Anchoring the Anchorage- Temporary Anchorage devices A Narrative review

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Abstract:

Orthodontists are used for controlling and optimizing anchorage utilising teeth and appliances, both intraoral and extraoral. These approaches have limitations since it is frequently challenging to get outcomes that match our treatment goals. Numerous case reports were published in the orthodontic literature demonstrating the potential for overcoming anchorage limitations through the use of Temporary Anchorage Devices, which are biocompatible devices anchored to bone for the purpose of moving teeth without the need of reactive unit , preventing anchor loss and being removed following its intended use . Skeletal anchorage in orthodontics is a potential concept, yet many questions remain unanswered . The following article includes an overview of the use of implants for orthodontic anchorage as well as information on the evolution of skeletal anchorage.

Introduction:

Absolute anchorage is defined as no movement of the anchorage units and can only be attained by using ankylosed teeth or dental implants [1]. Cope defined Temporary anchorage device as "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 which is subsequently removed after use". This skeletal based anchorage units includes miniscrews, mini-implant, bone screws and miniplate that are collectively called as Temporary Anchorage Devices(TADs)[2].

Anchorage loss refers to any unintentional movement of the anchor teeth, which can happen in any of the three spatial planes.[3]. Extraoral, intermaxillary or dental appliances were used to offer anchorage control for orthodontic tooth movement. However, due to the force systems used by these appliances, anchorage loss of reactive units may occur, compromising occlusion and lengthening the course of treatment[4]. Various authors integrated extraoral devices like headgear and chincups to get over this limitation, but the poor patient compliance led to anchor loss.[2] The absolute anchorage system has created a revolution in the world of orthodontics with an advantage of treating borderline surgical cases non surgically and increased amount of tooth movement in all three planes with no anchorage loss of reactive unit, thus expanding the envelope of discrepancy.[5]

Evolution and Background

Gainsforth and Higley proposed the orthodontic anchorage in the basal bone in 1945 for distalizing a maxillary canine by inserting Vitallium screws into a dog's ramus [6].The use of TADs was originally reported in 1983 by Creekmore and Eklund, who placed a vitallium bone screw to treat a patient with a severe impinging overbite, the screw was placed in the anterior nasal spine in order to bypass the root and correct the overbite [7]. Block and Hoffman (1995) first employed the Onplant, a prime example of a subperiosteal implant, as a skeletal anchorage system.[8]. The "Straumann Orthosystem" of palatal implants, designed by Wehrbein in 1996, was developed exclusively for use as an orthodontic anchor.[9]The therapeutic application of a mini-implant for orthodontic anchorage (5.0 mm x 1.0 mm titanium screw, Leibinger, Freiburg, Germany) was initially described by Kanomi in 1997.[10]

The Skeletal Anchorage System (SAS) was first introduced in 1999 by Sugawara and Mikako Umemori. In simple terms, it consists of titanium miniplates stabilised in the mandible or maxilla by screws. [11]. C implants, created by Kyu- Rim Chung and Nelson in 2007, provide stability primarily by osseointegration and secondarily through mechanical retention.[12]

Classification

Labanauskaite et al [13] classified implants as following:

According to shape and size

a. Conical (cylindrical)

- Miniscrew implants

- Palatal implants

- Prosthodontic implants

b. Miniplate implants

c. Disk implants (onplants)

According to implant bone contact

a. Osseointegrated

b. Non-osseointegrated

According to the application

a. Orthodontic implants

b. Prosthodontic implants

Based on chemical aspect:

a) Metals

b) Metallic alloys

c) Ceramics

d) Synthetic polymers and natural materials

Based on biological aspect:

a. Biotolerant (stainless steel, chromium-cobalt alloy)

b. Bioinert (titanium, carbon)

c. Bioactive (hydroxyapatite, ceramic oxidized aluminum)

Cope [3] classified Temporary anchorage devices as -

Biocompatible TADs.

a)Osseointegrated Implant

i. Dental implant

ii. Palatal implant

iii. Retromolar implant

- Onplant

i. Palatal implant

b)Mechanical retention

i. Fixation screws

ii. Fixation wires

Biologic TADs

-Osseointegration

I. Ankylosed teeth

-Mechanical

II. Dilacerated teeth

Properties

Biocompatibility

Orthodontic mini-implants, are produced using medical type IV or type V titanium alloy (Ti6Al4V), a titanium, aluminium, and vanadium alloy. Comparing medical grade titanium to commercially accessible pure titanium, the second type provides a greater level of biocompatibility and strength..[14]

Osseointegration

TADs have been designed to be retained within the bone mechanically.These devices have been developed with smoother surfaces to inhibit bone formation and encourage soft tissue attachment, without the use of any specific surface treatment techniques. [15.]

Types of anchorage

TADs can offer two distinct types of anchorage.

- Direct anchorage implies that the implant instantly receives the reactive pressures.
- In indirect anchorage, the implant is attached to the reactive unit using bars or wires.

TADs have been designed to withstand forces of up to 500g, whereas orthodontic movement requires are limited to 300g. [16]

Orthodontic Indications of TADs [17]

.In Orthodontics, TADs have been used for various cases like:

1. Correction of deep bite

2. Extraction space closure

3. Correction of occlusal cant and midline correction
4. Impacted canines alignment
5. Up-righting and extrusion of impacted molars
6. Intrusion of molars
7. Total maxillary and mandibular arch distalization
8. Molar mesialization and distalization
9. En masse retraction of anterior teeth
10. Expansion of the Maxillary arch

Clinical Procedure:

Case selection

Initially it is essential to review the patient's medical history and examine their oral cavity in order to look for periodontal disease and gingival inflammation. To evaluate the bone morphology and roots of adjacent teeth, intraoral radiographs of the indicated miniscrew site should be taken in addition to the conventional orthodontic records. [18]

Cone beam computed tomography (CBCT) scans can be used to measure bone density if a further assessment of bone quality is desired. The D4 and D5 bone types might not be appropriate for implants, based on literature.[18]

Sites of Insertion

TADs can be inserted in the incisive fossa, canine fossa, infra-zygomatic ridge, pre-maxillary region or mid-palatal region, and maxillary tuberosity of the maxilla. TADs can be implanted in the mandibular symphysis, canine fossa, anterior external oblique ridge, and retro-molar region.[19]

According to studies, the tuberosity region was the most inappropriate for implant placement due to the reduced bone thickness there, while the anterior and apical section of the maxilla was the safest site for TAD insertion. The safest insertion point in the mandible was between the first and second molars as well as between the first and second premolars.[21](Figure 1) The strongest bone support for implant implantation in the palate was found 3 to 6 mm paramedian and 6 to 9 mm posterior to the incisive foramen[20]. (Figure 2)

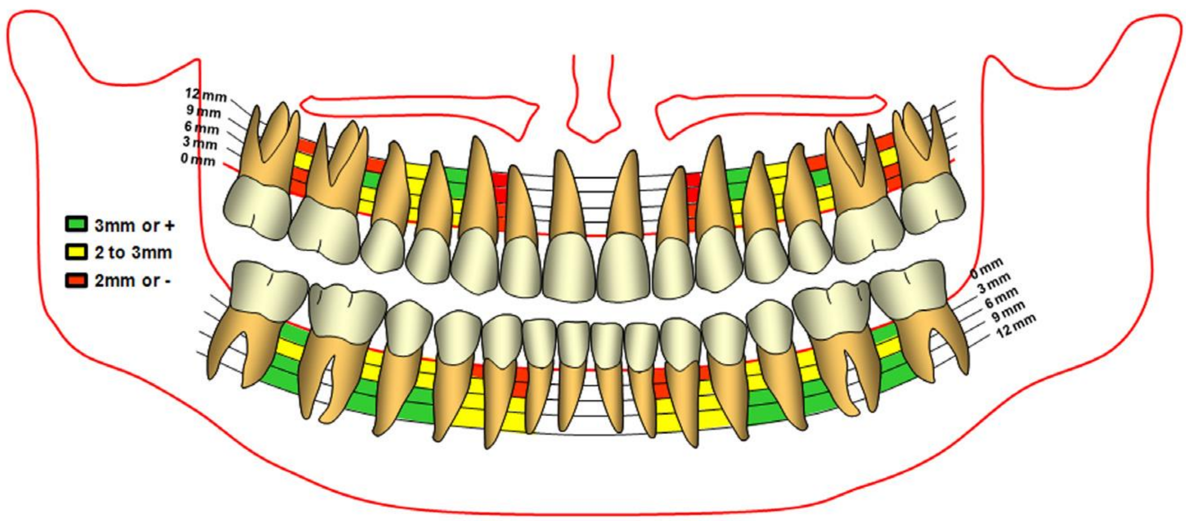

Figure 1: Safezone for miniscrew insertion .Red areas indicate dangerous sites, yellow areas show sites of average risk and green areas are the most favorable [21]

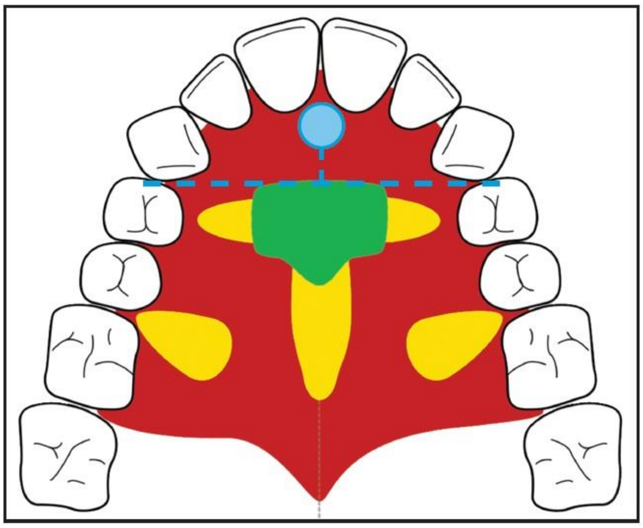

Figure 2:Suitability of potential miniscrew insertion sites in palate (green = optimal; yellow = restricted due to individual variability in bone thickness; red = unsuitable because of thick mucosa or vascular bundles; blue dot = incisive foramen [22]

Placement of TADs in the extra-alveolar bone will diminish tooth root contact and allows the force vector closer to the centre of resistance of the tooth. But such implants will lay in mobile alveolar mucosa which can be overcome by using trans-mucosal attachments.[3]

Direction of Insertion

The miniscrew implants are implanted obliquely in an apical orientation in the maxilla and parallel to the roots in the mandible. In the mandible, insertion angulation is between 10 and 20 degrees, but it is between 30 and 40 degrees in the maxilla.To reduce the risk of maxillary sinus perforation, it is advised to insert micro implants in a direction that is more perpendicular to the maxillary sinus.. [23,24,25]

Technique for Placement

- Self-drilling and self-tapping miniscrew implants were manufactured . Before implant placement, a surgical guide or adjustable acrylic template can be used.
- Clinicians have recently used 3D CBCT and tailored surgical guides made with stereolithographic techniques.
- Self-drilling miniscrews can be precisely positioned next to tooth roots and maxillary sinuses with this technique. (Figure 3)
- Predrilling for self-tapping screws is performed using a small amount of local anaesthetic.[26,27](Figure 3)
- At the placement location, soft tissue is removed away with a soft tissue punch, and the pilot hole is made with a drill bit with a drill rotating no faster than 1000 rpm.

- The pilot hole must be 0.3mm smaller in diameter than the screw and no deeper than 2 to 3mm. The implant will be secured in place using the proper implant driver.[27]
- The self-drilling screws contain specialised cutting flutes and tips which enable for insertion into the bone without the need for predrilling, eliminating the likelihood of injury to the tooth root, tooth germ, or nerves, thermal necrosis of the bones, and the possibility of drill bit breakage[15].
- However, if the thickness of the bone cortex is greater than 2 mm, a pilot hole must be drilled first, which could result in the screw's fine tip bending. [4]

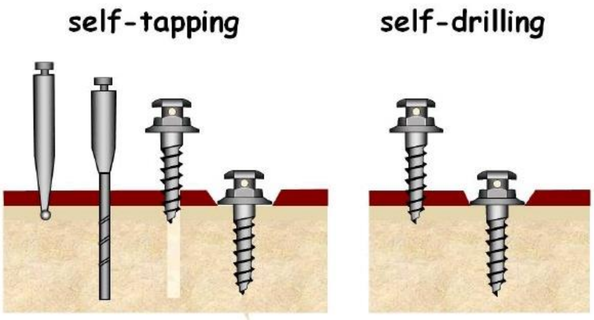

Figure 3: Self tapping and Self drilling screws

Loading and anchorage consideration

Orthodontic miniscrews can be immediately loaded with minimal force, unlike dental implants. As the implant might shift during orthodontic loading in some patients, it is advised to leave at least 2 mm between the implant and the neighbouring tooth root.[28]Based on FEM studies, direct stress can strain the TADs and the peri-implant bone, that might end up in TAD failure. Therefore, in situations when direct loading is not preferred, indirectly loaded TADs is a favourable option [29]

Risks, Complications of Orthodontic miniscrews [30].

Complications during insertion

i. Trauma to the periodontal ligament or the dental root.
ii. Miniscrew slippage.
iii. Nerve involvement.
iv. Air subcutaneous emphysema.
v. Nasal and maxillary sinus perforation.
vi. Miniscrew bending, fracture, and torsional stress.

Complications under orthodontic loading

i. Stationary anchorage failure.
ii. Miniscrew migration.

Soft-tissue complications

i. Aphthous ulceration.
ii. Soft-tissue coverage of the miniscrew head and auxiliary.
iii. Soft tissue inflammation, infection, and peri-implantitis.

Complications during removal

i. Miniscrew fracture.
ii. Partial osseointegration.

Bonescrews:

In order to reduce the danger of root damage, which is a typical issue with the insertion of miniscrews, the Bonescrews are placed in extraradicular space. Infrazygomatic crest in the maxilla and buccal shelf region in the mandible are the most often used sites for the insertion of bonescrews. Bonecrews are significantly longer than mini screws, ranging in size from 10 to 14 mm and with a 2 mm diameter.

Infrazygomatic screws are placed 2mm above the mucogingival junction, in the space between the first and second molars. This self-drilling screw is pointed 90 degrees towards the occlusal plane until the first notch is made, at which point the driver handle is turned 55 to 70 degrees downwards towards the root, bypassing the molar roots. The implant can be loaded up to 300-350g of force immediately. The most significant advantage is that gingival exposure and predrilling are not required for the placement of IZC bonescrews.

The buccal shelf bone screw is positioned 2 mm below the mucogingival junction, between the first and second mandibular molars. The screw is placed with the occlusal plane at a 90 degree angle.The driver is pointed downward at an angle of between 60 and 75 degrees after the initial notch is made in order to avoid the mandibular roots. Due to the mandible's thick cortical bone, predrilling and vertical buccal mucosa slitting are occasionally required.The bone screw can withstand an immediate load of 300–350g of force. [31]

Recent Advances :

Over the past decade or so, TADs and aligners have unquestionably changed the dynamics in orthodontics. It is now effectively useful to treat challenging malocclusions to the finest level of care employing these two procedures, either individually or in tandem, without the requirement for fixed appliances or dentoalveolar surgery.[32]

Conclusion:

Skeletal anchorage allows the orthodontist to predictably make changes that were resorted to orthognathic surgery alone previously. Careful planning is to be discussed between the orthodontist because this is not a technique that replaces orthognathic surgery while moderate to severe skeletal malocclusion still require surgical correction. Although it is relatively an emerging concept, it provides promise to the future of orthodontic treatment with relatively good literature to support its use in current practice today. The skeletal anchorage is a growing field that allows for interdisciplinary collaboration in expanding the patient's and provider's selection of treatment options to allow a satisfactory end point of treatment as determined by the patient.

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