TURKISH JOURNAL of ORTHODONTICS

DOI: 10.5152/ TurkJOrthod.2016.16027

REVIEW

Various Contemporary Intraoral Anchorage Mechanics Supported with Temporary Anchorage Devices

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ABSTRACT

The aim of this review was to provide an overview of the various types of contemporary intaroral anchorage mechanics that are being used with temporary anchorage devices (TADs) and to briefly mention the design and clinical use of these appliances. Original articles on "mini-implants in orthodontics, temporary anchorage devices, orthodontic miniscrews, mini-implants, and skeletal anchorage" were searched for on the PubMed database. Articles published between 2004 and May 2015 were used. References of 10 articles were also searched for and used. Beneslider, Miniscrew-supported EZ slider, Implant-supported Distal Jet, Mini-implant-Borne Pendulum B Appliance, Noncompliance-supported Maxillary Molar Distalization Appliance, Temporary Skeletal Anchorage Device-Supported Rapid Maxillary Expansion Appliance (RME), Mini-Implant-Supported Maxillary Expansion, Implant-Supported RME, Hybrid Hyrax, Frog Appliance, Palatally Anchored Mesialslider, Mousetrap Appliance, Lever Arm, and Mini-implant System were evaluated. In contemporary orthodontics, TADs have an important place. They can be combined with different intraoral mechanics and be efficiently used. The future of orthodontic intraoral anchorage may be based on TADs.

Keywords: Anchorage, miniscrew, orthodontics

INTRODUCTION

In simple words, anchorage is the resistance to unwanted tooth movement (1). Since the beginning of orthodontics, it has been important to control anchorage to achieve satisfactory treatment results (2). There are different ways to control orthodontic anchorage such as extraoral anchorage by a headgear and intraoral anchorage by lingual or palatal arches or intermaxillary elastics. Sometimes, due to less need for patient cooperation or inefficient supporting structures, anchorage cannot be precisely controlled (3).

Only ankylosed teeth or dental implants can provide absolute anchorage. Anchorage obtained using devices can be achieved by fixing anchor units to skeletal structures to achieve skeletal anchorage (4). The use of implants for orthodontic anchorage was quick after the satisfying results of replacement of missing teeth with successful bone implantation (1).

Dental implants, miniplates, and titanium screws are used to achieve skeletal stationary anchorage for various indications for orthodontic treatment (5). A dental implant is a device designed to be placed within the bone of the craniofacial complex and is used for supporting a dental prosthesis. Referring to this definition, an orthodontic implant can be defined as a device specially designed to be placed within, through, or upon the bones of the craniofacial complex to supply orthodontic anchorage (3).

Creekmon and Eklund were the first to use a bone screw applied to the ANS as a temporary anchorage device (TAD) to intrude maxillary the incisors in 1983 (6). Although there is no general consensus on the terminology of these orthodontic TADs, the terms "miniscrews," "microscrews," "miniscrew implants," and "mini-implants" are used to define these devices (7).

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Received: 30 October 2016
Accepted: 27 November 2016

Before zygoma ligature for zygomatic anchorage in 1998, Kanomi used miniscrews for intrusion in 1997 (2). The Orthoanchor™ K1 system (Dentsply-Sankin, Japan) was the first miniscrew system which was presented to the market by Kanomi in 1997 (8). The versatility, minimal invasiveness, low cost, useful dimensions that enables applications in various sites of the oral cavity, and not requiring patient compliance are the reasons of the popularity of miniscrews among orthodontists in recent years (8,9).

Lin et al. (8) summarized the properties of an ideal TAD as follows: 1. the screw material has to be biocompatible and resistant to force, 2. The screw material has to be immediately loadable, 3. The screw material has to be biomechanically designed, 4. The screw material has to be compatible with all kinds of orthodontic accessories, and 5. the surgical procedure has to be minimally invasive and noncomplicated.

Laursen et al. (10) reported that the most commonly used insertion sites for miniscrews are as follows: the buccal aspect of the alveolar process in the maxilla and mandible as well as the palatal side of the maxillary alveolar process in the premolar and molar region.

There are various types of orthodontic and dentofacial orthopedic movements that can be obtained using skeletal anchorage provided by miniscrews. This option widely increases the spectrum of treatment choices planned by orthodontists. Even in some cases requiring surgery, camouflage treatment becomes possible without surgery using skeletal anchorage (11). Intrusion, extrusion, impacted tooth movement, space closing, and tooth uprighting can be achieved using miniscrews (12).

In addition to these dentofacial orthopedic dentoalveolar movements, rapid maxillary expansion and correction of Class II and Class III malocclusions are achieved using miniscrews (7).

In this paper, we aimed to search for and review various intraoral anchorage systems, appliances, and mechanics applied by the support of TADs. They are as follows: Beneslider (13,14), Miniscrew-supported EZ slider (15), Implant-supported Distal Jet (16), Mini-Implant-Borne Pendulum B Appliance (17,18), Noncompliance-supported Maxillary Molar Distalization Appliance (19,20), Temporary Skeletal Anchorage Device-Supported RME (TSADRME) (21,22), Mini-Implant-Supported Maxillary Expansion (MISME) (23), Implant-Supported RME (23-26), Hybrid Hyrax (27-30), Frog Appliance (31), Palatally Anchored Mesialslider (29,30), Mousetrap Appliance (31), Lever Arm, and Mini-implant System (32,33).

INTRAORAL SKELETAL ANCHORAGE APPLIANCES

Beneslider: Beneslider (PSM Medical Solutions; Tuttlingen, Germany) is a distalization appliance supported with one or two pairs of mini-implants in the anterior palate. There are two springs on the appliance in the palatal molar–premolar region to deliver the distalization force of 240 g in children and 500 g in adults. The springs are activated by two sliding locks, and the activation is enabled via Benetubes (13). Effective maxillary molar distalization is done with the anchorage of a stable connection between mini-implants and abutments fixed to the distalization mechanics. At the end of the active distalization phase, labial- or lingual-fixed appliances or aligners can be used. A scissor-bite tendency has been previously reported, and the authors suggested that the intraoral compression of the 0.045″ wire with a three-prong plier can be helpful for this condition (14).

Miniscrew-supported EZ slider: The EZ slider (Ortho Technology Inc.; Tampa, FL) is a sliding auxiliary distalization mechanics used with miniplates to distalize the teeth in the posterior region. It is made of medical grade 304 stainless steel. There are auxiliary accessories of the mechanics used to deliver forces via buccally inserted TADs and closed coil springs. The mechanics can be efficiently applied to any archwire. There are three lengths of left- and right-sided variations. The 30 mm sliders are used for the distalization of the second molars, the 20 mm ones for the distalization of the first molars, and the 12.5 mm ones for the distalization of the premolars and canines. The second molars can limit the distalization of the first molars usually in the other distalization mechanics, except in the EZ slider. Each tooth is distalized solely to avoid this problem. The EZ slider may extrusion in the molars and premolars or intrusion in the canines; therefore, this appliance should not be used in high-angle patients. In indirect anchorage cases, the retraction force is applied from the mini-implant to the canine, and this may result in an increase in the vertical force vector. The occlusal plane may have a cant due to this vector. This side effect can be prevented by maximizing the horizontal vector by adding a power arm to the mechanics (15).

Implant-Supported Distal Jet: This appliance is a version of Distal Jet (American Orthodontics; Sheboygan, WI, USA), which is bone supported via two miniscrews inserted in the palatal region of the maxilla. The miniscrews are inserted in the paramedian position between the first premolar and first molars. For additional anchorage, they are placed within a metal plate covered with a Nance button. Implant-Supported Distal Jet can be safely used in dental Class II patients who have cooperation problems. Besides molar distalization, spontaneous premolar distalization of the first premolars can be achieved using this device (16).

Mini-Implant-Borne Pendulum B Appliance: The Pendulum B appliance is a skeletal-borne pendulum device that can be easily applied in a clinic. Two mini-implants are inserted in the palatal rugae area. Then, a Beneplate with a 0.8 mm b wire is adapted to the curvature of the palate, which connects the TADs with the molars. The active part of the Pendulum B appliance consists of a helix, a U-form bend, and a distal end inserted into the palatal molar sheath. The Beneplate is secured using two fixing screws (17).

There are other ways to manufacture implant-supported Pendulum appliances; however, these mostly require laboratory work. The advantage of the Pendulum B appliance is that it is more user-friendly as it can be applied at chairside (18).

Noncompliance Screw-Supported Maxillary Molar Distalization Appliance: The appliance has two miniscrews inserted in the right and left sides of the incisive canal. The upper first molars are banded with Teuscher tubes soldered on palatal sides near the level of the resistance center of these teeth. A stainless steel wire with a 1.1 mm diameter is adjusted in parallel with the occlusal plane and is placed through the tube. The stainless steel wire is bent to a U shape at 7 mm distally from the tube. Activation is achieved by a nickel–titanium coil spring. Using this device, bodily distalization of the molars can be achieved by applying the force at the level of its center of resistance. The distal tipping of the molars with this appliance has been reported to be 149 degrees in a previous study, while with other mini-implant-supported distalization mechanics, it has been reported to be 3 to 11.3 degrees (19,20).

TSADRME, MISME, Implant-Supported RME, and Hybrid Hyrax: These appliances are various types of the Hyrax **(**Hyrax®; Dentaurum; Ispringen, Germany) type maxillary palatal expander. They are all supported with miniscrews to get skeletal anchorage (21-24).

Dental tipping has been reported to be minimized with the rigid connection of TSADs to the molar bands (25). Vassar et al. (26) have reported mild dental tipping in patients treated using TSADRME and a great variability among subjects.

Mini-implant-supported maxillary expansion may be an alternative to a bonded maxillary expansion device, particularly in hyperdivergant cases. Instead of buccal tipping, palatal tipping has been reported in MISME in patients who had undergone MISME treatment. More skeletal expansion was achieved in MISME treatment than using conventional maxillary expanders (23).

Hybrid Hyrax: Hybrid Hyrax is an effective appliance in which mini-implants are used for maxillary expansion. Mini-implants can be inserted as far as approximately 2 mm anterior to the palatal suture. The Hybrid Hyrax appliance is less invasive compared to palatal distractors. Rapid palatal expansion can be effectively achieved with this device, and fixed orthodontic treatment can take place while this appliance is still in the mouth (24).

It has been reported that tooth-borne and tooth–bone-borne RME devices are effective appliances for maxillary expansion. The skeletal effects of the Hybrid Hyrax appliance were similar to those of Hyrax appliance. The Hyrax appliance resulted in a larger expansion in the premolar region than the Hybrid Hyrax (27). Mosleh et al. (28) reported that basal bone expansion was achieved in both tooth-borne and bone-borne maxillary expanders. The increase in maxillary width was greater in the bone-borne group, and the dental expansion was higher in the tooth-borne group.

Frog Appliance: Two paramedian mini-implants are used in the Frog Appliance (Forestadent; Pforzheim, Germany) for anchorage. The first molars are banded, and they are connected to palatal miniscrews via screws and a 0.032″ SS pre-performed transpalatal arch (26). Distalization of the upper molars can be done in an effective manner using the Frog appliance in Class II malocclusion cases with fully erupted second molars. An acceptable degree of loss of anchorage has been reported with some side effects, such as maxillary molar tipping and backward rotation of the mandible (29).

Palatally Anchored Mesialslider and Mesial-Distalslider: Clinicians can mesialize the posterior segment teeth with the help of a mesialslider. This appliance is skeletally anchored via two mini-implants placed on the anterior side of the palate (30). There is no need of laboratory work for producing the Mesial-Distalslider; it can be placed into the mouth at chairside. This appliance may be used for the mesialization and distalization of buccal segments; therefore, this appliance is useful in asymmetric molar positions. While a nickel–titanium coil spring is used for mesialization, an open coil spring is used for the distalization force (31).

Mousetrap Appliance: Two anterior mini-implants are connected via a Beneplate for providing anchorage of the Mousetrap Appliance. One or two lever arms are used, particularly for producing effective intrusion or extrusion forces. The use of lever arms ensures the delivery of measurable and continuous forces. In the passive position, the distal ends of the lever arms are located upward to the resistance center of the molars. To apply it to the molar teeth, the lever arm is pulled downward and connected to the molar to produce an effective intrusion force. The intrusion of overerupted molars can be done with this appliance. The Mousetrap Appliance has a bulky and complex design, but it delivers a measurable and continuous force intraorally. Screw fracture is a low probability because of its anchorage is in the anterior palate (32).

Lever Arm and Mini-Implant System: This system is built on a stable anchored retraction mechanism. Lever arms extending from the lingual brackets of the maxillary incisor teeth are tied with an anchorage unit of palatally inserted miniscrews using an elastic chain to retract the anterior teeth (33). The arms of the anchorage system can be designed to suit many kinds of mechanics and different amounts of distalization. The lever arm is easily formed and can be comfortably used by the patient (34).

CONCLUSION

This article aimed to present the use of orthodontic miniscrews in contemporary orthodontic practice. The easy surgical procedure, wide intraoral placement range, low cost, stationary an-

chorage, compatibility with other orthodontic appliances, and less need for patient cooperation makes TADs irreplaceable in daily orthodontic practice.

Beyond their singular use for anchorage purposes, miniscrews let orthodontists easily design various orthodontic appliances. Today, many conventional intraoral orthodontic appliances are being used combined with TADs. If properly planned and correctly applied, mini-screws help practitioners to achieve satisfying treatment results more easily, more effectively, and more comfortably.

It appears that the future of intraoral absolute anchorage will be widely based on TADs.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - G.S.; Design - G.S.; Supervision - G.S.; Resources - D.D.K.; Materials - G.S.; Data Collection and/or Processing - D.D.K.; Analysis and/or Interpretation - D.D.K.; Literature Search - D.D.K.; Writing Manuscript - D.D.K.; Critical Review - G.S.; Other - D.D.K, G.S.

Conflict of Interest: The authors declare that there is no conflict of interest.

Financial Disclosure: The authors declare that there is no financial disclosure.

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