A PARADIGM SHIFT IN ORTHODONTIC ANCHORAGE
A CLINICAL APPROACH

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Abstract
Anchorage control is one of the most important aspects of orthodontic treatment. The success of orthodontic treatment relies on the anchorage protocol planned for that particular case. Use of extraoral anchorage devices such as headgears requires full patient cooperation, which is sometimes not possible. Introduction of implants in orthodontics have solved this problem. Implants have become one of the best sources among the temporary anchorage devices. Implants have revolutionized the field of anchorage in orthodontics.

Keywords
Anchorage, Implants, Miniscrews

INTRODUCTION:
The importance of anchorage can best be described by the famous quote from the famous Greek philosopher Archimedes: "Give me a place and I will move the earth." Anchorage control is one of the most important aspects of orthodontic treatment. There are times when absolute or maximum anchorage, i.e., a high resistance to displacement, is needed. However, Newton's Third Law states that an applied force can be divided into an action component and an equal and opposite reaction component. In orthodontic mechanotherapy, even a small reactive force can cause undesirable tooth movement. Any uncontrolled reactive forces can have a negative effect on the outcome of the orthodontic treatment of a malocclusion. Therefore, it is virtually impossible to achieve absolute anchorage in which the reaction force producing no movement, especially with extraor al anchorage.

Anchorage preparation plays a key role in orthodontic treatment. The success of orthodontic treatment relies on the anchorage protocol planned for that particular case. When preparing anchorage, the clinician must be realistic enough to foresee the possibility of losing some anchorage. The type of anchorage is based on the desired type of tooth movement. Traditionally, extraoral anchorage has been used to reinforce intraoral anchorage. The use of extraoral anchorage ideally demands full cooperation of the patient as well as 24 hours per day of continuous appliance wear, objectives that are difficult to achieve and so they have unpredictable success rate. Adults and teenagers are prone to reject extraoral appliances because of esthetic problems and the discomfort they cause. Therefore, it is extremely difficult to undertake orthodontic treatment without compromising anchorage in some way. Clinicians and researchers have tried to use implants as orthodontic anchorage units for over a half century. Use of implants as a source of anchorage (Fig. 1) has number of advantages as compared to traditional anchorage such as no patient cooperation, easy to use, shortening of treatment time, good control on tooth movements.
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 Ottof's12 defined it as "the base against which orthodontic force or reaction of orthodontic force is applied." Most recently, Daskalognakis'2 defined anchorage as "resistance to unwanted tooth movement." It can also be defined as the amount of allowed movement of the reactive unit.

Ottof's1 also summarized the anchorage categories previously outlined by E.H. Angle and others as Intraoral (simple, stationary, reciprocal, intermaxillary) or Extraoral. Since that time, several noted authors have modified or developed their own classification. For example, Moyers'6 expanded Ottof'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.

Marcotte6 and Burstone7 classified anchorage into three categories – A, B, and C – depending on how much of the anchorage unit contributes to space closure. Tweed16 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.

Very early in our history, orthodontists realized the limitations of using teeth as anchorage to move other teeth. Gainsforth and Higley11 (1945) placed vitallium screws and wires in the dog ramus, and applied elastics that extended from the screw to the hook of the maxillary archwire for distalization. All screws failed within 16 to 31 days. Linkow17 (1969) used mandibular blade-vent implants in a patient to apply Class II elastics for retraction of maxillary incisors.

Branemark and co-workers19 (1970) reported the successful osseointegration of implants in bone; many orthodontists began taking an interest in using implants for using orthodontic anchorage. Sherman21 (1978) placed six vitreous carbon dental implants into the extraction sites of mandibular third premolars of dogs and applied orthodontic forces. Two of the implants were firm and were considered to be successful. Creekmore and Eklund26 (1983) attempted to determine if a small sized vitallium bone screw could withstand a constant force of adequate magnitude over a long period of time to depress the entire anterior maxillary dentition without becoming loose, infected, painful, or pathologic.

Block and Hoffman25 (1995) introduced the onplant (Fig.2) to provide orthodontic anchorage.

Kanomi27 (1997) reported that 1.2 mm diameter titanium mini-implants provided sufficient anchorage for intruding the lower anterior teeth. After four months, the mandibular incisors were intruded 6mm.

Costa and colleagues28 (1998) used 2mm titanium miniscrews (Fig.3) 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.
Park and Kim\textsuperscript{19} (1999) examined another 14 patients who had been treated orthodontically with the same skeletal anchorage system. Twenty three of 28 microscrew implants remained firm and stable during five months of orthodontic force. Five microscrew implants failed, presumably due to excessive force during treatment. Lee and colleagues\textsuperscript{20} (2001) reported on the use of microimplants for lingual orthodontic treatment. Lee and co-workers showed that microimplants can provide reliable and absolute anchorage for lingual orthodontic treatment as well as for conventional labial treatment. Fabienne Janssens et al\textsuperscript{11} (2002) reported a case of 12 year old girl for whom an implant was used as orthodontic anchorage and for extruding the impacted maxillary molars. The Onplant was placed on the left alveolar crest in the premolar region. After a healing period of 21 weeks the Onplant was loaded with elastics. 80 gm of force traction was applied to the molars. The total extrusion period was 17 weeks. The stability of Onplant was clinically confirmed as no moment appeared.

Junji Sugawara et al\textsuperscript{12} (2004) conducted a study to distalize molars using skeletal anchorage system which consisted of titanium anchor plates (Fig.4) and monocortical screws that are temporarily placed in either the maxilla or the mandible and evaluated the treatment and post treatment changes during and after distalization of mandibular molars.

Ravinda Nanda et al\textsuperscript{13} (2004) conducted a study to assess the effectiveness of skeletal anchorage for intrusion of maxillary posterior teeth, to correct open bite malocclusion, and to evaluate the usage of titanium mini plates for orthodontic anchorage. 10 patients with age group of 17 – 23 years old and characterized with an anterior open bite and excessively maxillary posterior growth were included. Titanium mini plates were fixed to the zygomatic buttress area, and a force was applied with 9 mm NiTi coil springs between the vertical extension of mini plate and the first molar buccal tube. Results showed that posterior molars intruded effectively by an average of 2.6 mm clock wise rotation of mandible with an average of 1.7 degrees and maxillary molars tipped buccally on an average of 2.8 degrees.

**CLASSIFICATION OF IMPLANTS FOR ORTHODONTIC ANCHORAGE**

1. According to the shape and size:
   a. Conical (Cylindrical)
   b. Palatal Implants
   c. Prosthodontic Implants
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)

**COMPARISON OF TREATMENT USING ORTHODONTIC IMPLANTS AND TRADITIONAL ORTHODONTIC TREATMENT**

<table>
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<td>2.</td>
<td>Stability of Anchorage</td>
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<td>3.</td>
<td>Number of Anchor teeth</td>
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<td>Treatment Efficiency</td>
<td>Applying force on teeth, part of it is wasted, due to periodontal ammoration</td>
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MINIPLATES:
The Miniplate Implants are comprised of bone plates and fixation screws. The plates and screws are made of commercially pure titanium that is biocompatible and suitable for osseointegration.

The miniplate consists of the three components—the head, the arm, and the body as shown in Fig. 5.

1. The head component is exposed intraorally and positioned outside of the dentition so that it does not interfere with tooth movement. The head component has three continuous hooks for attachment of orthodontic forces. There are two different types of head components based on the direction of the hooks.

2. The arm component is transmucosal and is available in three different lengths—short (10.5 mm), medium (13.5 mm), and long (16.5 mm) to accommodate individual morphological differences.

3. The body component is positioned subperiosteally and is available in three different configurations—the T-plate, the Y-plate, and the I-plate (Fig. 6).

The T-plates can be modified and used as L-plates by cutting off one of the screw holes. The surgical site requires at least 2 mm of cortical bone thickness to fix the anchor plate using monocortical screws, which are 2.0 mm in diameter X 5.0 mm in length. Each screw has an internal tapered square head with a self-tapping threaded body.

Sites of Placement:

MAXILLA:
The maxillary sites where screw fixation is possible are limited to the zygomatic buttress and the piriform rim. The Y-plate is usually placed in the maxilla at the zygomatic buttress to intrude or distalize upper molars. Although the lateral wall of the maxilla is usually too thin for screw fixation, the bone of the zygomatic buttress is almost always thick enough. The L-plate is most often placed at the anterior ridge of the piriform opening for intrusion of upper anterior teeth or protraction of upper molars.

MANDIBLE:
In the mandible, screw fixation is possible on the lateral cortex in most locations except adjacent to the mental foramen. The T-plate and/or the L-plate is usually placed in the mandibular body to intrude, protract, or distalize lower molars, or at the anterior border of the ascending ramus to extrude impacted molars.

Orthodontic force is usually applied about 3 weeks after surgical placement of the miniplate, waiting only for soft tissue healing, not for osseointegration. Immediately after orthodontic treatment, all of the anchor plates are removed.

TREATMENT PLANNING:
Miniplate treatment is performed according to an appropriate diagnosis and treatment plan based on the problem-oriented approach.

PRESURGICAL ORTHODONTICS:
Most patients who undergo the miniplate surgical
placement show mild to moderate facial swelling for several days after surgery. Although it is possible to start loading the miniplate immediately, orthodontic force application is usually delayed for 3 weeks to allow for resolution of postoperative facial swelling, soft tissue healing, and reinstatement of oral hygiene procedures. Therefore, it is advantageous to be in rigid archwires (ideally, 0.018 inch X 0.025 inch stainless steel) before surgery. We usually increase the size of archwires up to the level of a full-sized archwire. In addition, the 3rd molars should be extracted either before or during miniplate placement because they prevent distalization and intrusion of the 1st and 2nd molars.

SURGICAL PROCEDURE:
The surgical procedure is performed under local anesthesia with i.v. sedation. Initially, a mucoperiosteal incision is performed in the buccal vestibule. A vertical incision is usually made in the maxilla; a horizontal incision in the mandible. The mucoperiosteal flap is elevated following the subperiosteal dissection to expose the bony cortex. Based on the distance between the surgical site and the dentition on the pretreatment panoramic radiograph, the appropriate shape and length anchor plate is selected. The plate is contoured to the bone surface and placed in its final position. Then a pilot hole is drilled, and a self-tapping monocortical screw is placed. The remaining screws are inserted to firmly attach the anchor plate to the bone surface. Last, the surgical site is closed with resorbable sutures. The surgery takes approximately 10 to 15 minutes for each anchor plate.

- Of all orthodontic implants, miniscrews have gained considerable importance due to less surgical procedure and easy installation.

MINISCREWS:

Titanium miniscrews (Fig. 7) may be an ideal anchorage system that fulfills the clinical needs of the orthodontist. Some of their benefits include dependability, are well accepted by patients, can be immediately loaded, and are simple to insert and remove, and conform to the anchorage needs of the orthodontist. The miniscrew can be loaded immediately with forces in the range of 50 to 300 g. Complete osseointegration is neither expected nor desired with this anchorage system. This anchorage system can be used to support a variety of orthodontic tooth movements in clinical situations involving mutilated dentitions, poor cooperation, or extraction cases requiring maximum anchorage. This system is available in either 1.5- or 2.0-mm diameters. The 1.5-mm diameter screw comes in 6.0-, 8.0-, or 10.0-mm lengths, while the 2.0-mm diameter screw comes in 7.0-, 9.0-, or 11.0-mm lengths. Both diameters are available in three different transmucosal designs to accommodate the soft tissues—low profile, low profile flat, and regular. The low profile screw has a longer transmucosal collar combined with a flat head and is utilized in the thick soft tissues of posterior segments, the low profile flat screw has the same head combined with a short collar and is indicated in the thin tissue of the patient’s anterior segments, and the regular design has an intermediate length with a raised head, and when combined with a resin core can be used as a temporary prosthetic abutment.

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.

SITES OF PLACEMENT:

MAXILLA:

- Infrazygomatic crest area.
- Tuberosity area.
- Between 1st and 2nd molars buccally.
- Between 1st molar and 2nd premolar buccally.
- Between canine and premolar buccally.
- Between incisors facially.
- Midpalatal Area.

MANDIBLE:

- Retromolar Area.
- Between 1st and 2nd molars buccally.
- Between 1st molar and 2nd premolar buccally.
- Between canine and premolar buccally.
Symphysis facially.
- Edentulous Area.
- Mandibular Tori.

IMPLANT DRIVING METHODS:
There are two methods of placement of miniscrews.

1. **Self-tapping method**: In this method the miniscrews is driven into the tunnel of bone formed by drilling, making it tap during implant driving (See Fig.8). This method is used when we use small diameter miniscrews.

2. **Self-Drilling method**: Here the miniscrews is driven directly into bone without drilling (See Fig.9). This method can be used when we want to use larger diameter (more than 1.5mm) miniscrews.

PRESURGICAL ORTHODONTICS:
The surgical armamentarium for miniscrew insertion includes a low-speed contra angle hand piece, a bur with a depth stop, and a hand screwdriver. During surgical planning, the surgical site and screw length are determined. Every effort must be made to avoid contact with local anatomical structures. A site locator (Fig.10) can be fabricated from an orthodontic wire and utilized to determine the insertion position of the screw in the bone.

Long cone radiographs (Fig.11) are taken to visualize the site locator relative to the delicate anatomical structures. Each screw length corresponds to a bur with a depth stop of equal length.

SURGICAL PROCEDURE:
Topical anesthesia is recommended before infiltration anesthesia to reduce needle prick pain. Clinicians should not try to achieve profound anesthesia of the teeth, instead get numbness of soft tissue only. It is prudent for the teeth have some sensitivity, as the patient will complain of discomfort in the event of bone drill contacting the roots, then the drill can be redirected away from the roots. Only one-fourth to one-third of a local anesthetic cartridge is needed for this type of anesthesia. Common sterilizing agents can be used to prepare intraoral & extraoral scrub for keeping the surgical area aseptic.

In Self-tapping method, a round bur (0.9mm) is used to make an indentation on the bony surface as shown in Fig.12. Then pilot drilling is done to make a tunnel in the bone. In order to avoid damages due to overheating, the drilling must be undertaken using the contra-angle hand piece (optimal 800 rpm, maximal 1500 rpm) and external cooling with a sterile, cooled, physiological saline solution (5°C/41°F). The drilling should take place...
intermittently and without pressure so that the tip of the bur may cool down. Finally, miniscrew is loaded in the bone. In Self-drilling method, there is no pilot drilling and miniscrew is loaded directly into the bone.

POST SURGICAL TREATMENT:
Patients should be given standard surgical post operative instructions emphasizing the importance of inflammation control and cautioned not to brush or touch the implant for a week. Ibuprofen or its equivalent is usually adequate for discomfort, and antibiotics are rarely necessary. A chlorhexidine rinse is usually prescribed for 7-14 days, but no other post surgical care is required. Patients with miniscrews should return to the orthodontic office as soon as possible for loading, preferably within one week. In theory, vector of force to stabilize miniscrews is critical to counter tissue, tongue and masticatory forces. Osseointegration is not expected, therefore mechanical stabilization is crucial.

MINISCREW REMOVAL:
Fortunately, strong osseointegration does not occur between miniscrew and bone, and this simplifies the removal of these microscrews. Clinician can engage the miniscrew head (Fig. 13) with the driver and turn it in the opposite direction of the insertion that will easily remove it. What is more, local anesthesia is not needed during this procedure. Patients may have some minor discomfort when the implant irritates the soft tissue while its removal, but this gives far less discomfort than an anesthetic needle-prick.

CLINICAL IMPLICATIONS:
1. Closure of Extraction Spaces: Loss of posterior anchorage during extraction space closure can exacerbate the curve of Spee and deepen the bite. Miniscrews provide reliable skeletal anchorage for anterior retraction in either arch, whether a single tooth at a time or en masse (Fig. 14).

2. Symmetric Intrusion of Incisors: Many patients present with moderate - to - severe deep bites requiring pure intrusion of the anterior teeth to level the occlusal plane (Fig. 15). Unless the deep bite is so extreme that absolute anchorage is needed, it may be inadvisable to place miniscrews simultaneously in both arches in young patients. In these cases, miniscrews can be used to reinforce conventional orthodontic mechanics.

3. Correction of Canted Occlusal Plane: A canted occlusal plane is often considered impossible to level with traditional orthodontic treatment. Miniscrews, on the other hand, provide skeletal anchorage for intrusion of the appropriate teeth on the canted side (Fig. 16).
4. Molar Intrusion: Opinions have differed regarding the efficacy of orthodontic intrusion of posterior teeth. Although miniscrews can be a reliable source of anchorage, it is difficult to place them precisely in the narrow space between the roots of the first and second molars without interfering with the roots. In some cases, more than one screw might even be needed to withstand a relatively high intrusion force (Fig. 17).

Therefore, we suggest limiting the use of miniscrews to situations where simple intrusion of one or two molars is needed and here placement will be unproblematic.

5. Molar Mesialization: Molars are often moved mesially in orthodontic treatment to close extraction spaces or edentulous spaces. Molar mesialization is not a simple movement and can lead to problems such as loss of anterior anchorage and molar tipping. Furthermore, if there is a knife-edge alveolar ridge in the space to be closed, alveolar bone may be lost. A miniscrew placed mesial to the space, at a height that will produce a force vector approximating the center of resistance of the molar, can be a valuable source of anchorage. If the screw is inserted after the initial leveling and alignment have been completed, a full-size archwire can be used to prevent mesial crown tipping of the molar during space closure. Because mesial movement is usually slow, especially in the mandibular arch, no more than 2-3 mm of molar mesialization should be attempted.

6. Molar Distalization: Miniscrews + Distal Jet may be a solution. After the Distal Jet appliance has been placed and activated, palatal miniscrews are inserted between the roots of the first and second premolars, mesial to the activation locks attached to the anterior rests. The miniscrews block mesial movement of the appliance during distalization, thus preventing loss of anterior anchorage. Further compression of the Distal Jet's coil springs will move the locks distally, away from the miniscrews; during this phase, anchorage loss can be prevented by bonding light-cured composite between the screw heads and the locks. After molar distalization, the Distal Jet is converted to a passive retainer, and brackets are bonded to the teeth for completion of the Class II correction. Another option is to remove the miniscrew after molar distalization and replace it just mesial to the distalized molar, where it will stabilize the molar while the remaining teeth are moved posteriorly.

CONCLUSION:

Success of orthodontic treatment relies on anchorage control. So anchorage preparation is a very important part of orthodontic treatment. Prior to initiation of orthodontic therapy, it is essential to carefully assess the anchorage demands of an individual case so that appropriate treatment modalities can be executed. Various sources of anchorage have been used from the 17th century to till date. Every anchorage source has some advantages and some limitations. Anchor preparation is different from patient to patient. Use of extraoral anchorage such as headgears requires full patient cooperation, but this cooperation is not seen especially in teenagers. With the introduction of implants in orthodontics, this problem has been solved. Implants do not require any patient cooperation, so we can get a good anchorage control in our patients. Implants provide absolute anchorage i.e. complete bone anchorage. Implants have revolutionized the field of anchorage in orthodontics. So by choosing a correct anchorage source we can get good results in orthodontic treatment.

REFERENCES:


