

## IN BRIEF

- Anchorage is the resistance to unwanted tooth movement
- It can be obtained from a number of different sources
- Loss of anchorage can have a detrimental effect on treatment
- Safety is of prime importance when using extra-oral devices

## Orthodontics. Part 9: Anchorage control and distal movement

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Anchorage is an important consideration when planning orthodontic tooth movement. Unwanted tooth movement known as loss of anchorage can have a detrimental effect on the treatment outcome. Anchorage can be sourced from the teeth, the oral mucosa and underlying bone, implants and extra orally. If extra-oral anchorage is used, particularly with a facebow then the use of at least two safety devices is mandatory.

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Anchorage is defined as the resistance to unwanted tooth movement. Newton's third law states that every action has an equal and opposite reaction. This principle also applies to moving teeth. For example, if an upper canine is being retracted, the force applied to the tooth must be resisted by an equal and opposite force in the other direction. This equal and opposite force is known as anchorage.

Anchorage may be considered similar to a tug of war. Two equal sized people will pull each other together by an equal amount. Conversely a big person will generally pull a small one without being moved. However, if two or more smaller people combine then their chances of pulling a big person will increase. Similarly, the more teeth that are incorporated into an anchorage block, the more likely it is that desirable as opposed to undesirable tooth movements will occur. Undesirable movement of the anchor teeth is called loss of anchorage.

If an upper canine is to be retracted, with bodily movement using a fixed appliance, the force applied to the tooth will be approximately 100 g (Fig. 1a). Forces in the opposite direction varying from 67 g on the first permanent molar to 33 g on the upper second premolar resist this. Low levels will produce negligible tooth movement and the effect of a light force of 100 g would be to retract the canine with minimal anterior unwanted movement of the anchored teeth. However, if the force level is increased to say 300 g (Fig. 1b), the force levels on the anchor teeth increase dramatically to the level where unwanted tooth movements will occur. Although the canine may move a little distally,

the buccal teeth will also move mesially. Space for the canine retraction may be eliminated with insufficient space left for alignment of the anterior teeth. Figure 1c compares the root area of some of the upper teeth. The combined root area of the upper incisors and upper canines is around the same as that of the first molar and premolars. Therefore, if the upper labial segment including the upper canines is retracted in a block, there will be an equivalent mesial movement of the upper molar and upper premolar. These factors need to be very carefully considered in planning anchorage requirements and tooth movement.

Anchorage may be derived from four sources:

- Teeth
- Oral mucosa and underlying bone
- Implants
- Extra oral

### TEETH

The anchorage supplied by the teeth can come from within the same arch as the teeth that are being moved (intra maxillary) or from the opposing arch (inter maxillary).

### Intra maxillary anchorage

The anchorage provided by teeth depends on the size of the teeth, ie the root area of the teeth. Fig. 1c shows the root surface area of each of the teeth in the upper arch. The more teeth that are incorporated into an anchorage block the less likely unwanted tooth movement will occur. If a removable appliance is used, the base plate and retaining cribs should contact as many of

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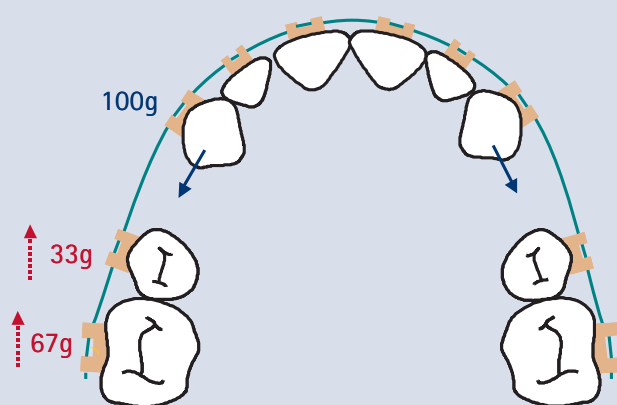


Fig. 1a A distalising force on the upper canine will produce a reciprocal force in the opposite direction on the anchor teeth. Provided the force level for bodily movement is kept low at about 100g then there will be minimal mesial movement of the anchor teeth

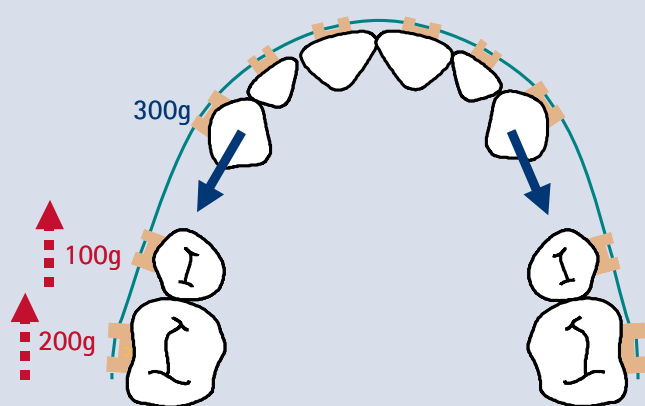


Fig. 1b As the distalising force level increases the reciprocal forces also increase with a greater risk of loss of anchorage

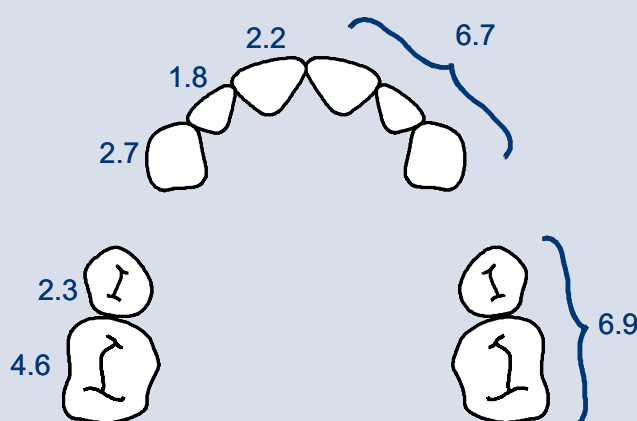


Fig. 1c The combined root surface area of the anterior teeth is almost the same as the molar and premolar. Attempting to move all the anterior teeth distally simultaneously will result in an equal mesial movement of the posterior teeth

the teeth as possible. Figure 2 illustrates the point. If upper canines are to be retracted with a removable appliance, cribs on the first permanent molars and upper incisors will not only help with retention but also increase the anchorage considerably. In addition, the base plate must contact the mesial surface of the upper second premolars and palatal to the upper incisors. If fixed appliances are to be used, the more teeth that are bracketed or banded, the greater will be the anchorage resistance (Fig. 3).

### Inter maxillary anchorage

Teeth in the opposite arch can provide very useful and important sites of anchorage control as Figs 4a,b illustrate. Good inter-digitation of the buccal teeth can help prevent mesial movement of the buccal segment. Although there is only anecdotal evidence to support this view, many clinicians feel this can be a useful source of anchorage.

The second way that opposing teeth can be used is by means of elastics or springs running from one arch to the other. Class II elastics (Fig. 4c) run from the lower molars to the upper incisor region, whereas Class III elastics (Fig. 4d) run from the upper molars to the lower incisor region.

Inter-maxillary elastic are invaluable in many cases but do rely very heavily on good patient co-operation. The elastics need to be changed every day and if they break (which they frequently do) they must be replaced immediately. Class II elastics will also tend to have unwanted effects on the occlusion. They tend to tip the lower molars mesially and roll them lingually. In addition, they can produce extrusion of the upper labial segment and the lower molars. Whilst extrusion of the lower molars can help with overbite reduction, extrusion of the upper incisors is usually an unwanted side effect and has to be counteracted by adding an upward curve to the upper arch-wire known as an increased curve of Spee. Extrusion of the buccal teeth is undesirable in patients with increased lower face height and therefore Class II elastics should be used sparingly in these cases. Similarly Class III elastics can extrude the upper molars, tip them mesially and roll them palatally. Molar extrusion will decrease the overbite, which is usually undesirable in Class III cases. Elastics also tend to cant the occlusal plane and have been implicated in root resorption in the upper labial segment, particularly if they are used for prolonged periods.

Functional appliances are another source of intermaxillary anchorage. Whilst some clinicians may believe these devices simply make the mandible grow, this is not the case and whatever mandibular growth does take place, is accompanied by quite substantial movement of the dentition over the apical base. This means that mesial tipping of the lower and distal tipping of the upper teeth occurs.

### ORAL MUCOSA AND UNDERLYING BONE

Contact between the appliance and the labial or lingual mucosa can increase anchorage considerably for either fixed or removable appliances. Contact between an orthodontic appliance and the vault of the palate provides resistance to mesial movement of the posterior teeth. The anchorage provided by this means is considerably greater if there is a high vaulted palate as shown in Figure 5a, which will produce a greater buttressing effect. A shallow vaulted palate (Fig. 5b) will provide much less anchorage control because the appliance will simply tend to slide down the inclined plane of the palate.

The mucosa and underlying bone can also be used when fixed appliances are used, for example a Nance palatal arch (Fig. 5c). This is an acrylic button that lies on the most vertical part of the palate behind the upper incisors and is added to a trans-palatal arch. These buttons are again of more limited use if the palatal vault is shallow.

### IMPLANTS

Osseo-integrated implants can be used as a very secure source of anchorage. Implants integrate with bone and do not have a periodontal membrane. Because of this they do not move when a force is applied to them and in some cases they can provide an ideal source of anchorage. Recently small implants for orthodontic use have been specifically designed and can be used in the retro-molar region to move teeth distally or anteriorly for mesial movement. Short 4mm implants can be

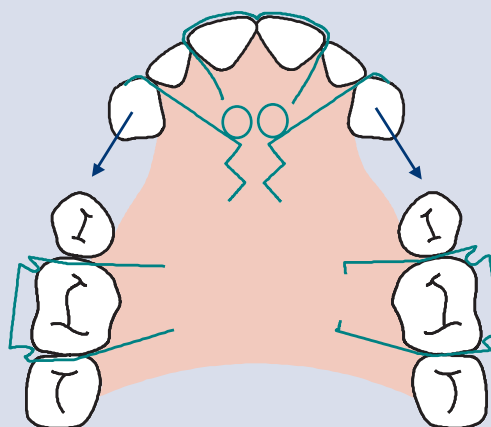


Fig. 2 Incorporating as many teeth as possible in the appliance design and covering the anterior palatal vault will increase the anchorage



Fig. 3 When fixed appliances are used, as many teeth as possible are banded to increase the anchorage



Fig. 4a,b Inter-digitation of the buccal occlusion can help increase anchorage



Fig. 4c Intermaxillary elastics use teeth in the opposite arch as a source of anchorage. Class II traction is shown here



Fig. 4d Class III elastics

paced in the anterior mid-line of the palate in the thickest part of the nasal crest and a trans-palatal bar then connects the implants to the teeth (Fig. 6).

#### EXTRA-ORAL ANCHORAGE

This can be applied via a number of devices and can be used in conjunction with either removable or fixed appliances. Headgear is not a recent invention and has been in use for over a century. Figure 7a is a picture of a Kingsley headgear, which was in use as early as 1861.

The force from the headgear is usually applied to the teeth via a face-bow (Klößen bow) as shown in Fig. 7b. This is fitted either to tubes attached to the appliance or integral with it as in the *en masse* appliance. The direction by which the force is applied can be varied depending on the type of headgear that is fitted. Headgear can be applied to both the maxillary and mandibular dentition, and there are a number of variations:

- Cervical
- Occipital
- Variable
- Reverse

##### Cervical Headgear

This is applied via an elastic strap or spring, which runs around the neck (Fig. 8a). It has the advantage of being relatively unobtrusive and easy to fit. However, it does tend to extrude the upper molars and tip them distally because of the downward and backward direction of force. This later effect can be counteracted to some degree by adjusting the height and length of the outer bow. Cervical headgear should not be attached to removable appliances because it is prone to dislodge the appliance and propel it to the back of the mouth.

##### Occipital

This is also known as high pull headgear and is applied via an occipitally placed head-cap (Fig. 8b). It is easy to fit but is more obvious than the neck strap and tends to roll off the head unless carefully adjusted. Because the force is in a more upward direction, there is generally less distal tipping of the upper molar and less extrusion, but also less distal movement than with cervical headgear. The tipping and extrusion effect again depend on the length and height of the outer bow.

##### Variable

This applies a force part way between cervical and occipital (Fig. 8c) and is our preferred choice. It takes slightly longer to fit than either cervical or occipital and is more obtrusive. However it is secure and comfortable and the vector of the force can be varied to produce relatively less tipping and/or extrusion.

Whilst headgear is a very useful source of anchorage, it has a number of disadvantages. These are as follows:

- Safety
- Clinical time
- Compliance
- Operator preference

The most important of these problems is the fact that headgear can be dangerous and a number of facial and serious eye injuries have been reported in the literature.<sup>1-3</sup> The Standards and Safety Committee of the British Orthodontic Society (BOS) have addressed these concerns. An advice sheet produced by the BOS is essential reading for anyone who wishes to use headgear.<sup>4</sup>

The main problems with headgear safety relate to the prongs at the end of the face-bow that fit into the headgear tubes on the intra-oral appliance. It is possible for the bow to become dislodged, either because it is pulled out of the mouth or when the patient rolls over when they are asleep. The recoil effect from the elastics can damage the teeth, oral mucosa, soft tissues of the face and most seriously, the eyes. In order to minimise these problem various safety devices have been suggested. These involve re-curving the distal end of the wire, using plastic coated face bows and various locking springs.<sup>5,6</sup> In addition a variety of snap-away face bows have been produced. If these are pulled beyond a pre set distance, the neck strap comes apart and prevents any recoil injury. Another popular method of preventing recoil is to fit a rigid safety strap, which prevents the bow from coming out of the mouth if it disengages from the tubes. Some examples of these safety devices are shown in Figures 8a-i.

The importance of headgear safety cannot be over emphasized and it is recommended that two safety mechanisms are simultaneously used, for example a locking spring and a snap away headgear or a safety face-bow and rigid safety strap.

##### Reverse

Reverse or protraction headgear is useful for mesial movement of the teeth, either to close spaces or help to correct a reverse overjet. It does not employ a face-bow, which is an advantage but instead employs intra-oral hooks to which elastics are applied (Fig. 9a,b).

#### LOSS OF ANCHORAGE

This is defined as the unplanned and unexpected movement of the anchor teeth during orthodontic treatment.

There are several causes of loss of anchorage. Some examples of these are:

- Poor appliance design
- Poor appliance adjustment
- Poor patient wear

##### Poor appliance design

Failure to adequately retain the appliance, or incorporate as many teeth into the anchor block as possible are common causes of anchorage loss. If fixed appliances are used, as many



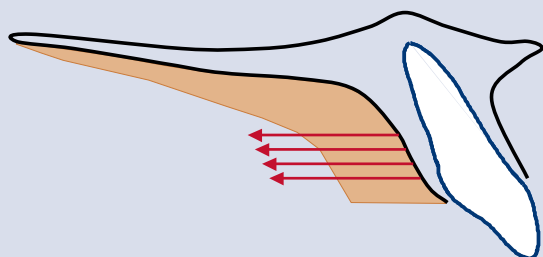


Fig. 5a A steep anterior palatal vault is a useful source of anchorage due to the buttressing effect

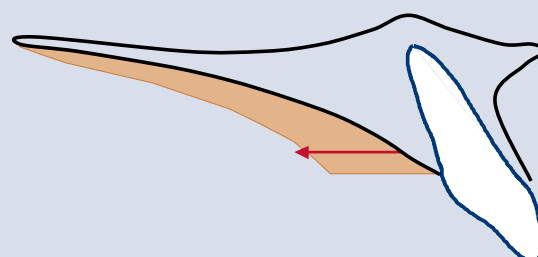


Fig. 5b A shallow palatal vault provides less anchorage



Fig. 5c The palatal vault can be used for removable or fixed appliances. An example of a Nance button is shown here



Fig. 6 An osseo-integrated implant with a bonded palatal arch is being used to help close space in the upper arch without retroclining the upper incisors



Fig. 7a An early Kingsley headgear circa 1860



Fig. 7b,c A facebow (Klößen bow) is attached to tubes welded to bands on the molars





Fig. 8a A neck strap. Note the snap away safety mechanism



Fig. 8b An occipital (high pull) headgear again with a snap away safety system



Fig. 8c A variable pull Interlandii headgear. A rigid plastic strip is employed as a safety mechanism to prevent the facebow disengaging from the molar bands and coming out of the mouth

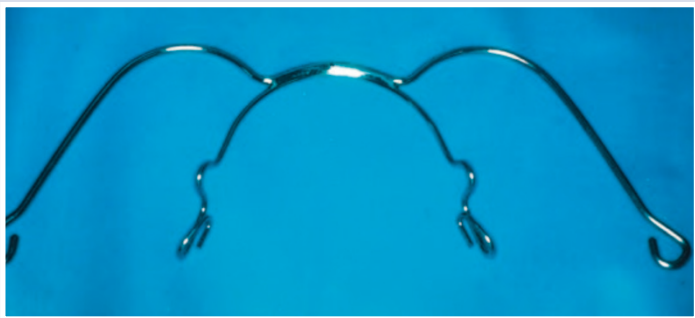


Fig. 8d,e The end of the facebow can be re-curved to improve safety



Fig. 8h,i A Samuel's locking spring. This secures the face bow to the tube preventing accidental disengagement. This should be used in conjunction with a safety neck strap or snap away headgear



Fig. 8f,g A plastic coated facebow together with a safety neck-strap



anchor teeth as possible should be banded in order to produce optimum anchorage. Removable appliances should have adequate retention using appropriate well-adjusted cribs or clasps with as much contact with the teeth and oral mucosa as possible.

### Poor appliance adjustment

The use of excessive force or trying to move too many teeth at the same time may result in unwanted movement of the anchor teeth. To avoid loss of anchorage, simultaneous multiple teeth movement should be avoided. If the appliance is poorly adjusted so that it doesn't fit very well, or the force levels applied to the teeth are too high, then undesired tooth movement may occur. High force levels produced by over activation are one of the key reasons for anchorage loss.

The optimal force for movement of a single rooted tooth is about 25–40 g for tipping and about 75 g for bodily movement. If the force is too low there will be very little movement, whereas too much force may result in loss of anchorage. Excess force does not increase the rate of tooth retraction as illustrated in Fig. 10.<sup>7</sup> As the force levels rise the rate of tooth tipping also increases up to about 40 g. Beyond this very little extra tooth movement occurs. Thus increasing the force levels above about 40 g will not increase the rate of tooth tipping.

The force levels that wires from fixed or removable appliances exert on teeth usually depends on the following:

- The material the wire is made from
- The amount it is deflected
- The length of the wire
- The thickness of the wire

Steel wire will exert a force that is directly proportional to the amount the wire is deflected up to its elastic limit. Figure 11 demonstrates how decreasing the wire thickness and increasing the length (sometimes by adding loops) controls the force produced.

Modern alloys such as super elastic nickel titanium wires do not act in the same way as steel. These remarkable wires are capable of producing

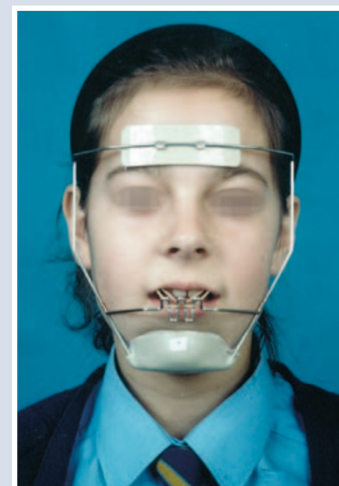


Fig. 9a, b A reverse, or protraction headgear

Rate of canine retraction  
(mm per month)

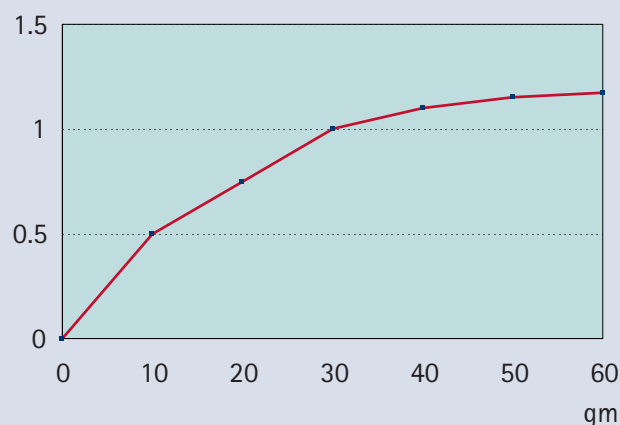


Fig. 10 The graph shows how increase force levels do not necessarily increase the rate of tooth movement. The y axis shows the rate of movement in mm. The x axis is the amount of tipping force applied to the tooth. As the force level initially rises the rate of tooth movement also increases. Above about 40 g the rate slows down and very little additional tooth movement occurs. There will however be a greater risk of loss of anchorage with increased force levels

Fig. 11 A 0.5 mm diameter wire can be deflected more than a 0.6 mm wire without increasing the force level. Thus a greater degree of activation is possible and the appliance will require less frequent adjustments. Similarly increasing the length of the wire, for example by incorporating loops allows a greater degree of wire deflection. The force characteristics may also be changed by altering the material the wire is made from

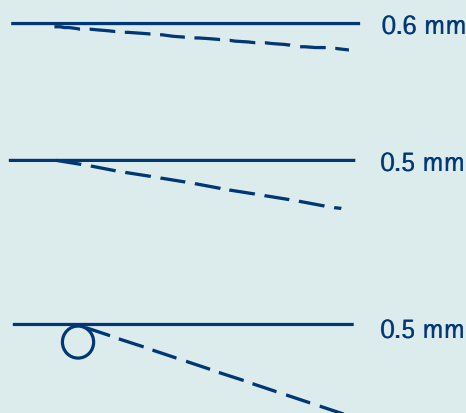
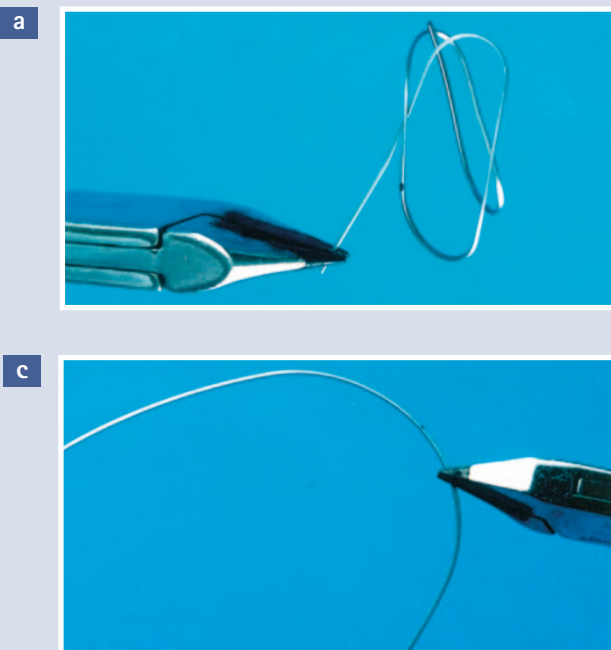




Fig. 12a–c Super elastic heat activated wires produce a light continuous force almost regardless of the amount of deflection. When cooled they become very flexible (12a) but return to their original shape as they warm in the mouth (12b,c)



a continuous level of force almost independent of the amount of deflection and have transformed the use of fixed appliances in recent years. Heat activated wire is now available that will increase its force level as the temperature changes. These wires exhibit a so-called shape memory effect. If the wire is cooled and tied into the teeth it deflects easily into position. As the wire warms in the mouth it gradually returns to its original shape moving the teeth with it (Figs 12a–c).

For optimal tooth movement it is important that continuous gentle forces are applied to the teeth. Fixed appliances are ideal for doing this. When removable appliances are worn, the patient should wear them full-time except for cleaning and playing contact sports. Part-time wear produces intermittent forces on the teeth and is likely to reduce the rate of movement.

When a force is applied to a tooth, there is an initial period of movement as the periodontal

membrane is compressed (Fig. 13). No tooth movement occurs for a few days after this, as cells are recruited in order to remodel the socket as well as the periodontal membrane. This cell recruitment takes a few days and is known as the lag effect. Part-time wear of appliances will not allow efficient cell recruitment and the lag phase will not be passed which may result in poor tooth movement. This is another reason why fixed appliances, which cannot be left out of the mouth by patients, are much more effective than removable appliances at achieving a satisfactory treatment outcome.

#### RETRIEVAL AND PRESERVATION OF ANCHORAGE

Extra-oral devices can be used for distal movement as well as anchorage reinforcement. For anchorage control wearing the headgear at night-time only is usually enough. In order to produce distal movement, the patient should wear the appliance in excess of 12 hours usually for the evenings as well as at nighttime. While some practitioners increase the force levels for distal movement purposes, it is our experience that this is not necessary and a force of approximately 250–300 g per side is adequate for both distal movement and anchorage control.

Many devices have been described to reduce or eliminate the need for headgear. These are however of limited use and can only produce a very small amount of extra space. If these gadgets are used without anchorage re-enforcement unwanted mesial movement of the anchor teeth could occur. Figures 14a–c shows one example known as a Jones jig. To produce distal movement of the molars the anchorage is reinforced with an anterior trans-palatal arch. A jig incor-

Fig. 13 Tooth movement requires light continuous forces. In this graph tooth movement in mm is shown on the y-axis and time in days on the x-axis. If a force is applied to a tooth the periodontal membrane is compressed and there is a small amount of initial movement. Movement then stops as bone cells are recruited and the socket starts to be remodeled. After about 14 days sufficient recruitment and remodeling has occurred to allow the tooth to move

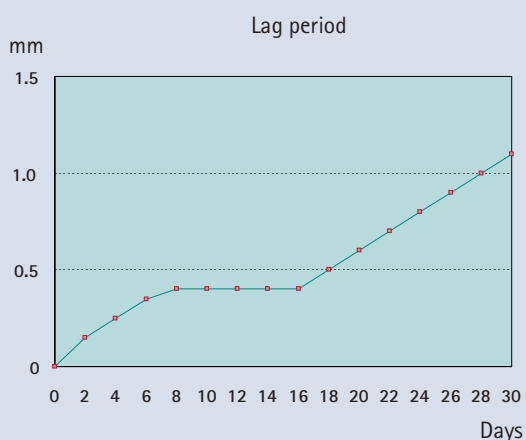




Fig. 14a-c A Jones jig for distal movement of the molars (14a). A palatal arch is fitted to the first premolars to increase the anterior anchorage. A jig is then inserted into the buccal arch wire and headgear tubes. An open nickel titanium coil spring is then slid over the shaft of the jig and compressed by sliding a collar onto the shaft and tying it to the premolar (14b). This then uses the upper premolars and palatal vault to distalise the molars (14c). Note the simultaneous mesial movement of the first premolars which is a sign of anchorage loss

a



b



c



porating a nickel-titanium coil spring is inserted into molar tubes and tied into the premolar bands. The molars are distalised using the anterior teeth from premolar to premolar as the anchorage block. It is important to note the loss of anchorage that is occurring as demonstrated by the simultaneous mesial movement of the first premolars. Once distal movement of the molars has been achieved the anchorage reinforcement can be transferred to the molars (palatal arch or Nance button) and the premolars, canines and incisors retracted. True anchorage re-enforcement with these devices is difficult to achieve and headgear, or implants must still be considered the mainstay of producing effective distal movement.

Thanks to Mr. R Cousley for figure 6 and Mr. J Kinelan for figures 14a-c

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