CLINICAL SECTION

Mini-screw implants (temporary anchorage devices): orthodontic and pre-prosthetic applications

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Mini-screw implants, often referred to as temporary anchorage devices (TADs), have become an accepted component of orthodontic treatment. The comparatively simple technique for the placement of these mini-screws is described with emphasis on the importance of correct site selection as well as an understanding of the possible complications that may arise. The application and description of appliances incorporating mini-screws are described with the aid of typodont models and clinical examples. While the technique is of primary relevance to orthodontists, the use of mini-screws as an aid for pre-prosthodontic tooth movement is also of relevance to prosthodontists. From the examples described in this paper, extrapolations can be made by individual clinicians to situations relevant to their particular treatment plans. Examples of appliances used in conjunction with mini-screws are described; however, depending on the requirements of individual malocclusions, these designs may be modified.

Key words: Orthodontics, mini-screws, temporary anchorage, anchorage, prosthodontics

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Introduction

Mini-screw implants, often referred to as temporary anchorage devices (TADs), are small titanium alloy or stainless steel surgical bone screws placed into either buccal or palatal alveolar bone. The rationale for their clinical use is the creation of a source of rigid bone-supported intra-oral anchorage. Cope[1] defines a TAD as follows: 'A temporary anchorage device is a device that is temporarily fixed to bone for the purpose of enhancing orthodontic anchorage either by supporting the teeth of the reactive unit or by obviating the need for the reactive unit altogether, and which is subsequently removed after use'. Currently, these screws are manufactured internationally by a number of commercial companies with variations in length of 5–12 mm, diameter of 1.2–2.0 mm, and a head configuration that can be described as either 'post' type or 'flat-top' type.

Their attachment to bone is mechanical with no intent to encourage or establish any form of osseointegration. Ideally, they should be placed in areas with adequate cortical bone and with the head of the screw in attached alveolar mucosa. Once they have served their purpose, they are removed.

While the value of mini-screws in the treatment of malocclusions is widely accepted and illustrated by examples in this paper, the use of mini-screws as a component of pre-prosthodontic tooth movement needs to be further explored, and in the context of multi-disciplinary treatment plans, prosthodontists need to be made aware of this comparatively new tool available to orthodontists. From some of the examples described in this paper, it is hoped that prosthodontists could extrapolate aspects relevant to their treatment protocols.

History

In one of the earliest publications on this subject, Creekmore and Eklund in 1983 reported on the use of a surgical vitallium screw placed in the region of the anterior nasal spine as a source of anchorage to elevate the maxillary incisors a distance of 6 mm.[2] In the ensuing years, little was published on the subject until a paper by Kanomi in 1997 describing the intrusion of mandibular anterior and buccal teeth using mini-screw implants.[3] Concurrently, other forms of intra-oral bone-based sources of anchorage, such as palatal onplants,[4] mid-palatal screws[5–7] and mini-plate implants[8,9] were

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being investigated and reported. Osseointegrated implants as used in restorative dentistry have also been investigated as a source of rigid bone supported anchorage for orthodontic treatment.[10,11] However, subsequent publications have indicated a growing acceptance by clinicians for the mini-screw implant as a source of anchorage in clinical practice rather than the above-mentioned alternatives.

Publications originating from Korea, Scandinavia, Italy and, more recently, the USA, provide ample evidence of the international appeal and interest in this form of anchorage.

An active group of Korean clinicians developed the Abso-Anchor Screw (Dentos Inc., Taegu, Korea). They have published extensively, presented lectures and given many courses on this subject.[12–14] Concurrently, Melsen and co-workers in Denmark, developed the Aarhus Mini-Implant (Medicon eG, Tuttlingen, Germany. ScanOrto A/S, Charlottenlund, Denmark) and provided scientific evidence for the possibility of immediate loading of mini-screw implants.[15] The Spider Screw (Health Development Company Via dell'Industria 11, 36030 Sarcedo,VI Italy) is similar in design to the Aarhus Screw and was developed in Italy by Maino and co-workers.[16] Recent articles by Cope[1] and Herman[17] have documented the American influence, initiated the term Temporary Anchorage Device (TAD) and described the IMTEC Mini Ortho Implants (IMTEC Corp, Ardmore, OK, USA).

The importance of anchorage in orthodontics cannot be over-emphasized, as understanding anchorage forms the basis of sound orthodontic treatment. Conventionally, over the last century, anchorage has been provided by other teeth, the palate, alveolar ridges, circum-oral musculature, and the head and neck via extra-oral appliances. The development of the mini-screw as a source of anchorage adds a further dimension to our armamentarium. While the subject of mini-screws is on the programme of virtually every orthodontic meeting and the volume of publications continues to expand, there is still a lack of sound scientific research with regard to controlled clinical trials, histological evaluation of the bone-screw interface or studies on the stress limits to which these screws can be subjected. In spite of this deficiency, their use continues to evolve and become more widely accepted, and clinicians continue to report cases describing different clinical applications for mini-screw implants.[18–20]

In order to build up a useful databank of the various applications, it is very helpful to continue to document as many cases as possible; this paper will describe the placement techniques for mini-screws, and their application in conventional orthodontics and pre-prosthodontic tooth movement.

Site selection

There are two major factors that govern site selection for the placement of mini-screws:

- The site of placement dictated by the quality and quantity of suitable bone with particular reference to the interdental root spaces.
- The site of anchorage dictated by the malocclusion

The first factor will be described within the context of the placement technique, and the second factor will be described using typodont models and clinical examples.

Placement technique

The procedure is an adjunct to orthodontic treatment and patients should not be deterred by apprehension, excess costs or inconvenience. Minimal outlay of equipment is needed and placement usually only requires about 20 minutes per implant with minimal discomfort during or after the procedure. Ideally, the orthodontist should be the clinician placing the implants as this allows for economy, efficiency and logistical benefits. Placing mini-screw implants is not a technically difficult exercise; however, it would be very prudent and, indeed, advisable for the clinician to receive instruction and training prior to clinical placement.

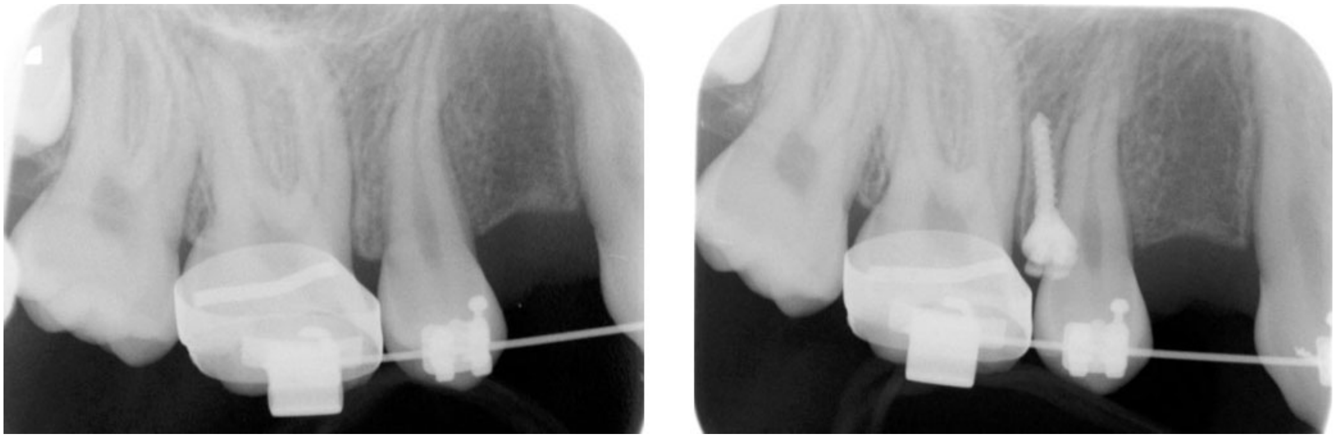
The equipment required consists essentially of:

- an electric motor and handpiece combination that allows a speed range of about 600 rpm to 12 rpm;
- local anaesthetic;
- mini-orthodontic implant kit, which should include a hand driver, a handpiece driver and a pilot drill.

Procedure

Prior to placing the implant an intra-oral peri-apical or a panoramic radiograph of the region is essential to evaluate the inter-radicular space available; ideally, a minimum of 2 mm is required (Figure 1a,b). Radiographic stents or guides such as twisted brass wire can be used as an aid to positioning (Figure 2). However, they only give a two-dimensional image, which indicates the correct implant insertion point, but offer no guidance to the drilling angle. This is best determined by direct vision as drilling proceeds.

A minimal amount of dental anaesthetic (about 0.3 ml) is given into the mucosa adjacent to the



(a) (b)

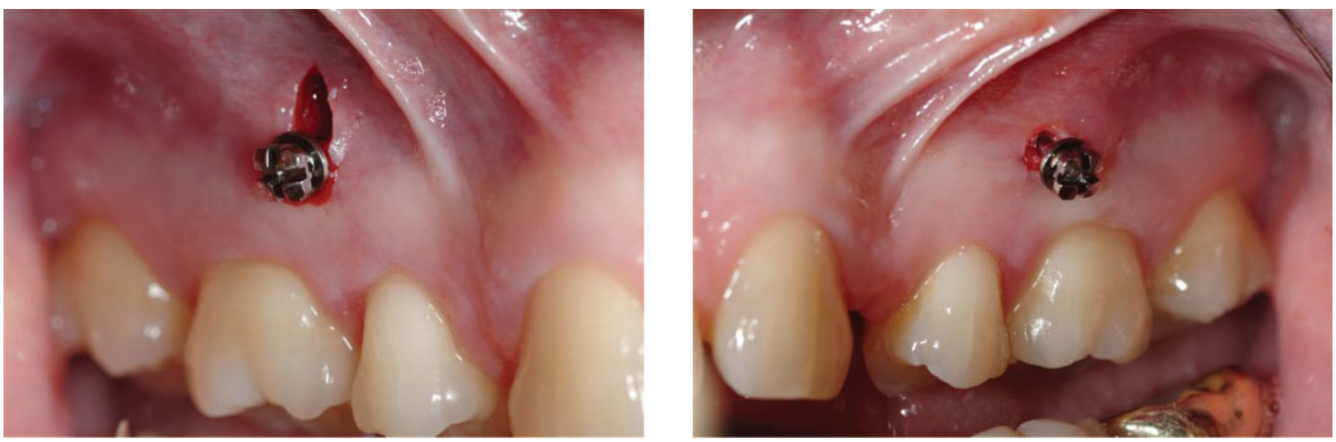
Figure 1 (a) Pre-operative radiograph with 2 mm inter-radicular space. (b) Post-operative radiograph with 1.5 mm mini implant

Figure 2 Brass wire radiographic marker on palatal aspect

proposed implant placement site. The underlying bone has no innervation and profound anaesthesia of the adjacent teeth and periodontal ligaments (PDL) is contra-indicated. Any approximation of the drill or implant to the PDL will elicit pain, which will, in turn, alert the dentist to redirect the implant. This important feedback from the patient would not be possible with profound anaesthesia.

Wherever possible, the implant head should protrude through the attached gingiva and not the unattached alveolar mucosa. Insertion through alveolar mucosa tends to create more bleeding, is more traumatic and requires an initial incision to be made through the mucosa with a scalpel to prevent entanglement of the bur (Figure 3a,b). For this reason and in order to take advantage of the increased apical inter-radicular space, the implant is placed at an angle of about 45° to the buccal/labial bone (Figure 4).

The implants come in various lengths (5–12 mm) and diameters (1.2–2 mm). It is the authors' experience that



(a) (b)

Figure 3 (a) Implant inserted through alveolar mucosa. (b) Implant inserted through attached gingivae

Figure 4 Oblique placement of implant (approximately 45°)

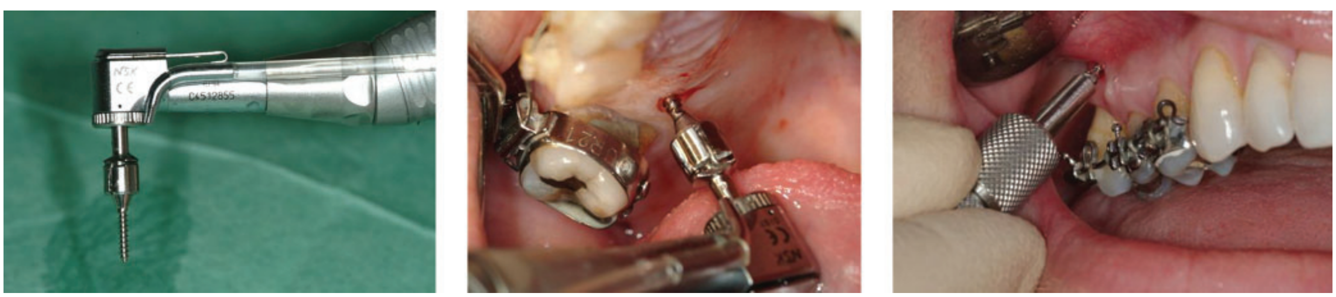
1.5 mm is the optimal diameter to use. Thinner implants risk breakage and thicker implants make root contact more probable. In the mandible, where the bone is generally denser, a 6–8 mm length is optimal, while in the maxilla an 8–10 mm length is preferred.

To prevent the pilot twist drill slipping on the surface of the cortical bone, first pierce the cortical bone at right angles with a #2 round bur and then change the inclination of the drill to 45° to allow oblique drilling with the pilot drill (Figure 5a,b). The pilot hole is drilled with a 1.2 mm twist drill, generally supplied with the implant kit, at ~600 rpm to just short of the implant length. Self-drilling implants are available, although in our opinion the risk of going off course during placement is higher. While some clinicians prefer the self-drilling screw, we believe that the force required to place a self-drilling screw in bone reduces the tactile feel for the operator and may increase the risk of root contact. A gently drilled pilot hole, in our experience, offers better tactile feedback and placement precision. However, as yet there is no scientific evidence to support either technique.

The sterile implant is removed from its package with the handpiece driver attached to the handpiece (Figure 6a). It is carried to the mouth without being touched by hand, placed into the pilot hole and driven, with the handpiece at ~12 rpm, three-quarters of the way (Figure 6b) and, if access permits, it is driven to its full depth with a hand driver. Using a hand driver to do the final tightening of the implant offers better tactile feedback as to the tightness and stability of the implant (Figure 6c). The implant needs only to be tightened to a torque value of 7–10 Ncm, which is achieved with mild finger tightening; achieving primary stability is essential.[21] A post-operative radiograph

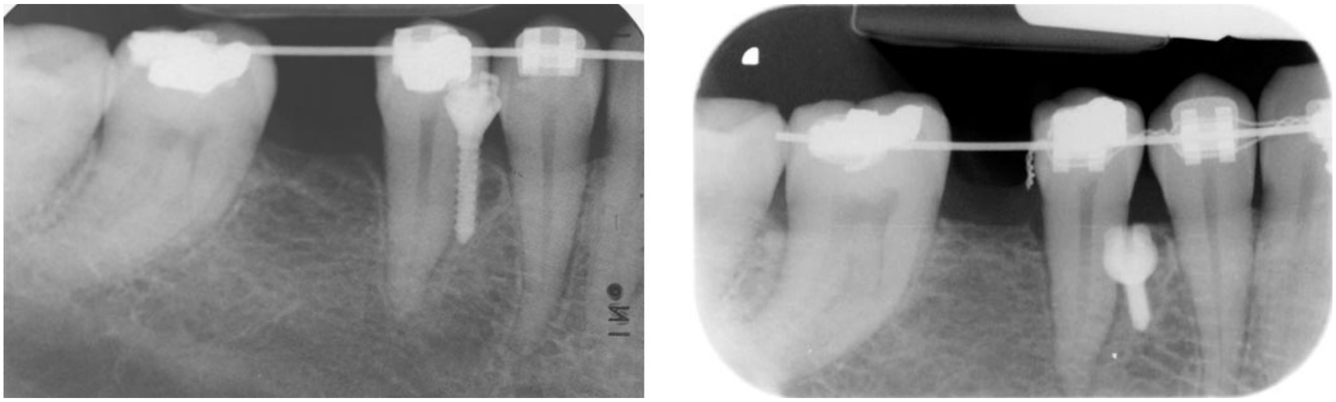
(a) (b)

Figure 5 (a) Initial cortical penetration perpendicular to bone. (b) Pilot hole drilling at oblique angle



(a) (b) (c)

Figure 6 (a) Implant attached to hand piece driver. (b) Placement of implant with hand piece driver. (c) Placement of implant with hand driver



(a) (b)

Figure 7 (a) Radiographic image of implant touching tooth root. (b) Implant repositioned to avoid tooth root

should be taken to assure correct positioning of the implants.

Complications

As with any surgical procedure, there are potential complications and although these are generally minor, the patient needs to be made aware of them.

Contact with adjacent roots

Usually this can be determined at time of placement by tactile sensation as the tooth root is generally much harder than the surrounding bone. During placement, if increased resistance is felt while drilling or placing the implant, a radiograph with the drill or implant in place should be taken; based on the radiographic evidence the drill or implant can then be redirected (Figure 7a,b).

Another important means of assessing root contact is via patient feedback, as alluded to earlier. If the patient expresses discomfort during the drilling or placement procedure this is indicative of PDL approximation.

In certain cases, the post-operative radiograph may indicate that the implant is contacting a root. However, this is impossible to assess accurately on a two-dimensional radiograph, and if implant placement has proceeded without any of the previously described signs or symptoms, a second radiograph should be taken from a different angle to clarify the implant position. There is evidence to show that minor root contact does not cause any serious long-term damage, but if the clinician is uncertain it is prudent to reposition the implant.[22–24]

Implant loosening (failure rate)

This appears to be the most common complication and may occur any time following implant placement. The failure rate for screws placed by us currently runs at 16%; this compares favourably with the failure rates of 15–16% quoted by Miyawaki *et al.*[25] Potential causes may relate to bone quality, excessive force application or approximation to the root surface. An explanation for root contact contributing to implant loosening may relate to the movement of the tooth in the socket during normal function. This may lead to inflammation of the PDL in the area of where the implant contacts the root, which may then lead to loosening of the implant. Other factors that have been cited as contributing to loosening of the implant are the use of screws with a diameter of 1.0 mm or less; inflammation of the peri-implant mucosa and a high mandibular angle (i.e. thin cortical bone).[25]

If the implant does become loose, an initial solution may involve simply tightening the implant a few more turns. If it then loosens again, it should be removed and replaced in a new position. If space permits, a larger diameter implant may be placed in the same hole.

A study by Liou *et al.* indicates that even if the screw does not become loose, it does not necessarily remain absolutely stationary under the influence of orthodontic forces. They show evidence of the screw head tipping approximately 0.4 mm.[26]

Implant breakage

This is a rare complication, particularly if a pilot hole is drilled. If excessive resistance is felt during implant placement, the implant should be unscrewed and the pilot hole widened. It is extremely rare for bone to offer enough resistance to break an implant; if resistance is encountered, the clinician should ensure that the implant is not being directed into a root. If implant breakage does occur, an attempt should be made to remove the fragment (Figure 8). If the fragment is deep within the bone, a decision can be taken to leave the

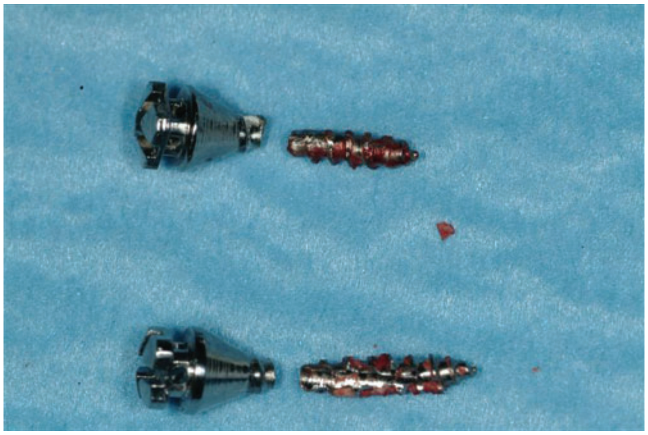


Figure 8 Broken implant fragments removed

fragment in place and allow the soft tissue to close over it. As a safeguard it is advisable to use a torquing screwdriver or wrench set at 6–7 N.

Damage to anatomic structures

This is an unlikely complication as there are generally no vital anatomic structures in the areas where the implants are placed. When implants are placed in the area of the upper premolars and molars the maxillary sinus may be approximated; however, because the implants are placed coronally in attached gingival, this is an unlikely occurrence. When the cortical bone of the sinus floor or wall is approached, an increase in resistance is felt; this bi-cortical arrangement may help anchor the implant.

The inferior alveolar canal, mental foramen and greater palatine artery are all generally positioned further apically than the implant site.[27]

To assist in site selection, Costa *et al.* evaluated the depth of hard and soft tissues at different sites in the maxilla and mandible.[28] Taking this study a step further, a map of 'safe zones' for the placement of mini-screws has recently been published by Poggio *et al.* They give an indication of safer sites available in inter-radicular spaces of the posterior regions of the maxilla and mandible.[29]

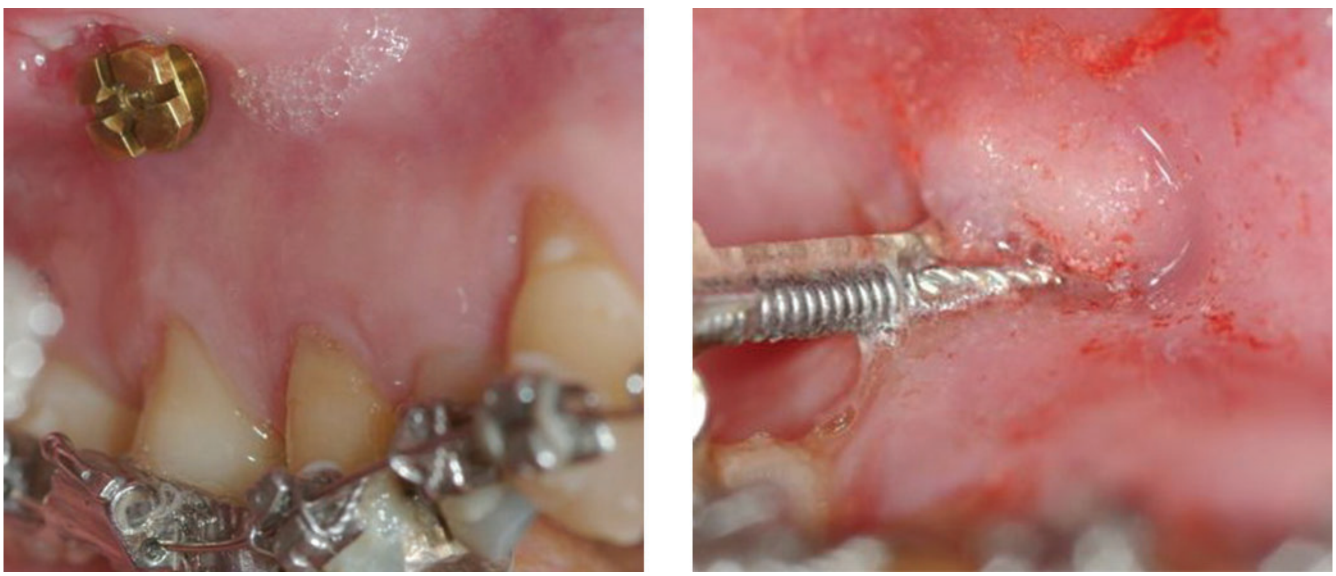
Soft tissue overgrowth

Soft tissue overgrowth of the head of the screw is generally avoided by ensuring the implant enters through attached gingiva and not the unattached alveolar mucosa. Placing the screw at an angle of 30–40° to the dental axis allows for the placement of a longer screw and keeps the head of the screw in the attached gingiva zone (Figure 9a,b).

Site of anchorage dictated by the malocclusion

There are three groups of tooth movements for which mini-screws could be used to reinforce anchorage:

- mesial or distal movement of buccal teeth;
- lingual or labial movement of anterior teeth;
- vertical intrusive movement of buccal or anterior teeth.



(a) (b)

Figure 9 (a) Implant placed in alveolar mucosa. (b) Soft tissue overgrowth of implant

(a) (b) (c)

Figure 10 (a) Mini-screw implant placed between the second premolar and first molar. Ligature tie from the mini-screw to the canine provides indirect anchorage. Coil spring placed between the first and second molar. (b) Mini-screw implant placed between the second premolar and first molar. Ligature tie from the mini-screw to a circle hook on the arch provides indirect anchorage for an expanding loop acting on the second molar. (c) Mini-screw implant placed between the second premolar and first molar. Ligature tie from the mini-screw to the canine provides indirect anchorage. Coil spring placed between the second premolar and first molar

For all these movements it must be assumed that the clinician will bear in mind an essential basic principle of orthodontic mechanotherapy, i.e. to ensure that space is already available or will be created for the desired tooth movements. Furthermore, in order to avoid overtaxing the anchorage potential of a mini-screw, it may be advisable to move one tooth at a time, rather than trying to move a number of teeth as a full segment. This assumption may be controversial and is based on our own clinical experience. However, there is no scientific evidence in support of either option. If the intention and mechanics dictate that teeth will need to slide along an archwire, attention should be paid to reducing friction between the bracket and archwire. It is always preferable to ensure that most of the applied force is utilized in moving the tooth, rather than overcoming friction.

Mesial or distal movement of buccal teeth

Distal movement of first or second molars

The site of choice for screw placement is in the buccal cortical bone between the first molars and second premolar. From this position the screw can provide indirect anchorage in a number of ways, depending on the malocclusion and the teeth available. A ligature tie can be placed from the screw to either:

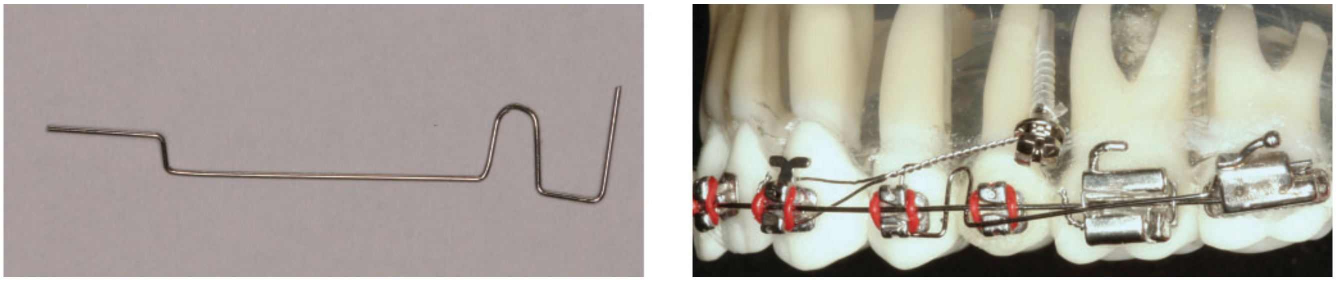
- a hook soldered or bent into the main archwire;
- the canine tooth;
- the first or second premolar tooth.

Once the segment anterior to the first molar has been secured, it becomes the source of anchorage for any mechanics designed to move the molars distally. If the second molar is erupted, an expanding coil spring can be placed between the first molar and second molar, (Figure 10a) or an arch incorporating an expansion loop can be used to distalize the second molar (Figure 10b). If the second molar is not present a coil spring may be threaded on the archwire between the second premolar and the first molar (Figure 10c), or as described for the second molar, an expanding arch may be used to distalize the first molar. However, whilst compressed coil springs do work, because of the limited interdental space between the teeth, they are technically difficult to place and their range of activation is limited.

A clinical example of a case where the treatment plan required the distal movement of maxillary molars followed by the premolars is shown in Figure 11a,b.

(a) (b)

Figure 11 (a) Mini-screw implant placed between second premolar and first molar. Ligature tie to the sectional arch provides indirect anchorage for the coil spring to move the molar distally (with permission from Dr A. Rumbak). (b) Mini-screw maintains the indirect anchorage while the premolars are moved distally (with permission from Dr A. Rumbak)



(a) (b)

Figure 12 (a) Expanding auxiliary, 0.016-inch stainless steel. (b) Mini-screw implant placed between the second premolar and first molar. Ligature tie from the mini-screw to the canine provides indirect anchorage. Expanding auxiliary placed between the first premolar and second molar

As a further option, if the attachments on the molars and premolars have vertical channels, an expanding auxiliary can also be used (Figure 12a,b). The advantage of an expanding auxiliary is the facility to place or remove it without disturbing the main archwire.

In certain cases where access is reasonable it may be expedient to place a screw in the retro-molar region; from this site an elastomeric thread or chain can be attached to both the buccal and palatal aspects of the relevant molar or premolar teeth. Failure to attach to both tooth surfaces may result in rotation of the tooth. The bone in the maxillary retro-molar region is generally not very dense and, in some cases, may not provide adequate retention for the mini-screw; by contrast, the bone in the mandibular retro-molar region is dense and provides good mechanical retention for the mini-screw.

The use of a mini-screw implant placed in the maxillary retro-molar region to assist in the pre-prosthodontic movement of teeth is illustrated in a case showing a mutilated malocclusion with an absent UL2 and a poor crown on UL3. The request from the prosthodontist was for UL3, UL4, UL5 and UL6 to be moved distally to allow for the replacement of the lateral incisor and reconstruction of the remaining buccal teeth (Figure 13a–e).

In a partially edentulous malocclusion where the treatment plan requires distal movement of the remaining buccal teeth, a mandibular retro-molar mini-screw provides excellent anchorage. (Figure 14a,b)

Distal movement of canines or premolars

For these movements the mini-screw can provide direct anchorage by placing elastic, elastomeric chain or coil spring traction from the screw directly to the relevant tooth (Figure 15a,b). An important proviso is that the screw should not impede anticipated movement of the root; if this is a problem, the screw should be removed and replaced in a more favourable position.

If the case is being treated with a lingual appliance, the screw is best placed into the palatal cortical bone either between the roots of the second premolar and first molar or distal to the first molar. The same design principles apply as on the labial; however, the design of the archwires and expanding auxiliaries will need to be modified. Figure 16 (a,b) shows a clinical example of a lingual appliance with mini-screw implants placed distal to the first molars, where the second molars were extracted and the molars and premolars retracted using the mini-screws as direct anchorage.

Mesial movement of premolars and molars

Ideally, the screw should be placed in the buccal cortical bone between the canine and first premolar teeth. Traction can be applied directly from the screw to any of the buccal teeth distal to the screw (Figure 17). A clinical example showing the mesial movement of a mandibular second premolar using a mini-screw placed between the canine and first premolar as indirect anchorage is shown in Figure 18 (a–d). Once the second premolar is in place, it is the clinician's intention to move the second molar mesially using the same mechanics. This illustrates the principle mentioned earlier where it is advisable to move one tooth at a time to avoid over taxing the anchorage potential of the mini-screw. If the angle of traction from the molar to the mini-screw is too acute, it will reduce the mechanical efficiency of the anticipated tooth movement. As an alternative, a vertical post should be soldered to the buccal tube on the molar enabling a more horizontal direction of traction (Figure 19).

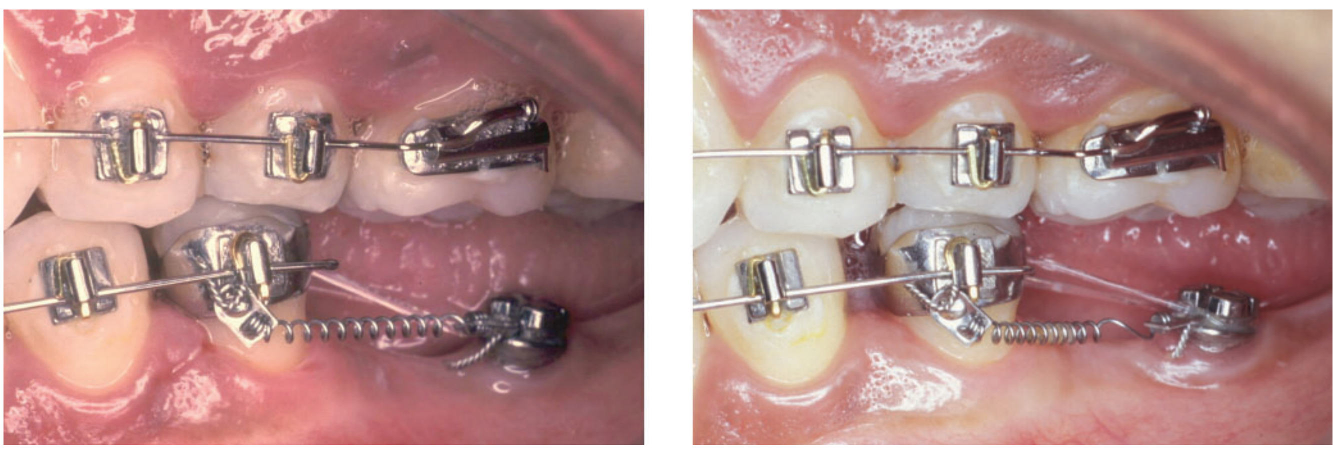
Lingual or labial movement of anterior teeth.

Lingual movement (retraction) of maxillary anterior teeth

Generally, the best position for the screw is in the buccal cortical bone between the roots of the second premolar

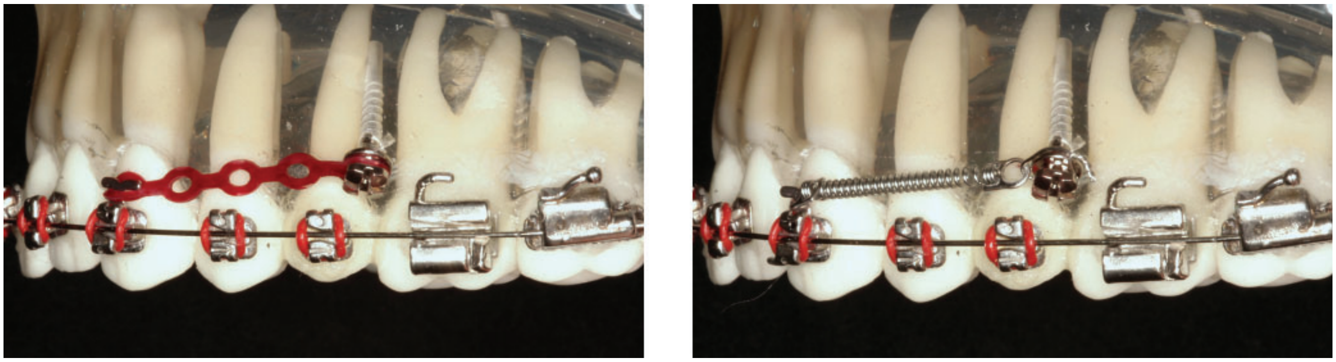
(a) (b) (c) (d) (e)

Figure 13 (a) Mutilated malocclusion; absent UL2, poor crown UL3. (b) Retro-molar mini-screw implant tied to the molar with elastomeric thread; direct anchorage for distal movement of the molar. (c) Palatal view showing distal movement of molar tooth. Note elastomeric thread tied to the lingual cleat. (d) Palatal view showing distal movement of the second premolar. (e) Distal movement of canine, premolars and molar completed, provisional crowns placed with the absent lateral incisor replaced by a bridge



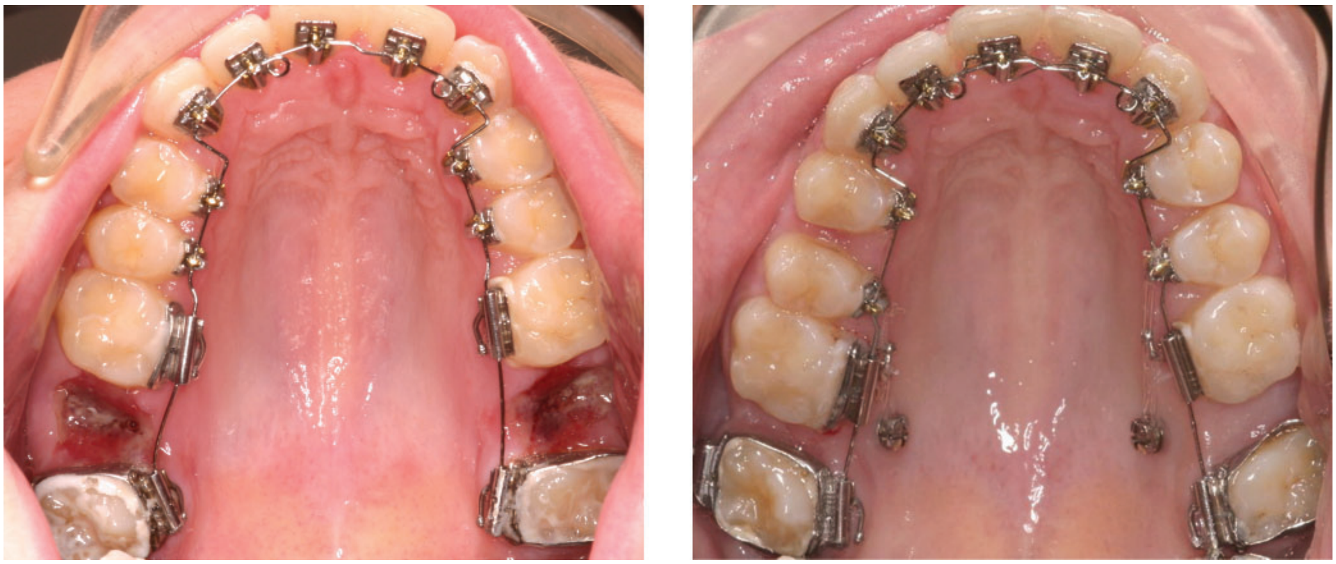
(a) (b)

Figure 14 (a) Mandibular retro-molar mini-screw implant placed for distal movement of second premolar tooth. Direct anchorage. (b) Mandibular second premolar moved distally with lingual elastomeric thread and buccal nickel titanium coil spring



(a) (b)

Figure 15 (a) Mini-screw implant placed between the second premolar and first molar. Elastomeric chain from the mini-screw to the canine tooth. Direct anchorage. (b) Mini-screw implant placed between the second premolar and first molar. Nickel titanium coil spring from the mini-screw to the canine tooth. Direct anchorage



(a) (b)

Figure 16 (a) Second molars have been extracted and a lingual appliance fitted. (b) Mini-screw implants placed distal to the first molars and elastomeric threads used to distalize the molars and premolars in stages

Figure 17 Mini-screw implant placed between the mandibular canine and first premolar. Elastomeric chain from the mini-screw to the mandibular molar. Direct anchorage

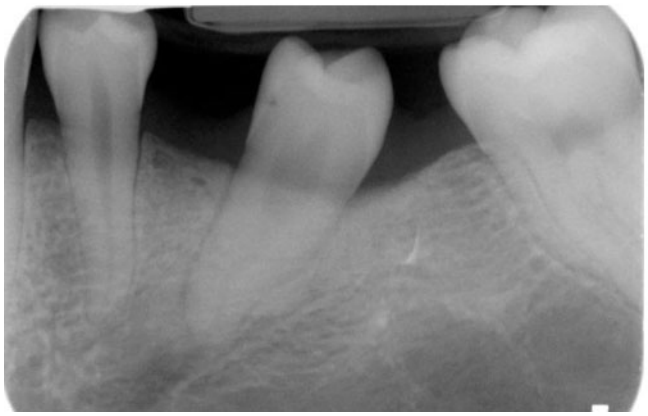
and first molar teeth. On the assumption that there is adequate space to retract the anterior teeth, elastic or spring traction can be applied directly from the screw to a hook placed between the canine and lateral incisor tooth on a free sliding archwire. The clinical example shown in Figure 20 (a,b) illustrates direct anchorage from the mini-screw to the archwire mesial to the lateral incisors. If there is any chance of the elastic or spring impinging on the gingiva overlying the canine root eminence, then the hook on the archwire should be placed between the canine and first premolar.

With a lingual appliance, the screw should be placed bilaterally in the palatal cortical bone between the second premolars and first molars (or between the first and second molars). Traction is then applied from the screw directly to a hook on the archwire either between the canine and lateral incisor or between the lateral and central incisor teeth (Figure 21).

In partially edentulous cases, where there are no buccal teeth either unilaterally or bilaterally, the


(a)


(b)


(c)


(d)

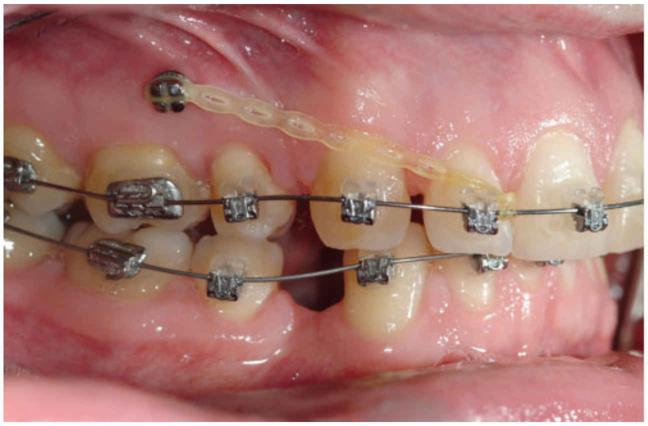
Figure 18 (a) Second premolar needs to be uprighted and moved mesially. Mini-screw implant placed between the canine and first premolar (with permission from Dr A. Rumbak). (b) Elastomeric chain from the canine to the second premolar. Ligature tie from the mini-screw to the first premolar. Indirect anchorage (with permission from Dr A. Rumbak). (c) Pre-treatment radiograph showing the distal position of the second premolar (with permission from Dr A. Rumbak). (d) Post-treatment radiograph showing the second premolar in an upright position in contact with the first premolar (with permission from Dr A. Rumbak)

Figure 19 Vertical arm soldered to buccal tube of the first molar. Direct traction to a mini-screw placed between the canine and lateral incisor (with permission from Dr S. Wagner)

maxillary sinus often encroaches deep into the alveolar ridge and placement of a mini-screw in the buccal cortical plate provides inadequate mechanical retention. In these cases, even though a labial appliance is used, it is preferable to place the mini-screw in the palatal cortical bone where the bone is thicker and denser. Elastic thread may be passed from the palatal screw through the contact points between the central and lateral incisor teeth and tied directly to the archwire (Figure 22a,b).

Labial movement (proclination) of anterior teeth.

With screws placed bilaterally in the buccal cortical bone between the canine and first premolar or second premolar teeth, indirect anchorage can be provided by tying the first molars to the screws with ligature wire. With stabilized distal segments, expanding loops placed



(a)

(b)

Figure 20 (a) Elastomeric chain from the mini-screw to the archwire. Direct anchorage (with permission from Dr G. Judes). (b) Spaces closed and overjet reduced (with permission from Dr G. Judes)

in the archwire mesial to the first molars will in turn procline the anterior segment. Expanding auxiliaries or coil springs can also be adapted to apply a mesially directed force to the anterior teeth using the tethered first molars as anchor units (Figure 23).

Vertical intrusive movement of buccal or anterior teeth.

Intrusion of buccal teeth

Loss of posterior teeth in one arch may lead to over-eruption of buccal teeth in the opposing arch. To intrude maxillary molars or premolars it is preferable to place one screw in the buccal cortical bone and one in the palatal cortical bone. Intrusive traction using elastomeric thread or nickel titanium coil springs is applied from the screws to the buccal and palatal attachments on the relevant tooth. If only one buccal screw is placed, it is likely that the maxillary molar will tip out buccally. It is essential to apply the intrusive force simultaneously to the buccal and palatal aspects of the tooth (Figure 24a,b). If more than one tooth requires intrusion, it is preferable to intrude one tooth at a time in order to avoid over-taxing the anchorage potential of the screws. Bear in mind that the screws are inserted not horizontally but obliquely with an angled vertical path of insertion. Under these circumstances extrusive forces that are too great may contribute to screw failure. This principle is illustrated in the clinical example shown in Figure 25 (a–f).

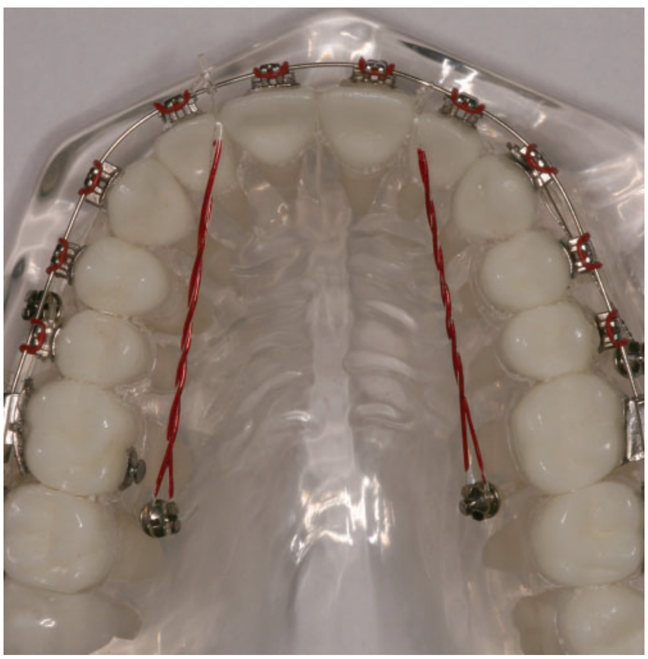


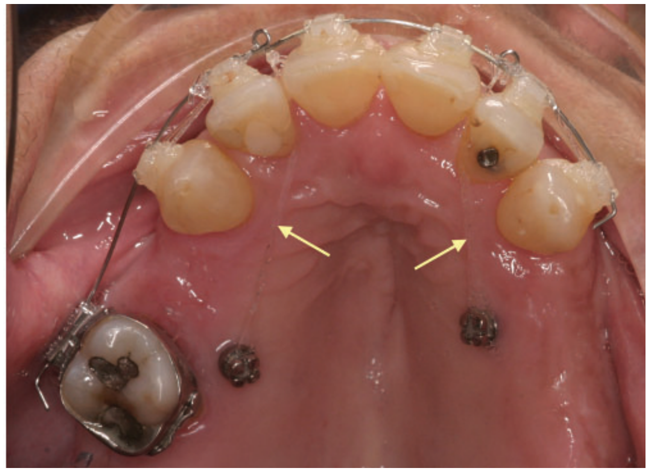
Figure 21 Palatal mini-screw implants placed distal to the first molars. Elastomeric thread tied from the mini-screws to the archwire between the central and lateral incisors for retraction of the anterior teeth

Mandibular buccal teeth generally have a lingual inclination; therefore, it may be possible to apply only a buccal intrusive force without causing undue buccal tipping.

Intrusion of anterior teeth

In cases where the maxillary or mandibular incisors have over-erupted, with a full dentition it is generally possible to reduce the increased overbite with conventional intrusive mechanics. The problem arises when posterior teeth are absent either unilaterally or bilaterally and it is not possible to use conventional intrusive archwire mechanics. Under these circumstances, making use of mini-screws is a valid alternative. For the intrusion of anterior teeth, there is a choice of using one midline screw, or two screws placed between the roots of the central and lateral incisors or between the roots of the lateral and canine teeth. In the maxilla it is preferable to

(a)



(b)

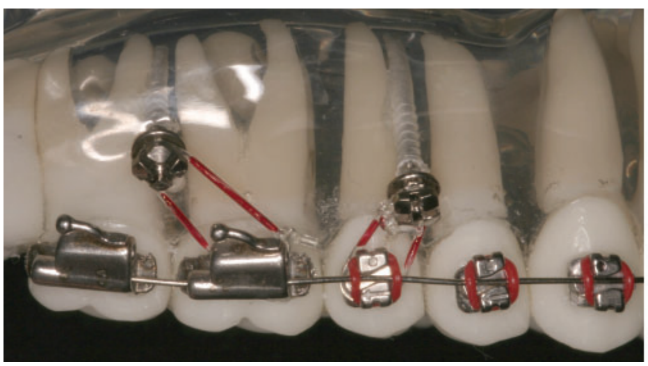
Figure 22 (a) Palatal view of a partially edentulous dentition with spaced and proclined anterior teeth. A labial appliance was placed and palatal mini-screw implants provided direct anchorage for retraction of the anterior teeth using elastomeric thread (see arrows). (b) Anterior retraction completed and spaces closed

Figure 23 Mini-screw implant placed between the mandibular canine and premolar. Ligature tie from the mini-screw to the second molar provides indirect anchorage for an expanding auxiliary acting from the first molar to the canine for anterior proclination

avoid the midline suture region. Intrusive traction can be applied either directly to a single tooth or in cases where all the anterior teeth need to be intruded, an elastomeric thread, chain or coil spring can be tied from the screw to the anterior archwire. This is in contradiction to the principle described earlier. However, incisor teeth have a smaller root surface area than posterior teeth and *en masse* intrusion of these teeth is possible (Figure 26). Furthermore, as the lips are easily irritated and the space in the muco-labial fold is limited, it may be preferable to choose a screw with a post type, rather than a flat-top head ensuring that the head is in attached gingiva and not in the unattached mucosa (where it will become rapidly embedded).

Summary

The description of the technique for the placement of mini-screw implants highlights, on the one hand, the



(a)

(b)

Figure 24 (a) Buccal mini-screws placed for intrusion of the first molar and second premolar. As an alternative the anterior screw could be placed between the first molar and second premolar. Intrusive force applied with elastomeric threads. (b) Palatal mini-screw placed for balancing intrusive force

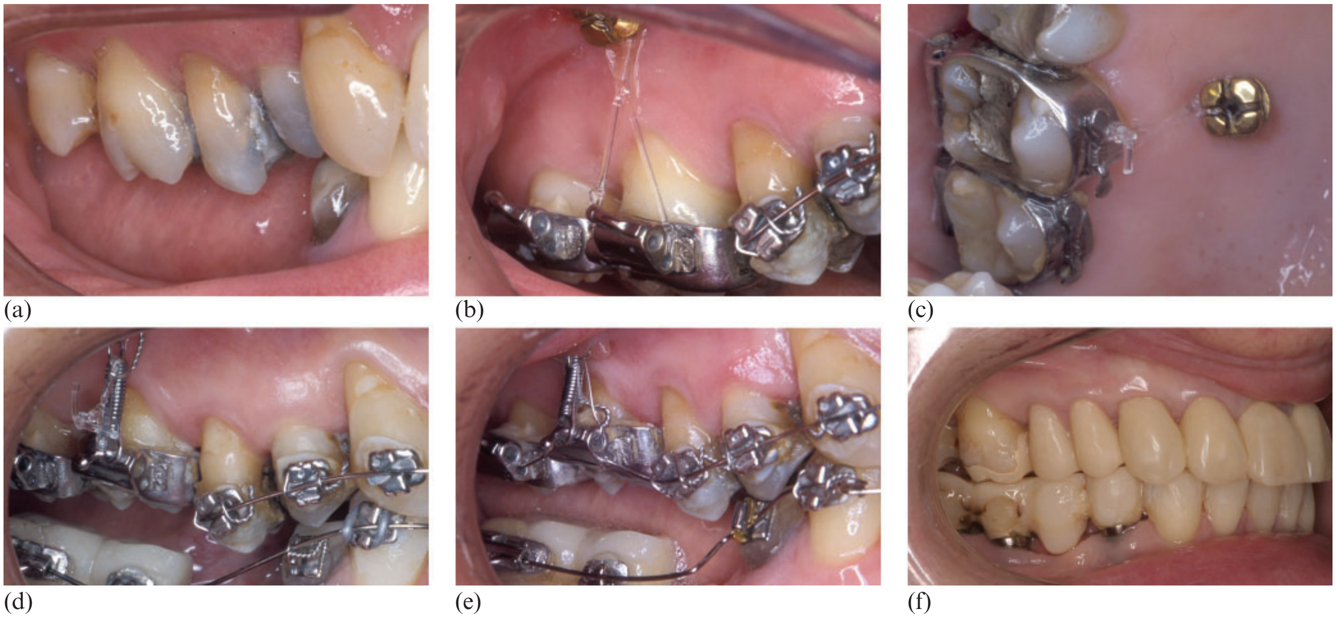


Figure 25 (a) Over-eruption of the right maxillary buccal segment. (b) Mini-screw implant placed in the buccal cortical bone distal to the maxillary first molar. Intrusive force applied with elastomeric thread. Note the archwire stops short of the molar tooth. (c) Mini-screw implant placed in the palate between the second premolar and molar to provide a counter balancing intrusive force. (d) Completion of the required intrusion. (e) The intruded molar is stabilized with a ligature tie. A flexible arch is now used to intrude and level the adjacent teeth. (f) Intrusion and levelling completed, lower osseointegrated implants placed with maxillary and mandibular provisional crowns prior to placement of final restorations

simplicity of the technique, but on the other also covers the importance of correct site selection and the possible complications that may arise. The clinical applications illustrated using typodont models and clinical material cover most of the situations where mini-screw implants can be of assistance. They provide good bone-supported intra-oral anchorage for orthodontic treatment and pre-prosthodontic applications. However, variations in the design of appliances as dictated by the malocclusion and biological/anatomical boundaries are limited only by the ingenuity of the individual clinician.

Figure 26 Mini-screw implant placed in the mandible between the roots of the mandibular incisors

References

1. Cope JB. Temporary anchorage devices in orthodontics: a paradigm shift. *Semin Orthod* 2005; **11:** 3–9.
2. Creekmore TD, Eklund MK. The Possibility of skeletal anchorage. *J Clin Orthod* 1983; **17:** 266–69.
3. Kanomi R. Mini-implant for orthodontic anchorage. *J Clin Orthod* 1997; **31:** 763–67.
4. Block MS, Hoffman DR. A new device for absolute anchorage for orthodontics. *Am J Orthod Dentofacial Orthop* 1995; **107:** 251–58.
5. Wehrbein H, Glatzmaier J, Mundwiller U, Diedrich P. The Orthosystem—a new implant system for orthodontic anchorage in the palate. *J Orofac Orthop* 1996; **57:** 142–53.
6. Gedrange T, Boening K, Harzer W. Orthodontic implants as anchorage appliances for unilateral mesialization: a case report. *Quintessence Int*, 2006; **37:** 485–91.
7. Celenza F. Implant-enhanced tooth movement: indirect absolute anchorage. *Int J Periodontics Restorative Dent* 2003; **23:** 533–41.
8. Sherwood KH, Burch JG, Thompson WJ. Closing anterior open bites by intruding molars with titanium miniplate anchorage. *Am J Orthod Dentofacial Orthop* 2002; **122:** 593–600.
9. De Clerck H, Geerinckx V, Siciliano S. The Zygoma Anchorage System. *J Clin Orthod* 2002; **36:** 455–59.

10. Smalley WM. Clinical and laboratory procedures for implant anchorage in partially edentulous dentitions. In Higuchi KW, Ed., *Orthodontic applications of osseointegrated implants*. Chicago: Quintessence, 2000: 33–69.
11. Roberts WE, Helm FR, Marshall KJ, Gongloff RK. Rigid endosseous implants for orthodontic and orthopedic anchorage. *Angle Orthod* 1989; **59:** 247–56.
12. Park HS. The skeletal cortical anchorage using titanium microscrew implants. *Korean J Orthod* 1999; **29:** 699–706.
13. Park HS, Bae SM, Kyung HM, Sung JW. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. *J Clin Orthod* 2001; **35:** 417–22.
14. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic micro-implants for intraoral anchorage. *J Clin Orthod* 2003; **37:** 321–28.
15. Melsen B, Costa A. Immediate loading of implants used for orthodontic anchorage, *Clin Orthod Res* 2000; **3:** 23–28.
16. Maino BG, Bednar J, Pagin P, Mura P. The spider screw for skeletal anchorage. *J Clin Orthod* 2003; **37:** 90–97.
17. Herman R, Cope JB. Miniscrew implants: IMTEC Mini Ortho Implants. *Semin Orthod* 2005; **11:** 32–39.
18. Park HS, Kyung HM, Sung JH. A simple method of molar uprighting with micro-implant anchorage. *J Clin Orthod* 2002; **36:** 592–96.
19. Carano A, Velo S, Leone P, Siciliani G. Clinical applications of the Miniscrew Anchorage System. *J Clin Orthod* 2005; **39:** 9–24.
20. Paik CH, Woo YJ, Kim J, Park JU. Use of miniscrews for intermaxillary fixation of lingual-orthodontic surgical patients. *J Clin Orthod* 2002; **36:** 132–36.
21. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. *Clin Oral Implants Res* 2006; **17:** 109–14.
22. Fabbroni G, Aabed S, Mizen K, Starr DG. Transalveolar screws and the incidence of dental damage: a prospective study. *Int J Oral Maxillofac Surg* 2004; **33:** 442–46.
23. Borah GL, Ashmead D. The fate of teeth transfixed by osteosynthesis screws. *Plast Reconstr Surg* 1996; **97:** 726–29.
24. Roberts WE, Helm FR, Marshall KJ, Gongloff RK. Rigid endosseous implants for orthodontic and orthopedic anchorage. *Angle Orthod* 1989; **59:** 247–56.
25. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano- Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *Am J Orthod Dentofacial Orthop* 2003; **124:** 373–78.
26. Liou EJ, Pai BC, Lin JC. Do miniscrews remain stationary under orthodontic forces? *Am J Orthod Dentofacial Orthop* 2004; **128:** 42–47.
27. Reiser GM, Bruno JF, Mahan PE, Larkin LH. The subepithelial connective tissue graft palatal donor site: anatomic considerations for surgeons. *Int J Periodontics Restorative Dent* 1996; **16:** 130–37.
28. Costa A, Pasta G, Bergamaschi G. Intraoral hard and soft tissue depths for temporary anchorage devices. *Semin Orthod* 2005; **11:** 10–15.
29. Poggio PM, Incorvati C, Velo S, Carano A. 'Safe zones': A guide for miniscrew positioning in the maxillary and mandibular arch. *Angle Orthod* 2006; **76:** 191–97.