Use of Miniscrews and Miniplates in Orthodontics

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Paradigms have started to shift in the orthodontic world since the introduction of mini-implants in the anchorage armamentarium. For example, miniscrews have allowed the management of wider discrepancies than those treatable by conventional biomechanics because force can be applied directly from the bone-borne anchor unit. Therefore, miniscrews not only free orthodontists from anchorage-demanding cases, but they also enable clinicians to have good control over tooth movement in 3 dimensions. This review will illustrate the versatility of skeletal anchorage provided by mini-implants in the correction of malocclusion, focusing on orthodontic or orthopedic movements in the 3 spatial planes. Adjunctive orthodontic treatments in adult periodontal conditions and treatment for impacted teeth with the aid of miniscrews will also be discussed.

Since the introduction of implants for orthodontic anchorage, different types of implant devices and methods of application have been explored. The inclusion of implants for skeletal anchorage in our armamentarium is changing not only how far orthodontists can move a tooth without the use of headgear, but also their approach to managing different orofacial deformities, malocclusions, or space problems before the prosthetic replacement of missing teeth. For example, case reports have described how implants can be used as anchorage for facemask protraction in adolescent patients with maxillary hypoplasia and obligodontia. Several studies have also been conducted on the use of implants to correct open bite of different severities. In addition, intrusion of overerupted teeth before prosthetic replacement of missing teeth in the opposing arch can be achieved with skeletal anchorage.

The use of skeletal anchorage not only changed how far teeth can be moved, but also offered more treatment options to patients. Orthodontic camouflage of malocclusion, which needs surgical correction, becomes possible to achieve without surgery by skeletal anchorage. In this review article, the different uses of miniscrews and miniplates in orthodontic and orthopedic management of malocclusion will be discussed with respect to the 3 spatial planes of movement—namely, sagittal, vertical, and transverse.

Sagittal Plane

RETRACTION OF ANTERIOR TEETH

Three main systems are used to retract the anterior teeth: palatal implants, miniscrews, and miniplates.

Palatal Implants

Wehrbein et al prospectively studied 9 patients with Class II malocclusion in whom anchorage was indirectly reinforced by connection of a transpalatal bar to a palatal implant after extraction of the upper first premolars. The loading force applied was 200 g over 11 months and the reduction of overjet ranged from 5.1 to 7.8 mm (mean, 6.22 mm). The loss of anchorage ranged from 0.2 to 1.6 mm, and was attributed to the deformation of the transpalatal bar.
**Miniscrews**

Most of the published studies on the retraction of anterior teeth with miniscrews are case reports.\(^{14,17-20}\) In the cases presented, the miniscrews were applied directly to the hooks on the archwire to retract all upper 6 anterior teeth simultaneously with a loading force of about 150 g. Furthermore, the extraction space was fully utilized in the retraction of anterior teeth without anchorage loss. The posterior teeth even moved distally slightly in some cases.\(^{17-20}\) One of the advantages of the mechanics involved in these cases was the direct application of load to the vertical hooks on the archwire: in this setup, the point of force application was close to the center of resistance of the anterior segment, thereby allowing bodily sliding of the whole segment with minimal tipping, and in turn, shortening the treatment time.\(^{20}\)

Park et al\(^ {25}\) described a case of anterior retraction in which an innovative miniscrew technique circumvented the need for brackets during retraction. First, maxillary miniscrews were placed between the first molar and second premolar. Second, a segmental hard acrylic splint with 2 lever arms distal to the canines was fabricated on the 6 anterior teeth. Elastics were then attached from the miniscrews to the lever arm. The 6 anterior teeth that were embedded in the clear splint were thus retracted without a bracket during the 6 months of retraction. Brackets were needed only in the finishing stage in the last 6 months.

In a prospective split-mouth study, Thiruvanakathchari et al\(^ {24}\) measured anchorage loss during canine retraction in 10 patients in whom only 1 side of the mouth received miniscrew treatment. The canines were retracted in 4 to 6 months, with no anchorage loss on the implant side but with 1 to 2 mm of anchorage loss on the nonimplant side.

**Miniplates**

Miniplates have also been used to retract anterior teeth.\(^ {21,22}\) De Clerck et al\(^ {21}\) followed up 27 patients undergoing retraction of canines (11 bilateral and 16 unilateral) using a miniplate fixed with 3 miniscrews. The setup used sliding mechanics, with power arms attached to the canines and a loading force of 50 to 100 g. The mean rate of distalization among the patients studied was 1.14 mm per month.

In addition, Bengi et al\(^ {25}\) treated a case of Class II:1 malocclusion with zygomatic miniplates, with the aim of retracting the upper incisors to achieve rapid canine distalization after extraction of the upper first premolar. Distalization was completed in 5 months.

**RETRACTION OF WHOLE DENTITION OR DISTALIZATION OF MOLARS**

In general, 3 kinds of implants—bone plates, palatal implants, and miniscrews—have been used to retract the whole dentition or to distalize the molars. The anchorage provided by the implant can be direct or indirect.

**Bone Plates**

The first case report of molar distalization was published in 1985 by Jenner and Fitzpatrick.\(^ {26}\) A bone plate was inserted into the ramus and direct traction was applied to distalize a lower first molar by 3.5 mm in 5 months.

In 2004, Sugawara et al\(^ {27}\) published another study comprising 25 nongrowing patients treated with a miniplate system to distalize the maxillary first molars after the extraction of either the second or third maxillary molars. The mean amount of distalization was 3.78 mm at crown level and 3.20 mm at root level.

In 2006, Sugawara et al\(^ {28}\) published another study using palatal implants for distalization. These include indirect distalization by way of a transpalatal arch with a spring, and direct distalization by way of a transpalatal bar or other appliance.

**Indirect distalization.** Mannchen\(^ {29}\) performed 2 cases of indirect distalization using a transpalatal arch supported by a palatal implant on which a yoke-shaped bar was attached. A push coil was then used to distalize an upper molar that had a bracket welded on its palatal side.

In a study of 25 patients aged 11.3 to 16.5 years using palatal implants to distalize maxillary molars, Gelgor et al\(^ {30}\) placed a miniscrew of 1.8-mm diameter in the palate and connected a transpalatal arch to 1 premolar on either side through the implant. An open-coil spring of 250-g loading force was then fitted between the first molars and the anchorage-reinforced premolars to push the molars distally. In this configuration, the implants served as indirect anchorage. The upper first molars were distalized by a mean of 3.9 mm according to cephalograms and 5.0 mm according to dental casts. A mild protrusion of the upper central incisors, of 0.5 mm, was also noted.

**Direct distalization.** Kyung et al\(^ {31}\) developed a direct method to distalize Class II molars after facemask treatment for an 11-year-old boy and a 10-year-
old girl. The 2 upper first molars were splinted together by a transpalatal bar, and a miniscrew was placed distally and directly pulled by a powerchain connected to the bar. The upper first molars were distalized by 3.5 mm from the apices and 5 mm from the crowns, in 3 months for the boy and 5 months for the girl.

On the other hand, Byloff et al secured a surgical bone plate with 4 miniscrews and attached a pendulum appliance to the plate to directly distalize the upper molars with 250 g of loading force. The whole system was named the Graz implant-supported pendulum. Similar designs were subsequently developed, as reviewed by Kinzinger et al—namely, the Aachen miniscrew-supported distal jet, Mainz implant pendulum, and Aachen implant pendulum.

Miniscrews

In 2005, Chung et al described a case of distalization of the whole mandibular dentition using miniscrews for indirect anchorage. Two miniscrews of 1.8-mm diameter were inserted between the upper premolars and molars. Class III elastics were then run from the upper miniscrews to 2 lower distalizing jigs. As a result, the mandibular dentition was distalized 5 mm on the left side and 2 mm on the right side.

LINGUAL ORTHODONTICS

One of the difficulties of lingual orthodontics is the control of anchorage and torque of the anterior teeth. Several case reports have focused on using miniscrews for anchorage in lingual appliances. In a report of 2 cases, Hong et al stressed the importance of the insertion of miniscrews with a lever arm to reinforce anchorage and torque control of the anterior teeth.

PROTRACTION OF MOLARS OR WHOLE DENTITION

The use of implants to protract molars or the whole dentition was first described in 1990. The 2 main ways of protracting the lower molars are the insertion of small-sized miniscrews between the roots or the placement of conventionally sized implants in the retromolar area. Freudenthaler et al studied the effectiveness of miniscrews in protracting the lower molars of 8 patients aged from 13 to 46 years. Either the lower first permanent molars or the deciduous second molars were first extracted owing to agenesis of the second bicuspids. Miniscrews of 2-mm diameter were then inserted in the area between the 2 premolars at the level of the apical thirds or in the mesial side of a molar extraction socket. With both methods, the immediate loading force of 150 g was maintained for 7 to 20 months during active treatment. Similarly, Kyung et al reported on a patient in whom the lower second molars were protracted by 9 mm with 150 g of loading force over 9 months. In that patient, protraction was aided by miniscrews inserted between the premolars after the lower first molars had been extracted.

A prospective study conducted by Higuchi and Slack demonstrated the successful protraction of the whole lower dentition in 6 of 7 adults receiving push-coil treatment with direct anchorage from conventional implants. The 400-g loading force on each side resulted in 2 to 6 mm of movement for the lower second molars and 3 to 5 mm of movement for the lower incisors. Roberts et al also used retromolar implants to protract the lower second molars in 5 adults to close first molar extraction sites. The implants provided indirect anchorage because the premolars were connected to the implants with archwires. The rate of mesial translation of the second molars was approximately 0.60 mm per month during the first 8 months. Thereafter, the rate was approximately 0.34 mm per month until space closure was complete.

ORTHOPEDICS

The use of implants for orthopedic purposes was first reported in 1999 by Henry et al. The patient was a 13-year-old girl with maxillary growth retardation following the repair of a unilateral cleft and palate defect. Two implants of 7-mm diameter were placed in the zygomatic buttress of the maxilla, which was allowed to heal for 5 months. Following traction with 800 g of loading force by way of a face mask for 8 months (14 hours per day), the maxilla was advanced anteriorly and inferiorly by 4 mm.

In 2003, Enacar et al described a 10-year-old girl with Class III skeletal relationship, maxillary hypoplasia, and severe oligodontia. Owing to the lack of adequate teeth to anchor a facemask, a titanium screw was placed in the processus pterygoideus of the maxilla. After 3 weeks of healing, 800 g of loading force was applied to the facemask for 16 hours a day for 7 months. The maxilla was advanced forward and convexity improved from −4 mm to 3 mm.

In 2006, Kircelli et al reported on a 11-year-old girl with severe maxillary hypoplasia and hypodontia. Miniplates were fixed onto the lateral nasal wall of the maxilla as anchorage for facemask protraction. The technique achieved 8 mm of maxillary advancement with 350 g of loading force.

Vertical Plane

INTRUSION OF DENTITION

Intrusion of posterior or anterior dentition is always difficult to achieve without the side effect of extru-
Intrusion of the anchorage teeth, and the placement of mini-implants for skeletal anchorage may provide the solution. For example, intrusion of posterior teeth is essential in the correction of open bite, and case reports have shown that miniplates can lead to the intrusion of upper and lower molars by 3 to 5 mm, while also achieving counterclockwise mandibular rotation. Sugawara et al investigated the amount of intrusion of mandibular molars among 9 patients after miniplate treatment, and found that the upper incisors by 3.5 mm.

In 2006, DeVincenzo used a new appliance, called a vertical adjustable corrector, to treat extreme dolichocephalic malocclusion. The vertical adjustable corrector is a skeletal implant connected to a rigid buccal U-shaped steel bar that runs from 1 first molar auxiliary tube to the contralateral side. This rigid bar is a few millimeters above the dentition, and elastics can be applied to intrude different teeth. Intrusion of posterior or anterior teeth can change the occlusal plane and correct open bite or gummy smile, as demonstrated in 5 cases, showing that this method represents an alternative to the surgical option.

Intrusion of Individual Teeth

In the management of overeruption of unopposed teeth, molar intrusion is a common indication for orthodontic treatment before prosthetic replacement of missing teeth. Two cases have been reported in which overerupted lower and upper molars were intruded with miniscrews but without any braces on other teeth. Upper molars can also be intruded with miniscrews on buccal and palatal sides before the prosthetic restoration of the lower missing teeth is commenced. In 1 case, overerupted upper left first and second molars were intruded by the fixation of a miniscrew on palatal bone, with a loading force of 150 to 200 g delivered by a powerchain.

Extrusion of Individual Teeth

A miniscrew has been used for forced tooth extrusion in a 51-year-old woman who presented with a bridge that replaced a missing upper right incisor with the central incisor and canine as abutments. Because the gingiva at the central incisor and canine had receded by 3 to 4 mm, both of them required extrusion to match the gingival level of the contralateral side before a new bridge could be constructed. To do this, a miniscrew was placed into the alveolus of the missing upper lateral incisor and an open coil was applied perpendicularly to an orthodontic wire connecting the central incisor and canine.

In another case, a patient had a mandibular left first premolar that displayed radicular perforation and biological width invasion slightly below the bone crest. To restore the biological distance, rapid extrusion of the premolar was done using adjacent prosthetic implants for skeletal anchorage.

Transverse Plane

Expansion

Titanium screws were used in a pilot study to provide skeletal anchorage for a rapid maxillary expander after surgical splitting of the maxilla. For the 2 women studied, who were aged 21 and 23 years, 8 mm of expansion was achieved after 21 and 45 days, respectively. The authors concluded that a skeletal supported rapid maxillary expander provided better anchorage and caused less buccal tilting of the posterior teeth than conventional expander.

Other Uses of Mini-Implants

Insufficient Tooth Anchorage

In an investigation conducted by Odman et al, 9 patients with 7 to 20 missing teeth who underwent orthodontic treatment were aided with endosseous implants. All the implants served their purpose as anchorage units, remained stable, and were used as abutments for permanent prostheses.

In addition, Fukunaga et al demonstrated that malocclusion in a patient with periodontal disease could be successfully treated with the aid of a miniplate. Preoperatively, the patient had generalized horizontal bone loss, vertical bone loss in the posterior segment, 5 mm of space in the upper anterior teeth, and 7.5 mm of overjet. The upper incisors were uprighted, retracted, and intruded with a temporary miniplate in the zygomatic process.

Uprighting Molars and Disimpaction

When conventional orthodontic methods are employed to upright ectopically positioned molars, undesirable side effects include extrusion of the target molars and reciprocal forces exerted on anchorage units. The application of mini-implants for skeletal anchorage has eliminated such side effects because orthodontic brackets are not required, and no forces are applied to other teeth during anchorage.

In 1996, Kokich published a case report illustrating how an endosseous prosthetic implant could upright...
and intrude the mandibular molars. Subsequently, Janssens et al62 described the extrusion of 2 unerupted horizontal upper first molars with the aid of an on-plant on the palate.

As the popularity of mini-implants increased, Park et al63,64 reported in 2002 and 2004 that mini-implants could upright mesially inclined molars in mandibular and maxillary second molars. In the mandible, microimplants that were inserted in the retromolar area distal to the second molars allowed the application of an uprighting force (50-70 g) through an elastic thread to the second lower molars. As a result, the mesially angulated mandibular second molar was uprighted after 6 to 8 months. In the maxilla, a micro-implant was inserted in the maxillary tuberosity and 70 g of loading force was applied through an elastic thread to the lingual cleats buccal and lingual to the second molar. The mesially angulated maxillary second molar was uprighted after 4 months.

Park et al65 also placed mini-implants palatal to the upper first and second molars and buccal to the lower second molar, attaching to the teeth with elastomeric thread to correct posterior lingual crossbite. Furthermore, the same researchers65 disimpacted upper canines of 2 patients and brought the canines into the arch orthodontically with miniscrew instead of brackets and wire. Bonding of the brackets was delayed until the canine was brought into a reasonable position.

Giancotti et al66 uprighted an impacted mandibular second molar by applying 50 g of loading force from a closed-coil spring attached to a miniscrew that had been implanted in the retromolar region. In 2005, Yun et al67 assessed the use of miniscrews for indirect anchorage to upright 2 cases of mesially tipped mandibular second molars. This setup, in which a rectangular stainless steel wire connected the screw and the anchor teeth, uprighted the molars without unwanted movement in the reinforced anchor teeth.

The introduction of miniscrews and miniplates into orthodontics has had a revolutionary impact on the specialty. Retraction or protraction of the whole dentition in the anteroposterior direction, absolute intrusion of posterior teeth in the vertical direction, and expansion of the palate without buccal tilting of the molars were never easy tasks to accomplish. Skeletal anchorage with mini-implants offers more options for patients and dentists to achieve better results than ever before. Future studies should explore further applications of skeletal anchorage in the correction of malocclusions and skeletal discrepancies.

References


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