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Upper Arch Molar Distalization Appliances in Treatment of Class II Malocclusion: A Critical Analysis

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Abstract: *The number of new upper molar distalization appliances keeps climbing since the headgear's appearance at the end of the 60s. The aim of this critical review of the literature is to list and explore current upper arch molar distalization appliances in treatment of Class II malocclusion available in the market to this day. This article critically analyzes their benefits as well as their side effects and limitations.*

Keywords: *upper molar distalization, Class II malocclusion, intraoral appliances, tooth movement*

Introduction

Since more than 75% of cases observed and treated in my cabinet are Class II malocclusions, it was not shocking to notice that an extremely large percentage of the orthodontic field of research is dedicated to this treatment. With the constant improvement of dentistry and orthodontics, the correction of Class II malocclusion is often a non-extraction or non-surgical treatment, conserving the patient's dentition. To avoid extractions, treatments usually require maxillary molar distalization by means of intraoral or extra oral forces (this paper will not present the muscular forces associated with the upper molar distalization). Lack of space available in the upper arch for such a major movement is a significant disadvantage of such treatments. Patient's request for non-extraction treatment generated a need for orthodontic appliances that could enlarge the upper arch in a transversal and distal direction. The main issue in distalization was, and is still, the loss of anchorage during the treatment. The anchorage control (concentration of desired force and dissipation of reactionary force) is a capital concern in designing such appliances. As addressed below, many appliances were unable to provide such control, and only a few were sufficiently effective.

Extra Oral Forces

Traditional techniques imply the use of extra oral strengths with cervical, occipital, or combined anchoring. Although this category of appliance has shown its benefits, these techniques mainly rely on patient cooperation, and it is no secret that the patient compliance is a key factor in obtaining successful results. Furthermore, these devices have a considerable effect on the cervical column.[1]

Headgear

In 1969, Frank Nelson published a paper introducing his new invention: the orthodontic headgear.[2] He enhanced the problem that "orthodontists have been handicapped by the lack of suitable external head-engaging fixtures to provide an anchor or external support for the appliance passing through the patient's mouth and secured to the teeth." Back then, the headgear was a helmet and was covering the whole patient's head. Today, a lot of patients reject this option for obvious reasons of aesthetics, discomfort and social acceptance, even though it is much more discreet and does not require wearing a helmet.

Today's literature counts three different types of headgear for Class II classified by their point of attachment, direction of pull, and the targeted treatment.[3] The cervical headgear (Figure 1-A) presents an extra oral anchorage at the back of the neck with a cervical pull. It is easy to wear with minimal exterior show. However, it often causes extrusion of the upper first molars creating an open bite. 4 The high pull headgear's (Figure 1-B) anchorage is at the back of the head. It will not extrude upper molars, but it presents more hardware for patients, and it is more difficult to achieve posterior forces on the maxilla.[3] The combination headgear has been discarded over the years for obvious reasons such as lack of control on the force. Side effects of headgear are substantial. Studies often report unwanted extrusion forces on the maxillary molars and distal tipping of

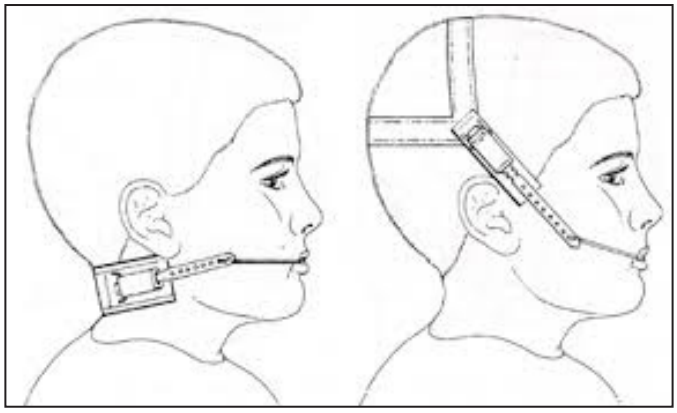

Figure 1

molars. Moreover, it is undisputed that the main issue with this device is the need for patient compliance. A pilot study in 2003 investigated the compliance rate of headgear use and the role of timing headgear as a motivator.[4] The headgears were equipped with time recorders without the participants knowing it. Among their conclusions, it was determined that the mean actual hours of daily wear relative to the providers' requirements was 56.7%. The acknowledgement of the monitoring regarding the wearing time is known to increase the patient's cooperation to 62.7%. In conclusion, a headgear successful treatment depends on patient compliance and tolerance. That's why it is not the most efficient treatment.

Intraoral Forces

Looking for less interference of patient compliance and tolerance with the treatment, orthodontists have invented a vast number of intraoral appliances for upper molar distalization: these appliances are simple to construct and use, and they are a good alternative for non-cooperating patients.

Pendulum®

Hilgers[5] first described the Pendulum® appliance in 1992. It consists of a palatal Nance component with rests that are bonded to the occlusal surface of the first and/or second premolar teeth (Figure 2). It is designed to provide consistent and dependable upper molar distalization and rotation without the need for patient cooperation. Interestingly, this device does not require any coil mechanics. Research evaluating the distal molar movement using the Pendulum® appliance showed that it moved the molars distally without creating dental or skeletal bite opening and with little incisor anchorage loss.[6] However, important molar tipping was noticed. Other studies have compared the Pendulum® appliance[7] to other intraoral appliances (Distal Jet,® headgear) and the subjects.[8] The standard Pendulum® appliance was then modified by integrating a distal screw into its base and by special preactivation of the pendulum springs. The springs have an adjustment loop that can be manipulated to increase molar expansion, rotation, and distal root tip.

Figure 2

Pend-X Appliance®

Then came the Pendex appliance,®[5] which is actually a Pendulum® appliance but incorporates an expansion screw in the design to allow both molar distalization and expansion. It is similar in nature to the Pendulum® and uses the expansion screw to widen the upper palate, correcting class II malocclusions and the patient's bite.

Other modifications of Pendulum® appliances were also created through the years:

- M Pendulum®, Scuzzo, 1999[9]
- Franzulum Appliance,® Buyoff, 2000[10]
- Modified Pendulum with removable arms,® Scuzzo, 2000[11]
- Bone anchored pendulum appliance,® Byloff, 2006[12]

Jones Jig®

The Jones Jig® (Figure 3) is a sectional archwire coil spring device. It is fixed and uses palatal anchorage with an applied force of 70-75g delivered by a NiTi spring to move the maxillary first molars distally, reaching a Class I molar relationship. Studies compared the effects of the Jones Jig® to the Pendulum,®[13, 14] and both concluded that the Jones Jig® appliance is creating mesial tipping, mesial angulation, and extrusion of the maxillary second premolars. It was also shown that there does not seem to be any particular advantage in using the Jones Jig® as a noncompliance appliance. Indeed, a randomized clinical blinded study[15] compared two groups of patients to measure the effectiveness of an upper removable appliance (URA) and the Jones Jig's:® twelve patients were randomly allocated to URA treatment and 11 patients to a Jones Jig.® The results revealed that the amount of tooth movement from using these two types of appliance was small, and both type of appliances were equally effective. They concluded that the amount of distal molar movement with a Jones Jig® or URA was non-significant. Furthermore, other studies[16] have reflected the equivalency of the results using a Jones Jig and many other appliances (Herbst appliance®, Wilson mechanics,® Repelling magnets,® Pendulum,® cervical headgear), concluding that the Jones Jig® does not stand out regarding efficiency or major advantage.

Figure 3

Sliding Jig®

The Sliding Jig® (Figure 4) is mainly a 2-inch length of 0.22 stainless steel wire in which one part is sliding over the main archwire and the distal part inserted in the buccal accessory tube of the first molar. It is activated by Class II inter arch elastic. It has proved most helpful in certain light wire treatment to convey distal elastic force to the molar on one side only.[17] It can easily be added to the current fixed appliance and quickly constructed at chair side.

Distal Jet®

The Distal Jet®[18] (Figure 5) is considered to be among the devices that present good control over tooth movement and creates minimum loss of anchorage for treatment of Angle class II. The studies on Distal Jet® demonstrated advantages, including the relatively short duration of treatment (4 in 9 months).[1] The disadvantage of this appliance mainly comes with the necessity to reactivate frequently the compression of the palatine spring. Even though is it a more controlled appliance, and the loss of anchorage is limited, the results of other studies pointed out that loss of anchorage is inevitable and is to be expected.[19] With all those identified key components that could be upgraded, Carano and Testa[20] reviewed their appliance and applied some changes to develop a more effective and practical tool. They completely redesign the lock and changed the manufacture of the lock from a machining process to a casting process. Their modifications reduced chair time, improved patient comfort, and enhanced treatment efficiency and reliability without changing the biomechanical foundation of the Distal Jet.®

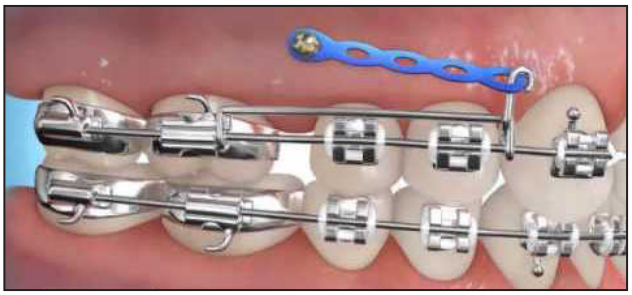

Figure 4

NiTi Distalizer – DNT

Inspired by the success of Distal Jet,® Dr. Michel Champagne introduced in 2003 the NiTi Distalizer.®[21] Later in 2011, Dr. Patti and his team[1] combined the principle of guiding tubes located near the center of resistance while modifying the drawing of NiTi springs (Figure 6) to minimize and even eliminate the need for reactivation. The technology is focused on the distalized tooth's center of resistance, and it allowed him to develop an appliance that requires no patient compliance and reduces the so called inevitable molar tipping effect. They elongated the tubes to allow the insertion of longer NiTi springs that would not require any reactivation. Once the backward movement are achieved, the springs are deactivated. The major difference with this appliance is that the guiding tube is slightly distoapicaly angled (2-3 degrees) in order to control the molar tipping. Other variations of the NiTi Distalizer® are known as Gonzalez Distalizer,® C.D. distalizer,® and Inman distalizer.®

Figure 5

Figure 6

Figure 7

Fast Back Expansor Appliance®

Fast Back Expansor appliance® (Figure 7) is also called the fastback molar distalizer® (3 versions FB1, FB2, FB3). This was created in 2000. It is now definitely one of the most popular appliance for molar distalization in the orthodontic field. The Fast Back Expansor® is based on the principle of placing constant forces on the molars by incorporating Memoria springs® delivering between 200g-300g on the molar to be distalized.[22] This spring- activated device provides bodily distalization of the upper molars, and once distalization has begun, activation should be carried out, on average, every 30-45 days. It allows for delivery of continuous forces, and the direction of the spring is determined by the arm on the expansion appliance and does not require the cooperation of the patient during treatment because it is activated by the dentist. Recent research showed that the Fast Back® was as effective as the Pendulum.®[23]

Temporary Anchorage Devices® – TADS

Also referred as mini-implants or mini-screw in the literature, TADS®[24, 25] are small skeletal anchors: They provide maximum anchorage,[26] minimizing the side effects of traditional orthodontic technologies. Before their use, many cases reported dental tipping, bite opening, anterior anchorage loss, and thus they were invented to overcome anchorage limitations encountered with devices cited below. They are biocompatible devices fixed to the bone and removed once the distalization is completed. Studies have shown that TADS® allow a much more stable anchorage. However, this no anchorage loss has a price: there are several problems related to these mini-implants: the screw can fracture, and risks of infection around the screw are significant.[26]

PSM Medical Solution[27] offers three types of temporary anchorage devices that represent most commonly used TADS.® The Benefit System® is particularly effective for molar anchorage and distalization as well as anchorage for the retraction of anterior teeth and space closure.[27] It is a palatinal anchorage, and it can be placed in any area of the maxilla or mandibule for aligning teeth prior to prosthodontics. A Beneslider®[28] can be anchored to one or more Benefit mini-implants® in the anterior palate to create distalization. For enhanced stability, "the Mentoplate System® provides a special orthodontic bone anchored plate for intraoral fixation in the maxilla and the mandible."[27] To minimize and prevent lingual tipping during the space closure process, a T-wire can be employed, or a Mesialslider® can be used as a direct anchorage device.[29] It is attached to the mini-implants anchored in the anterior palate. Finally, the Quattro System® (Figure 8) is designed to replicate an orthodontic bracket and buccal tube. It is the only system you can use exactly like a bracket on a tooth or a tube on a molar band.[27]

A very large study[30] investigated 904 implants TADS® in 455 patients with different clinical with different clinical diagnoses including malocclusions (333/455), jaw deformities, etc. The aim of this retrospective study was to determine factors that might cause complications in use of TADS® (plate type and screw type). The measurement of implant mobility or implant loss was observed in only 62/904 implants. Both screw and plate type implants had a high success rate, and the overall results showed 90% rate of successful treatment. The number of publications on implants in the orthodontic literature is constantly rising. Among those, Crismani, et al.[31] published a meta-analysis evaluating 14 reports of clinical trials published before September 2007 with at least 30 mini-screws. All 14 reports described success rates sufficient for orthodontic treatment.

TADS® (Figure 9) can be used in combination with almost every appliance creating a multitude of possibilities. No matter what, in each variation of their use, they offer ultimate anchorage and almost non-existent loss of anchorage when inserted accurately.

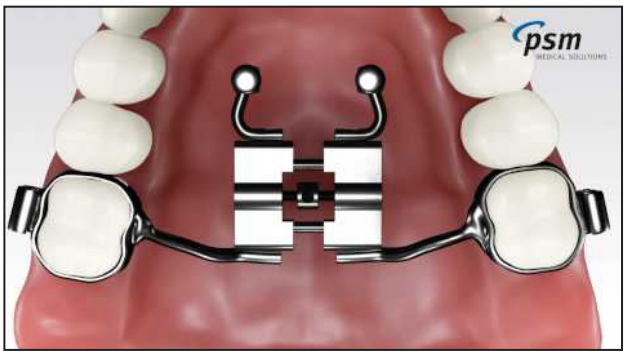

Figure 8

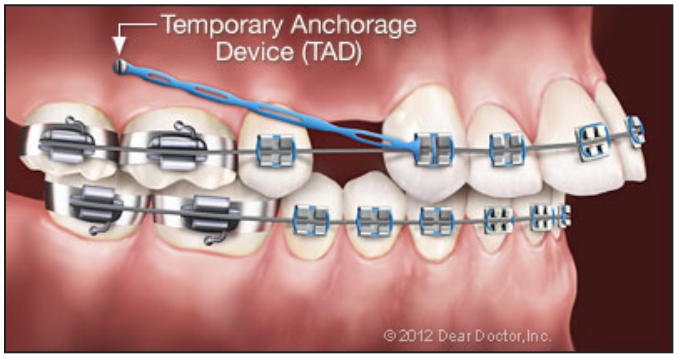

Figure 9

Keles Slider®

The Keles Slider® (Figure 10) was created to avoid distal tipping of maxillary Class II first molars. It was assembled with NiTi coil spring and screws. The Keles Slider® is a very effective fixed device to distalize molars bodily.[32] It was also tested with bilateral distalization,[33] and the anchorage loss was not significant. Other studies reported that the Keles Sliders® demands regular reactivation of the coil springs and that it presents several limitations.[34]

Figure 10

First Class Appliance® – FCA

The First Class Appliance® introduced by Fortini and his team[35] consists of four bands, a vestibular side, and a palatine side. It is a screw-based appliance with forces generated by a telescopic screw mechanism. It is reported to be an efficient non-compliance appliance to distalize molars in mixed dentition without distal rotations. However, it is associated with distal molar tipping as well as anchorage loss of the anterior teeth.[36] A modified version of the First Class Appliance® called the First Class Leone® (Figure 11) produces a rapid distalization of the first and second molars and does it with bodily movement without producing any tipping effect. Moreover, it was reported that the appliance was not producing any loss of anchorage or changes in the vertical dimension.[37]

Figure 11

Intraoral Bodily Molar Distalizer® – IBMD

The intraoral bodily molar distalizer®[38] is composed of two parts: the anchorage unit and the distalizing unit (Figure 12). The anchorage unit is a wide acrylic Nance button, and the active unit consists of TMA distalizing springs. "The springs distalize the maxillary first molars towards the direction in which the springs are inactive, exerting a distalizing force of 230g. It enhances molar distalization by discluding the posterior teeth."[39] It achieved bodily distal movement of maxillary molars and also eliminated the need for patient cooperation and did not require headgear wear for molar root uprighting.

Figure 12

Wilson's Appliance:® Rapid Molar Distalization

William L. Wilson created a treatment called "rapid molar distalization"® also known as the Wilson bimetric distalizing appliance® or Wilson 3D appliance.®[40] Wilson's "rapid molar distalization appliance"® (Figure 13) was created in 1978 to move the upper molars back without changing the position of the front teeth.[41] It consists of compression springs positioned mesial to the maxillary first molar and class II elastics. A study showed that paired with elastics, the Wilson bimetric distalizing arch® provided efficient and simple Class II mechanics. However, there is a serious risk of anterior undesirable movement of the premaxila if the elastics are not worn. Another study showed that the distal tipping of the maxillary first and second molars, and first and second premolars and canines were statistically significant.[42] One advantage of the Wilson appliance® is that delayed bracketing of the premolars and second molars minimizes friction within the appliance which could allow for more rapid bodily movement of the molars.[43]

Figure 13

Carriere Distalizer Appliance®

The Carriere Distalizer® device[44] (Figure 14) consists of a fixed functional appliance for Class II treatment. It was designed to create a Class I molar-canine relationship. It allows distal movement of the canine along the alveolar ridge without tipping and provides a hook for the attachment elastics. With this device, you have to carefully choose the source of anchorage, depending on the patient's skeletal and neuromuscular pattern. One limitation of this device is that brachyfacial patterns respond better to treatment; dolichofacial types are less responsive.[44]

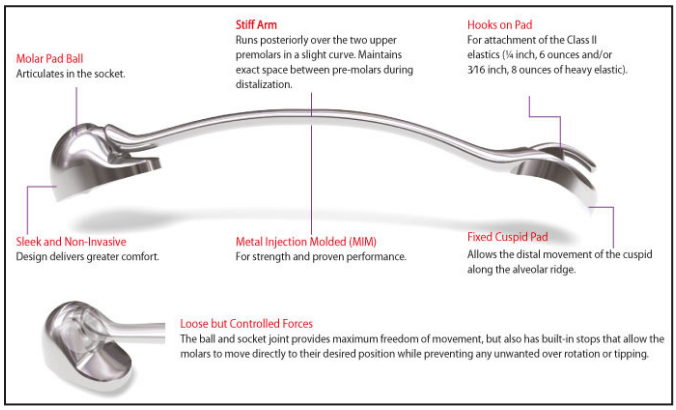

Figure 14

Simplified Molar Distalizer® (also called The Frog Appliance®)

To date, very few studies have evaluated the efficiency of the recently developed intraoral Frog appliance.® An interesting comparative study[45] evaluated the single use of the Frog appliance® (Figure 15) to its use combined with the high pull headgear worn at night. This study concluded that the Frog appliance® does indeed distalize the upper molars, but the movement is (like with a lot of other intra oral appliances) associated with undesirable changes such as tipping of molar axes, but nothing more than the typical tipping expected with the Pendulum® and the Distal Jet.® The results showed that both treatments combined improved the distalization time and also improved the ratio of maxillary molar distalization movement relative to the overall opening space between the first maxillary molars and second premolars. In 2011, the Skeletal Frog,®[46] which is a modified version of the Frog® appliance, was created to eliminate the need for dental anchorage and its unfavorable effects on the anterior arch. It is an innovative mini-implant-supported molar-distalization appliance that requires no dental support or acrylic palatal button. One major contribution of this modified version is that it reduces treatment time because the alignment of the maxillary arch and the distal movement are occurring simultaneously.

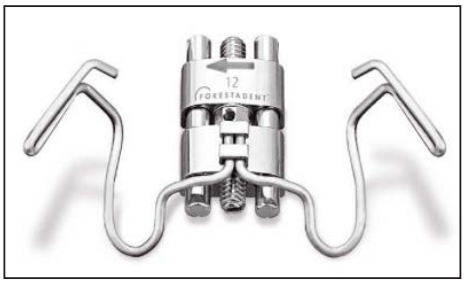

Figure 15

Cetlin Appliance®

The Cetlin Transpalatal Arch® (TPA) is a fixed appliance (Figure 16). It is the same appliance as the ACCO®[47] but does not have headgear loops. It was developed by Dr. Norman Cetlin, and it utilizes a removable appliance intraorally to tip the crowns distally and then uses an extraoral force to upright the roots.[48] Today, this appliance is rarely used in practice.

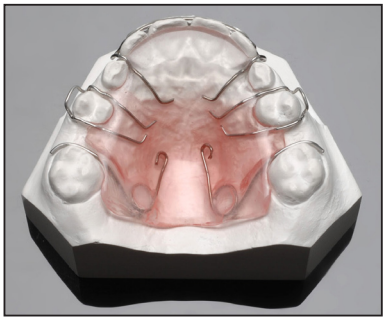

Figure 16

The Acrylic Cervical Occipital Appliance® – ACCO

The Acrylic Cervical Occipital Appliance® is a removable appliance that consists of an acrylic palatal section to create disclusion, Adams Clasps on the first premolar, labial bow across the incisors, and a finger spring at the mesial aspect of the first molar. With the combined use of headgear, it was more likely to create bodily movement of the molar. At the beginning of the century, a study reported a bodily movement only in 9% of patients, and a distal crown tipping was found in 70% of treated cases.[49]

Lokar Molar Distalizing Appliance®

The Lokar Molar appliance® is a recent appliance, and more studies are needed regarding its effectiveness. It is inserted into the molar attachment with a rectangular wire and a compression spring that is activated by a sliding sleeve[50] (Figure 17). This appliance presents advantages like minimal breakage and ease of activation and insertion. Still there is a lack of data on this appliance to objectively discuss its efficiency on molar distalization.

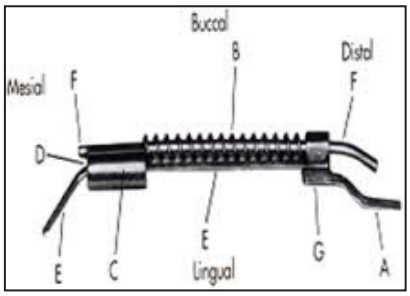

Figure 17

Reppeling Magnets®

Magnetic devices introduced by Gianelly, et al in 1988[51] consisted of distalization by means of samarium-cobalt repelling magnets® (SmCo5). "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"[52] (Figure 18). As the molar distalization is achieved in a relatively short period, occlusal adjustment, including uprighting and derotation of the maxillary molars as well as post-treatment retention, seems recommendable.[53] Revivew of the literature showed that these were tested and compared to many other intraoral molar distalization procedures. They were reported less effective than coil springs[54] in terms of movement achieved, less efficient in maxillary molar distalization in individuals with Class II malocclusion, deeper bite than superelastic coils,[55, 56] and were less effective than the NiTi appliance® for distal bodily movement of maxillary molars.[57]

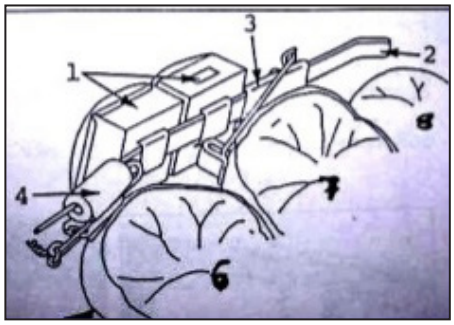

Figure 18

K-Loop Molar Distalizer®

The K-Loop appliance® (Figure 19) developed by Dr. Kaltra[58] is used to distalize molars in a more bodily way. One of the most important characteristics of the K-Loop® is the special V-bend in the K-Loop® that moves both the crown and the root distally.[59] It is made of TMA wire, and the legs of the K are inserted into the molar tube and the premolar bracket. This appliance provides minimum tipping.

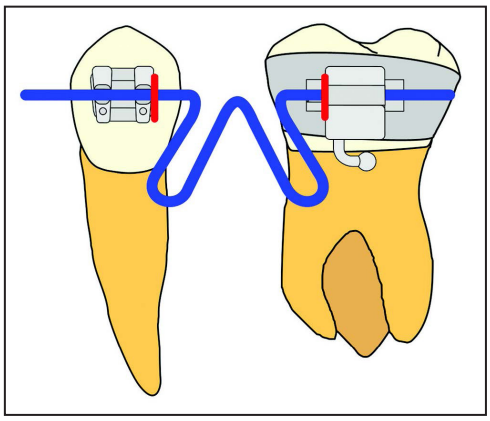

Figure 19

Fixed Piston Appliance®

This device was first described by Raphael Greenfield in 1997. Its purpose is to distalize bodily without creating tipping of the crown and without loss of posterior anchorage. It consists of stainless steel wires and tubing banding the first maxillary molar and first bicuspid together. The force is applied by nickel titanium open-coil springs. This appliance has proved its efficiency in that it causes less posterior anchorage loss.[60] In a comparison study of various distalization appliances,[61] tip was reported to be of 6.5° (+/- 6.6°) in an average distal movement of 3.9 mm.

Conclusion

All appliances mentioned above are able to create distalization movement of the upper posterior molar. Although some appliances create more undesirable side effects such as loss of anterior anchorage, mesial drift of anterior anchorage, tipping of the molar during movement, and opening of the bite caused by molar extrusion--most of these disadvantages (mainly anchorage lost) can be in part or totally neutralized by modifying the appliances with supplementary TADs anchorage. Tipping and opening of the bite depend more on the nature of the mechanic used in the appliance and the intrinsic design of the appliance. Therefore, they are more difficult to bypass. Appliances that depend more on patient cooperation have shown less predictable results. Choice of appliance may also be guided by the fact that the patient is already into treatment, and full bracketing has already occurred.

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