Mohammed Almuzian Fahad Alharbi Jill White Grant McIntyre

Distalizing Maxillary Molars – How do you do it?

Abstract: Maxillary molar distalization has been used in orthodontics for over 100 years. This technique has been used to gain space in the maxillary arch for relief of crowding, correction of a Class II molar relationship and reduction of an increased overjet. A plethora of appliances have been developed over the years with each having advantages and disadvantages. This article details the indications and contra-indications for maxillary molar distalization and details the various appliances that are available to clinicians, presenting the available evidence supporting the use of these various appliances.

Clinical Relevance: Clinicians should be familiar with the clinical indications for maxillary molar distalization, the potential unwanted effects and how these can be minimized. Clinicians should also appreciate how molar distalization can be incorporated with other aspects of orthodontic care.

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Angle used traction headgear appliances to retract the maxillary molars in cases with Class II division 1 malocclusion.[1] Molar distalization is the term that is now used for lengthening the dental arch by posterior movement of the buccal segment teeth in order to provide space in the maxillary arch.[2] Distal movement of the maxillary molars is mainly used to correct a Class II molar relationship,[3,4] to reduce a mild to moderately increased overjet[5] or for treatment of midline deviation problems.[6] As an interceptive measure, maxillary molar distalization can also provide space for spontaneous eruption of ectopic canines. This has been shown to have a success rate of 80% compared to 50% in a control group.[7] In addition, molar distalization can be used to regain lost space caused by mesial migration of molars in premolar crowding cases and to upright maxillary first permanent molars when they are impacted against maxillary deciduous second molars.[8,9]

Limitations and contra-indications

The indications for, and contra-indications of, maxillary molar distalization are summarized in Table 1. Most distalization techniques result in loss of anchorage in the form of incisor proclination and are therefore contra-indicated where the incisors are already proclined, where the overjet is increased, or for patients with a protrusive profile. Molar distalization should be avoided in cases with thin labial bone and gingival problems due to the risk of gingival recession and bone dehiscence associated with any resultant incisor proclination.[3,10-12] Additionally, distalization of the maxillary molars is not advised in patients with a high Frankfort mandibular plane angle or an anterior open bite. This is because the majority of molar distalization methods are extrusive in nature, resulting in a wedging effect that may open the occlusion.[11,13,14] Buccally flared maxillary molars are a further limitation to molar distalization since a force applied buccally to the centre of rotation may cause further buccal tipping. This is due to the cortical bone of these teeth being less resistant than palatal bone which favours buccal tipping. This, in turn, may compromise the overbite and cause a backwards rotation of the mandible.[15]

Maxillary molar distalization is

Mohammed Almuzian, BDS(Hons), MFDS RCS(Edin), MFD RCS(Irel), MJDF RCS(Eng), MSc(Orth), MScHA(USA), DClinDent(Orth) (Glasg), MOrth RCS(Edin), MRCDS Ortho(Aus), IMOrth RCS(Eng)/RCPS(Glasg), Lecturer in Orthodontics, University of Sydney, NSW, Australia, **Fahad Alharbi,** BDS, MOrth RCS(Edin), Orthodontic PhD Student, Dundee Dental Hospital and School, **Jill White,** BDS, FDS RCPS, MOrth RCS(Edin), PhD, FDS(Orth) RCPS(Glasg), Consultant Orthodontist, Glasgow Dental Hospital and School, 378 Sauchiehall Street, Glasgow, G2 3JZ and **Grant McIntyre,** BDS, FDS RCPS(Glasg), MOrth RCS(Edin), PhD, FDS(Orth) RCPS(Glasg), FDS RCS (Edin), FHEA, Consultant/Honorary Reader in Orthodontics, Dundee Dental Hospital and School, 2 Park Place, Dundee, DD1 4HR, UK.

not a solution to significant crowding (more than 6 mm) since the actual maximum amount of space gained with a headgear appliance is somewhat disappointing at between 2 mm–2.5 mm.[16] Maxillary molar distalization should be used with caution in cases with posterior crossbites since the distalized molars tend to occlude more palatally to the wider part of the opposing mandibular dental arch. This can be counteracted by incorporating a midpalatal screw in the distalization appliance (see 'pendulum appliance' and 'nudger appliance' sections below), activated twice per week to create expansion in the molar region.[17] Moreover, as the maxillary molar is tipped distally, it has a tendency to rotate around the palatal roots, depending on the site of applied force, buccal or palatal. If the distalization technique includes a palatally applied force, as in a pendulum appliance, placing approximately 30 degrees of rotation in the terminal legs of the pendulum/pend-X springs can compensate for this.[18] One important fact to consider is the depth of the palatal vault, as intra-oral molar distalization appliances that rely on palatal bone anchorage are not effective in cases with a shallow palatal vault.[19]

Molar distalization techniques

Contemporary maxillary molar distalization techniques are shown in Figure 1.

Indications	Contra-indications and limitations
1. Class II molar relationship 2. Mild-moderately increased overjet 3. Deviated midline 4. Mild crowding 5. Interceptive treatment for palatally displaced canine 6. Management of mesial migration of molars following early loss of deciduous molars	1. Protrusive profile or proclined incisors 2. Increased overjet 3. Thin labial gingival biotype 4. High Frankfort mandibular plane angle 5. Buccally flared molars 6. Severe crowding (more than 6 mm) 7. Posterior crossbite

Table 1. Indications and contra-indications for maxillary molar distalization.

Mini-distalization techniques

These include the use of brass wire ligatures, elastomeric separators and steel spring clip separators which all act by disimpacting molars that are mesially impacted against an adjacent tooth. Mini-distalizing has been shown to assist partially erupted, tipped and impacted molars to erupt normally.[20] Other methods include the Halterman appliance (Figure 2)[21] and the Humphrey appliance, the latter consisting of a Nance appliance attached to the deciduous molars and a welded 'S'-shaped wire spring bonded to the mesial ridge of the ectopic molar using composite (Figure 3).

Macro-distalization techniques

Macro-distalization methods have been investigated in a number of studies (Table 2). In general, the macro-distalization techniques can be subdivided into:

- Compliance appliances; and
- Non-compliance Class II appliances.

Compliance appliances

One of the most well-known methods of maxillary molar distalization is headgear. It is attached via a facebow to molar bands on the maxillary first permanent molars in a high or low pull

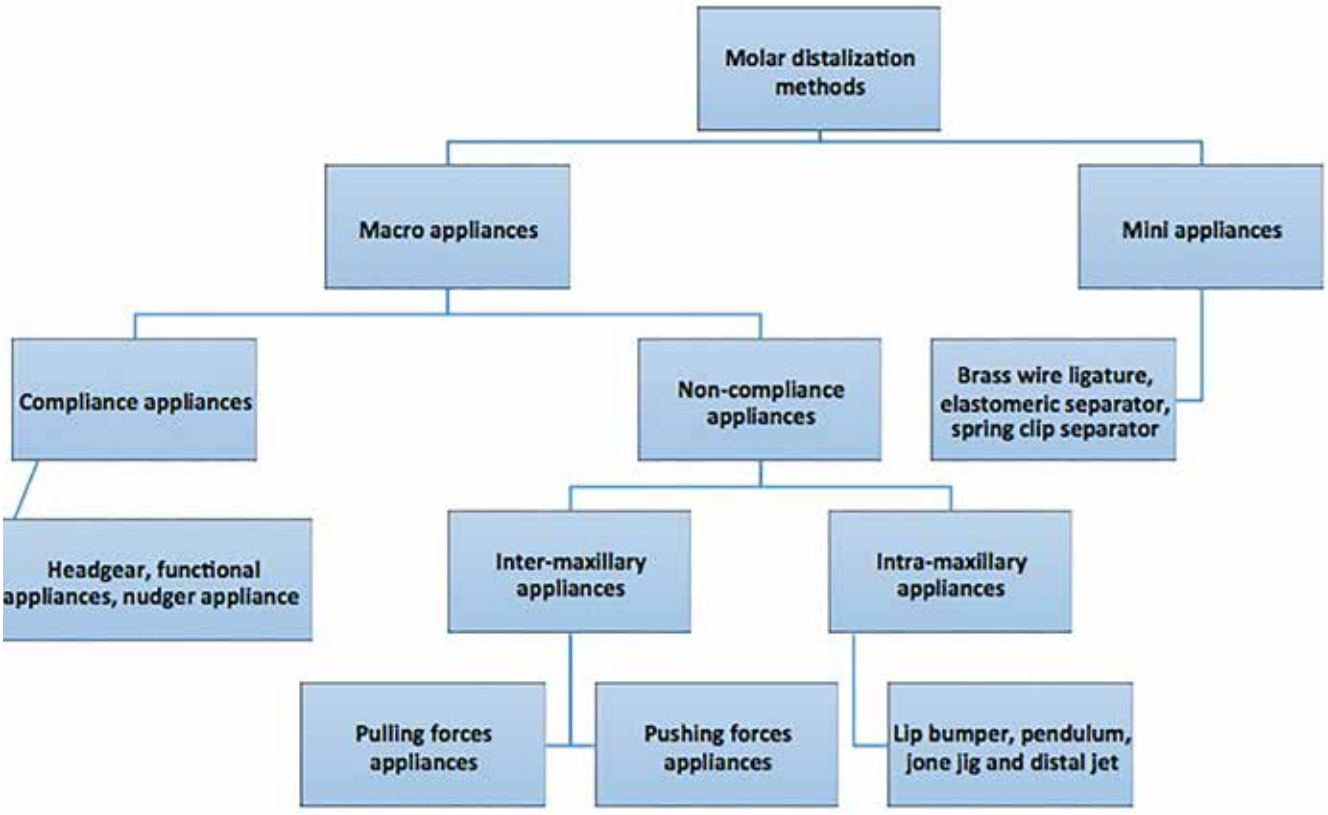

Figure 1. Methods for maxillary molar distalization.

Figure 2. Halterman appliance (consists of a transpalatal arch on molars with an attached distal spring bonded to the first permanent molars).

Figure 3. Humphrey appliance (reproduced from Nagaveni NB, Radhika NB. Interceptive orthodontic correction of ectopically erupting permanent maxillary first molar. A case report. *Virt J Orthod* 2010; **8**: 1–13.)

Distalization Method	Type of Study	Results (Amount of Molar Distal Movement)
Bass v Frankel/Harvold/ Bionator	RCT	Bass appliance achieved 1.6 mm while others achieved no detectable changes
Ni-Ti coil springs v Acrylic splint Herbst	CCT	Ni-Ti coil springs achieved 3.8 mm compared to 0.5 mm with Acrylic splint Herbst
Herbst	Cohort studies	2.7 mm
Enmasse + headgear	A case series	5.7 mm
Herbst v combination headgear with edgewise appliance	Case series	Headgear achieved the least distal movement

Table 2. Effectiveness of maxillary molar distalization with different methods (adapted from Atherton *et al*[16]).

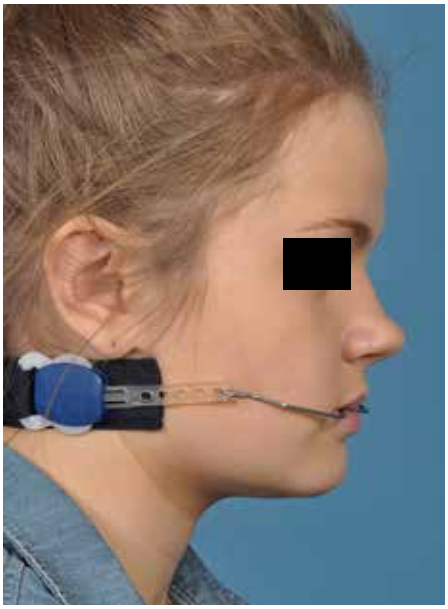

Figure 4. Extra-oral photo of low pull headgear.

Figure 5. An upper removable appliance (nudger appliance) with two screws to distalize the upper right buccal segment and to counteract the potential crossbite.

direction, depending on the overbite (Figure 4). The force level used is 300–350 gm per side and if the appliance is worn 14 hours/day around 2–3 mm of molar distalization can be achieved.[16]

Removable functional appliances can be considered as a compliance-dependent maxillary molar distalization technique. One of the effects of functional appliances is correction of the molar relationship. This is achieved by a combination of skeletal changes (19% in the maxillary base and 22% in the mandibular base), as well as dento-alveolar changes (26% in the maxillary dentition and 33% in the mandibular dentition).[22]

A removable appliance (nudger appliance) can be used for maxillary molar distalization. Either palatal finger springs (0.6 mm wire) or screws can be used as the active component (Figure 5). A Southend clasp on the incisors and Adams clasps for the molars and premolars aid with appliance fixation. An anterior or posterior biteplate may be required to disengage the occlusion and permit uprighting of the tilted permanent molar (as well as reduction of an increased overbite). Anchorage loss normally manifests as an increase in the overjet.[23]

A nudger appliance and headgear in combination can be used for maxillary molar distalization to achieve bodily tooth movement. The combination system consists of an upper removable appliance (URA) with palatal finger springs (activation of 2–3 mm) that act to tip the crown of the molar distally. High-pull headgear worn at night, directed above the centre of rotation of the molar, acts to distalize the root and hold the crown movement achieved during the day-time wear of the URA.[24] In addition, the headgear provides a method of reinforcing the anchorage during subsequent retraction of the anterior teeth. Ferro *et al*[25] showed an average of 3.6 mm of molar distal movement and 0.7 mm of anchorage loss when a nudger appliance was used in conjunction with cervical headgear.

Additionally, a removable appliance can also be used for en masse maxillary molar distalization. The standard design of an en masse removable appliance described by McCallin consisted of Adams clasps for the maxillary first permanent molars and first premolars, L-shaped rests over the first molars and headgear tubes soldered to the bridges of the Adams clasps on the first permanent molars. A coffin spring to provide expansion is embedded in the heat-cured acrylic baseplate.[26] Other modifications of the en masse appliance, as described by Orton, include replacement of the coffin spring by a midline expansion screw to provide symmetrical bilateral expansion, double clasps for the upper first permanent molars and second premolars, T-shaped occlusal rests and headgear tubes soldered to the molar clasps. Headgear delivering 300–350 gm per side should be used for 14 hours per day. Extraction of the upper second permanent molars may be

required. This method has been claimed to achieve 6 mm distal movement of the molars.[27]

Another compliance method for maxillary molar distalization is the 'molar distalizing bow'. It consists of two components. First, a 0.8–1.5 mm thick thermoplastic splint is placed over the maxillary model covering the dentition except the teeth to be moved and is extended into the buccal sulcus for better support and retention. A distalizing bow with open coil springs to apply a force to the permanent molars is then fitted into the anterior slot that is embedded in the splint.[28]

Class II elastics with sliding jigs to distalize the buccal segments are the last in the list of the most commonly used compliance-based maxillary molar distalization techniques (Figure 6). Unlike other inter-maxillary compliance-dependent methods, elastics produce a pulling force rather than a pushing force. Class II elastics are a mainstay of the original Tweed technique in which the pulling forces from the Class II elastics are transmitted to a pushing force via the sliding jigs to distalize the maxillary molars. A force level of 300–350 gm per side is required. One of the side-effects of the Class II elastics is the clockwise rotation of the occlusal plane. It is possible to compensate for this in a growing patient but sliding jigs and Class II elastics are not recommended for more than a period of 6 months in adult patients due to unwanted occlusal effects.[28,29]

Figure 6. Class II elastics with sliding jigs used to distalize upper left buccal segment (decompensation of a Class III malocclusion before orthognathic surgery).

Non-compliance appliances

These have been subdivided by McSherry and Bradley[30] into

- Inter-maxillary; and
- Intra-maxillary appliances.

Inter-maxillary appliances can be sub classified into:

I. Appliances producing pulling forces

The Severable Adjustable Intermaxillary Force (SAIF) springs (**www.truforce.com**) were developed by Jasper in 1995.[31] They consist of long nickel-titanium closed coil springs that are used to apply Class II inter-maxillary traction when fully bonded fixed appliances are in place. The springs are available in two lengths; 7 mm and 10 mm.[30] No long-term studies have been published on the use of SAIF springs and they are not used widely because of difficulties encountered in appliance management, including breakage, oral hygiene difficulties and problems with patient comfort.

II. Appliances producing pushing forces

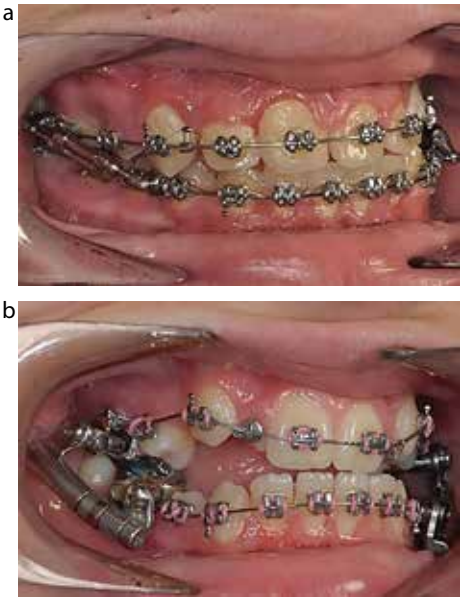

Figure 7. (a) *Forsus* (3M, Monrovia, California, USA) and **(b)** *AdvanSync* bite correctors (Ormco, California, USA).

These include appliances that deliver a 'pushing' force vector, forcing the attachment points of the appliance away from one another.[31] In this category are the Class II bite correctors which can be considered as a method of molar distalization since there is thought to be a 'headgear effect' with these appliances.[32] Class II bite correctors include:

1. *The Herbst appliance* (**www.americanortho.com**): a fixed functional appliance popularized by Pancherz.[33] It consists of a bilateral telescopic mechanism that protrudes the mandible with compensatory maxillary molar distalization. The sagittal correction of the molar relationship results from a combination of skeletal changes (43%) and dento-alveolar changes (57%).[32] Its action is similar to that of the *Forsus* springs (3M, Monrovia, California, USA) and *AdvanSync* bite correctors (Ormco, California, USA) that are used in conjunction with a transpalatal arch (Figure 7a and b).
2. *The Jasper Jumper* (**www.americanortho.com**) consists of two vinyl coated auxiliary springs attached to the maxillary first permanent molars and to the mandibular archwire anteriorly, with the springs resting in the buccal sulcus. The springs hold the mandible in a protruded position. The majority of the action is reported to be dental, rather than skeletal, change.[34]
3. *The adjustable bite corrector* is similar to the Herbst appliance and to the Jasper Jumper. The advantages are the adjustable length, stretchable springs, and easy adjustment of the attachment parts.[35] No long-term studies have been published on this appliance to date.[30]
4. *The Mandibular Anterior Repositioning Appliance (MARA)*[30] (**www.ortho-concept.com/mara**) consists of heavy 'elbow-shaped' wires attached to tubes on the maxillary first permanent molar bands or stainless steel crowns. A mandibular first permanent molar crown has an arm projection which engages the elbow of the maxillary molar. The appliance is adjusted so that, when the mandible elevates, the elbow wire guides the lower first permanent molars and repositions the mandible forwards into a Class I relationship. The results of treatment with the MARA are very similar to those produced by the Herbst appliance but with less 'headgear' effect on the maxilla and less mandibular incisor proclination than with the Herbst appliance[36] (Figure 8).

Intra-maxillary appliances

Figure 8. Mandibular anterior repositioning appliance.[31]

include:

1. *Lip bumper*: this consists of a thick round stainless steel wire that fits into the headgear tube of the molar band and is held away from the labial surface of the incisor by loops mesial to the entrance of the molar tubes. The anterior part of the wire is embedded in an acrylic shield which actively displaces the lip forward. The reciprocal force of the displaced lip is transferred to the molars via the heavy wire and results in molar uprighting and distalization. Changes in the soft tissue equilibrium due to the lip bumper can lead to proclination of the incisors, an increase in intercanine width, as well as buccal rolling of the molars.[24,37]
2. *Pendulum appliance*: this consists of a large Nance button supported and retained by premolar bands and 0.032" titanium-molybdenum alloy (TMA) springs inserted into lingual sheaths on the palatal surface of the bands to distalize the maxillary molars. For additional retention, bonded occlusal rests on the primary molars or second premolars can be included. If a midline screw is added to counteract a potential crossbite, or to correct an actual crossbite, then the appliance is called a Pend-X appliance (Figure 9).[18] Generally, the amount of net distalization ranges from 1/3–2/3 of the created space.[38,39] However, the presence of the maxillary second molars change the ratio so, if the appliance is used after eruption of the second molars, the ratio will be 2/3.[18] This is a similar to the result found by Karlsson and Bondemark,[40] who showed that the most opportune time to distalize maxillary first permanent molars is before eruption of the second molars. Although an inclusion of an uprighting bend in the distalizing spring of the pendulum appliance could reduce molar tipping, it is associated with mild anchorage loss and increased treatment duration.[41]
3. *Jones jig and Lokar distalizing appliance*: the Jones jig (**www.americanortho.com**) uses open-coil nickel-titanium springs attached to the maxillary first permanent molars, and a Nance button attached to the maxillary first or second premolars or the primary molars.[42] A similar mechanism, called the Lokar distalizing appliance (**www.ormco.com**) has reported advantages of ease of insertion and ligation.[30] Interestingly, Paul *et al*[43] found no difference between the effectiveness of the nudger URA and the Jones jig for maxillary molar distalization.
4. *Distal jet* (**www.americanortho.com**): this uses bilateral tubes of 0.036" internal diameter attached to an acrylic Nance button with a coil, and screw clamps that slide over the tube. The wire from the acrylic ends in a bayonet bend and inserts into a palatal sheath on the maxillary molar band. The Nance button is also attached to a premolar band via a connecting wire. It is claimed that this appliance overcomes the disadvantages of other appliances used for distalizing maxillary molars by reducing the tendency for the teeth to tip, because the force acts through the centre of resistance of the molar and thus produces true bodily tooth movement.[15] (Figure 10).
5. *Nance palatal arch and coil springs*: several authors have described the use of a modified Nance palatal arch with coils to distalize maxillary molars.[19] One of these studies compared the effect of headgear (HG) and Nance palatal arch with coil spring (NAC) and found that the NAC was more effective than HG in distalizing molars; however, the anchorage loss was greater.[44] Another study by the same research team compared the effect of NAC and the repelling rare earth magnet (RRRM group) in molar distalization. The authors showed that the amount of molar distalization was greater in the NAC group than the RRRM group, with improved patient perception in the former group.[45]
6. *Repelling magnets*: it has been shown that it is possible to achieve distal movement of the molars using repelling magnets with faster results when the second permanent molars are unerupted.[45] However, one of the difficulties of using repelling magnets is the force decay over time with the need for frequent reactivation (on a weekly basis), in addition to the difficulty of using them with other metallic appliances such as headgear.[46]
7. *Goshgarian appliance*: the Goshgarian appliance can be used to distalize the maxillary molars unilaterally or bilaterally to correct a mild Class II molar relationship by activating the V-shape bend of the TPA, as described by Rebellato in 1995.[47] In a unilateral maxillary molar distalization case, it is better to reinforce the stable side with headgear, place torque in the archwire to take advantage of cortical anchorage,

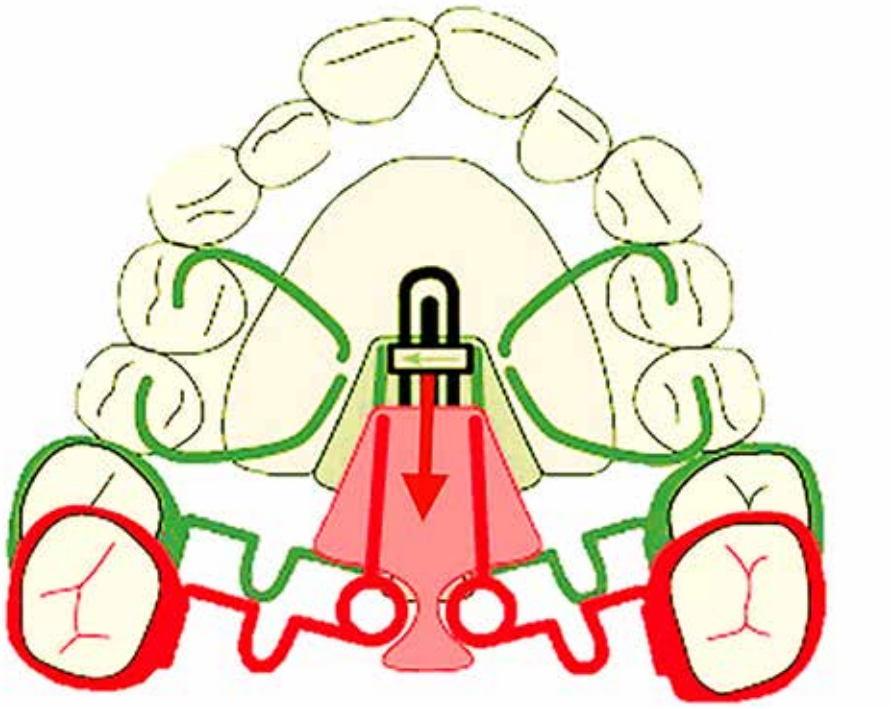

Figure 9. Pend-X appliance.

Figure 10. Distal jet appliance.

or use temporary anchorage devices.[48-52]

8. *Mini-implants*: Ismail and Johal[53] used mini-implants for anchorage to allow for distalization of the maxillary molars. They showed that suitable sites for the implants are the palatal vault and the retromolar region. If extractions of the maxillary second permanent molars are carried out, then 4–5 mm of distalization is achievable.[53] Other uses of the miniscrew implant in the distalization of the maxillary molars is by supporting anchorage, in addition to placing a distal jet appliance[54] or pendulum appliance.[14]

Evidence for the effectiveness of molar distalizaton

Both retrospective and prospective studies using headgear appliances have shown slightly disappointing findings. In one retrospective study, distal movement of the maxillary molars in patients who wore cervical headgear for an 8-month period did not differ from that of an untreated group when they were re-evaluated 7 years later.[55] Benson *et al*[2] compared headgear and a midpalatal implant in a randomized clinical trial as a method of maxillary molar distalization in a group of 51 patients. They found that the molar movement was greater in the implant group than in the headgear group and point 'A' in the cephalometric tracings moved in the opposite direction in the headgear group. They concluded that there is no difference between these methods for maximizing anchorage.[2]

Systematic reviews have shown similarly modest amounts of maxillary molar distal movement can be achieved. Atherton *et al* undertook a systematic review to investigate various distalization methods and detected the amount of maxillary molar distalization that could be achieved is in the range of 2 mm–2.5 mm (Table 2).[16] Another recent systematic review was undertaken by Antonarakis and Kiliaridis in 2008.[56] They found that intra-oral appliances for maxillary molar distalization are more effective than extra-oral appliances. However, they recorded moderate but acceptable anchorage loss with intra-oral appliances, causing an increase in the overjet, whereas the extra-oral appliances resulted in a decrease in the overjet. Neither appliance had any significant skeletal effects. They concluded that the optimum time to move maxillary first permanent molars distally is before eruption of the second permanent molars. These findings have been confirmed by the latest Cochrane review with regards to the effectiveness of different molar distalization techniques.[57]

Transition from molar distalization to fixed appliances

The techniques for transition (or retention) following maxillary molar distalization are similar to that of the transition from functional appliances to fixed appliances. These include:[58,59]

- Overcorrection: moving the molars into a mild Class III relationship to compensate for any relapse;
- Quick-Nance: fabricated from 0.032" stainless steel that feeds inside the lingual sheath of the molar bands. The palatal button can be adapted and cured using light cure acrylic resin (Triad, **www.dentsply.com**);
- Conventional Nance arch or transpalatal arch;
- Short-term headgear: this also helps distally upright molar roots at a force range of (250–300 gm/side) 12 hours per day;
- Stops on the archwires can stabilize the maxillary molar position. However, any rebound will be expressed as an increased overjet, so additional anchorage techniques should be used as well;
- Maxillary utility arch (which acts in a similar way to stops on the archwire). This can be used in the mixed dentition and in cases with a Class II division 2 malocclusion where correction of a deep overbite often results in incisor proclination, thus reducing the overbite. The utility arch has an advantage if treatment involves the use of Class II elastics since this archwire provides a method for elastic attachment;
- Immediate Class II elastics can be used but one of the drawbacks is the need for a mandibular arch appliance which becomes more complicated to place if the overbite is increased;
- Lip bumper for the maxillary arch;
- Hawley-type retainers: these may be utilized when the tissues are overly inflamed for immediate transition to a fixed appliance;
- Functional appliances, such as the Bionator appliance, to maintain the distalized maxillary molar position while encouraging forward movement of the mandibular arch. The Herbst appliance can allow concurrent bonding and space closure in the maxillary arch.

The method selected will depend on the clinician preference and patient-related factors such as cost, compliance and type of malocclusion, which should be taken into account.

Conclusion

Distal movement of the maxillary molars to produce space for relief of crowding, correction of a Class II molar relationship and reduction of an increased overjet can be undertaken with a range of appliances. Clinicians should be aware that the amount of tooth movement achieved with these appliances is modest.

References

1. Angle EH. *Treatment of Malocclusion of the Teeth*. Philadelphia: SS White Dental Manufacturing Company, 1907.
2. Benson PE, Tinsley D, O'Dwyer JJ, Majumdar A, Doyle P, Sandler PJ. Midpalatal implants vs headgear for orthodontic anchorage – a randomized clinical trial: cephalometric results. *Am J Orthod Dentofacial Orthop* 2007; **132**: 606–615.
3. Proffit WR, Fields HW Jr, Sarver DM. *Contemporary Orthodontics*. St Louis: Mosby/Elsevier, 2006.
4. Keles A, Sayinsu K. A new approach in maxillary molar distalization: intraoral bodily molar distalizer. *Am J Orthod Dentofacial Orthop* 2000; **117**: 39–48.
5. Malik V, Yadav P, Grover S, Chaudhary G. Non-extraction orthodontic treatment with molar distalization. *J Orofac Res* 2012; **2**: 99–103.
6. Holmes A, Nashed RR, O'Keeffe CD. The correction of dental centre line discrepancies using an edgewise appliance. *Br J Orthod* 1989; **16**: 271–276.
7. Leonardi M, Armi P, Franchi L, Baccetti T. Two interceptive approaches to palatally displaced canines: a prospective longitudinal study. *Angle Orthod* 2004; **74**: 581–586.
8. Kennedy DB, Turley PK. The clinical management of ectopically erupting first permanent molars. *Am J Orthod Dentofacial Orthop* 1987; **92**: 336–345.
9. Kurol J, Bjerklin K. Treatment of children with ectopic eruption of the maxillary first permanent molar by cervical traction. *Am J Orthod* 1984; **86**: 483–492.
10. Aziz T, Flores-Mir C. A systematic review of the association between appliance-induced labial

movement of mandibular incisors and gingival recession. *Aust Orthod J* 2011; **27**: 33–39.
11. Melsen B, Allais D. Factors of importance for the development of dehiscences during labial movement of mandibular incisors: a retrospective study of adult orthodontic patients. *Am J Orthod Dentofacial Orthop* 2005; **127**: 552–561.
12. Gianelly AA. Distal movement of the maxillary molars. *Am J Orthod Dentofacial Orthop* 1998; **114**: 66–72.
13. Ngantung V, Nanda RS, Bowman SJ. Posttreatment evaluation of the distal jet appliance. *Am J Orthod Dentofacial Orthop* 2001; **120**: 178–185.
14. Kircelli BH, Pektas Z, Kircelli C. Maxillary molar distalization with a bone-anchored pendulum appliance. *Angle Orthod* 2006; **76**: 650–659.
15. Carano A, Testa M, Bowman S. The distal jet simplified and updated. *J Clin Orthod* 2002; **36**: 586–591.
16. Atherton G, Glenny A-M, O'Brien K. Development and use of a taxonomy to carry out a systematic review of the literature on methods described to effect distal movement of maxillary molars. *J Orthod* 2002; **29**: 211–216.
17. Hilgers JJ. A palatal expansion appliance for non-compliance therapy. *J Clin Orthod* 1991; **25**: 491–497.
18. Hilgers JJ. The pendulum appliance for Class II non-compliance therapy. *J Clin Orthod* 1992; **26**: 706–714.
19. Gianelly AA, Bednar J, Dietz VS. Japanese NiTi coils used to move molars distally. *Am J Orthod Dentofacial Orthop* 1991; **99**: 564–566.
20. McDonald RE, Avery DR. *Dentistry for the Child and Adolescent*. St Louis: Mosby/Elsevier, 2010.
21. Roberts M. Treatment of ectopically erupting maxillary permanent first molars with a distal extended stainless steel crown. *ASDC J Dent Child* 1986; **53**: 430–432.
22. O'Brien K, Wright J, Conboy F *et al*. Effectiveness of early orthodontic treatment with the Twin-block appliance: a multicenter, randomized, controlled trial. Part 1: Dental and skeletal effects. *Am J Orthod Dentofacial Orthop* 2003; **124**: 234–243.
23. Lewis DH, Fox NA. Distal movement without headgear: the use of an upper removable appliance for the retraction of upper first molars. *Br J Orthod* 1996; **23**: 305–312.
24. Cetlin NM, Ten Hoeve A. Nonextraction treatment. *J Clin Orthod* 1983; **17**: 396–413.
25. Ferro F, Monsurró A, Perillo L. Sagittal and vertical changes after treatment of Class II Division 1 malocclusion according to the Cetlin method. *Am J Orthod Dentofacial Orthop* 2000; **118**: 150–158.
26. McCallin S. Extra-oral traction in orthodontics. *Trans Br Soc Stud Orthod* 1961: 1–14.
27. Orton HS, Battagel JM, Ferguson R, Ferman AM. Distal movement of buccal segments with the "en masse" removable appliance – its value in treating patients with mild Class II, Division 1 malocclusions: Part I, clinical techniques (how to do it). *Am J Orthod Dentofacial Orthop* 1996; **109**: 234–243.
28. Jeckel N, Rakosi T. Molar distalization by intra-oral force application. *Eur J Orthod* 1991; **13**: 43–46.
29. Tweed CH. *Clinical Orthodontics* **I**. St Louis: The CV Mosby Company, 1966.
30. McSherry P, Bradley H. Class II correction-reducing patient compliance: a review of the available techniques. *J Orthod* 2000; **27**: 219–225.
31. Jasper JJ, McNamara JA Jr. The correction of interarch malocclusions using a fixed force module. *Am J Orthod Dentofacial Orthop* 1995; **108**: 641–650.
32. Pancherz H, Anehus-Pancherz M. The headgear effect of the Herbst appliance: a cephalometric long-term study. *Am J Orthod Dentofacial Orthop* 1993; **103**: 510–520.
33. Pancherz H. Treatment of Class II malocclusions by jumping the bite with the Herbst appliance: a cephalometric investigation. *Am J Orthod* 1979; **76**: 423–442.
34. Cope JB, Buschang PH, Cope DD, Parker J, Blackwood III H. Quantitative evaluation of craniofacial changes with Jasper Jumper therapy. *Angle Orthod* 1994; **64**: 113–122.
35. West RP. Adjustable bite corrector. Google Patents, 1994.
36. Pangrazio-Kulbersh V, Berger JL, Chermak DS, Kaczynski R, Simon ES, Haerian A. Treatment effects of the mandibular anterior repositioning appliance on patients with Class II malocclusion. *Am J Orthod Dentofacial Orthop* 2003; **123**(3): 286–295.
37. Bergersen EO. A cephalometric study of the clinical use of the mandibular labial bumper. *Am J Orthod* 1972; **61**(6): 578–602.
38. Byloff FK, Darendeliler MA. Distal molar movement using the pendulum appliance. Part 1: clinical and radiological evaluation. *Angle Orthod* 1997; **67**: 249–260.
39. Ghosh J, Nanda RS. Evaluation of an intraoral maxillary molar distalization technique. *Am J Orthod Dentofacial Orthop* 1996; **110**(6): 639–646.
40. Karlsson I, Bondemark L. Intraoral maxillary molar distalization: movement before and after eruption of second molars. *Angle Orthod* 2006; **76**: 923–929.
41. Byloff FK, Darendeliler MA, Clar E, Darendeliler A. Distal molar movement using the pendulum appliance. Part 2: the effects of maxillary molar root uprighting bends. *Angle Orthod* 1997; **67**: 261–270.
42. Jones R, White J. Rapid Class II molar correction with an open-coil jig. *J Clin Orthod* 1992; **26**: 661–664.
43. Paul L, O'Brien K, Mandall N. Upper removable appliance or Jones Jig for distalizing first molars? A randomized clinical trial. *Orthod Craniofac Res* 2002; **5**: 238–242.
44. Bondemark L, Karlsson I. Extraoral vs intraoral appliance for distal movement of maxillary first molars: a randomized controlled trial. *Angle Orthod* 2005; **75**: 699–706.
45. Bondemark L, Kurol J, Bernhold M. Repelling magnets versus superelastic nickel-titanium coils in simultaneous distal movement of maxillary first and second molars. *Angle Orthod* 1994; **64**: 189–198.
46. Gianelly AA, Vaitaa AS, Thomas WM. The use of magnets to move molars distally. *Am J Orthod Dentofacial Orthop* 1989; **96**: 161–167.
47. Rebellato J. Two-couple orthodontic appliance systems: transpalatal arches. *Semin Orthod* 1995; **1:** 44–54.
48. Ten Hoeve A. Palatal bar and lip bumper in nonextraction treatment. *J Clin Orthod* 1985; **19**: 272–291.
49. Cooke MS, Wreakes G. Molar derotation with a modified palatal arch: an improved technique. *Br J Orthod* Oct 1978; **5**: 201–203.
50. Dahlquist A, Gebauer U, Ingervall B. The effect of a transpalatal arch for the correction of first molar rotation. *Eur J Orthod* 1996; **18**: 257–267.
51. Ingervall B, Göllner P, Gebauer U, Fröhlich K. A clinical investigation of the correction of unilateral first molar crossbite with a transpalatal arch. *Am J Orthod Dentofacial Orthop* 1995; **107**: 418–425.
52. Mandurino M, Balducci L. Asymmetric distalization with a TMA transpalatal arch. *J Clin Orthod* Mar 2001; **35**: 174–178.
53. Ismail S, Johal A. The role of implants in orthodontics. *J Orthod* 2002; **29**: 239–245.
54. Karaman A, Basciftci F, Polat O. Unilateral distal molar movement with an implant-supported distal jet appliance. *Angle Orthod* 2002; **72**: 167–174.
55. Melsen B, Dalstra M. Distal molar movement with Kloehn headgear: is it stable? *Am J Orthod Dentofacial Orthop* 2003; **123**: 374–378.
56. Antonarakis GS, Kiliaridis S. Maxillary molar distalization with noncompliance intramaxillary appliances in class II malocclusion: a systematic review. *Angle Orthod* 2008; **78**:1133–1140.
57. Jambi S, Thiruvenkatachari B, O'Brien KD, Walsh T. Orthodontic treatment for distalising upper first molars in children and adolescents. *Cochrane Database Syst Rev* 2013 Oct 23; 10:CD008375.
58. Hilgers JJ. Hyperefficient orthodontic treatment using tandem mechanics. *Semin Orthod* 1998; **4**: 17–25.
59. Prakash A, Tandur AP, Shyagali T, Bhargava R. Post distalization-methods of stabilization of molars. *Orthod Cyber J* (online) 2011.