



Miniscrew Implants as Temporary Anchorage Devices in Orthodontics: A Comprehensive Review

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ABSTRACT

In recent times, the use of miniscrew implants to obtain absolute anchorage has gained momentum in clinical orthodontics as rigid anchorage modality. Miniscrew implants offers many advantages when used as temporary anchorage devices like, easy placement and removal, immediate loading, can be used in a variety of locations, provide absolute anchorage, economic and requires less patient cooperation. This makes them as a necessary treatment option in cases with critical anchorage that would have otherwise resulted in anchorage loss if treated with conventional means of anchorage. The aim of this comprehensive review is to highlight the gradual evolution, clinical use, advantages and disadvantages of the miniscrew implants when used to obtain a temporary but absolute skeletal anchorage for orthodontic applications.

Keywords: Anchorage, Miniscrews, Implants, Absolute, Temporary anchorage.

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INTRODUCTION

Graber defined anchorage as ‘Nature and degree of resistance to displacement offered by an anatomic unit when used for the purpose of effecting tooth movement’.¹ It is based on Newton’s third law and is a prerequisite for successful orthodontic treatment of malocclusions.^{2,3} Angle realized the limitations of moving teeth against other teeth used for anchorage, introducing ideas such as the use of occipital, stationary and occlusal anchorage.⁴ Anchorage conservation in has been an everlasting problem to the orthodontist. Conventional means of supporting anchorage have been used by either intraoral sites or relying on extraoral means. Both of these have their limitations.

The extraoral forces cannot be used on 24 × 7 basis to resist the continuous tooth moving forces and are also

taxing on patients compliance. On the other hand, strict reliance on intra oral areas, usually dental units does not offer any significant advantage, except the fact that patient cooperation is less critical, therefore, it is important to have absolute anchorage to avoid reactive forces which might incur undesirable tooth movements.^{5,6} Absolute anchorage is defined as no movement of the anchorage units.¹ Such an anchorage can only be obtained by using ankylosed teeth or dental implants as anchors. However, both these units are dependent on bone to inhibit movement.⁷

Mini-implants refer to systems in which osseointegration occurs prior to loading, whereas screws to self-tapping devices that may be used without the condition of osseointegration. However, the word mini-implant should be applied to both palatal implants, to mini-implant, to miniscrew, and to microscrews.⁸ Intraoral extradental anchorage systems⁹ and temporary anchorage devices¹⁰ have also been suggested to describe devices, such as mini-implants that are temporarily fixed to bone to provide skeletal or absolute anchorage.

HISTORICAL PERSPECTIVE

Implants are an excellent alternative to traditional anchorage methodologies. It was Gainsforth and Higley in 1945 who first mentioned about orthodontic implants in print for augmentation of anchorage. They used vitallium screws, which were inserted in the ramal area. The implants were immediately loaded and used for canine retraction in the upper arch. Unfortunately just in a month’s time after loading, all implants were lost.¹¹

In 1970 Linkow used an implant for replacing a missing molar, to retract upper anteriors and the results were quite encouraging.¹² Toward the end of 1980s, a number of clinicians focused on the use of standard dental implants as an anchorage for orthodontic tooth movement and then

as permanent abutments for replacement. In a case report, Creekmore described the use of vitallium implants for providing anchorage for upper anterior teeth intrusion. The screws were inserted just below the ANS which were then loaded after a period of 10 days and force was applied with an elastic thread. Within a years time 6 mm of intrusion was demonstrated.¹³

Roberts WE, Marshall KJ, Mozsary PG (1989) placed a two stage endosseous implant in the retromolar area of the mandible, as a source of rigid anchorage in order to translate 2nd molars 10 to 12 mm mesially into an atrophic edentulous ridge. Over a three-year period the endosseous implant remained rigid (osseointegrated).¹⁴ Roberts WE, Nelson CL, Goodcare CJ (1994) used an anchorage implant (3.76 × 7 mm standard Branemark fixture) in the retromolar area about 5 mm distal to the mandibular 3rd molar for the 1st half of space closure. Forces were delivered on the buccal with elastic chains. For the last half, closing loops were placed by which about 0.8 mm of space was closed. Treatment time was approximately 24 months with the retromolar implant staying stable all throughout the treatment time.¹⁵

More recently, new on plants, miniplates and palatal implants have been developed specifically for use in orthodontics. The mini plate implants have been used for space closure and distalization of maxillary molars. Because these new devices still have many of the same limitations as standard dental implants, most orthodontists have turned to miniscrews. Repeating the experience of Creekmore, they have found that small screws work well for orthodontic anchorage purpose.

A study proposed an on plant of thin titanium disk textured and coated with hydroxyapatite (HA) on one surface and threaded hole on the opposite. It was inserted subperiostally on the palatal bone with the HA coated side against the bone for biointegration. They presented a dog study demonstrating unilateral tooth movement toward the on plant and a monkey study to demonstrate its efficiency in anchoring the molars for anterior retraction.¹⁶

It was Kanomi in 1997, who first described mini implant of 1.2 mm diameter and 6 mm length to be specifically used for orthodontic purposes. He successfully used this mini-implant to intrude the mandibular incisors. The implant was placed between the mandibular central incisors, 2 to 3 mm from the root apex.¹⁷

Various case reports showed the usage of implants (1.2 mm diameter, 6-12 mm in length) in uprighting of molars. These cases were illustrated to show that upper second molars were uprighted without any side effects on the anterior teeth and without using orthodontic brackets.¹⁸ Bae SM, Park HS, Kyung HM, Won OW, Sung JH (2002)

inserted microimplants of the same dimensions between the maxillary 1st and 2nd premolars, for retraction of the maxillary anterior teeth. The micro implants were stable for the entire length of treatment and were easily removed with a screw driver after debonding and debanding. Total treatment time was 26 months.¹⁹

The advent of miniscrews have revolutionized orthodontic anchorage and simplified the biomechanics. Mini-implants can successfully be used for all orthodontic movements. Maino, Pagin, and Mura devised a new miniscrew system called 'Spider screw' for gaining skeletal anchorage. The authors advocated the use of these implants in cases requiring patient cooperation or patients with incomplete arches.²⁰ Orthodontic mini anchorage system was developed (OMAS)²¹ in 2003 that claim to tolerate heavier orthodontic forces of the order of 500 to 600 gm and have low rate of loosening and failure. A self-drilling method was used for inserting the screw in between the maxillary 1st molar and 2nd premolar with just a screw driver.

Kyung et al put forward another system of microimplant called 'Absoanchor'.²² The authors stated that the safe sites for implant placement are interradicular spaces both buccal and palatal of maxillary canine and lateral incisors and maxillary 1st molars and 2nd premolars. Also, a tapered mini-implant gives a tighter fit with the surrounding bone.

A clinical pilot study was conducted to evaluate the stability, surrounding soft-tissue health, patient comfort and acceptance of a mini-implant used as anchorage for maxillary permanent canine retraction. It showed that placement protocol strongly affects the stability of the implants. After the study period, they concluded that around stable implants the surrounding soft tissue remained healthy whereas it was less healthy around implants that were mobile or lost. Patient comfort was excellent in all but 1 patient. It was concluded that orthoimplants are adequate anchorage for maxillary canine retraction when properly placed.²³ Another study assessing the failures of mini-implants revealed that the diameter of the peri-implant tissue and high mandibular plane angle (i.e. thin cortical bone) were the major factors when the screw was placed in the buccal alveolar bone for the purpose of orthodontic anchorage.²⁴

Among the anchorage devices, mini screw implants have increasingly being used for orthodontic anchorage because of their absolute anchorage, easy placement and removal, and low cost. They can be placed into bone between the teeth owing to their small size and subsequently, insertion is a less traumatic procedure. Since there is no osseointegration around the screws but only fibrous integration, they can also be loaded immediately with orthodontic force. However, a notable complication is loosening of the screws even though they consist of a biocompatible titanium alloy.²⁵

CLASSIFICATION

Based on their origin, skeletal anchorage devices can be classified into two main categories.²⁶ The first category isosseointegrated dental implants which includes the orthodontic mini-implants, the retromolar implants, and the palatal implants. The second category are the surgical mini-implants as used by Creekmore and Eklund,¹³ Kanomi,¹⁷ and Costa et al.²⁷ The main difference between them is that surgical mini-implants are small, can be loaded shortly after insertion and have smooth surfaces.²⁶

They can also be classified as either biocompatible or biologic in nature. The biologic group included ankylosed and dilacerated teeth, whereas the biocompatible group included temporary anchorage devices. He further subclassified both groups-based on the manner in which they are attached to bone- into biochemical (osseointegrated) or mechanical.²⁸

Labanauskaite et al²⁹ suggested the following classification:

1. According to shape and size
 - a. Conical (cylindrical)- miniscrew implants
 - Palatal implants
 - Prosthodontic implants
 - b. Miniplate implants
 - c. Disk implants (onplants);
2. According to implant bone contact
 - a. Osseointegrated
 - b. Nonosseointegrated
3. According to the application
 - a. Orthodontic implants
 - b. Prosthodontic implants

PROPERTIES

The main differences between the currently available miniscrew implants relate to their composition, size, design and include: (1) the alloy or metal used for their fabrication, (2) the diameter of threaded portion, (3) the length of the implant and (4) the design of the head.

Biocompatibility

All implant systems are made of grade V titanium alloy except for orthodontic mini-implant which is fabricated from stainless steel.

Osseointegration

Because complete osseointegration of screws used in orthodontic applications is a disadvantage that complicates the removal process, most of these devices are manufactured with a smooth surface, thereby minimizing the development

of bone ingrowth and promoting soft tissue attachment at ordinary conditions and in the absence of special surface treatment regimens.^{8,30,31}

Types of Anchorage

The miniscrew implants can provide 2 different types of anchorage: direct and indirect anchorage means that they are connected through bars or wires to the reactive unit, whereas direct anchorage means that they directly receive the reactive forces by acting as an anchor unit.

Head Design

The most frequent is the button like design with a sphere or a double sphere like shape or a hexagonal shape. With a hole through the head or neck of the screw, usually 0.8 mm in diameter, this design is mostly used for direct anchorage (Fig. 1). Further a bracket like design and a hook like design is also available which can be used both for direct and indirect anchorage.

Thread design

The thread body can be either conical as in miniscrew anchorage system or parallel tapering only at the end as in orthodontic mini-implant. They are available in different lengths but Costa³² suggested 4 to 6 mm as safe in most regions. Most miniscrew implants have a thread diameter ranging from 1.2 to 2.0 mm and a length from 4.0 to 12.0 mm³³⁻³⁷ although some of them are also available at lengths of 14 or even 21 mm.^{38,39}

CLINICAL APPLICATIONS

The absolute indication for various miniscrew implant systems are the high anchorage cases.⁴⁰ Generally, they are used in cases where the support of dental units is quantitatively or qualitatively compromised, as in partial edentulous patients or periodontally involved teeth.



Fig. 1: Miniscrew implants

According to Melsen,²⁶ these can be used in patients with insufficient teeth for conventional anchorage, for asymmetric tooth movement in all planes of space or in some cases as an alternative to orthognathic surgical procedure.

The miniscrew implants have been used in a variety of cases including deep bite correction,^{13,34,41} extraction space closure,⁴² canted occlusal plane and dental midlines correction,³⁴ in impacted canines alignment,⁴³ uprighting and extrusion of impacted molars,⁴⁴ intrusion of molars,⁴⁵ maxillary molar distalization and distalization of mandibular teeth,^{3,46} molar mesialization,⁴⁷ *enmasse* retraction of anterior teeth,⁵ and correction of vertical skeletal discrepancies.⁴⁸

CLINICAL PROCEDURES

Site of Placement

In maxilla, the possible sites for insertion of miniscrew implants are, the area below the nasal spine, median or the paramedian area of the palate, the alveolar process between the roots of the teeth in the buccal and palatal regions, the maxillary tuberosity and infrazygomatic crest. Various sites in the mandible are, the alveolar process between the roots of the teeth and the retromolar area.^{26,34,35} symphysis and parasymphysis. A study showed that bone stock for placement of screws was found to exist primarily mesial to first molars in maxilla and mesial and distal to first molars in the mandible. This further prevents soft tissue irritation.⁴⁹

Direction of Implant Insertion

Melsen²⁶ recommends oblique angle of insertion in an apical direction in maxilla whereas, parallel to the roots in mandible. Kyung³³ et al propose inserting miniscrew implant at a 30 to 40° angulation to the long axes of the teeth in maxilla, and 10° to 20° in the mandible. Carano³⁴ advised an angle of 30° to 45° in the maxilla to avoid damage to the sinus wall.

INSERTION METHOD

Miniscrew implants can also be either self-drilling or nonself drilling. The difference is that, in self-drilling the pilot hole is not required except where the cortex is thicker than 2 mm where dense bone can bend the tip of the screw which is an advantage. They are newly designed osteosynthesis screws with specially formed tips and cutting flutes, which acts like a corkscrew and can be inserted into bone without predrilling.⁵⁰ Since, predrilling is required there are chances of damage to the nerves, tooth roots or tooth germs, thermal necrosis of the bone and drill bit breakage.^{51,52} An adjustable acrylic template or surgical guide⁵³ prior to miniscrew implant placement should be used (Figs 4 and 5). The procedure is performed under a small

amount of local anesthesia or infiltration. Pilot drilling should be done preferably by an oral surgeon. Firstly, soft tissue from the site of placement is removed using a soft tissue punch. Thereafter, a pilot hole is drilled using a drill bit (Fig. 2) and a drill rotating no more than 1000 rpm. The pilot hole should be 0.3 mm thinner and not more than 2 to 3 mm deep (Fig. 6).^{26,34} The implant is then placed by using an appropriate screw driver (Figs 3 and 7).

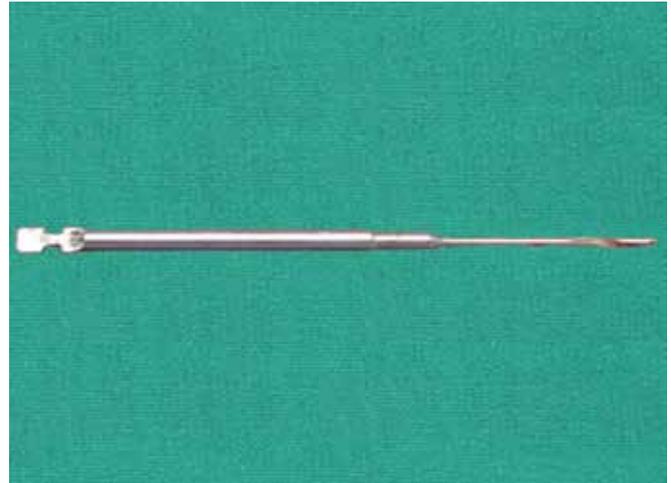


Fig. 2: Drill bit

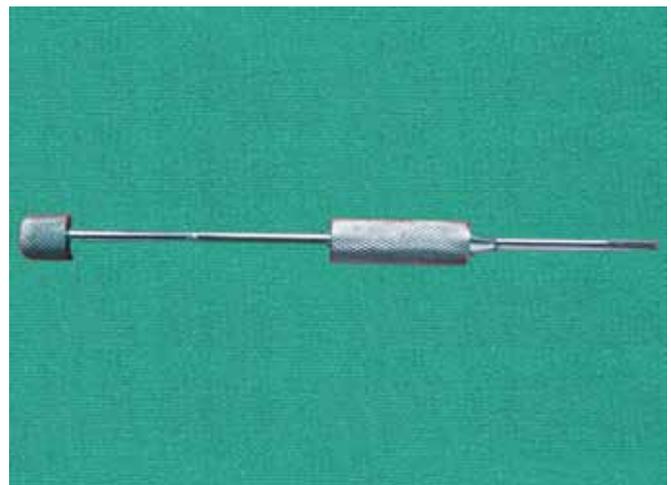


Fig. 3: Screwdriver



Fig. 4: Acrylic template on cast



Fig. 5: Template in mouth



Fig. 6: Predrilling with drill bit



Fig. 7: Implant insertion

Loading and Anchorage Considerations

Orthodontic miniscrews are loaded immediately unlike the dental implants, but, using light forces only.^{27,30,34,35} Liou et al⁵⁴ suggested at least 2 mm of clearance between implant and roots of adjacent teeth as implants might move according to orthodontic loading. It has been concluded from a study that mini-implants are stable source of anchorage, but did not remain absolutely stationary, throughout the period of orthodontic loading and sometimes move according to the direction of orthodontic force in some patients.⁵⁵ A study was done to evaluate the stability of miniscrew implants and the factors considered were, the timing, amount, and

location of force application. The results support the notion that immediate miniscrew implant loading with light forces (25-50 gm) can be accomplished with high rates of success, producing clinically relevant and successful tooth movements that are not influenced either by the amount of force, or the location of application.⁵⁶

IMPLANT REMOVAL

The implant is unscrewed using the screw driver with or without the use of topical or local anesthesia. In the event of its nonremoval, it is advised to wait for 3 to 7 days as the induced microfractures can cause the screw to loosen.

COMPLICATIONS

Inflammation, infection and tissue irritation of the surrounding soft tissues can occur. Various factors determine the success rates and the clinical success of screw implants used as orthodontic anchorage units. According to studies, mobility, jaw (whether maxilla or mandible), side of placement (whether right or left) and inflammation have significant differences in success rates. To minimize the failure of screw implants, inflammation around the implant must be controlled especially for screws placed in the right side of the mandible.² The proximity of a miniscrew to the root is a major risk factor for the failure of screw anchorage. This tendency is more obvious in the mandible.⁵⁷

The use of 0.2% chlorhexidine mouthrinses is advised. It is advised that miniscrews should be inserted in keratinized gingiva when possible and that frenum and muscle tissue should be avoided as hypertrophy of mucosa can occur. Another complication includes injuring adjacent roots, periodontal ligament, nerves and blood vessels. Failure can also occur if there is inadequate thickness of the cortical bone. Finally, fracture of the miniscrew implant may occur during removal if the neck of the screw is too narrow.

CONCLUSION

To conclude, miniscrew implants offers many advantages when used as temporary anchorage devices like, easy placement and removal, immediate loading, can be used in a variety of locations, provide absolute anchorage, economic and requires less patient cooperation.

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