TEMPORARY ANCHORAGE DEVICES (TADs) IN ORTHODONTICS

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Abstract

The recent upsurge in the field of orthodontics has been overwhelming. Several new implant systems have been marketed in the recent past owing to the widespread commercialisation. An understanding of the indications, contraindications and force system aspects of implants is very crucial for the modern day Orthodontist.

Introduction

The explosive development of temporary anchorage devices (TADs) presents a professional dilemma for Orthodontists. Although a large body of evidence supports osseointegrated anchorage, most miniscrew and microscrew systems currently are not designed for osseous integration (osseointegraion) and were marketed with little or no fundamental scientific verification[1].

Clinical applications have superseded the scientific rationale for their effective use. In the absence of adequate (evidence-based) research, clinicians must rely on a limited number of basic science studies, supplemented by scientific justification of fundamental data derived from investigations of other types of endosseous implants. Nevertheless, the TADs have been proven superior to conventional anchorage[2,3].

Historical Perspective

Dental implant anchorage has progressed from non-integraed screws (1940's) to Osseo-integrated devices (1972 to present).

In 1945, Gainsforth and Higley used vitallium screws and stainless steel wires in dog mandibles to apply orthodontic forces. However, the initiation of force resulted in screw loss.

In 1964, Brånemark et al observed a firm anchorage of titanium to bone with no adverse tissue response.

In 1969, they demonstrated that titanium implants were stable over 5 years and osseointegrated in bone under light microscopic view.

Since then, dental implants have been used to reconstruct human jaws or as abutments for dental prostheses. The success has been attributed to the material, surgical techniques, and the manner that implants are loaded.

In 1969, Linkow placed blade implants to anchor rubber bands to retract teeth, but he never presented long-term results.

The first documented use of Osseointegrated Orthodontic Anchorage was in a patient treated from 1972 to 1975 by Dr. Tom Horton (Columbus, Georgia) and Dr. Hilt Tatum (Opelika, Alabama). Dr. Horton corrected a buccal cross-bite with a bite plate and cross-elastics anchored by an osseo-integrated Ti blade implants.

In 1984, Roberts et al corroborated the use of implants in orthodontic anchorage. 6 to 12 week after placing titanium screws in rabbit femurs, a 100g force was loaded for 4 to 8 weeks by stretching a spring between the screws. All but 1 of 20 implants remained rigid. Titanium implants developed osseous contact, and continuously loaded implants remained stable.

The results indicated that titanium implants provided firm osseous anchorage for Orthodontics and Dentofacial Orthopedics.

Although clinical application of screws had been fairly rapid, the scientific evidence of its success and stability was lagging.

From 1980 -1988, Eugene Roberts performed a series of experiments to develop Orthodontic anchorage devices, at the Bone Research Laboratory at the University of Pacific in San Francisco,. Titanium miniscrews 2 mm in diameter with an acid etched surface, were tested in rabbits, dogs and monkeys.

These devices were very predictable when placed in extraoral sites such as rabbit femur and nasal bones, but the intraoral use of the mini-screws in dogs and monkeys was less successful (failure rate - 25% to 50%).

Thus it was apparent that the biological efficacy of miniscrews and implants was lagging behind the rapid increase in their cinical use.

Because of the long history of clinical success without any serious complications (e.g., osteomyelitis. neoplasms), the implant systems started getting approval from the various certification boards around the globe.

Since 1995 over 10-15 new systems of implant have been introduced including the Aarhus system, Lomas system & K-1 system from Kanomi.

Classification of Temporary Anchorage Devices (TADs) According to Origin/Evolution [1]

According to Birte Melsen[1]

Skeletal anchorage systems can be classified into two categories according to their origin.

Group one: It has been developed from dental implants and is characterised by an intraosseous part that is surface treated to enhance the osseo-integration.

This category includes Palatal implants and Retromolar implants.

These devices are inserted as dental implants with a - procedure followed by a healing period for osseo-integration before loading is accomplished. A special variant in this category is the onplant introduced by Block and Hoffman. The onplant is considered less invasive because it is not placed into bone but rather between the periosteum of the palate and the bone using a tunneling procedure.It consists of a titanium - hydroxyapatite-coated disk with a threaded hole that is placed towards the mucosa;

Group two: The other category of skeletal anchorage originates from surgical screws and is characterized by a polished inraosseous part with a surgical screw attached. It is loaded immediately after insertion The two main subgroups are:

(1) Miniplates With Various Trans-mucosal Extensions

As Developed From Dental Implant	As Developed From Surgical Screws
Palatal Implants	Mini-plates
Onplants	Mini-screws
Retromolar Implants	
Orthodontic Mini Implants, Micro Implants	

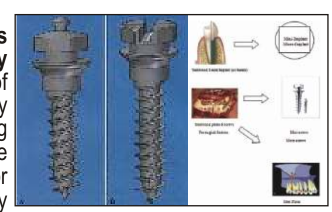
(2) Single Screws

As Developed From Dental Implant	As Developed From Surgical Screws
Rough/treated Surface,	Smooth Untreated Surface
Treated With Acid Etching Or Sandblasting,	Untreated Surface
With Or Without Hydroxy-apatite Coating,	Untreated Surface
Without Threads	With Threads
Lag Time For Loading	Immediate Loading (mostly)

A third hybrid variety is of implants that are developed from screws but have been surface treated for osseointegration property.

Ex Aarhus mini-implant

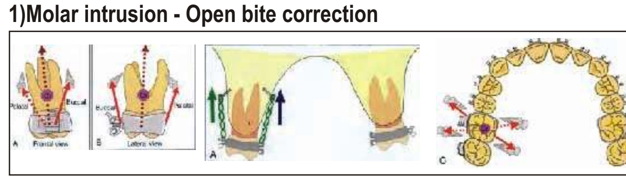
Indications[1]



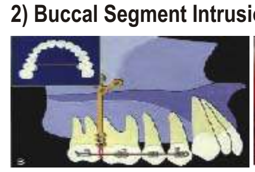
Types of tooth movements performed with Temporary Anchorage Devices : The use of TADs has been reported in a variety of Orthodontic cases including bialveolar protrusion[4],deep overbite & gummy smile[5,6],maxillary incisor intrusion[7],Rapid maxillary expansion[8,12],open bite[9],intrusion of multiradicular teeth[10],en masse retraction of anterior teeth[11],molar distalistaion[13,16],anchorage reinforcement in adult patients[14],canine retraction[15],en masse distalisation of entire upper arch[17],ectopic canine[18],reinforcement of poeterior anchorage[19].

Some of the common movements achieved by TADs are enlisted below:

1)Molar intrusion - Open bite correction

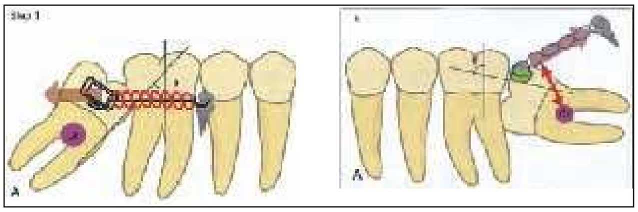


2) Buccal Segment Intrusion



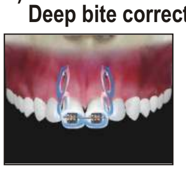
3) Molar Distalisation

4) Molar Uprighting

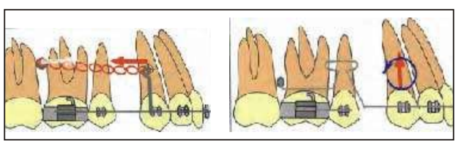


5) Molar Protraction

**6) Incisor Intrustion-
Deep bite correction**



7) Space Closure



Contraindications[1]

The ORTHO Implant should not be placed in patients with the following:

Absolute Contraindications

History of bisphosphonate therapy, hypersensitivity, titanium allergies, metabolic bone disorders, bone pathologies, poor bone healing, uncontrolled periodontitis, undergoing radiation therapy, severely decreased bone quality/quantity or localized active infection.

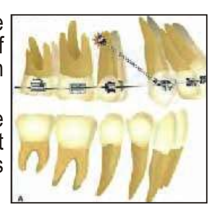
Relative Contraindications

Use of tobacco, oral mucosal pathologies, poor oral hygiene, poor patient compliance, physical handicaps that prevent adequate oral hygiene and/or maintenance, insufficient interradicular/intraradicular space.

Direct Versus Indirect Anchorage[1]

Anchorage from TADs can be obtained directly or indirectly.

Direct Anchorage



It is the application of a force directly from the skeletal anchorage device to a tooth or group of teeth; thus it can be described as a TAD-tooth interaction.

The line of force is usually at an angle to the occlusal plane, resulting in an ever present intrusive force when direct intra-arch anchorage is applied.

Indirect Anchorage

It is a tooth - tooth interaction.

The anchor unit or reactive unit (tooth or group of teeth) is attached rigidly to the skeletal anchor device.

Therefore the force is generally applied along the occlusal plane.

The indirect approach can be easily integrated to the straight wire technique or any other traditional orthodontic technique.

The most common example of the indirect anchorage approach is the Orthosystem implant (Straumann, Waldenburg. Switzerland) in the palate.

This mini-implant once osseo-integrated in approximately 10 weeks, is connected by a rigid palalal bar to the anchor teeth (usually the molars).

Force System[1]

Mini-screws are used to generate a constant single force with mild to moderate magnitude, regardless of the patient's compliance.

The actual treatment outcome therefore largely depends on the force system designed by the Orthodontist. To achieve predictable results with the mini-screws, two factors are essential:

(1) A thorough understanding of the anatomical structure to find appropriate insertion site (2) The knowledge of biomechanics to construct a precise force system. The force delivered by the miniscrews can be characterized as follows:

(1) Single linear force: A single mini-screw and the elastic components (elastic chains or nickel titanium Ni·Ti coil springs) engaged to the screw head generate a linear force whose line of action is represented by the direction of the elastic component. It is not yet recommended to apply torsional force on a single miniscrew because it may threaten the miniscrew stability, whether it is a winding or unwinding motion.

The line of action is thus determined by the insertion site and the location of the attachments on the tooth or the hooks on the archwire.

(2) Moderate magnitude of force: A single mini-screw is expected to withstand approximately 200 to 300 grams (g) of force which appears to be sufficient to move segments of teeth or a single tooth.

This conversely implies that multiple miniscrews may be needed to provide anchorage to heavier forces for the movement of larger segment, such as the posterior segment or the whole arch.

(3) Intrusive component of force: Conventional Orthodontic mechanics tend to extrude the teeth by "jiggling" motion.

Because miniscrews are usually placed apical to the archwire, the forces from the miniscrews normally have an intrusive component, causing some intrusion of the dentition.

In Conventional Mechanics the molars or posterior teeth have always served as the anchor, with the rest of the arch as the moving part.

The biomechanical principles were complicated because the force system had to be differentially expressed in the moving part and the non-moving (anchor) part in the same arch.

In contrast, when mini-screws are incorporated in the system as third counterpart , selective movement of the anterior and posterior segments is possible.

However, precise planning for the amount of tooth movement desired is thus a pre-requisite before active treatment can be initiated.

Appliance Design[1]

(Step By Step Construction Of Mini-Screw System)

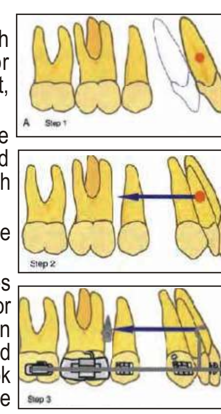
Appliances are Constructed according to the following step·by·step procedure:

Step I. Determine the required type of tooth/segment movement.

Step II. Determine the required force system.

Step III. Determine the insertion site and point of force application.

Step IV. Modify the appliance as needed



Step 1 refers to the type or amount of tooth movement desired. such as tipping or translation. This is the step for deciding "what, where, and how' to move the specific tooth.

Step 2 is construction of a suitable force system, including line of force(s) and moment(s) for the desired tooth movement with regard to the estimated center of resistance.

Step 3 is the final stage of appliance design**.**

For example: If a line of force passes through the center of resistance of the anterior segment for retraction, the mini-screw position and the archwire hook need to be determined accordingly so that the line connecting the hook and the mini-screw head is identical to the planned line of force.

Step 4 is sometimes necessary because of limitations in the insertion sites and appliance design.

Placement System

(a) Drill-free System: (Self Drilling) : In this system, the mini-screw is self drilling and there is no need of pre-drilling at the insertion site by a bur.

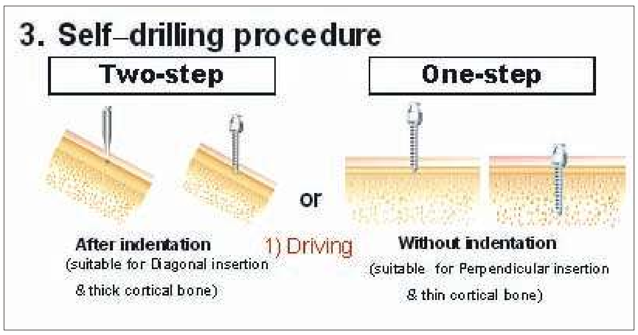
Advantages:

(a) Operative procedure is relatively simple because it does not require costly armamentarium, such as a handpiece, engine. and surgical burs for pilot drilling. (b) Manual drilling can provide better tactile sense enabling the operator to sense probable root contact during insertion. (c) Orthodontic loading can be applied immediately after mini-screw insertion. (d)The self-drilling type of screw can lead to significantly greater bone-implant contact. Guide drilling may threaten the stability by an increase in localized remodelling or cell death caused by excessive heat generation when the revolutions per minute (rpm) value is high.

(b) Drill System (Self Tapping): In this system a pilot drilling is done to make the housing for the mini-screw into the bone and then the screw itself is inserted into it.

The bone density and thickness of the cortical bone are less in the maxilla than that in the mandible.[20]

According to Lohr et al a self-tapping screw is suitable for the dense, thick bone and a self-drilling screw for the thin cortical bone area.[21]



Two major factors in the increased use of skeletal anchorage devices are

(1) Difficulty in obtaining satisfactory compliance from patients which has led Orthodontists to focus on appliances that function independently of compliance (compliance-free anchorage), (2) The growing number of adult and elderly patients in whom reduced dentition rules out the use of conventional appliances.

Conventional anchorage/intraoral dental anchorage is based on the rule of thumb that more teeth deliver anchorage against the displacement of fewer teeth. Because there is no lower limit for the force that can produce tooth movement, none of these appliances can deliver absolute anchorage.

Another compliance free anchorage approach is the differential moment concept, in which the stimulus to the anchorge unit is "translatory movement, whereas the stimulus to the unit of teeth to be moved is "tipping".

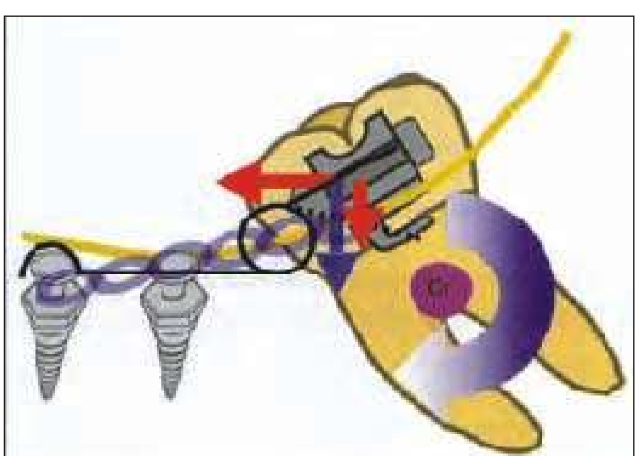
The differential moment approach is based on tipping being easier to accomplish than translatory movement, and thus anchorage is preserved.

Although some conventional/compliance free anchorage systems have been able to provide differentiated anchorage, none of the methods has yet been able to deliver the absolute anchorage desired by Orthodontists.

Only through ankylosed teeth and skeletal anchorage systems has "absolute anchorage" been achieved.

Advantages Of Skeletal Anchorage[1]

Skeletal anchorage is most frequently used to replace conventional anchorage, especially headgear, thereby reducing problems with compliance for adequate anchorage.



Some case reports and clinical studies have also demonstrated that skeletal anchorage can widen the spectrum of Orthodontics, allowing treatment previously considered difficult.

Melsen et al(1998)[22] performed retraction and intrusion of anterior teeth against a surgical wire placed through the infrazygomatic crest in patients with missing molars.

Robert et al(1990)[23] used Orthodontic implants to displace the second and third molars into the extraction space of a first molar, without displacing any teeth in a posterior direction.

Conclusion

The skeletal anchorage through Temporary anchorage devices has been widely used in orthodontics scenario these days. Although its usage has proven to provide superior anchorage value as compared to conventional means of harnessing anchorage, the temporary anchorage devices should be rationally prescribed for a patient and their unjudicious use and overexploitation should be avoided.

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