

Review Article

Molar Distalization By Miniplates- A Review

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ABSTRACT

Treatment of Class II malocclusions, without extractions, frequently requires distalization of maxillary molars into a Class I relationship by means of extra-oral or intraoral forces. Several methods and devices can be used to distalize maxillary molars and to correct Class II malocclusions. The most conventional method for distalizing the maxillary molars involves use of cervical headgear but the success of the treatment depends heavily on patient cooperation. Several intraoral appliances have been used to distalize the maxillary molars in Class II patients without the patient's cooperation; these include nickel-titanium spring, magnet distal jet, first class, Jones jig, pendulum, and Keles slider appliances.

Introduction

Treatment of Class II malocclusions, without extractions, frequently requires distalization of maxillary molars into a Class I relationship by means of extra-oral or intraoral forces. Several methods and devices can be used to distalize maxillary molars and to correct Class II malocclusions. The most conventional method for distalizing the maxillary molars involves use of cervical headgear but the success of the treatment depends heavily on patient cooperation. Several intraoral appliances have been used to distalize the maxillary molars in Class II patients without the patient's cooperation; these include nickel-titanium spring, magnet distal jet, first class, Jones jig, pendulum, and Keles slider appliances. All of these intraoral distalization appliances distalize the maxillary molars; however anchorage loss was unavoidable, characterized by the

protrusion of maxillary incisors, an increase in overjet, and decrease in overbite. Anchorage, defined as a resistance to unwanted tooth movement¹, is a prerequisite for the orthodontic treatment of dental and skeletal malocclusions.^{2,3}

In 1983, the first clinical use of a screw for orthodontic anchorage was reported.⁴ After that, temporary skeletal anchorage devices were rapidly developed. There have been 3 major trends in the field of temporary skeletal anchorage devices: palatal implants, miniscrews, and miniplates. When compared with the other temporary skeletal anchorage systems, miniplates offer better stability. The average failure rates are 7.3% for miniplates, 10.5% for palatal implants, and 16.4% for miniscrews.⁵

In the history of miniplate anchorage in orthodontics, the first use of a surgical bone plate for orthodontic anchorage was reported in 1985.⁶ Since that time, a

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number of miniplate systems have been specially designed as orthodontic anchors. A skeletal anchorage system, with its anchor plates and screws made of pure titanium, was developed in 1999 for use as absolute orthodontic anchorage units.^{7,8} The skeletal anchorage system was monocortically placed, and this allowed rigid anchorage because of the osseointegration effects on both the anchor plates and the screws.⁹ The failure rate of the skeletal anchorage system is 6%, and it shows excellent clinical performance.¹⁰ A zygomatic anchorage system, consisting of plates and screws, also a rigid anchorage system, was introduced in 2002.¹¹ The success rate of the zygomatic anchorage system was 98.6%.¹² In another example, a locking plate (Compact lock 2.0) has been used as posterior maxilla anchorage,¹³ and its success rate is 93.4%.¹⁴ Miniplates are widely used in maxillofacial surgery as osteosynthesis devices for facial fracture repair and for fixation osteotomies. Miniplates used in the orthodontic practice are modified devices with a connection bar passing through the attached gingival. They overcome the disadvantages of miniscrew implants, such as difficulty in finding a suitable site, and can serve as more reliable and long standing skeletal anchorage units that provide excellent stability. The fixation screws of miniplates can be placed at various regions of the maxilla and mandible (zygomatic buttress or aperture piriformis of the maxilla, posterior cortical bone and symphyseal regions of the mandible). Miniplates present however some disadvantages; they are more expensive than miniscrews, they must be placed by a maxillofacial surgeon in an operating room and both placement and removal may cause swelling and discomfort for the patient.

Miniplates have been used for skeletal anchorage for intrusion or distalization of molars, in en masse distalization of the entire dental arch, for buccal segment distalization, for severe skeletal class 3 as an alternative to orthognathic surgery or where anchorage teeth are lacking, and to apply orthopedic forces for treatment in both class 2 and class 3 cases.

Structure and composition of miniplates

Miniplates are made of titanium or titanium alloys and come in various shapes and sizes. All miniplates have 3 parts: head, arm, and body. The head portion is intra-orally exposed and positioned outside the dental arches. The head comes in a variety of shapes: circular,¹⁵ hooked,^{16,17} and tubular.¹⁸ Some are like bendable sticks that can be manipulated into the desired shape.¹⁹ The arm portion is transgingival or transmucosal and tends to be rectangular or round. The body portion is positioned subperiosteally, and its surface is attached to the bone. The body portions are classified into 4 basic shapes: T, L, Y, and I (straight). The body portion is fixed on the bone surface of the zygomatic buttress or the mandibular body with 2 or 3 miniscrews. Although there are many variations in miniplate heads, there are fewer variations in the body portions. Standard miniplates, used in maxillofacial surgery, are also used for orthodontic anchorage but the emergence area is not rounded and they have sharp corners, which can cause delayed wound healing and more soft tissue irritation.

Yen-Wen Huang et al²⁰. concluded that The peak von Mises cortex stress values were highest with the I-type plates followed by the L-type, Y-type, and T-type plates. Bone stress decreased as the screw numbers increased but was not related to screw length. Bone stress increased as the cortex thickness decreased.

Bone stress was linearly proportional to the force magnitude, and the highest values were produced when the force was in the forward direction.

Various system of miniplate for Distalization

1. The Zygoma Anchorage System

In 2002 Hugo De Clerck *etal*²¹ developed a new anchorage system (ZAS) in which the miniscrews are placed at a stage distance from the roots of the upper molars. Because of its location and its solid bone structure, the inferior border of the zygomatico maxillary buttress, between the first and second molars, was chosen as the implant site. Combining three miniscrews with a titanium miniplates can bring the point of the force application near the center of resistance of the first permanent molar.

Appliance Design and Placement

The upper part of the Zygoma Anchor is a titanium miniplate with three holes, slightly curved to fit against the inferior edge of the zygomaticomaxillary buttress, A round bar, 1.5 mm in diameter, connects the miniplates and the fixation unit. A cylinder at the end of the bar has a vertical slot, where an auxiliary wire with a maximum size of 0.032" x 0.032" can be fixed with a locking screw.

The plate is attached above the molar roots by three self tapping titanium miniscrews, each with a diameter of 2.3 mm and a length of 5mm or 7mm. the miniscrews do not need to be sandblasted, etched, or coated. Square holes in the center of the screw heads accommodate a screw driver for initial placement, while pentagonal outer holes are used to remove the screws at the end of treatment. To place the anchor, an L-Shaped incision, consisting of a vertical incision mesial to the tress and a small horizontal incision at the border between the mobile and attached gingival,

is made under local anesthesia. The mucoperiosteum is elevated, and the upper part of the anchor is adapted to the curvature of the bone crest. Three holes with a diameter of 1.6mm each are drilled, and the Zygoma Anchor is affixed with the three miniscrews. The Cylinder should penetrate the attached gingiva in front of the furcation of the first molar roots at a 90 angle to the alveolar bone surface. The miniplate is covered by the mucoperiosteum and sutured with resorbable stitches. When indicated, premolars are extracted at the same appointment.

Clinical Application

To connect the Zygoma Anchor with the anterior teeth a rigid power arm was designed to fit in the large vertical slot of a canine bracket. The hook at the end of the power arm is situated at the level of the canine's center of resistance. A nickel titanium closed coil spring with a force of 50-100gm is attached between the power arm on the canine and the Zygoma Anchor, so that. The direction of force is parallel to the main archwire.

The first molar can be distalized with a sliding jig before force is applied to the upper canines. The ZAS can also be used with open coil springs to neutralize the reaction forces generated by distal movement of the upper molars. During retraction and intrusion of the anterior segment with T-loop arches, the ZAS is used as an indirect anchorage unit.

After orthodontic treatment the mini screw are removed under local anesthesia through a small vertical incision in the gingival converging the miniplate. A special screwdriver that fits into the pentagonal outer holes of the screw heads is used. After the screws are removed, only three 1.6mm diameter holes remain, minimizing bone loss.

The ZAS uses three miniscrews, increasing total anchorage over other types of implants. Because the miniscrews and miniplate have excellent mechanical retention, immediate loading is possible. The point of application of the orthodontic forces is brought down to the level of the furcation of the upper first molar roots. The vertical slot with the locking screw makes it possible to attach an Auxiliary wire, which can move the point of force application some distance from the anchor. The connection between the anchor and the conventional fixed appliance can easily be adapted to changing anchorage needs throughout treatment. So, ZAS seems to be an effective alternative to conventional extraoral anchorage.

2. Skeletal Anchorage System for Distalization

Sugawara *et al.* in 2006²² developed the Skeletal Anchorage System (SAS), which is a noncompliance appliance that uses a similar concept as the palatal implant system, but mechanically differ from it. The SAS consists of titanium anchor plates and monocortical screws that are temporarily placed in either the maxilla or the mandible or in both, as absolute anchorage units for adult orthodontics. And it is possible to move maxillary molars distally with ease.

Anchor plates were made up of pure titanium and therefore were suitable for osseointegration and tissue integration. Also, they were sufficiently strong to resist the usual orthodontic forces even at the headgear force level, and could be bent with ease for fitting into the bone contour of the implantation site. The head position was intra-orally exposed and positioned outside the dentition so that it never disturbed the distalization of the maxillary molars. Each head portion has 3 continuous hooks for easier application of the orthodontic force vectors. The arm

portion was transmucosal and had 3 graduated lengths, short (6.5mm), medium (9.5mm) and long (12.5mm) to compensate for individual morphological differences. The body portion was positioned subperiosteally.

The implantation sites of the anchor plates required sufficiently thick cortical bone, at least 2 to 3 mm, to enable fixation of the anchor plates with monocortical miniscrews. The screws were also made of pure titanium. Each screw had a head with a tapered inside square self tapping thread. The diameter of the screw was 2mm and the available length was 5mm. The anchor plates were placed at the zygomatic buttress to distalize the maxillary molars.

For placement of anchor plates, the operation was carried out under local anesthesia administered with intravenous sedation. First, a mucoperiosteal incision was made at the buccal vestibule of the implantation site. A mucoperiosteal flap was elevated after subperiosteal ablation and the surface of the cortical bone at the implantation site was exposed. The anchor plate was selected according to the distance between the implantation site and the dentition. The selected plate was contoured to fit the bone surface. Then a pilot hole was drilled, and a self tapping and monocortical screw was inserted. After the placement of the remaining screws, the anchor plate was then firmly attached to the bone surface. The wound was closed and sutured with absorbable thread. The surgery took 10 to 15 minutes for each anchor plate.

Orthodontic force was usually applied about 3 weeks after the implantation surgery. After post-surgical management, but it was not necessary to wait for the osseointegration of the titanium screws and plates. All anchor plates were removed immediately after debonding.

For Distalization first 0.022' slot preadjusted multi bracketed appliance placed. Heat treated 0.018 x 0.025" blue Elgiloy wires were used as the main archwires for distalization of the maxillary molars. The orthodontic forces were approximately 200gm for single molar distalization and approximately 500gm for enmass molar distalization. Orthodontic forces were mostly provided by nickel titanium springs or elastic chain modules.

It is important to address the amount of distalization of the maxillary first molars and anchorage loss at the first stage. But a more important matter is the anchorage slip of the distalized molars at the second stage. The progress of the maxillary molar distalization with the SAS is completely different from previous molar distalizing methods. The distalized molars are never required as part of the anchorage during retraction of the premolars and the anterior teeth, because the orthodontic anchor plates placed at the zygomatic buttresses. It is possible to perform en masse movement of the molars, the premolars, and anterior dentition in sequence without a separation into 2 stages. The sequential and efficient distalization is a distinct advantage of SAS biomechanics as compared with previous methods.

Maxillary first molar distalization by SAS was around 3.78 mm at the crown level; therefore, the SAS can be considered an effective modality for noncompliance molar distalization. Also, distalization at root level was 3.20 mm on average, distalization with the SAS can be considered as bodily translation.

3. Zygoma-Gear Appliance For Intraoral Upper Molar Distalization

Nur et al in 2010²³ designed an intraoral upper molar distalization system supported by the zygomatic region named as the Zygoma-Gear Appliance (ZGA).

The system consists of two zygomatic anchor plates, an inner-bow, and heavy intraoral elastics. The zygomatic anchor is a titanium miniplate with three holes, which continues into a round bar. The anchor plate is adjusted to fit the contour of the lower face of each zygomatic process and fixed by three bone screws (length, 7.0 mm). The inner-bow is made from stainless steel wire, 1.1 mm in diameter and designed like the inner part of a conventional facebow. Two hooks are soldered onto the inner-bow at the lateral teeth regions, and U bends are bent bilaterally in front of the upper first molars. The inner-bow is adjusted to the headgear tubes on the upper first molar bands. A distally directed force is applied to the upper molar teeth via the heavy intraoral elastics, which are placed between the zygomatic plate and the inner-bow hooks. Results showed the mean treatment period required to achieve a Class I molar relationship was 5.21 months. The distalization amount of the maxillary molars was 4.37mm and, thus, the rate for the distal movement of the molars was 0.84 mm per month. Maxillary first molars showed a slight intrusion (0.50 mm), while distal tipping was only 3.30 degree. Furthermore, there was a decrease in overjet, indicating that there was no anchorage loss with use of the ZGA and thus they concluded that maxillary molar distalization without anchorage loss can be achieved in a short time.

Kilkis et al in 2012²⁴ conducted a study to present the orthodontic treatment of a 15-year-old boy with a unilateral maxillary molar distalization system, called the zygoma-gear appliance. It consisted of a zygomatic anchorage miniplate, an inner bow, and a Sentalloy closed coil spring. A distalizing force of 350 g was used during the distalization period. The unilateral Class II malocclusion was corrected in 5 months with the zygoma-gear appliance. The maxillary left first

molar showed distalization of 4 mm with an inclination of 3 degree. The maxillary premolars moved distally with the help of the transseptal fibers. In addition, there were slight decreases in overjet (0.5 mm) and maxillary incisor inclination, indicating no anchorage loss from the zygoma-gear appliance. This study showed that this new system, the zygoma-gear appliance, can be used for unilateral maxillary molar distalization without anchorage loss.

Discussion

Several reports²⁵⁻²⁸ have shown different appliances for molar distalization in the treatment of dental Class II malocclusions. However, anchorage loss of the maxillary premolars and flaring of the maxillary incisors as well as a considerable amount of relapse during retraction of the premolar and the anterior teeth were reported.²⁹ Therefore, intraoral distalizing mechanics combined with palatal implants have recently been used for distalization of maxillary molars.^{30,31} Although these methods can be used effectively to achieve distalization of maxillary molars without anchorage loss, the retraction of the anterior teeth is limited as a result of the proximity of palatal implant to the roots of anterior teeth or the presence of a bulky acrylic Nance appliance behind the upper incisors. In addition, Liou et al.³² and Kinzinger et al.³³ examined the anchorage quality of the miniscrews and concluded that they did not fully maintain their positions under continuous loading. To overcome this the use of miniplates for direct anchorage can support all treatment required for distalization of the complete maxillary dental arch with little need for patient compliance during treatment apart from maintenance of oral hygiene.

The surgical intervention required for the placement of miniplates is more invasive than that for miniscrews. The other problem has to do with exactly who should put the miniplate into place. With regard to the surgical intervention, miniplates for distalization is implanted at the zygomatic buttress a mucoperiosteal flap operation is inevitable. After implantation surgery, patients have facial swelling for about a week. These clear disadvantages come hand in hand with the use of miniplates. Thus, a risk-benefit analysis must be carefully carried out to clarify whether the patient will benefit significantly by the use of miniplates rather than miniscrews.

Conclusion

Newer appliances continue to evolve as trend changes from headgear to intra-oral appliances that attempt to favorably alter the posterior relationships of the jaws and occlusion and that also require a minimum of patient cooperation. The newer materials like mini-implants are no doubt revolutionizing the procedure of molar distalization and with the today's scenario as the non-extraction therapies are fast catching up, who knows what the so called next generation force delivery system may have in hands for us.

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