REVIEW ARTICLE

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Upper molar distalization: a critical analysis

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Abstract: Traditional upper molar distalization techniques require patient co-operation with the headgear or elastics. Recently, several different intraoral procedures have been introduced to minimize the need for patient co-operation. This article reviews the appliances currently available for maxillary molar distalization and critically analyses their dentoalveolar and skeletal effects.

Key words: class II malocclusion; molar distalization; non-compliance therapy

Introduction

Non-extraction treatment of Class II malocclusion frequently requires upper molar distalization into a final Class I relationship. To achieve this, a variety of treatment modalities have been suggested. For more than 100 years the most common procedure has been the headgear applied to upper molars, and its performance has been reliable (1–8). Unfortunately, headgear requires patient compliance to be effective. Often, the patient is not willing to wear the headgear for the recommended 12–14 h per day. To overcome this problem, several alternative methods have been proposed. These new molar distalizing appliances have been possible because of advances in technology especially new materials capable of delivering light and constant forces over a wide range of deactivation, and a better understanding of biomechanics and tissue reaction to orthodontic tooth movement. Consequently, the clinician nowadays can choose among a great variety of

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devices. To date the effects produced by all the various distalizing appliances, however, have not been critically evaluated in a single article. In fact, the majority of studies found in the literature describe just a single appliance and its effects. Therefore, a comparative analysis of all the distalizing appliances available on the market is needed. Accordingly, the purpose of this article is to describe all the different types of appliances used for molar distalization and to critically analyse their mode of action and effects on the dentition and skeleton based on evidence.

Headgear

In the nineteenth century several devices with extraoral support and extraoral forces were used (1, 2). Kloehn (3) showed successful results with headgear Class II treatment and invented the facebow design that we use today, attaching the bows to the inner arch with a soldered union in the incisor area (4).

Three different types of extraoral traction have been described depending upon the line of action of the force: high-pull, combi-pull and cervical pull. The high-pull headgear produces mostly intrusion of upper molars with hardly any movement posteriorly (Fig. 1a). The combi-pull headgear has principally a sagittal effect (Fig. 1b) whereas, the cervical pull delivers extrusion and posterior displacement or the molar (Fig. 1c) (5). Headgears correct the Class II malocclusion not only by distal movement of molars, but also by a skeletal effect: maxillary growth is inhibited and the palate rotated (6, 7).

Concerning the long-term stability of headgear effects, a number of published studies report conflicting results. Wieslander and Buch (8), in their 9-year follow-up study, concluded that the posterior movement of the maxillary molar, the basal maxillary changes and the surrounding anatomic structures were relatively stable. In contrast, Melsen (9), in an implant study, evaluated the effects of cervical traction during therapy and then 7–8 years after treatment. The effects of headgear on the growth pattern of the facial skeleton appeared reversible and temporary. In fact, during post-treatment growth, the direction of growth of the maxillary complex was more forward, on average, than would be expected in an untreated population. Variability in the above mentioned results could be attributed to differences

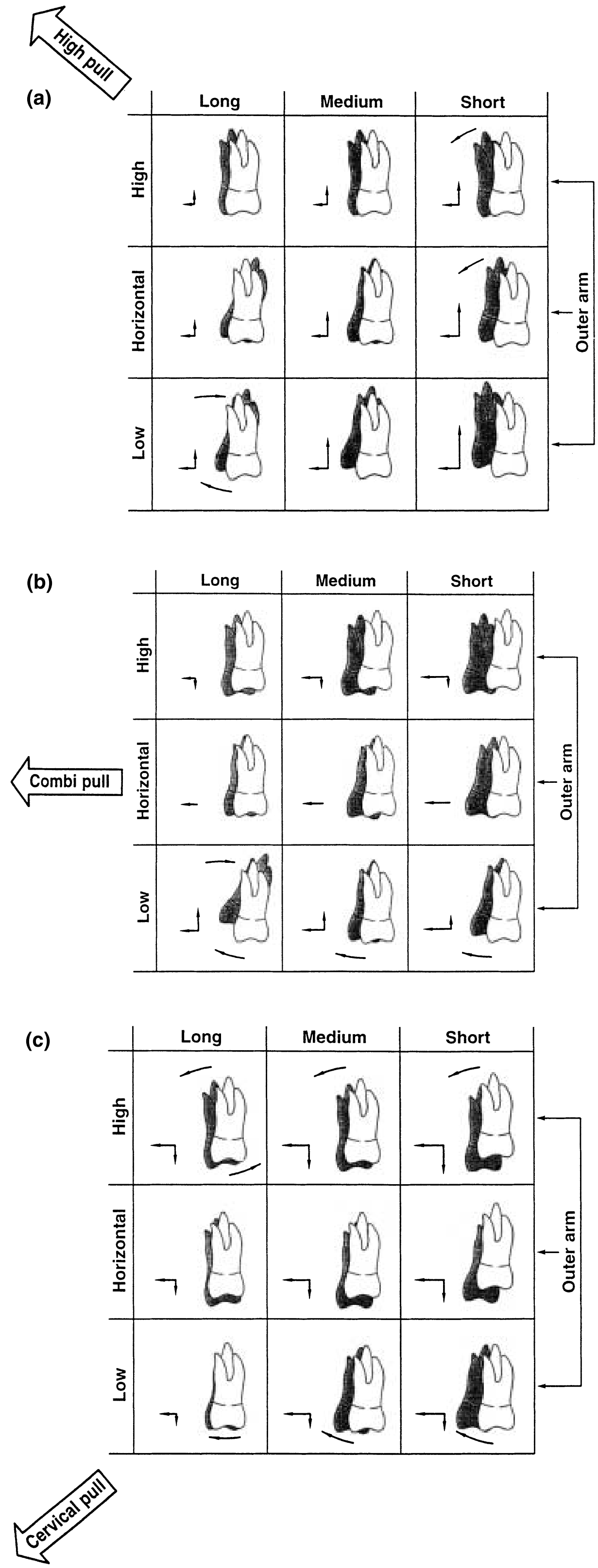

Fig. 1. (a) Dental effects produced by high-pull headgear. (b) Dental effects produced by combi-pull headgear. (c) Dental effects produced by cervical-pull headgear.

in the length of headgear treatment, methods used and experimental design. Further long-term studies are therefore needed to assess and define the stability of molar distalization.

Advantages of the headgear include extraoral anchorage, ease of application and inexpensiveness. The disadvantages are represented by patient co-operation, discomfort and difficulty in producing a bodily tooth movement. Therefore, we suggest these appliances be used when anterior anchorage loss must be avoided in the cooperative and growing patient.

Acrylic cervical occipital (ACCO)

This appliance consists of an acrylic palatal section (1 mm bite plate) to disclude the posterior teeth, modified Adams clasps on the first premolars, a labial bow across the incisors for retention, finger springs against the mesial aspects of the first molars for molar distalization in association with an extraoral traction (Fig. 2). With the combined use of ACCO and headgear, molars can be moved distally in a more bodily fashion. The finger springs move the crowns, and the headgear moves the roots (10), however, it is clinically difficult to monitor the two different force vectors. A recent study (11) reported a bodily upper molar distalization in only 9% of the patients. A distal-crown tipping was found in 70% of the treated cases, whereas in 21% of the patients a mesial-crown tipping occurred. Beyond molar tipping, another disadvantage of the ACCO appliance is anchorage loss. Mesial movement of the upper front teeth is associated with an increase in overjet. Labial displacement and proclination of the upper incisors was found in 81% of the patients (11). If anchorage loss exceeds 2 mm, it is recommended to bracket the incisors, place a sectional wire so that Class II elastics (100 g) can be placed. The lower arch anchorage can be augmented by a lip bumper (12). The use of a bite plate to disclude the posterior teeth can allow a faster distalization, however, it could result in a clockwise mandibular rotation. The stainless steel springs appear out-of-date when compared with the mechanical properties of new super-elastic materials.

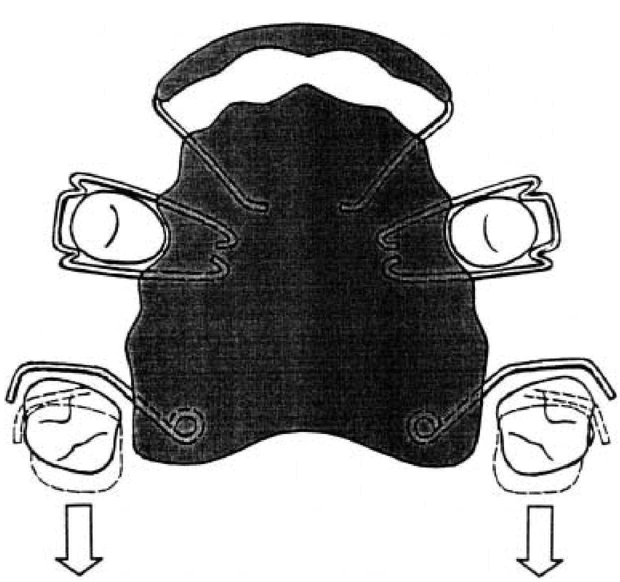

Fig. 2. Acrylic cervical occipital (ACCO).

We recommend the use of this appliance in Class II growing patients, with deep bite and normal or retroclined upper front teeth. It is contra-indicated in dental and skeletal open bites with high mandibular plane angle, increased lower face height, and proclined upper front teeth.

Transpalatal arch

The transpalatal arch (TPA) consists of a rigid stainless steel 0.9 mm wire, which enables the clinician to gain arch length by rotation, expansion and distalization of molars, and does not rely on patient compliance. The biomechanical understanding of the TPA is complex, because it is generally a two-bracket system that is constrained at both ends. A unilateral first-order activation of the TPA is useful in the correction of a unilateral Class II dental malocclusion, where distal movement of only one maxillary molar is required. A toe-in of only one insert will produce a clockwise moment (Ma) and a mesial force (F1) on the molar that receives the toe-in activation, and a distal force (F2) on the contralateral molar (Fig. 3). To minimize the side-effect of the F1 and Ma, a headgear can be used. Two-bracket systems where the appliance is engaged in the brackets/sheats of both teeth are statically indeterminate force systems. This means that it is difficult to measure clinically the forces and moments produced by the appliance. In contrast, one-bracket systems, which are inserted into a bracket or tube at one end and tied as a single point contact at the other, deliver forces and moments that can be measured clinically and are therefore very predictable. Such a system is statically determinate (13).

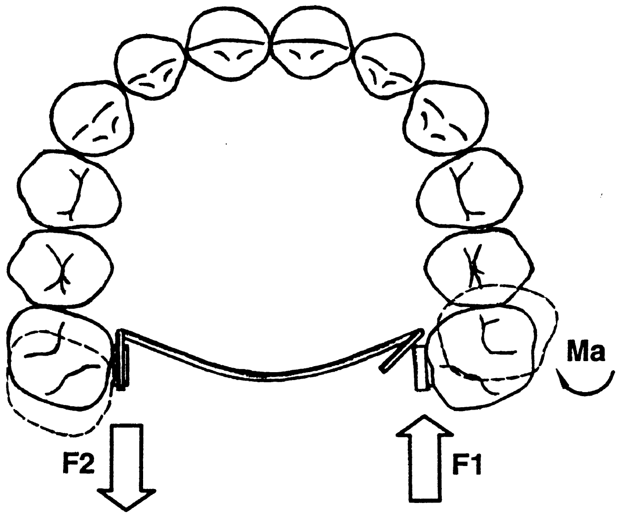

Fig. 3. Biomechanical force system produced by a unilateral first-order activation of a statically indeterminate TPA.

Haas and Cisneros (14) reported that the TPA is able to correct Class II malocclusions as a result of disto-buccal rotation and distal tipping of the activated molar. Distal forces were 1/4–1/8 of those generated with a headgear. As it has been shown that the distal movement produced by the TPA is very limited, we believe that it is useful in the correction of a unilateral Class II dental malocclusion or when both molars are very mesially rotated.

Wilson bimetric distalizing arch (BDA) system

It consists of a buccal upper arch with an open coil spring pushing against the first molar bands. Patient co-operation with Class II intermaxillary elastics is required to prevent advancement of the maxillary incisors. Anchorage in the lower arch is reinforced by means of a 3-D lower lingual arch contacting the cingulae of the incisors and attached to the lingual of the mandibular first molars. If maximum anchorage is required, a full fixed appliance can be bonded on the lower arch (Fig. 4; 15–17).

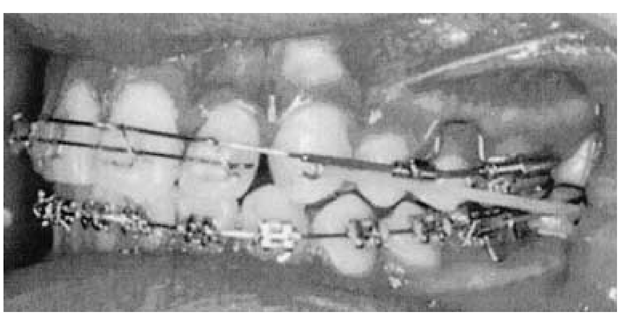

Fig. 4. Wilson Bimetric Distalizing Arch and lower full-fixed bonded appliance.

Several studies (18–20) have evaluated the dental effects produced by this appliance. Within certain variability, the results showed distal-crown tipping of the maxillary molars, flaring and extrusion of the upper incisors (18–20), extrusion of the mandibular first molars, mandibular incisor flaring, canting of the occlusal plane posteriorly and inferiorly (18, 20). Muse et al. (18) also found a mesial movement of the mandibular first molars and a reduced total lower arch length, in contrast to what is reported in other studies (17, 19). The presence of erupted maxillary second molars did not correlate with the rate of maxillary first molar movement, magnitude of movement, or amount of tipping (17, 18). The variability of the above mentioned results can be attributed to small sample size, differences in Class II elastic modules and scheduling, and difference in the alloy of the open coil springs (stainless steel, Elgiloy, Ni–Ti).

Compared with the headgear and ACCO appliance, the Wilson appliance produces less discomfort and requires less patient compliance. Disadvantages are represented by upper and lower anterior anchorage loss, upper and lower molar tipping and canting of the occlusal plane posteriorly and inferiorly. We therefore suggest such appliance in Class II growing patients, with retroclined mandibular incisors. It is contra-indicated in dental and skeletal open bites with high mandibular plane angle and increased lower face height.

Herbst

This appliance was introduced in 1909 by Herbst and popularized by Pancherz in 1979 (21). The Herbst appliance works as an artificial joint between the maxilla and the mandible. A bilateral telescopic mechanism attached to orthodontic bands, acrylic splints or, better, to cobalt chromium cast splints keeps the mandible in a protruded position. In contrast to functional appliances, the Herbst appliance has several advantages: (a) it works 24 h a day, (b) co-operation by the patient is not required, and (c) active treatment time is short (approximately 6–8 months). It has been shown that the Herbst appliance displaces the maxillary molars at a slower rate than other distalizing devices. This reduced rate of movement could be partly because of the fact that the Herbst appliance was originally designed to alter the growth of basal bones rather than to displace maxillary molars (22). Class II correction is mainly the result of an increase in mandibular length, remodelling of the glenoid fossa and restraining effect on maxillary growth (23, 24).

The Herbst produces backward and upward movements of maxillary molars in conjunction with distal-crown tipping. Because of the intrusive effect, distal movement of the maxillary molars does not tend to open the mandible. These effects are similar to those produced by high-pull headgear and are independent of the presence or absence of erupted second molars (25). For these reasons, in contrast to most of rapid molar distalization devices, the Herbst appliance does not cause the mandible to rotate downward and backward, opening the mandibular plane angle. Furthermore, in the mandibular arch, proclination of mandibular incisors occurs concomitantly with the anterior displacement of the dentition (23, 24) (Fig. 5). It has been shown that the lower anterior anchorage loss is inevitable, regardless of the system used, although less mandibular dentoalveolar changes have been reported when using acrylic Herbst appliances (23).

As the Herbst appliance was originally designed for orthopaedic correction of Class II malocclusion rather than to displace maxillary molars, we suggest this appliance be used in skeletal Class II post-adolescent patients, with deep bite and retroclined mandibular incisors. When only dentoalveolar correction is required, we prefer to use other non-compliance appliances, which are less bulky, more comfortable and less expensive. The ideal timing for Herbst treatment is at or just after the pubertal growth spurt, and when the permanent dentition is established. Treatment in the mixed dentition is not recommended, because of the difficulty with the primary molars being shed. In summary, the use of Herbst is limited to patients who can tolerate proclination of the mandibular incisors.

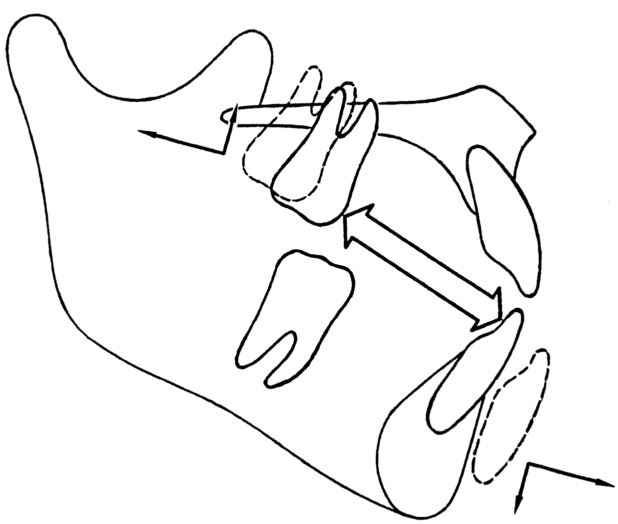

Fig. 5. Dental effects produced by the Herbst appliance.

Jasper Jumper

In 1987 James J. Jasper developed a new device for the correction of Class II malocclusions, which was similar to the Herbst appliance in terms of design and force vectors. It consists of two vinyl coated auxiliary springs that are fitted to fully banded upper and lower fixed appliances. The springs are attached to the maxillary first molars posteriorly and to the mandibular archwire anteriorly, and they hold the mandible in a protruded position (Fig. 6). A heavy rectangular stainless steel archwire is used both in the maxillary and in the mandibular dental arch. In the latter, labial root torque is added in the anterior region to enhance lower anchorage. Also, a transpalatal bar and a lower lingual arch are used for anchorage purposes.

Cope et al. (26) described the orthopaedic and orthodontic changes associated with the Jasper Jumper therapy. They showed that the majority of action was the result of dental, rather than skeletal change, although the maxilla underwent significant posterior displacement and the mandible backward rotation. The maxillary molars underwent significant distal tipping and relative intrusion, of greater magnitude than found

Fig. 6. Jumper mechanism connected to a SS 0.017″ × 0.025″ sectional wire.

with the Herbst. The mandibular incisors underwent significant uncontrolled buccal tipping and intrusion. More recently, similar results were reported by Covell et al. (27). We therefore recommend the use of this appliance in Class II growing patients, with deep bite and retroclined mandibular incisors. It is contra-indicated in dental and skeletal open bites with high mandibular plane angle and increased lower face height, as the Jasper Jumper produces significant molar distal tipping associated with clockwise rotation of the mandible.

The Adjustable Bite Corrector

West (28) described this appliance, which functions similarly to the Herbst and the Jasper Jumper. The advantages include universal left and right sides, adjustable length, stretchable springs and easy adjustment of the attachment parts. To date, however, no long-term studies have been carried out to investigate the effects produced by this appliance.

The Eureka Spring

DeVincenzo (29) introduced the Eureka Spring, which is a fixed interalveolar force delivery system. Its main component is an open-wound coil spring encased in a telescoping plunger assembly. The springs attach posteriorly to the headgear tubes on the maxillary first molars and anteriorly to the lower archwire distal to the cuspids. At the attachment end, the ram has either a closed or an open ring clamp that attaches directly to the archwire. Similarly to the Jasper Jumper, we believe that this appliance could be indicated in Class II growing patients, with deep bite and retroclined mandibular incisors. It is contra-indicated in dental and skeletal open bites with high mandibular plane angle and increased lower face height. To date, no long-term studies have been carried out to investigate the effects produced by this appliance.

Forsus

Very recently, a new appliance which functions similarly to the Jasper Jumper and Eureka Spring has been introduced. It consists of two Nitinol springs which are fitted to fully banded upper and lower fixed appliances. The springs are attached to the maxillary first molars posteriorly and to the mandibular archwire anteriorly, and they hold the mandible in a protruded position (Fig. 7). The indications and contra-indications for this device are the same mentioned for the Jasper Jumper and Eureka Spring. To date, no published clinical trials have emerged on this system.

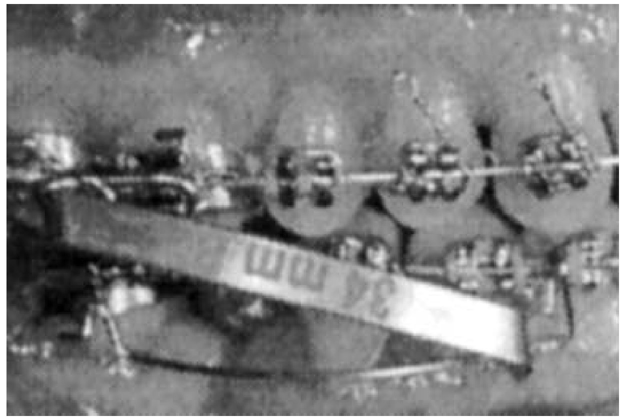

Fig. 7. Forsus appliance.

Repelling magnets

In 1988–89 Gianelly et al. (30, 31) described a new intra-arch method for distalization of first maxillary molars by means of samarium–cobalt repelling magnets ($SmCo_5$). The system consists of two repelling magnets per side, one anchored to the molar to move posteriorly, the other connected to the premolar or deciduous molar of the same quadrant, which is in turn anchored to a modified Nance holding arch extended until the palatal surface of the maxillary incisors to reinforce the anchorage. The magnetic force results in a rapid distal movement of the first molars. The movement separates the magnets, which must be reactivated by being placed back in contact every 2 weeks.

According to Itoh et al. (32), molar distalization occurs almost entirely as a bodily movement, with slight distal tipping and rotation. However, as the line of force action lies occlusally and buccally in respect to the centre of resistance of the molar and the anchorage unit (Fig. 8a,b), we would expect the molars to be tipped and distally rotated and the premolars to be mesially tipped. These side-effects have been confirmed by other authors (33, 34). Moreover, it has been shown (32–34) that the Nance holding arch is not a valid system for absolute anchorage: labial tipping of the maxillary incisors, about 30–50% of the distal movement of the molars, has been reported (32). Gianelly et al. (30) found an anchorage loss of 20%.

Because of the size of the magnets, some discomfort of the buccal mucosa has been experienced by the patients during the first week of therapy. Also, some difficulty in brushing has been reported (32, 33). Probably because of all the side-effects associated with such appliance and its high cost, magnets have lost popularity over the years.

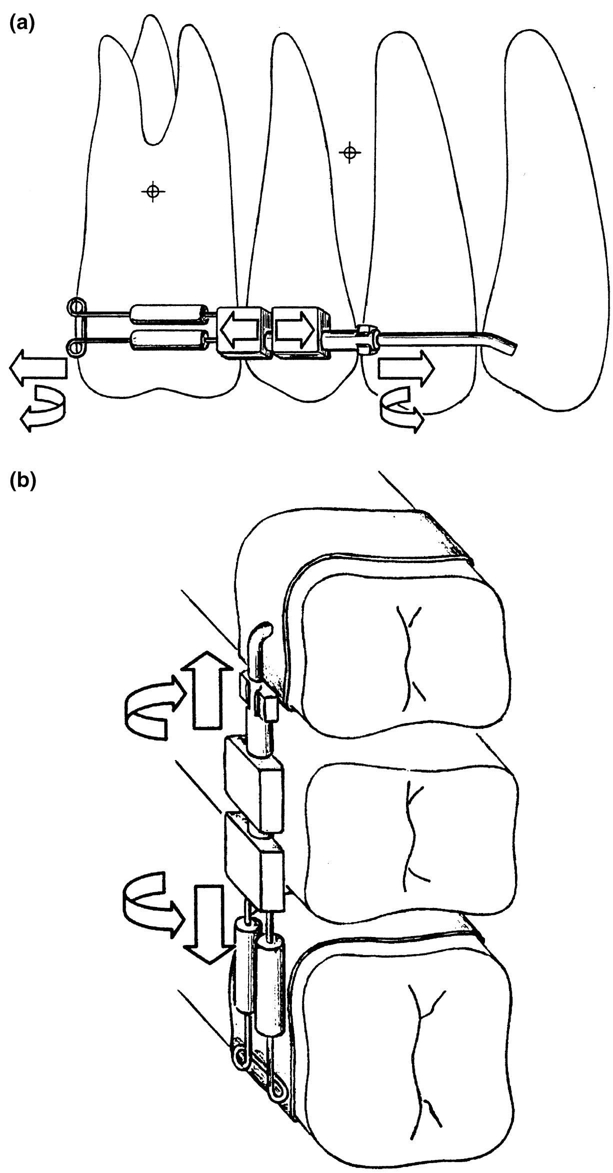

Fig. 8. (a,b) Biomechanical force system produced by repelling magnets – sagittal (8a) and occlusal view (8b).

Ni–Ti coil springs

Gianelly et al. (35) have developed another distalization system consisting of 100 g Ni–Ti superelastic coil springs placed on a passive 0.016″ × 0.022″ wire between first molar and first premolar. In addition, a Nance-type appliance is cemented onto the first premolars. To enhance anchorage further, an 0.018″ uprighting spring is placed in the vertical slot of the premolar bracket, directing the crown distally (Fig. 9), and Class II elastics are used. Because the line of force action lies occlusally and buccally in respect to the centre of resistance of the molar, we would expect the molar to be distally tipped and rotated. These side-effects have been confirmed by Pieringer et al. (36), who reported a distal-crown tipping of maxillary molars and a buccal tipping of the maxillary incisors in all the patients treated with such appliance.

Bondemark et al. (37), comparing repelling magnets vs. superelastic Ni–Ti coil springs in the distalization of maxillary molars, found, after 6 months of treatment, that superelastic coils were more efficient than repelling magnets. This can be explained by the differential decrease of force in the two systems. The open coils produce a more constant force, while the magnet forces drop rather quickly with increased distance between the poles as a result of physical properties. These results were confirmed by the work of Erverdi et al. (38).

The Ni–Ti coils are indicated in Class II malocclusions, with normally or retroclined upper front teeth. They are contra-indicated in dental and skeletal open bites with high mandibular plane angle, increased lower face height, and proclined upper front teeth.

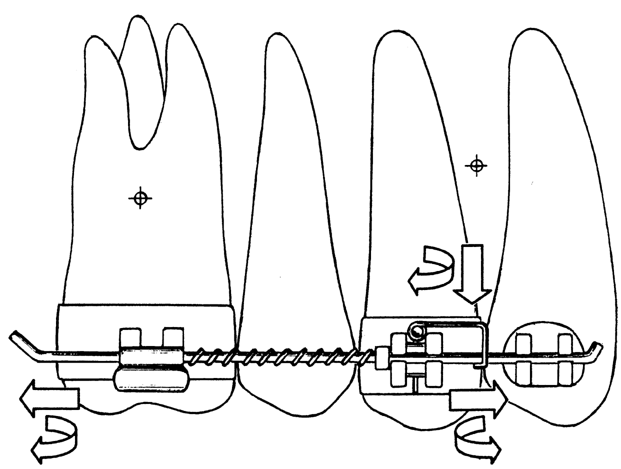

Fig. 9. Biomechanical force system produced by Ni–Ti coil springs.

Jones Jig

The Jones Jig is an open Ni–Ti coil spring delivering 70–75 g of force, over a compression range of 1–5 mm, to the molars (39). A modified Nance appliance is attached to the upper first or second premolars, or the second deciduous molars. Because the line of force action lies occlusally and buccally in respect to the centre of resistance of the molar (Fig. 10a,b), we would expect the molars to be distally tipped and rotated, whereas the premolars to be mesially tipped. The reports of other authors have corroborated these side-effects (40–42).

Gulati et al. (40) reported significant hinge opening of the mandible that result from excessive extrusion of the maxillary molars. Thus, we recommend only patients with normal or low mandibular plane angles to be treated with such appliance. Obviously, it would be contraindicated in cases of excessive vertical growth. Haydar and Üner (41) compared the Jones Jig molar distalization appliance with extraoral traction. The Jones Jig was found to produce more distal-crown tipping of the molars and significant mesial tipping of the anchorage unit. Moreover, extrusion of maxillary first molars was observed in both groups, but it was found statistically significant only in the Jones Jig group. The Jones Jig and cervical headgear comparisons were made also by Brickman et al. (42). They noted differences in the changes of final position of the maxillary incisors between the cervical headgear and the Jones Jig sample. The findings, however, were not statistically significant. The variability of the above mentioned results could be attributed to differences in sample size and mean age, type of malocclusion, and additional use of Class II elastic modules in combination with headgear. Although advantages of the Jones Jig include minimal patient compliance and ease of fabrication and use, we recommend to use such appliance in cases where mesial movement and protrusion of the anchorage unit during intraoral distalization can be tolerated.

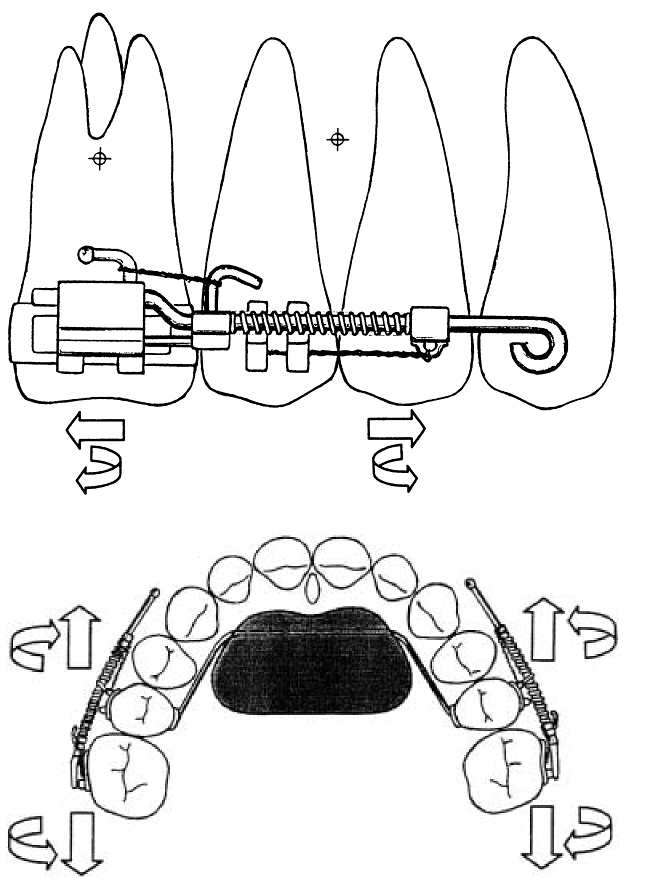

Fig. 10. (a,b) Biomechanical force system produced by the Jones Jig – sagittal (10a) and occlusal view (10b).

Ni–Ti wires

Locatelli et al. (43) used a 100-g rectangular superelastic Ni–Ti wire (NeoSentalloy) compressed between maxillary first premolar and first molar. Anchorage was controlled by placing 100–150 g Class II elastics against the first premolars, or placing the hooks between the lateral incisors and canines. An alternative was a Nance appliance cemented to the first premolars (Fig. 11).

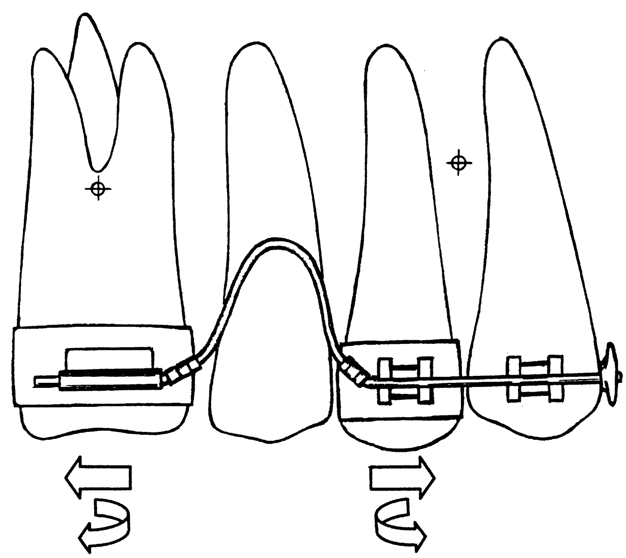

Fig. 11. Biomechanical force system produced by Ni–Ti wire.

Giancotti and Cozza (44) developed a system consisting of two NeoSentalloy superelastic Ni–Ti wires for simultaneous distalization of maxillary first and second molars. An 80-g NeoSentalloy archwire is placed between first premolars and first molars, while two sectional Ni–Ti wires, one for each side, are compressed between the second premolars and the second molars. Uprighting springs are inserted into the vertical slots of the first premolar bands, and Class II elastics are used to reinforce the anchorage. In both systems, however, the line of force action lies occlusally and buccally in respect to the centre of resistance of the molar and of the anchorage unit. Therefore, as mentioned for the repelling magnets and the Ni–Ti coils, we would expect the molars to be distally tipped and distally rotated, and the premolars to be mesially tipped. Moreover, there is a risk of producing different occlusal planes caused by the use of Class II elastics and uprighting springs on superelastic wires. These systems can be used in Class II malocclusions, with normally or retroclined upper front teeth. They are contra-indicated in dental and skeletal open bites with high mandibular plane angle, increased lower face height, and proclined upper front teeth. To date, no published clinical trials have emerged on either of those systems.

Pendulum

It consists of a Nance button that incorporates four occlusal rests that are bonded either to the deciduous molars or to the first and second bicuspids. An alternative method is to solder retaining wires to bands on the maxillary first bicuspids. Two TMA 0.032″ springs inserted into an 0.036″ lingual sheath on the maxillary molar bands are used as active elements for molar distalization. The springs are mounted as close to the centre and distal edge of the button as possible to produce a broad, swinging arc (or pendulum) of force. Each spring consists of a closed helix, an omega-shaped adjustable horizontal loop for molar expansion and prevention of the cross-bite following the palatal movement of the molar (Fig. 12; 45). The force is applied occlusally in respect to the centre of resistance of the molar. Therefore, the molars are not distalized in a bodily fashion, but distal tipping is expected. If expansion of the maxillary arch is indicated, then a midline screw is added to the appliance (Pend-X). An alternative is a fixed rapid palatal expander that incorporates the rotation and distalization components of the Pendulum appliance (46).

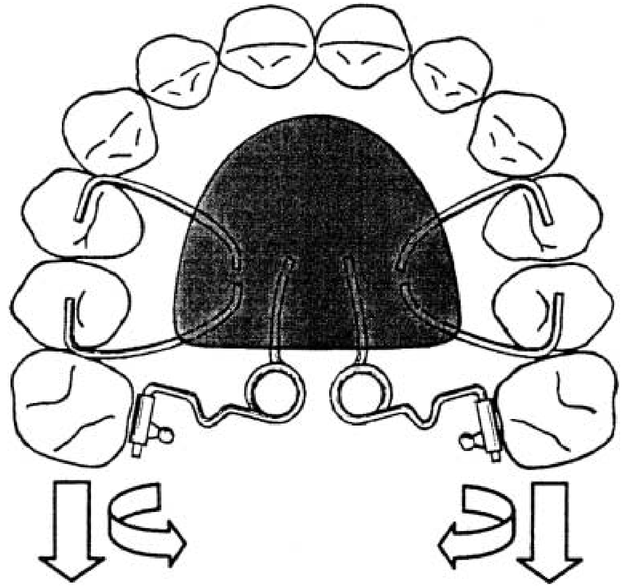

Fig. 12. Biomechanical force system produced by the Pendulum – occlusal view.

Several studies (47–49) reported maxillary first molar distalization, with significant distal-crown tipping and intrusion. Mesial movement of the first premolars was reported with mesial tipping and extrusion was also observed (50). The eruption of maxillary second molars had minimal effect on distalization of first molars. The maxillary second molars were also posteriorly displaced, tipped distally and moved buccally (47). A significant correlation between the amount of distalization and the degree of distal molar tipping was found (48, 49). Byloff et al. (51) attempted to correct the molar tipping by incorporating an uprighting bend (10–15° in the sagittal plane) in the Pendulum spring after distalization and achievement of a super Class I molar relationship. The introduction of an uprighting bend into the clinical management of the Pendulum resulted in reduced molar tipping, more anchorage loss and 64.1% increased treatment time.

Anterior anchorage loss was a constant finding of several studies. A significant amount of incisor labial tipping, producing an anterior anchorage loss which represented 24–29% of the space opened between molars and premolars. Consequently, distal molar movement represented 71–76% of that space (48, 52). Therefore, we consider the Pendulum appliance to be detrimental for the patients who cannot tolerate maxillary incisors advancement (i.e. presence of thin labial bone, deficient gingival height, or severe incisor proclination).

Evaluation of the effects of the Pendulum appliance on the lower anterior facial height has shown conflicting results. Bussick and McNamara (52) reported statistically significant increases in lower anterior facial height in all their patients, regardless of facial type, whereas Ghosh and Nanda (47) reported a significant increase only in patients with higher mandibular plane angle measurements. Contrasting these reports, Joseph and Butchart (49) found very little change in vertical dimension in their sample, whereas Byloff and Darendeliler (48) did not report any dental or skeletal bite opening. Variability amongst those studies may be related to differences in sample size, mean age, vertical facial pattern and criteria used to classify the patients according to pre-treatment lower anterior facial height. Considering such variability of outcomes, the clinician must be aware of the side-effects associated with this appliance, and use it carefully in cases of extreme vertical growth pattern.

Distal-Jet

Carano and Testa (53) described the design and use of this appliance. Bilateral tubes of 0.036″ internal diameter are attached to an acrylic Nance button. A Ni–Ti coil spring and a screw clamp are slid over each tube. The wire from the acrylic ends in a bayonet bend and inserts into a palatal sheath on the molar band. An anchor wire from the Nance button is soldered to the bands on the first or second premolars. The Distal-Jet is reactivated by sliding the clamp closer to the first molar once a month. The force acts close to the centre of resistance of the molars (Fig. 13), thus, we would expect less molar tipping and a better bodily movement compared with other intraoral distalizing devices. The force, however, is applied palatally. Therefore, the rotational control of the molars during distalization is quite difficult and, once distalized, the mesial rotation is a common finding. Furthermore, significant anterior anchorage loss can be expected, because the Nance holding arch alone has been demonstrated to be insufficient for absolute anchorage with other distalizing devices (32–35). These findings have been confirmed by a recent study (54). Advantages of the Distal-Jet include improved aesthetics and comfort, simple insertion and activation, better molar bodily movement, and easy conversion into a Nance holding arch after molar distalization. As the main disadvantage is represented by a significant anterior anchorage loss, we recommend not to use this appliance in cases presenting maxillary incisor proclination, anterior open-bite and protrusive profile.

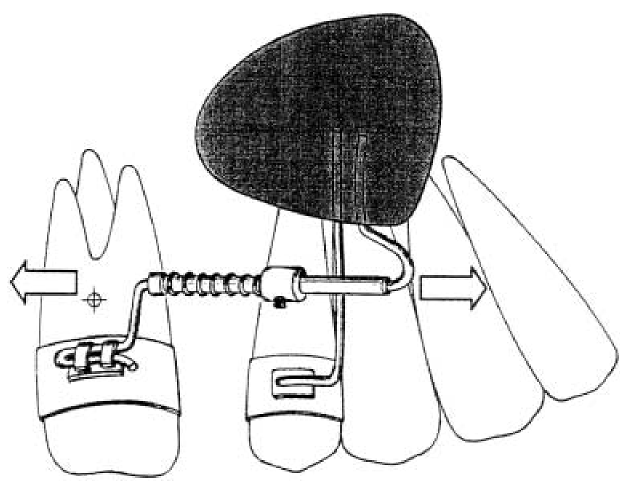

Fig. 13. Biomechanical force system produced by the Distal-Jet – sagittal view.

First class

It consists of vestibular and palatal components. Screws are soldered on the buccal sides of the first molar bands, occlusal to the single tubes. Split rings welded to the second premolar bands control the vestibular screws. In the palatal aspect the appliance is much like a modified Nance button, but it is wider and has a butterfly shape for added stability and support. Ni–Ti coil springs are fully compressed between the bicuspid joints and the tubes on the first molars (55). The line of force action lies occlusally in respect to the centre of resistance of the molar and of the anchorage unit. Therefore, as mentioned for the repelling magnets and the Ni–Ti coils, we would expect the molars to be distally tipped, and the premolars to be mesially tipped (Fig. 14). As it has been shown that the Nance button anchorage support cannot completely resist the mesial reciprocal force of these types of molar distalization appliances (32–35, 54), a significant anterior anchorage loss can be anticipated. Thus, additional anchorage may be necessary in some

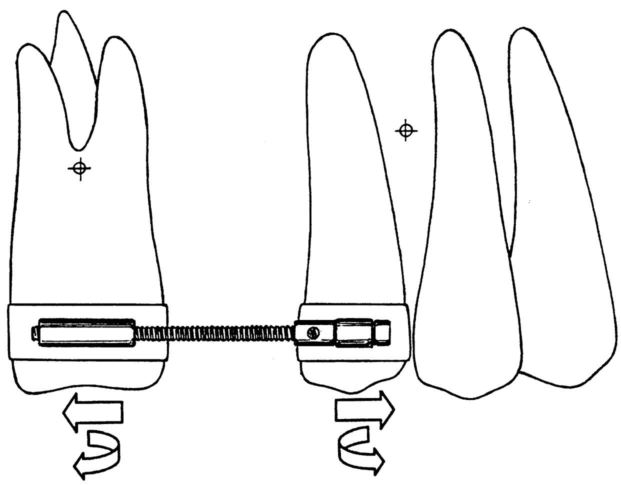

Fig. 14. Biomechanical force system produced by the First-Class – sagittal view.

instances. Compared with the Distal-Jet, this device is able to avoid molar mesial rotation during distalization, however, we would expect more molar distal tipping. To date, however, no clinical trials have been published on this appliance.

Discussion

This article describes the current methods available for molar distalization and critically analyses their mode of action and effects on the dentition based upon available research. As previously reported, extraoral traction has been found to be the only device able to move molars distally without anterior anchorage loss (41) and, thus, it is well indicated in cases of critical anterior anchorage. Other advantages of the headgear include ease of application and use, and inexpensiveness. Its distalizing effects, however, are strongly dependent upon patient compliance. Consequently, several alternative methods have been proposed to move molars distally with reduced dependence on patient co-operation. The TPA does not rely on patient compliance, but the amount of posterior movement produced is very limited. Furthermore, additional use of a headgear is indicated when the TPA is used for the correction of a unilateral Class II dental malocclusion, in order to minimize the side-effect of the F1 acting on the contralateral molar. Compared with the headgear and ACCO appliance, the Wilson appliance is better tolerated, but it requires patient compliance with the use of Class II elastics, which results also in lower anterior anchorage loss. The bite-jumping devices (Herbst, Jasper Jumper, etc.) are completely independent of patient co-operation; unfortunately, their use is limited to patients who can tolerate proclination of the mandibular incisors.

The non-compliance intra-arch molar distalizing methods mainly rely on a Nance button to reinforce the anterior anchorage. It has been shown in a number of studies that the Nance button does not serve as an absolute anchorage both during and after molar distalization and anterior anchorage loss is a constant finding (32–35, 50, 54). With this appliance once the molars have been distalized, some patient compliance is often required during distalization of premolars and anterior teeth by means of Class II elastics, Class II elastics on sliding jigs, headgear, etc. A future improvement to the available non-compliance distalizing devices will be the use of palatal implants or miniscrews connected to the Nance button for reinforcing the anchorage and avoiding side-effects in the anterior region (Fig. 15).

As far as the type of molar posterior displacement is concerned, it is difficult to produce a bodily tooth movement by means of headgear and ACCO appliance, because the line of force hardly passes through the centre of resistance of the maxillary molars. The remaining devices have shown significant molar distal-crown tipping, as the line of force action lies occlusally in respect to the centre of resistance of the molar, except for the Distal-Jet, which has been found to produce a better bodily molar movement (54). Perhaps, the only appliance that can move the

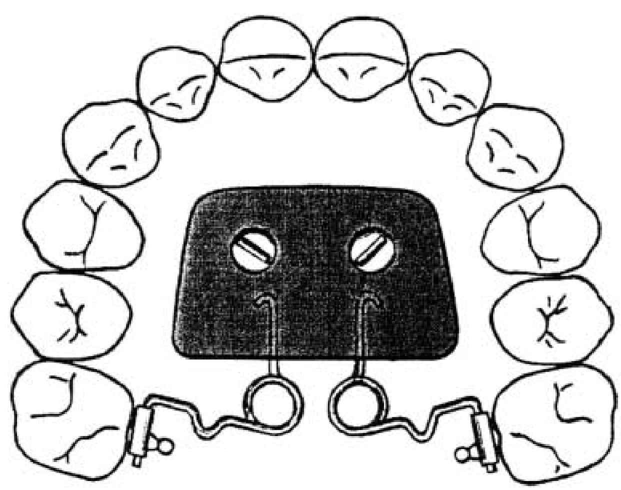

Fig. 15. Modified Pendulum with absolute anchorage by means of palatal implants.

maxillary molar distally (and possibly intrude) is the Coats Translator. Such effects are possible because it employs vertical tubes on the molars. It is fabricated by AOA Laboratories (Sturtevant, WI, USA). Studies of its effectiveness have not yet been published, but it too cannot escape from anchorage loss at the premolar region.

Conventional molar distalization is not always indicated for Class II correction. It is contraindicated in open-bite patients and in the presence of a protrusive facial profile. In open-bite patients molar distalization would determine a clockwise mandibular rotation, thus increasing the lower face height and worsening the facial appearance. In the case of protrusive facial profile the anterior anchorage loss, which occurs during molar distalization, would worsen the inclination of the front teeth and, consequently, the profile itself. Molar distalization is recommended for the correction of Class II malocclusions in deep-bite patients and in the presence of a concave or normal facial profile. In borderline patients, the choice between whether to extract teeth or distalise molars must be made also taking into account the possibility of a longer treatment time of a non-extraction approach.

There are no ideal molar distalizing appliances without side-effects. It is difficult to quantitatively compare the mode of action and side-effects of all the current methods available for molar distalization. A meta-analysis (56) might enable the clinician to make evidence-based decisions, but unfortunately, there are no published results of randomized clinical trials.

The molar distalizing methods for the non-compliant patient might be considered a breakthrough in the treatment of Class II malocclusions. Indeed, they enable the clinician to perform a non-extraction treatment in non-compliant patients who would alternatively be treated only with extractions. Clearly, the orthodontist must be aware of the disadvantages associated with those appliances and select the most appropriate distalization device on an individual base after a careful diagnosis and treatment plan. Regarding the long-term stability of molar distalization, unfortunately, apart from the studies by Wieslander and Buck (8) and Melsen (9), there are no data available in the literature. Until additional studies are conducted, it cannot be said with certainty that molar distalization is a stable orthodontic procedure.

Conclusions

According to what has been published some guidelines, albeit loosely defined, can be formulated:

1. In skeletal Class I or mild Class II, if patient compliance is good and in cases of critical anterior anchorage, it is best to use extraoral traction for molar distalization.
2. If the patient does not cooperate as requested, we recommend the use non-compliance molar distalizing methods, always taking into account the disadvantages and side-effects associated with those appliances.
3. In cases of pseudo or true skeletal Class III with crowded upper arch and Class II molar relationship, the use of intra-arch non-compliance molar distalizing methods is preferable, as the eventual maxillary anterior anchorage loss is generally not contraindicated in those patients.

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