorage. It achieves this in two ways. First, teeth in addition to those which carry clasps can contribute to the anchorage through the close fit of the acrylic around their necks. The acrylic should fit around as many teeth as possible. An exception to this rule is that when first molars are being clasped it is usually better not to extend the acrylic around the second molars. The appliance is better tolerated when it does not extend this far distally and the second molars are frequently incompletely erupted and able to contribute little to anchorage.

The second way in which the base plate can contribute to