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Complications associated with Orthodontic Micro-implants - A Review

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Abstract

Orthodontic micro-implant is increasingly gaining popularity in clinical orthodontics to affect skeletal anchorage. The mode of anchorage facilitated by these implant systems has a unique characteristic owing to their temporary use, which results in a temporary, though absolute anchorage. The foregoing properties together with the recently achieved simple application of these screws have increased their popularity, establishing them as a necessary treatment option in complex cases that would have otherwise been impossible to treat. The aim of this comprehensive review is to present and discuss the complications associated with Orthodontic micro implants used to obtain a temporary but absolute/ skeletal anchorage for orthodontic applications.

Anchorage control is one of the most important aspects of orthodontic treatment. According to the glossary of the American Association of Orthodontics (2006), it is defined as the resistance to activation force. To enhance orthodontic anchorage, micro implants have been introduced to reduce reciprocal orthodontic tooth movement (Park et al, 2001). It transfers the anchorage required from the tooth directly to the bone, which results zero loss of anchorage. This technique has enabled many difficult orthodontic movements such as en masse dental retraction, dental intrusion, and rotations of the occlusal plane to be incorporated into the orthodontic treatment plan (Sung et al, 2006). Microimplants have been used to convert cases that previously required orthognathic surgery into cases treatable by orthodontic treatment alone with microimplant support.

Traditionally, orthodontists have used teeth, intraoral appliances, and extraoral appliances to control anchorage, thus minimizing the movement of certain teeth while carrying out the desired movement of other teeth. However, because of Newton's third law—that is, for every action there is an equal and opposite reaction—the ability to completely control all aspects of tooth movement is limited. For example, orthodontists often have inadequate mechanical systems with which to control anchorage, which leads to a loss of anchorage in the reactive unit and thus incomplete correction of intraarch and interarch alignment problems. Moreover, in an attempt to overcome these limitations, clinicians often incorporate bulky acrylic appliances or extraoral appliances, which when combined with the ever challenging problem of uncooperative patients, are often a futile attempt at best.

A temporary anchorage device (TAD) is a device that is temporarily fixed to bone for the purpose of enhancing orthodontic anchorage 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. Temporary anchorage devices can be located transosteally, subperiosteally, or endosteally and they can be fixed to bone mechanically (cortically stabilized) or biochemically (osseointegrated). It should also be pointed out that dental implants placed for the ultimate purpose of supporting prosthesis, regardless of the fact that they may be used for orthodontic anchorage, are not considered TADs because they are not removed after orthodontic treatment. An important note, however, is that the initial incorporation of dental implants into orthodontic treatment made possible infinite anchorage, which has been defined in terms of implants as showing no movement (zero anchorage loss) as a consequence of reaction forces.(Cope, 2005)

Orthodontic micro-implant s have proven to be a useful addition to the orthodontist's armamentarium for control of skeletal anchorage in less compliant or noncompliant patients, but the risks involved with Orthodontic micro-implant s placement must be clearly understood by both the clinician and the patient. Complications can arise during Orthodontic micro-implant s placement and after orthodontic loading in regard to stability and patient safety. A thorough understanding of proper placement technique, bone density and landscape, peri-implant soft-tissue, regional anatomical structures, and patient home care are imperative for optimal patient safety and Orthodontic micro-implant s success.

Risks and complications of Orthodontic micro-implants can be classified under following heading as given by Neal D. Kravitz (2007)

1. COMPLICATIONS DURING INSERTION

a. Trauma to the periodontal ligament or the dental root
b. Orthodontic micro-implant slippage
c. Nerve involvement
d. Air subcutaneous emphysema
e. Nasal and maxillary sinus perforation
f. Orthodontic micro-implant bending, fracture, and torsional stress

2. COMPLICATIONS UNDER ORTHODONTIC LOADING

a. Stationary anchorage failure
b. Orthodontic micro-implant migration

3. SOFT-TISSUE COMPLICATIONS

a. Aphthous ulceration
b. Soft-tissue coverage of the Orthodontic micro-implant head and auxiliary
c. Soft tissue inflammation, infection, and peri-implantitis

4. COMPLICATIONS DURING REMOVAL

a. Orthodontic micro-implant fracture
b. Partial osseointegration

COMPLICATIONS DURING INSERTION

Trauma to the periodontal ligament or the dental root

Interradicular placement of orthodontic Orthodontic micro-implant ss risks trauma to the periodontal ligament or the dental root. Dental roots damaged by orthodontic Orthodontic

micro-implant have demonstrated complete repair of tooth and periodontium in 12 to 18 weeks after removal of the Orthodontic micro-implants

In the maxillary buccal region, the greatest amount of interradicular bone is between the second premolar and the first molar, 5 to 8 mm from the alveolar crest. In the mandibular buccal region, the greatest amount of interradicular bone is either between the second premolar and the first molar, or between the first molar and the second molar, approximately 11 mm from the alveolar crest.

During interradicular placement in the posterior region, there is a tendency for the clinician to change the angle of insertion by inadvertently pulling the hand-driver toward their body, increasing the risk of root contact. To avoid this, the clinician may consider using a finger-wrench or work the hand-driver slightly away from their body with each turn. If the Orthodontic micro-implant begins to approximate the periodontal ligament, the patient will experience increased sensation under topical anesthesia. If root contact occurs, the Orthodontic micro-implant may either stop or begin to require greater insertion strength. If trauma is suspected, the clinician should unscrew the Orthodontic micro-implant or 3 turns and evaluate it radiographically.

Orthodontic micro-implant slippage

The clinician might fail to fully engage cortical bone during placement and in advertently slide the Orthodontic micro-implant under the mucosal tissue along the periosteum. Highrisk regions for Orthodontic micro-implant slippage include sloped bony planes in alveolar mucosa such as the zygomatic buttress, the retromolar pad, the buccal cortical shelf, and the maxillary buccal exostosis if present. Slippage in the retromolar pad can lead to the greatest risk of iatrogenic harm if the Orthodontic micro-implant moves lingually in the submandibular or lateral pharyngeal space near the lingual and inferior alveolar branch nerves. In the retromolar region, serious consideration should be given to flap exposure for direct visualization and a predrilled pilot hole, even for self-drilling Orthodontic micro-implants. Orthodontic micro-implant slippage can occur in dentoalveolar regions of attached gingiva if the angle of insertion is too steep. Placement of Orthodontic micro-implant less than 30° from the occlusal plane, typically to avoid root contact in the maxilla or to gain cortical anchorage in the mandible, can increase the risk of slippage. To avoid this, the clinician can initially engage bone with the Orthodontic micro-implant at a more obtuse angle before reducing the angle of insertion after the second or third turn.

Nerve involvement

Nerve injury can occur during placement of Orthodontic micro-implant in the maxillary palatal slope, the mandibular buccal dentoalveolus, and the retromolar region. Most minor nerve injuries not involving complete tears are transient, with full correction in 6 months. Long-standing sensory aberrations might require pharmacotherapy (corticosteroids), microneurosurgery, grafting, or laser therapy. Placement of Orthodontic micro-implant in the maxillary palatal slope risks injury to the greater palatine nerve exiting the greater palatine foramen. The greater palatine foramen is located laterally to the third molar or between the second and third molars. Orthodontic micro-implant inserted in the palatal slope should be placed medial to the nerve and mesial to the second molar.

Placement of the Orthodontic micro-implant in the mandibular buccal dentoalveolus risks injury to the inferior alveolar nerve in the mandibular canal. The mandibular canal travels forward in an S-shaped curve moving from buccal to lingual to buccal. The inferior alveolar nerve occupies its most buccal position within the body of the mandible at the distal root of the second molar and the apex of the second premolar, before exiting from the mental foramen. Orthodontic micro-implant inserted near the mandibular second molar and the second premolar is at greatest risk for accidental damage to the inferior alveolar nerve. Greater caution is needed in adult patients who might have a more occlusal position of the mandibular canal due to resorption of the alveolar ridge. Placement of Orthodontic micro-implant in the retromolar pad risks injury to the long buccal nerve and the lingual nerve. To avoid nerve involvement and slippage, we recommend that the retromolar Orthodontic micro-implant should be no longer than 8 mm and placed in the buccal retromolar region below the anterior ramus.

Air subcutaneous emphysema

Air subcutaneous emphysema is the condition in which air penetrates the skin or submucosa, resulting in soft-tissue distention. Subcutaneous emphysema can occur during routine operative dental procedures if air from the high-speed or air- water syringe travels under the gingival tissues. The main symptom of air subcutaneous emphysema is immediate mucosal swelling with or without crepitus (crackling). The clinician should be alert for subcutaneous emphysema during Orthodontic micro-implant placement through the loose alveolar tissue of the retromolar, mandibular posterior buccal, and the maxillary zygomatic regions. If a purchase point or pilot hole is to be drilled through the mucosa, the clinician should use slow speed under low rotary pressure.

In case of subcutaneous emphysema, the clinician should immediately discontinue the procedure and take periapical and panoramic radiographs to determine the extent of the condition. The patient should not be dismissed until the swelling begins to regress and an infection can be ruled out. Upon dismissal, the patient should be instructed to apply light pressure with an ice pack for the first 24 hours (Table). The clinician could prescribe a mild analgesic, an antibacterial rinse, such as chlorhexidine, and an antibiotic prophylaxis for a week. In most cases of subcutaneous emphysema, careful observation for further problems or infection is adequate and swelling and symptoms generally subside in 3 to 10 days

Price Protocol for Soft Tissue Swelling (Bleakley, 2007)

Protection	To the injured area
Rest	Avoid heavy mastication
Ice	Apply ice pack to the injury 20 minutes on and 20 minutes off every few hours on first day.
Compression	Apply compression with ice pack to minimize swelling
Elevation	Lie down, but keep injured area elevated

Nasal and maxillary sinus perforation

Perforation of the nasal sinus and the maxillary sinuses can occur during Orthodontic micro-implant placement in the maxillary incisal, maxillary posterior dentoalveolar, and zygomatic regions. A posterior atrophic maxilla is a major risk factor for sinus perforation. The

sinus floor is deepest in the first molar region and can extend to fill a large part of the alveolar process in posterior edentulous spaces. If the maxillary sinus has been perforated, the small diameter of the Orthodontic micro-implant does not warrant its immediate removal. Orthodontic therapy should continue, and the patient should be monitored for potential development of sinusitis and mucocele. For Orthodontic micro-implant placed in pneumatized, edentulous regions of the maxilla, or placed higher in the posterior maxilla when intrusive forces are desired, the clinician should consider angulating the Orthodontic micro-implant perpendicular to the alveolar ridge to avoid damage to the sinus

Orthodontic micro-implant bending, fracture, and torsional stress

Increased torsional stress during placement can lead to implant bending or fracture, or produce small cracks in the peri-implant bone, that affect Orthodontic micro-implant stability. Self-drilling Orthodontic micro-implant should be inserted slowly, with minimal pressure, to assure maximum Orthodontic micro-implants bone contact. A purchase point or a pilot hole is recommended in regions of dense cortical bone, even for self-drilling Orthodontic micro-implants. During Orthodontic micro-implant placement in dense cortical bone, the clinician should consider periodically derotating the Orthodontic micro-implant 1 or 2 turns to reduce the stresses on the Orthodontic micro-implant and the bone. The clinician should stop inserting the Orthodontic micro-implant as soon as the smooth neck of its shaft has reached the periosteum. When removing the hand-driver from the Orthodontic micro-implant head, the clinician should gently separate the hand driver handle from its shaft and then gently remove the shaft from the Orthodontic micro-implant head

COMPLICATIONS UNDER ORTHODONTIC LOADING

Stationary anchorage failure[2] is often a result of low bone density due to inadequate cortical thickness. Bone density is classified into 4 groups (D1, D2, D3, and D4) based on Hounsfield units (HU)—an x-ray attenuation unit used in computed tomography scan interpretation to characterize the density of a substance. D1 (>1250 HU) is dense cortical bone primarily found in the anterior mandible and the maxillary midpalatal area. D2 (850-1250 HU) is thick (2 mm), porous cortical bone with coarse trabeculae primarily found in the anterior maxilla and the posterior mandible. D3 (350–850 HU) is thin (1 mm), porous cortical bone with fine trabeculae primarily found in the posterior maxilla with some in the posterior mandible. D4 (150–350 HU) is fine trabecular bone primarily found in the posterior maxilla and the tuberosity region Sevimay et al reported that osseointegrated dental implants placed in D1 and D2 bone showed lower stresses at the implant-bone interface. D1-D3 bone is optimal for self-drilling Orthodontic micro-implants.

Classification of Bone Density

Bone Density	***Description***	***Tactile Analog***	***Location***
D1	Dense Cortical	Oak	Anterior Mandible Maxillary Midpalatal
D2	Porous Cortical/ Coarse Trabecular	White Pine/ Spruce	Anterior Maxilla Posterior Mandible
D3	Porous Cortical/ Fine Trabecular	Balsa Wood	Posterior Maxilla Posterior Mandible Zygoma
D4	Fine Trabecular	Styrofoam	Posterior Maxilla Tuberosity

Placement of Orthodontic micro-implant in D1 and D2 bone might provide greater stationary anchorage under orthodontic loading. Placement of Orthodontic micro-implant in D4 bone is not recommended due to the reported high failure rate. In general, stationary anchorage failure is greater in the maxilla, with the exception of the midpalatal region, due to the greater trabeculae and lower bone density Peri- implant soft-tissue type, health, and thickness can affect stationary anchorage of the Orthodontic micro-implants. Orthodontic micro-implant placed in nonkeratinized alveolar tissues have greater failure rates than those in attached tissues.

Primary stability refers to the movement, or the lack thereof, of Orthodontic micro-implant upon initial placement. A lack of primary stability almost routinely leads to overt Orthodontic micro-implant mobility, with subsequent failure. Recent evidence suggests that the majority of primary Orthodontic micro-implant stability comes from cortical bone, with lesser stability coming from medullary bone. Upon placement, Orthodontic micro-implant should have at least 0.5 mm to 0.75 mm of available bone stock around its circumference. Because most Orthodontic micro-implant are intended to be placed and loaded at the same visit, the Orthodontic micro-implant must have adequate cortical bone purchase and exhibit no mobility.

Another reason for inadequate primary stability is an overdrilled pilot hole. This problem is more likely in areas of thin cortical bone. The main reason for hole over enlargement is the clinician's inability to hold the handpiece stable and perpendicular to the bone surface during drilling. Any lateral movement during drilling will over enlarge the pilot hole. Excessive trauma during implant surgery is considered an important cause of implant failure. During a pilot-hole osteotomy, most of the energy not used in the cutting process is transformed into heat. Heat production leading to a temperature rise above 47^{o}C for more than 1 minute negatively affects living bone and compromises its regeneration. Complications in this area are best avoided by using drill-free screws.

Orthodontic micro-implant can remain clinically stable but not absolutely stationary under orthodontic loading. Unlike an endosseous dental implant that osseointegrates, orthodontic Orthodontic micro-implant achieve stability primarily through mechanical retention and can be displaced within the bone. Liou et al reported that orthodontic Orthodontic micro-implant loaded with 400 g of force for 9 months extruded and tipped –1.0 to 1.5 mm in 7 of 16 patients. To account for potential migration, the clinician should allow a 2-mm safety clearance between the Orthodontic micro-implant and any anatomical structures.

SOFT-TISSUE COMPLICATIONS

Aphthous ulceration

Minor aphthous ulcerations, or canker sores, can develop around the Orthodontic micro-implant shaft or on the adjacent buccal mucosa in contact with the Orthodontic micro-implant head. Placement of a healing abutment, a wax pellet, or a large elastic separator over the Orthodontic micro-implant head, with daily use of chlorhexidine (0.12%) or Povidine Iodine (3-5 %), typically prevents ulceration and improves patient comfort. The occurrence of an aphthous ulceration does not appear to be a direct risk factor for Orthodontic micro-implant stability, but its presence might forewarn of greater soft tissue inflammation.

Soft-tissue coverage of the Orthodontic micro-implant head and auxiliary

Orthodontic micro-implant placed in alveolar mucosa, particularly in the mandible, might become covered by soft tissue. The bunching and rubbing of loose alveolar tissue can lead to coverage of both the Orthodontic micro-implant head and its attachments (ie, coil spring, elastic chain) within a day after placement. Soft-tissue coverage might be a risk factor for Orthodontic micro-implant stability, as well as a clinical concern for the patient, who might think that the Orthodontic micro-implant has fallen out. Orthodontic micro-implant attachments (elastic chain, coil spring) that rest on tissues will likely become covered by tissue. The soft-tissue overlaying the Orthodontic micro-implant is relatively thin and can be exposed with light finger pressure, typically without an incision or local anesthetic. Soft-tissue overgrowth can be minimized by placement of a healing abutment cap, a wax pellet, or an elastic separator. In addition to its antibacterial properties that minimize tissue inflammation, chlorhexidine slows down epithelialization and might reduce the likelihood of soft-tissue overgrowth. The authors suggest partial insertion with a longer Orthodontic micro-implant (10 mm) in regions of loose alveolar mucosa, leaving 2 or 3 threads of the shaft exposed to minimize the possibility of soft-tissue coverage.

Soft tissue inflammation, infection, and peri-implantitis

Healthy peri-implant tissue plays an important role as a biologic barrier to bacteria. Tissue inflammation, minor infection, and peri-implantitis can occur after Orthodontic micro-implant placement. Inflammation of the periimplant soft tissue has been associated with a 30% increase in failure rate. The clinician should be forewarned of soft-tissue irritation if the soft tissues begin twisting around the Orthodontic micro-implant shaft during placement. Some clinicians advocate a 2-week soft-tissue healing period for Orthodontic micro-implant placed in the alveolar mucosa before orthodontic loading.

COMPLICATIONS DURING REMOVAL

Orthodontic micro-implant fracture

The Orthodontic micro-implant head could fracture from the neck of the shaft during removal. The authors recommend a minimum diameter of 1.6 mm for self-drilling Orthodontic micro-implant that are 8 mm or longer placed in dense cortical bone. The proper placement technique can minimize the risk of Orthodontic micro-implant fracture during its removal. If the Orthodontic micro-implant fractures flush with the bone, the shaft might need to be removed with a trephine.

Partial osseointegration

Although orthodontic Orthodontic micro-implant achieve stationary anchorage primarily through mechanical retention, they can achieve partial osseointegration after 3 weeks, increasing the difficulty of their removal. The Orthodontic micro-implant typically can be removed without complications a few days after the first attempt of removal.

Conclusion

The concept of temporary anchorage devices is a relatively new application of more established clinical methodologies. Although the clinician can look to the literature for many answers, much is unknown and will only be answered by well-designed prospective basic science and clinical trials. The future development of temporary anchorage devices for orthodontic

anchorage will establish a more complete understanding of the biology and biomechanics associated with both osseointegrated and nonintegrated TADs.

As, to achieve absolute orthodontic anchorage has been one of the dreams of most orthodontic clinicians, and using the micro-implants has given as the most effective, powerful way to get the anchorage we want to achieve. Therefore, application of micro-implant will make the treatment procedure easier, and so there is no doubt that it is one of the most useful methods to provide absolute orthodontic anchorage but with caution.

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