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Temporary Anchorage Devices: A Review

YAMINI KAUL[1], DARSHIT DHANANI[2], ASHISH CHOUDHARY[3]

ABSTRACT

The need for skeletal anchorage in orthodontics has increased with the growing number of adult patients seeking orthodontic treatment. In addition, complex treatment goals, patients with missing teeth, non-compliance with extra-oral anchorage have all added to the growing need for skeletal anchorage. The success of implants being used as anchors has widened the horizons of the orthodontist and are welcome additions to the armamentarium of a clinical orthodontist, which should be explored to the best possible advantage for treating patients.

KEYWORDS: Temporary anchorage devices, Anchorage, Mini screws, Mini implants

INTRODUCTION

Anchorage is a critical issue in orthodontics. The struggle to control anchorage can be one of the most challenging factors for an orthodontist during the course of treatment.[1]

Anchorage, if inadequate, can be the most limiting factor of therapy, no matter which technique or philosophy the clinician follows. Traditionally, orthodontists have used teeth, intraoral appliances, and extraoral appliances, to control anchorage— minimizing the movement of certain teeth, while completing the desired movement of other teeth. However, the main drawback was that most relied on patient compliance to be successful.[1]

Temporary Anchorage Devices (TADs) represent a revolutionary change to obtain absolute anchorage without the need for patient compliance. They are a new means to an end, not defined previously. Thus, the promise of temporary skeletal anchorage devices is that they can serve as controllable and efficient anchors for any tooth movements the orthodontist would care to make. They are a completely new method of solving an old problem.[2]

Evolution of skeletal anchorage

The first evidence of the use of implants dates back to 600 AD in the Mayan population. They used fragment of a mandible as the implant to replicate three lower incisor teeth.[3]

In 1809, Maggiolo described the process of fabricating and inserting gold roots to support teeth.[4]

In 1891, a physician named Hartman proposed that dentures be fixed to the jaws using metal screws. Although a great number of failures quickly led to the demise of this procedure as well, the foundation was laid for the first crude, potentially successful dental implant system.[1]

Greenfield, in a patent of 1909 entitled "Mounting for Artificial Teeth," envisioned a replacement for teeth, the basis of which was a metal frame that would be inserted into a cavity drilled into the jaw bone.[2] However, according to Alvin Strock, the iridioplatinum meshwork of Greenfield was not strong enough to withstand the forces placed on it.[5]

The concept of using implants to enhance orthodontic anchorage was first published in 1945 by Gainsforth and Higley, who used vitallium screws in the ascending ramus in dogs for canine retraction.[2]

In the 1960s, P. I. Brånemark, a Swedish physician and orthopedic surgeon, found that bone had a high affinity for titanium and coined the term osseointegration. He used specially designed optical titanium chambers to study the intravascular dynamics of bone marrow circulation by transillumination in vivo. In 1969, Linkow described the endosseous blade implant for orthodontic anchorage.[2]

The first clinically reported use in humans came from Creekmore and Eklund in 1983 when they inserted vitallium bone screws in the anterior nasal spine to treat a patient with deep bite. In 1985, Jenner and Fitzpatrick described the mini plates. In 1995, Block and Hoffman introduced the onplant to provide orthodontic anchorage.[1]

However, the use of mini-implants was not embraced until 1997 (cost, limitation of space) when Kanomi described mini screws specifically made for orthodontic use.[2]

Classification of TADs

1. According to site[6]
   - Subperiosteal
   - Endosseous
   - Transosseous
2. According to the configuration of head[6]
   - Button
   - Bracket
3. According to the biological behavior[6]
   - Osseointegrated
   - Non osseointegrated
4. According to insertion technique[1]
   - Self -tapping - These screws require a a pilot hole before insertion
   - Self-drilling-Can be inserted directly
5. According to surface characteristics[6]
   (a) - Threaded
   - Non-threaded
   (b) - Porous
   - Non-porous
6. According to implant material[3]
   - Bioactive (Vetro ceramic apatite Hydroxide)
   - Bioinert (Titanium)
   - Biotolerant (Stainless Steel, Chromium-Cobalt Alloy)
7. According to implant degradation[1]
   - Biodegradable (Polylactide, polyglycolide)
   - Non biodegradable (Titanium)

Primary versus secondary stability

Immediately after the mini screw implants are inserted their retention is entirely mechanical, due to primarily the characteristics and amount of the bone contacting the implant especially the cortical bone. This mechanical type of retention is known as primary stability.

For orthodontists this is very important as it allows the implant to be immediately loaded. Primary stability is the key for any implant or TAD procedure.[1]

Following the placement of an endosseous implant, primary mechanical stability is gradually replaced by biologic secondary stability as the osteoclasts remove old, damaged bone and osteoblasts form new bone. This second phase of increased stability is referred to as secondary stability .It is due to the osseointegration that occurs around the implant.

The stability observed clinically is the net or overall stability composed of both primary and secondary stability.[1]

Placement of TADs

Selection of the location and placement of TADS is a technique sensitive procedure. The choice of mini-implant insertion sites should be based on appropriate regions of soft tissues such as the presence of attached gingiva, adequate amounts of cortical bone, the angulation and the size of the mini-implant and foremost, the type of tooth movement that is desired, intrusion, extrusion, or space closure with both mesial or distal movement.[7]

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.[1]

The CBCT study of Deguchi et al. suggested that the best available position for a miniscrew is in the posterior maxilla 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 6 mm of bone contact with a diameter of 1.3 mm.[8]

An alternative site is the palate. Clear benefits include the facts that the palatal bone is of good quality and there is no interference with the roots of the teeth.[9]

In the mandible, the most common miniscrew placement sites are:
• Interradicular spaces, both buccal and lingual
• Lateral to the mentalis symphysis
• Extraction spaces.[1]

According to Poggio et al., the mesiodistal widths of the interradicular space are more favourable between the mandibular permanent first and second molars at almost every level, starting 2 mm below the alveolar crest. The second best location in the region is between the mandibular second premolar and first molar.[10]

A study was done by Bittencourt et al. to determine the optimal interradicular spaces for miniscrew placement in the mandible and maxilla using CT images of 12 adult patients at heights of 2, 5, 8 and 11 mm from the alveolar crest. The study concluded that the best site for implant placement in the maxilla, is at a height of 6-9 mm from the crest of the second premolar and first molar and in the mandible, at a height of 9-12 mm between the molars.[11]

Application of TADs

Intrusion-For many years, dental intrusion was considered impossible or problematic especially posterior intrusion and was associated with numerous side-effects on the periodontium and cementum (root resorption).[12] In a study conducted by Mittal et al., the upper incisors were intruded to a mean value of 2.8 mm(mean time period of 3.3 months) with no observed molar extrusion.[13] Yao et al did a study to investigate the envelope of intrusive movements of maxillary molar using mini-implants. The mean intrusive movement of the maxillary first molars was 3-4 mm, with a maximum of over 8 mm.[14]

Distalization-Headgears were traditionally used for molar distalization but, in modern orthodontics, mechanics requiring minimal patient cooperation are more desirable both for orthodontists and patients. Also, the fixed appliances produce a reaction force on anterior teeth that may lead to anchorage loss.[7] In a study conducted by Gelgor et al. to investigate the efficiency of intraosseous screws for maxillary molar distalization it was concluded that the distalizing force resulted in 88% molar distalization and 12% reciprocal anchorage loss. No significant vertical changes were observed during distalization. The advantages of this treatment approach were elimination of compliance-dependent intraoral and extraoral anchorage aids, relatively predictable outcomes, favorable esthetics, reduction of orthodontic appliances.[15]

Protraction-Sometimes molar protraction is needed in minimum or moderate anchorage cases or unusual extraction cases (Eg: extraction of first molar). The treatment of choice in such patients is either a fixed three-unit bridge or an endosseous dental implant. Alternatively, orthodontic space closure of a remodelled edentulous space by second molar substitution for missing first molars is a viable treatment option if adequate anchorage is established.[16] However, molar protraction is one of the most difficult tooth movements to accomplish, especially in patients with a horizontal growth pattern and a deep bite. Microimplants for molar protraction are generally placed between the roots of the mandibular canine and first premolar or first premolar and second premolar.[16] According to Nihara et al the most ideal force system for molar protraction appeared to be the longest extension arm (10 mm) with the addition of a lingual force of half or equal magnitude of the labial force.[17]

Retraction-The use of mini-implants to assist in the anterior retraction phase is likely to benefit individuals who find it difficult to cooperate by wearing headgear, intermaxillary elastics or other traditional anchorage methods and those having the need for absolute anchorage. Prior to the installation of TADs the orthodontist should understand the vertical effect that the force vector will exert upon the anterior teeth. The retractive force can have an intrusive, extrusive and intermediate force depending on the vertical implant placement.[18]

An RCT carried out by Sibaie et al.[19] concluded that:

1.En-masse retraction with mini-implants not only eases the biomechanics involved but also controls the antero-posterior and vertical movements of the anterior and posterior teeth.

2. Avoidance of disto-palatal rotations and distal tipping of retracted canines, and eliminating the appearance of unsightly spaces distal to the lateral incisors following canine retraction.
3.Shortens the treatment duration significantly.

Uprighting- Molar uprighting is frequently indicated for mesially impacted second molars as well as first molars that have tipped mesially following premature loss of the second deciduous molar.[1] In moderately tipped second molars the mini screw can be placed between the second premolar and first molar. The open coil spring can be used initially to unlock the second molar and later the molar uprighting spring is then hooked on the mini screw head to deliver a tip back moment. For severely tipped second molars a button is bonded to the distal surface of second molar and a miniscrew placed in the retromolar region. In case the third molar is in the way while moving the second molar, it is removed.[1]

Tranverse correction-Miniscrews have been used to assist in the correction of a transverse discrepancy. From a force system perspective this is the least of the indication for TADs. Expansion can be easily obtained from a force system exerting equal and opposite forces delivered by an orthopedic device (Eg: palatal expander) or by conventional orthodontic force delivered through an expanded archwire.[16] Tausche et al evaluated 3D changes in dental, alveolar, and skeletal structures caused by a bone-borne implant supported rapid maxillary expander device using CT. The average increase in the transverse dimension at the alveolar bone to be 7.52 mm in the premolar region and 7.17 mm in the molar region, noting that these were greater skeletal increases than previous studies using tooth-borne expanders.[20]
However, Lagravere using CBCT found that immediately after completion of appliance activation, the skeletal and dental changes for both treatment groups were similar.[21]

Success/failures of TADs
Success of a mini implant is defined as a miniscrew with minimal mobility and inflammation and the ability to obtain full functional correction either through direct or indirect anchorage.[22]
Failure is defined as severe clinical mobility of the mini implant requiring replacement, spontaneous loss, or loss of an mini implant while checking its mobility with the cotton tweezers less than 8 months after placement or before the end of treatment.[1] According to a systemic review by Schatzle et al[23] the failure rate of mini screws was 16.4%. Park and Kuroda found a failure rate of about 10%.[16] Dalessandri et al[24] outlined the factors associated with success/failure of TADs. These can be broadly classified as follows:
1.**Patient related**-Age, sex, oral hygiene, smoking, type of malocclusion, thickness and kind of mucosa, thickness of the cortical bone, location in the bone, side of placement, location in relation to roots, soft tissue inflammation.
2.**Implant related**-Type of TAD, length of TAD, diameter of TAD
3.**Management related**-Time of loading, type of tooth movement, clinician skills

CONCLUSION
A historical review by Curtis published in 2000 listed the most important orthodontic developments in the first half of the 20th century as: 1) The edgewise therapy (Angle), 2) functional appliances (Robin, Andreasen), 3) cephalometric radiography (Broadbent, Hofrath) and 4) extraction therapy (Tweed).[1] The most critical advances in orthodontics in the last half of the 20th century have been the development of 1) modern orthodontic materials, 2) orthognathic surgery, 3) fundamental principles of biomechanics at the clinical level and 4) rigid implant anchorage.[1]

Although all of these relatively recent advances were very important, it can be argued that routine use of rigid endosseous anchorage is the leading technical frontier as orthodontics and dentofacial orthopedics entered the 21st century.[1] The presently available implant systems are bound to change and evolve into more patient friendly and operator convenient designs. Long-term clinical trials are awaited to establish clinical guidelines in using implants for both orthodontic and orthopaedic anchorage.

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AUTHOR AFFILIATIONS:

1. MDS(Orthodontics)
2. MDS(Orthodontics)
3. Dental Surgeon, J&K Health Services, Jammu & Kashmir

Corresponding Author:
Dr. Yamini Kaul
MDS(Orthodontics)
+91 9717978308
kaulyamini162@gmail.com