**Temporary anchorage devices – Mini-implants**

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**ABSTRACT**

Orthodontists are accustomed to using teeth and auxiliary appliances, both intraoral and extraoral, to control anchorage. These methods are limited in that it is often difficult to achieve results commensurate with our idealistic goals. Recently, a number of case reports have appeared in the orthodontic literature documenting the possibility of overcoming anchorage limitations via the use of temporary anchorage devices—biocompatible devices fixed to bone for the purpose of moving teeth, with the devices being subsequently removed after treatment. Although skeletal anchorage is here to stay in orthodontics, there are still many unanswered questions. This article describes the development of skeletal anchorage and provides an overview of the use of implants for orthodontic anchorage.

**Key words:** Anchorage, mini-implant, TAD

**Orthodontic Anchorage**

Although the principle of orthodontic anchorage has been implicitly understood since the 17th century, it does not appear to have been clearly articulated until 1923 when Louis Ottofy defined it as “the base against which orthodontic force or reaction of orthodontic force is applied.” Most recently, Daskalogiannakis defined anchorage as “resistance to unwanted tooth movement.” It can also be defined as the amount of allowed movement of the reactive unit. Using this definition requires clarification of the reactive unit (tooth/teeth acting as anchorage during movement of the active unit) as well as the active unit (tooth/teeth undergoing movement).

Ottofy also summarized the anchorage categories previously outlined by E.H. Angle and others as simple, stationary, reciprocal, intraoral, intermaxillary, or extraoral. Since that time, several noted authors have modified or developed their own classification. For example, Moyers expanded Ottofy’s classification system by clearly outlining the different subcategories of extraoral anchorage, as well as breaking down simple anchorage into single, compound, and reinforced subcategories. Later, others developed their own classification terminology. Gianelly and Goldman suggested the terms maximum, moderate, and minimum to indicate the extent to which the teeth of the active and reactive units should move when a force is applied. Marcotte and Burstone classified anchorage into three categories—A, B, and C—depending on how much of the anchorage unit contributes to space closure. Tweed went further to define anchorage preparation, or the uprighting, and even the distal tipping of posterior teeth to utilize the mechanical advantage of the tent peg before retracting anterior teeth.

Considering the above classification systems, it becomes apparent that a lack of consensus exists on the terminology for describing anchorage. Moreover, these systems are outdated and do not currently provide clear guidelines with which the orthodontist can clearly and concisely communicate. For example, these classification systems only account for anteroposterior dental relationships and do not really account for vertical or transverse relationships. They also only account for the anteroposterior extent of the dental bases and do not account for distalizing the dentition to create a Class I dental relationship without the need for extractions or surgery.

Moreover, they only account for groups of teeth; they do not account for individual teeth, nor do they account for the entire occlusal plane. The reason for the latter is most likely because at the time these classification systems were developed, it was not possible to achieve the type of control over tooth movement that we now possess with the use of temporary anchorage devices.
systems were developed, the possibility of, for example, intruding posterior teeth to correct a skeletal anterior open bite without surgery was unimaginable. Given the recent advances in biology, materials, and clinical treatment, this movement is not only a possibility, but also a reality; it thus becomes apparent that a new anchorage classification system is needed.

**Temporary Anchorage Devices**

A temporary anchorage device (TAD) 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 is subsequently removed after use. They can be located transosteally, subperiosteally, or endosteally; and they can be fixed to bone either 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 temporary anchorage devices since they are not removed and discarded after orthodontic treatment. Importantly, the incorporation of dental implants and TADs 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.\(^8-10\)

**Indications**

Precise indications for skeletal anchorage are not well documented. Most of the published articles have been case reports in which new devices have been described as alternatives to other anchorage methods—for example, in extraction cases using implants instead of headgear.\(^1,8\) Mini-implants have replaced other types of fixed appliances for the delivery of differentiated force systems for posterior tooth movement or extrusion of impacted canines.\(^9,13\)

Miniscrews have also been used as anchorage for tooth movements that could not otherwise have been performed, which are as follows.

In cases to achieve class I molar relationship by molar distalization [Figure 1].

Cases where the forces on the reactive unit would generate adverse side effects [Figure 2].

Patients with a need for asymmetrical tooth movements in all planes of space [Figure 3].

In some cases, as an alternative to orthognathic surgery.

**Selection of mini-implant size and location**

The diameter of the miniscrew will depend on the site and space available. In the maxilla, a narrower implant can be selected if it is to be placed between the roots. If stability depends on insertion into trabecular bone, a longer screw is needed, but if cortical bone will provide enough stability, a shorter screw can be chosen. The length of the transmucosal part of the neck should be selected after assessing the mucosal thickness of the implant site.\(^9\)

**Historic Development**

The evolution of temporary anchorage devices was based on the development and improvement of traditional orthodontic anchorage, dental implants, and orthognathic fixation methods. Later, modifications of these techniques were unified with basic biologic and biomechanical principles of osseointegration into orthodontic mechanics that was finally improved based on experiences with interdisciplinary dentistry. Branemark and coworkers\(^11\) (1970) reported the successful osseointegration of implants in bone; many orthodontists began taking an interest in using implants for orthodontic anchorage. Costa and colleagues\(^12\) (1998) used 2 mm titanium miniscrews for orthodontic anchorage. The screws were inserted manually with a screw driver directly through the mucosa without making a flap and were loaded immediately. Of the 16 miniscrews used during the clinical trial, two became loose and subsequently were lost before treatment was finished.

**Classification of implants for orthodontic anchorage**

1. According to the shape and size
   - a) Conical (cylindrical)
     - • miniscrew implants
     - • palatal implants
     - • prosthodontic implants
   - b) Mini plate implants
   - c) Disc implants (onplants)

2. According to implant bone contact
   - a) Osteointegrated
   - b) Non-osteointegrated

3. According to the application
   - a) Used only for orthodontic purposes (orthodontic implants)
   - b) Used for prosthodontic and orthodontic purposes (prosthodontic implants)
Possible insertion sites include, in the maxilla: the area below the nasal spine, the palate, the alveolar process, the infrrazygomatic crest, and the retromolar area; in the mandible: the alveolar process, the retromolar area, and the symphysis. An intraoral radiograph is required to determine the correct location. A small, ellipsoid template made of rectangular orthodontic wire can be attached to the teeth in the region with light-cured composite to facilitate this evaluation.

Whenever possible, the mini-implant should be inserted through attached gingiva. If this is impossible, the screw can be buried beneath the mucosa so that only a wire, a coil spring, or a ligature passes through the mucosa.
In the maxilla, the insertion should be at an oblique angle, in an apical direction; in the mandible, the screw should be inserted as parallel to the roots as possible if teeth are present. A transcortical screw can be used for added stability in edentulous areas, where trabecular bone is usually scarce. We do not use surgical guides “or special stents” for screw placement.\footnote{14,15}

**TREATMENT PLANNING**

Treatment planning must include a careful choice of miniscrew location. The placement location will enable the clinician to control or effect extrusive and intrusive movements of teeth. The placement of the screw requires a location that has sufficient bone depth to accommodate the miniscrew and at least 2.5 mm of bone width to protect the anatomic structures.

**IMPLANT CRITERIA**

**Implant materials**
The material must be nontoxic and biocompatible, possess excellent mechanical properties, and provide resistance to stress, strain, and corrosion. Commonly used materials can be divided into three categories: biotolerant (stainless steel, chromium–cobalt alloy), bioinert (titanium, carbon), and bioactive (hydroxyapatite, ceramic oxidized aluminum). Because of titanium’s characteristics (no allergic and immunologic reactions and no neoplasm formation), it is considered an ideal material and is widely used.

Bone grows along the titanium oxide surface, which is formed after contact with air or tissue fluid. However, pure titanium has less fatigue strength than titanium alloys. A titanium alloy—titanium–6 aluminum–4 vanadium—is used to overcome this disadvantage.

**Implant sizes**
Implant fixtures must achieve primary stability and withstand mechanical forces. The maximum load is proportional to the total bone–implant contact surface. Factors that determine the contact area are length, diameter, shape, and surface design (rough vs. smooth surface, thread configuration). The ideal fixture size for orthodontic anchorage remains to be determined. Various sizes of implants, from “mini implants” (6 mm long, 1.2 mm in diameter) to standard dental implants (6–15 mm long, 3–5 mm in diameter), have proved to effectively improve anchorage. Therefore, the dimension of implants should be congruent with the bone available at the surgical site and the treatment plan.

**Implant shape**
This determines the bone–implant contact area available for stress transfer and initial stability. The design must limit surgical trauma and allow good primary stability. It is difficult to identify the “perfect” implant shape. The most commonly used is cylindrical or cylindrical-conical, with a smooth or threaded surface. Studies have shown that the degree of surface roughness is related to the degree of osseointegration. Most implants used for orthodontic anchorage are similar to conventional designs. Specially designed implants are discussed below.

**IMPLANT DRIVING METHOD**

There are two methods of placement of mini-implants: 1. Self-tapping method: In this method, the miniscrew is driven into the tunnel of bone formed by drilling, making it tap during implant driving. This method is used when we use small diameter miniscrews. 2. Self-drilling method: Here, the miniscrew is driven directly into bone without drilling. This method can be used when we want to use larger diameter (more than 1.5 mm) miniscrews.

**Mini-implant problems**
In years of experience with skeletal anchorage, I have noticed several common problems, which can be classified as follows:

**Screw-related problems**
- A screw can fracture if it is too narrow or the neck area is not strong enough to withstand the stress of removal. The solution is to choose a conical screw with a solid neck and a diameter appropriate to the quality of bone.
- Infection can develop around the screw if the transmucosal portion is not entirely smooth. If a screw system with variable neck lengths is used, the clinician can select one that suits the particular implant site.

**Operator-related problems**
- Application of excessive pressure during insertion of a self-drilling screw can fracture the tip of the screw.
- Overtightening a screw can cause it to loosen. It is crucial to stop turning the screw as soon as the smooth part of the neck has reached the periosteum.
- With a bracket-like screw head, the ligature should be placed on top of the screw in the slot perpendicular to the wire. Turning the ligature around the screw will make it impossible for the patient to keep the area free of inflammation.
• It is important not to wiggle the screwdriver when removing it from the screw head. The screwdriver will not stick if the long extension is removed before the part surrounding the screw.

Patient-related problems
• The prognosis for primary stability of a mini-implant is poor in cases where the cortex is thinner than 0.5 mm and the density of the trabecular bone is low.
• In patients with thick mucosa, the distance between the point of force application and the center of resistance of the screw will be greater than usual, thus generating a large moment when a force is applied.
• Loosening can occur, even after primary stability has been achieved, if a screw is inserted in an area with considerable bone remodeling because of either the resorption of a deciduous tooth or post-extraction healing.
• Mini-implants are contraindicated in patients with systemic alterations fit the bone metabolism due to disease, medication, or heavy smoking.

Implant maintenance
After surgery, the surrounding soft tissues must be maintained to ensure longevity of the implant. Plaque accumulation near the gingival margin can cause perimucositis. Prolonged inflammation leads to breakdown of bone around implants and peri-implantitis; this, without proper management, can lead to implant failure. Therefore, patients must be instructed to follow daily plaque control at home and have periodic professional care, similar to regular periodontal maintenance.

Conclusion
This article was intended to highlight the use of mini-implant as temporary anchorage devices. In my opinion, skeletal anchorage is clearly not a replacement for other proven anchorage systems. Skeletal anchorage should serve merely to expand the orthodontic services we can offer our patients.

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