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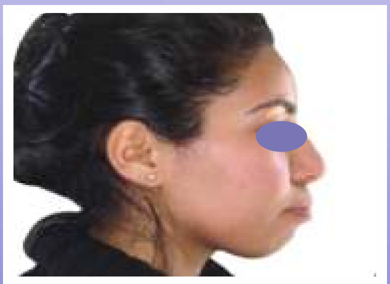

Knowledge of Dental trauma and impact on tooth movement

Application of temporary anchorage devices

Combined orthodontic and periodontal management: A case report

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The Use and Application of Temporary Anchorage Devices in Orthodontic Treatment: A Review

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Abstract

Anchorage control plays an important role in orthodontic treatment. Tooth movement, as seen during orthodontic treatment is made possible with good and adequate anchorage to allow for tooth movement in the desired direction. The success of orthodontic treatment hinges on the anchorage protocol planned for any particular case.

Over the years, anchorage has been sought with the use of conventional methods, ranging from the use of intraoral structures (teeth) to the use of extraoral devices such as headgear, which require full patient cooperation for effectiveness.

These methods are limited in that it is often difficult to achieve results that are commensurate with the ideal goals of treatment. With the introduction of implants in the form of temporary anchorage devices (TADS), absolute and compliance-free intraoral anchorage has been provided, taking care of the possible problem of anchorage in orthodontic treatment. This is a review article that seeks to describe the current use and application of TADS in the contemporary management of orthodontic patients.

Keywords: Temporary anchorage devices, orthodontics, implant, anchorage.

ORIGINAL ARTICLE

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Introduction

All orthodontic appliances can be said to have two components- the active and the resistant components. The active component generates the force and the resistant component is responsible for providing the resistance to make the force effective.[1]

Tooth movement during orthodontic therapy is brought about by forces generated by the active components of an orthodontic appliance.[2] For every force applied, there is an equal and opposite reactive force (Newton's 3rd law of motion) on the anchorage units, tending to cause their movement, which is not desirable. For tooth movement to occur in the desired direction, this reactive force should be equal to or greater than the applied force. The areas or units which provide the resistance to the reactive force, thus preventing their undesired tooth movement, are referred to as the anchorage units.[2]

Graber defined anchorage as the 'Nature and degree of resistance to displacement offered by an anatomic unit, when used for the purpose of effecting tooth movement.[3] Anchorage, which is based on Newton's third law of motion, is a prerequisite for successful orthodontic treatment of malocclusions.[3]

Traditionally, orthodontists have used teeth, intraoral appliances, and extraoral appliances, to control anchorage. Traditional appliances for reinforcement of anchorage have included headgear and intraoral elastics.[4]

Conventional intraoral and extraoral anchorage systems often fall short of providing absolute/stable anchorage[5], even with the full cooperation of the patient.[4] These methods often have inadequate mechanical systems for anchorage control leading to anchorage loss of reactive units and results in unfinished intra and inter-arch alignment.[6] The incorporation of bulky acrylic appliances or extraoral appliances by clinicians has resulted in poor patient compliance which contributed to loss of anchorage.[6] Absolute anchorage is defined as no movement of the anchorage units and can only be achieved by using ankylosed teeth or dental implants.[7]The introduction of skeletal anchorage in the form of temporary anchorage devices (TADs) or mini-screws has greatly benefited orthodontists in finding a way into anchorage control with minimum patient compliance, and without anycomplicated clinical and removal procedures[,7]

Temporary anchorage device (TAD) is a device that is temporarily fixed to the bone to enhance orthodontic anchorage, either by supporting the teeth of the reactive unit, or by obviating the need for the reactive unit altogether, which is subsequently removed after use.[5, 7] The incorporation of 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 the reaction forces applied.[5,7]

Types

TADS can provide anchorage in two different ways- directly and indirectly. In direct anchorage, the mini-screws directly receive the reactive forces by acting as the anchor unit, while in indirect anchorage, the mini-screws are connected by bars or wires to the reactive unit.[3]

Multiple types of implant anchorages are available, these include palatal plates, onplants, miniplates, and mini-screws.[8]

Temporary anchorage devices have been classified according to different types:[9]

1. Based on morphology
   i. Screw type - mini screw implant
   - Micro implant
   - Aarhus implant
   - Spider screw
   - Disc type - On plant
   - Plate type - Mini plate implants
   - Zygoma anchorage system

2. Based on head exposure
3. Open
4. Closed
5. Based on surface texture
6. Threaded
7. Non-threaded
8. Porous
9. Non-porous

Temporary anchorage devices used are subdivided into two main types.[10]

1. Surgical miniplate implants – Orthodontic anchorage is accomplished via altered or mini plates of sterile titanium with intra-oral expansion.

2. Mini-screw implants – In dental orthopaedics, these devices feature mechanical retention and provide short-term anchoring.

Classification of Skeletal anchorage devices

Skeletal anchorage devices can be classified into two groups based on their origin.[7] The first group belongs to osseo-integrated dental implants and includes the orthodontic mini-implants, the retromolar implants, and the palatal implants.

The second group originates from the surgical mini-implants such as the one used by Creekmore and Eklund.[7]

Orthodontic implants have been classified according to:[10]

1. Shape and size
   a) Conical (cylindrical)
      - Mini screw implants
      - Palatal implants
      - Prosthodontic implants
   b) Miniplate implants
   c) Disc implants (onplants);

2. Implant bone interface
   a) Osseointegrated
   b) Non-osseointegrated
3. Application
   a) Orthodontic implants
   b) Prosthodontic implants
4. Location
   a) Subperiosteal: Implant body lies over the bony ridge
   b) Transosseous: Implant body penetrates the mandible completely.

c) Endosseous: Partially submerged and anchored within the bone. Endosseous implants are commonly used for orthodontic purposes.

5. Configuration design

a) Root form implants: These are the screw-type endosseous implants – the name derived from their cylindrical structure.

b) Blade/plate implants: These are flatter and can be used in resorbed knife-edge ridges.

6. Composition

a) Stainless steel

b) Cobalt- chromium-molybdenum (Co-Cr-Mo)

c) Titanium

d) Ceramic implants

e) Miscellaneous, such as vitreous carbon and compositescarbon and composites

7. Surface structure

a) Threaded or non-threaded: The root form implants are generally threaded as this provides for a greater surface area and stability of the implant.

b) Porous or non-porous: The screw type implants are usually non-porous, whereas the plate or blade implants (non-threaded have vents in the implant body to aid in the growth of bone, and thus a better interlocking between the metal structure and the surrounding bone.[5,11]

Surface modification

Mini-screws need to be mechanically stable during treatment to provide sufficient anchorage and predictable force control, and as temporary devices, they need also to be easily removable after treatment. These requirements dictate the approach as to how their clinical performance can be optimized. The stability of orthodontic mini-screws is paramount to their clinical acceptability. Their clinical stability has been proven to be exceptionally high.[12]

Various surface modifications have been proposed to enhance their stability, thereby allowing the orthodontist to optimize and expand their clinical uses. The various surface treatments of titanium implants have been known to modify both the surface composition as well as its topography, thereby increasing the implant surface roughness and area, which might lead to enhanced bone screw contact (BSC).[12-14] Surface modification also enhances the interactions with biological fluids and cells, and thereby, accelerates peri-implant bone healing and improves osseointegration at sites with insufficient quantity and/or quality of bone.[12]

Broadly, surface modification can be categorized into either subtractive or additive methods. The subtractive methods are machining/turning, sandblasting, acid-etching, sandblasting (large-grit) combined with acid etching (SLA), dual acid-etching, and laser treatment.[12]

The additive methods are anodization (also known as anodic oxidation), fluoride surface treatment, plasma spraying (titanium or hydroxyapatite), sol-gel coating, sputter deposition, electrophoretic deposition, biomimetic precipitation (Ca-P), and most recently, nanoscale modifications with or without drug incorporation.[12,15] A more recent method is the non-additive and non-subtractive method – the ultraviolet (UV) photo-functionalization.[12]

The SLA, micro-grooving, anodization, plasma ion implantation, resorbable blasting media (RBM), and nanoscale modifications are techniques meant to be incorporated into the manufacturing process, while the UV photo-functionalization technique can be used as a chair-side method for surface treatment of mini-screws. This technique (UV photo-functionalization) is yet to be tested clinically with orthodontic mini-screws.[12]

Indications for temporary anchorage devices (TADS)

TADs are generally mini-screws placed in either the alveolar bone or extra-alveolar bone, to provide anchorage. As opposed to a dental implant that serves as an anchor device with the intention of utilization as a dental prosthesis following its use as an orthodontic anchor. The hallmark of the TAD is its intended removal once its function is completed in the treatment regimen.[16] TADs have found application in the following clinical situations:[17,18]

Absolute anchorage: In maximum retraction requirements, for patients not compliant with headgears, in cases of missing first molars – TADs can provide anchorage as well as space management for difficult tooth movements such as anterior or posterior intrusion, en masse distalization of the upper or lower arches.[6]

Anterior retraction: This is the commonest use of TADs, it is utilized in cases where the bicuspids have been extracted, or in cases with generalized spacing where anchorage concerns are significant. This could be achieved through direct or indirect methods.[16]

Protraction of posterior teeth: In this clinical situation, posterior teeth are moved anteriorly, often to prevent having to place an implant and a lifetime maintenance for a young patient. One of the promising uses of TADs for protraction occurs when a second primary molar is lost and there is no second bicuspid to replace it. The molar relationship is determined by the absence or presence of teeth in the opposing quadrant.[16]

Molar or posterior arch intrusion: This is done in conjunction with the prosthodontic replacement of teeth, in cases where there is supra-eruption of unopposed teeth in an opposing arch. It is useful for the correction of occlusal cants and the intrusion of posterior teeth for open-bite correction.[6,16]

Molar distalization for Class II correction: This could be achieved by the use of palatal TADs attached to a trans-palatal arch bonded to the first or second bicuspids.[16] This can also be achieved by TADS placed distal and buccal to the molars to be distalized.

Anterior intrusion for deep bite correction: This could be achieved through direct or indirect anchorage for the intrusion of anterior teeth for the correction of a deep overbite especially in patients with excessive gingival display and maxillary incisor display.[16]
Reads can be used additionally with expansion appliances for palatal expansion in patients who were thought to have passed the age at which the palate can be expanded,[16] and in adult orthodontics for complex tooth movements.[6] Other uses of TADs include - Uprighting molars, appliance anchorage, eruption of impacted teeth, correction of midline asymmetry and cant of occlusion[6], and

- As attachments for elastics in condylar fractures in young patients (especially in those whose have erupted all permanent teeth) essentially replacing archbars.[6,16]

For patients with a need for asymmetrical tooth movement in all planes of space andin some cases, as an alternative to orthognathic surgery,[19, 20] this is particularly common in the management of moderate cases of Class III skeletal malocclusion with a reverse overjet, where surgery may be indicated, TADs are used to achieve sufficient molar distalization and subsequent correction of the Class III incisal relationship.

Contraindications

1. Mixed dentition where developing permanent teeth will interfere with the placement of the mini-screws (US Food and Drug Administration has approved orthodontic mini-screws for adults and adolescents of age 12 and older only).[17]

2. Midpalatal region of the growing patient, where the micro-implants can restrict the horizontal growth of the maxilla.[17]

3. In patients with systemic alteration in bone metabolism due to disease, medication, or heavy smoking.[17]

The absolute contraindications for their use include severe systemic disorder e.g. osteoporosis, psychiatric diseases, e.g. psychoses, dysmorphia, and alcoholic drug abuse; while the relative contraindications are insufficient bone volume, poor bone quality, patients undergoing radiation therapy, insulin-dependent diabetes, and heavy smokers.[17]

Patient selection

Case selection in the use of TADs like any other implant therapy will go a long way in determining the success of the implant system. Initially, the patient's medical history, and assessment of the oral cavity for the absence of gingival inflammation and periodontal diseases are done.
Informed consent should always be obtained from the patient or the parent. Alongside the usual orthodontic records, intraoral radiographs of the proposed miniscrew sites should be taken to assess the bone morphology and roots of adjacent teeth.[6,21] For further assessment of bone quality if required, a cone beam computed tomography (CBCT) may be taken for bone density values.

Site selection for placement of TADs

Selection of the location and placement of TADs is a technique-sensitive procedure.[18] The choice of mini-implant insertion sites should be based on appropriate regions of soft tissues, such as the presence of attached gingiva, adequate amount of cortical bone, the angulation and size of the mini-implant, and foremost, the type of movement that is desired.[18]

In the maxilla, interradicular alveolar areas like the width of buccal cortical bone on the entire maxillary alveolar process arelimited (3mm to 4mm), so longer screws are needed.[11]

The sites most often utilized for miniscrew insertion in the maxilla include:

- Inter-radicular spaces, both buccal and lingual.
- Extraction spaces
- Inferior surface of the anterior nasal spine.[18]
- The palate
- The alveolar process, the infra-zygomatic crest, and the retromolar area.[3,19,22]

The best available position for a mini-screw is in the posterior maxilla, following a CBCT study by Deguchi et al,[23] are as follows:

1. Mesial or distal to the first molar
2. The best angulation is 30° apically to the long axis of the tooth, and
3. The safest length is 6mm of bone contact with a diameter of 1.3mm.[23]
4. Between the two central incisors, which is particularly good for intrusion
5. Infrazygomatic region – zygomatic buttress
6. Maxillary tuberosity region
7. Mid palatal area.[11]

Alternatively, the palate can be used with the clear benefits that the palatal cortical bone is of good quality and thickness,[11] and there is no interference with the roots of the teeth.[18]

In the mandible: inter-radicular alveolar area- as the cortical bone on the buccal area in the mandible is very dense, the screws are smaller in size, so the possibility of root contacts is remote.[11]

In the mandible, the commonest miniscrew placement sites are:

- Between the second premolar and the first permanent molar.
- Between the first and second permanent molars.
- Between the two central incisors
- Between the mandibular canine and premolar buccally.[11]
- Interradicular spaces, both buccal and lingual.
- Lateral to the mentalis symphysis
- Extraction spaces[18]
- In the alveolar process, the retromolar area, and the symphysis, an intraoral radiograph is required to determine the correct location.[19,22]

The mesiodistal widths of the interradicular space are more favourable between the mandibular permanent first and second molars at almost every level, starting from 2mm below the alveolar crest. The second-best location in the region is between the mandibular second premolar and first molar.[24]

In general, thin keratinized tissue is preferred over non-keratinized tissue, while placement in attached gingiva or at the mucogingival junction reduces tissue overgrowth,[20] ideally, 4-5mm interradicular bone stock.[25]

Sites to be avoided during placement of TADs include anatomic vital structures – the inferior alveolar nerve, artery, vein, mental foramen, maxillary sinus, and nasal cavity.[11] The diameter of the screw will depend on the site available. In the maxilla, a narrow implant can be selected if it is to be placed between the roots. If stability depends on the 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 of the implant should be selected after assessing the mucosal thickness of the implant site.[22]

Placement technique

The mini-screw implants can be either self-drilling or non-self-drilling. In the self-drilling, the pilot hole is not required, except where the cortex is thicker than 2mm, where dense bone can bend the tip of the screw.[3, 22] They are newly designed osteosynthesis screws with specially formed tips and cutting flutes which are like a corkscrew and can be inserted into bone without pre-drilling.[3] In the non-self-drilling type, predrilling is required. With predrilling there are chances of damage to the nerves, tooth roots or tooth germs, thermal necrosis of the bone, and drill bit breakage.[3] The pilot drill should be 0.2 - 0.3mm thinner than the screw and should be inserted to a depth of no more than 2-3mm.[22] Pilot drilling should be done in a surgical environment, as with the placement of a dental implant, it should be preferably done by an oral surgeon.[3,22] The procedure is performed under a small amount of local anaesthesia. Soft tissue from the site is first removed using issue punch, then a pilot hole is drilled using a drill bit rotating at not more than 1000rpm. The implant is the placed using an appropriate screwdriver.[3] Tactile sensation is felt on contacting a tooth root when manual screwdriver is used for placement of the implant, thus resulting in minimal damage.[22]

The site will determine the diameter and length of the TAD to be used. Before insertion, the decision on whether or not to use the radiographic stent is made. An adjustable acrylic template or surgical guide, prior to the mini-screw implant placement, should be used.[3] The radiographic stents are used in the anterior region where interradicular placement of TADs can be particularly challenging because of the chairside vantage point and proximity of the roots to the facial cortical plate. In the posterior buccal region, the roots are diverged. If needed, TADs are placed using only panoramic evaluation.[25]

Proper angle of insertion is important for cortical anchorage, biomechanical control, and avoidance of root contact. In the posterior buccal region, the angle of insertion should be 30° to 45° to the occlusal plane, with the exception of posterior impaction cases or edentulous regions in which the angle of insertion should approximate 90° to the occlusal plane (parallel to the sinus floor). While angulations less than 45° increase cortical bone-implant contact[23] and minimize the likelihood of root perforation, it may increase the risk of TAD slippage.[25] 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 the teeth are present.[22]

How to insert a TAD

Select carefully the area where the mini-implant will be placed, taking into cognizance the adjacent roots, the mental foramen, and the inferior-alveolar nerve. The use of a preprocedural antimicrobial mouth rinse is often recommended to reduce the bacterial load and risk of infection. Apply some numbing gel after which little topical lidocaine is injected in the area. Care should be taken so as not to over anaesthetize the area as the sensation of the adjacent root is needed in case the screw touches the roots. A fine explorer is used to place a small pinch mark on the site where the mini-implant will be placed. When ready, the mini-implant is held with the mini-implant handle, ensuring that the mini-implant head is locked in the handle. The placement procedure is begun by placing the mini-implant head perpendicular to the bone where the pinch mark was placed, inserting the implant gently in the clockwise direction to get some bone engagement. With the tip of the mini-implant engaged in the bone, tilt the mini-implant more apically and completely insert the mini-implant in the bone exposing only the head. This will help to get more bone engagement and minimize the chance of root encroachment. Take a simple X-ray to make sure the mini-implant is placed correctly.[22] After a successful insertion procedure, over-the-counter (OTC) analgesics can be prescribed for 1 to 2 days for discomfort.[25]

Implant maintenance

After the placement procedure, the surrounding soft tissues must be maintained to ensure the longevity of the implant. Plaque accumulation near the gingival margin can cause peri-mucositis, while prolonged inflammation leads to breakdown of bone around implants and peri-implantitis. Without proper management, this can lead to implant failure. Patient therefore must be instructed to follow daily plaque control at home and have periodic professional care, similar to regular periodontal care.[19]

Implant removal

On the completion of treatment, the implant is unscrewed using the screwdriver with or without the use of topical or local anaesthesia. In the event of its non-removal, it is advised to wait for 3-7 days as the induced microfractures can cause the screw to loosen.[3]

Advantages of TADs

1. TADs control anchorage as needed
2. Shorten treatment time
3. It helps to direct orthodontic forces in any given direction
4. It helps to provide extra retention in certain cases.
5. The provision of sufficient anchorage for tooth movement
6. Convenience of placement and removal
7. Low cost.[26]
8. Relatively comfortable and adaptable
9. Reduces the need for patient compliance
10. Makes certain oral surgeries unnecessary
11. Eliminates the risk of ocular damage associated with headgear use.
12. Good access to various placement sites
13. Minimal discomfort with no residual surgical defects
14. Versatile placement i.e. buccal or palatal.[11]
15. Immediate loading
16. Economic.[3]

Disadvantages of TADs

1. Different anatomic sites with different anatomical features
2. Rotational instability
3. Impairment of anchorage
4. Irritation of the mucous membrane
5. Injury to roots or neurovascular bundles.[27]
6. Fracture of the miniscrew
7. Need for surgery and high cost (for mini plates).[26]

Complications

Although the success rate was high with the use of TDAs, possible complications include pain, inflammation, and fracture of the device,[28] infection and tissue irritation of the surrounding tissues can occur, likewise injury to adjacent roots, periodontal ligament, nerves, blood vessels, failure when there is inadequate thickness of the cortical bone or fracture of the miniscrew implant during removal if the neck is too narrow.[3]

Conclusion

For the successful treatment of orthodontic cases, there is a need for absolute anchorage to prevent the undesired movement of teeth in the undesired direction. The introduction of temporary anchorage devices (TADs) in the orthodontist armamentarium with its versatility of use and most importantly its ability to provide maximum anchorage, which is independent of patient compliance, has greatly improved the outcome of orthodontic treatments.

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