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Skeletal anchorage system in orthodontics: A literature review

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Abstract
Conservation of anchorage in totality has been perennial problem to traditional orthodontist. Paradigms have started to shift in the orthodontic world since the introduction of mini-implants in the anchorage armamentarium. Orthodontic implants or temporary anchorage device (TAD) are 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. They have become increasingly popular because they are small and easy to insert and remove, they can be loaded immediately after insertion, and they can provide absolute anchorage for many types of orthodontic treatment, with minimal need for patient compliance. The purpose of this article is to review the skeletal anchorage system or TADs in the context of orthodontics and will deal with various aspects of orthodontic implants—their types, indications, contraindications, placement sites and complications.

Keywords: Anchorage, implants, orthodontics, retraction

Introduction

“Give me a lever long enough, a place to stand & I shall lift the earth!” so said Archimedes! "A place to stand "is what anchorage is. Anchorage in orthodontics means resistance to displacement [1]. It is defined as the nature and degree of resistance to displacement offered by an anatomic unit when used for the aim of effecting tooth movement. Every orthodontic appliance consists of two elements- an active element and a resistance element. The active components of the orthodontic appliance are involved in tooth movements. The resistance units offer resistance (anchorage) that makes tooth movements attainable.

During orthodontic treatment the teeth are exposed to forces and moments, and these acting forces generate reciprocal forces of same magnitude but opposite in direction. To avoid unwanted tooth movements and maintain treatment success, these reciprocal forces should be diverted or resisted.

Absolute anchorage is a concept implying no movement of the anchorage unit, which may be needed within the treatment of a maximum anchorage case. Skeletal anchorage is a technique utilizing some variety of bony anchor in order to provide absolute anchorage. It expands the range of biochemical possibilities with screws, pins or some promptly removable implants anchored to the jaws, in order to apply forces to produce tooth movement in any direction without harmful reciprocal forces.

The anchorage from implants applied is either direct or indirect. Direct techniques are those that apply force directly from the anchor to the segment or tooth that is to be moved. The active unit is attached to the TAD and bypasses anchorage to the other teeth.

In indirect techniques, the anchorage or reactive unit are connected to the implant; that is, the teeth to be moved is not attached directly to the implant. Therefore, rather than connection between the anchor and the arch wire, indirect anchorage involves an inelastic or even rigid connection between the anchor and the orthodontic appliances.

History

Gainsforth and Higley at first reported Vitallium metal bone screws which could provide intra-oral anchorage, in dogs in 1945.

Beder and Ploger reported that titanium caused no harmful tissue response in bone and Branemark showed that they were stable for five years and also osseointegrated with bone. After this, Linkow reported on the successful use of mandibular blade-vent implants to supply anchorage, which re-ignited the interest within the use of implants to supply orthodontic anchorage.

Roberts *et al*. represented the employment of Ti endosseous implants against which the molars were protracted. Wehrbein represented the Orthosystem mid-palatal implant, developed by Straumann. Such a system needs placement of a short cylindrical implant into the anterior palatal vault and a latent period of 12 weeks, so that osseointegration can be achieved, before the implant is loaded. Creekmore and Eklund reported the employment of a single Vitallium bone screw placed into the ANS for proclination of maxillary incisors. Kanomi described the use of four 1.2 mm diameter × 6 mm length mini bone screws and coined the term 'mini-implant'. Melsen and Costa investigated the histological tissue reaction around Aarhus micro-implant. It was concluded that the degree of osseointegration which occurred around the micro-implants varied from 10 - 58% and was time-dependent. So, it was concluded that immediate loading of micro-implant was effective.

Classification of implants

Implants can be classified under following headings [2]

1. **Based on the Location**
- Subperiosteal: Implant body lies over the bony ridge.
- Transosseous: Implant body penetrates the mandible completely.
- Endosseous: Partially submerged and anchored within the bone-endosseous implants are most commonly used for orthodontic purposes.

2. **According to the Composition**
- Stainless steel
- Cobalt-chromium-molybdenum (Co-Cr-Mo)
- Titanium
- Ceramic implants
- Miscellaneous, such as vitreous carbon and composites

3. **According to the shape and size**
- Conical (cylindrical)
- mini screw implants
- palatal implants
- prosthodontic implant
- Mini-plate implants
- Disc implants (onplants)

4. **According to the implant bone contact**
- Osseointegrated
- Non-osseointegrated

5. **According to the Implant Morphology**
- Implant disks
- Onplant
- Screw designs
- Mini-implant
- Ortho system and implant system
- Aarhus implant
- Microimplant
- Newer systems (spider screw, OMAS system, Leone implant)
- Plate designs
- Skeletal anchorage system (SAS)
- Graz implant-supported system
- Zygoma anchorage system

Miniscrews

Miniscrew anchorage was introduced in 1997 by Kanomi, and gained wide acceptance within the orthodontic profession significantly as a lot of refined miniscrews were developed.

Size: Diameters vary from 1.2 to 2 mm and lengths between 7, 9 and 11 mm.

Sites for placement

Maxilla
- Area below the nasal spine, the palate (on the median or the paramedian area
- Infrazygomatic crest
- Maxillary tuberosities
- Alveolar process (both buccally and palatally between the roots of the teeth)

Mandible
- symphysis or parasymphysis
- alveolar process (between the roots of the teeth)
- retromolar area

Force application: Miniscrews can withstand forces from 300 g up to 800 g[3].

Insertion method

1. A small amount of local anesthesia is usually sufficient for the placement of miniscrew implants.
2. In case of non–self-drilling miniscrew implants, a pilot hole is important. Firstly, soft tissue from the site of the placement is either incised or removed employing a soft tissue punch. Thereafter, a pilot hole is drilled using a drill rotating no more than 1000 rpm. The pilot drill is typically 0.2 to 0.3 mm thinner than the miniscrew implant. The miniscrew implant is then screwed in place by using an appropriate screwdriver.
3. In case of self-drilling miniscrew implants, no incision or soft tissue removal is necessary. Infection control is similar to that for an extraction. After selecting the appropriate site, the miniscrew implant, and the corresponding site of placement, it is inserted in place.

Indications for miniscrews
- Molar protraction
- Molar distalization
- Anterior retraction
- Molar uprighting
- Intrusion
- Extrusion

Miniplates

Miniplates, developed by Sugawara and Nishimura, address the disadvantages of miniscrews. They may supply sturdy anchorage, have high success rates, a low likelihood of root damage, and low risk of fracture as benefits.

Design and Sizes
- The miniplate implants consists of bone plates and fixation screws.
- The plates and screws are fabricated from commercially pure titanium that's biocompatible and appropriate for osseointegration [4].

- The miniplate consists of the 3 components—the head, the arm and the body.

Sites for placement
- The maxillary sites where screw fixation is possible are limited to the zygomatic buttress and the piriform rim.
- In the mandible, screw fixation is possible on the lateral cortex in most locations except adjacent to the mental foramen.

Force application: They can withstand approximately 500 – 900 g of force [5].

Insertion method
- The surgical procedure is performed under local anesthesia with IV 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, and mucoperiosteal flap is elevated.
- 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 attached the anchor plate to the bone surface.
- Last, the surgical site is closed with resorbable sutures.

Indications
Miniplates have been used to carry out the desired movements in both the vertical and the sagittal plane.
- Sagittal plane – Retraction, Complete arch distalization, Molar protraction and orthopaedic forces for skeletal correction.
- Vertical plane – Complete arch or individual tooth intrusion.

Palatal implants
Palatal implants are osseointegrated and can be connected to the teeth of the reactive segment by a transpalatal arch (TPA), thereby providing absolute orthodontic anchorage.
The benefits of orthodontic anchorage on palatal implants embrace easy use, reliable stability, not dependent on patient cooperation, and improved aesthetics of the fixed bracket appliance.

Types and Sizes
Two most generally used palatal implants-
1. **Flange fixture [6] (Branemark, Nobel Biocare, Göteborg, Sweden)**
- Superior to the endosseous body is a 5.5-mm-diameter perforated flange.
- Made of commercially pure titanium, it has a self-tapping screw-shaped endosseous body with a length of either 3 or 4 mm and a threaded diameter of 3.75 mm.
- A threaded abutment is mounted on top of the flange with an external hexagon connected to forestall rotation.

2. **The Straumann Orthosystem ® (Institut Straumann AG, Waldenburg, Switzerland)**
- This single unit self-tapping palatal implant of commercially pure titanium.
- It has a length of either 4 or 6 mm, a diameter of 3.3 mm, and an SLA surface.
- Its 2.5-mm transmucosal collar has a highly polished surface.

Site for placement
The anterior palate appears to be one of the best sites for orthodontic miniscrews or palatal implant.

Insertion method (Surgical Technique)
1. **Radiographic stent**
- A radiographic stent is formed within the laboratory.
- The stent contains two metal tubes with identical diameter and length as the implant (length 6 mm, diameter 3.3 mm), positioned inside an acrylic base plate.

2. **Surgical stent**
- The radiographic stent is now converted into a surgical stent which will be used at the time of surgery.
- This modification is achieved by removing the markers and preparing a hole in the thinned base plate, through which the implant preparation drills can be used.
- As a guide to the orientation of the implant, a 10 mm section of 0.7 mm stainless steel wire is embedded into the acrylic at the appropriate angle to indicate to the surgeon how the drill must be held.

3. **Surgical preparation**
- For placing transmucosal Orthosystem implants, the palatal mucosa is removed with a mucosal trephine and an elevator.
- Then a pilot hole is created in the cortical bone of the hard palate with a 2.3-mm round bur, followed by osteotomy preparation with the ortho profile drill.
- The self-tapping implant is seated in the osteotomy by hand then slowly screwed to place with a ratchet.
- During the 12- week healing period, the implant is covered with a healing cap. Functional loading should be avoided during this time.

Indications
- Opening or closing spaces in the maxilla.
- Mesializing or distalizing maxillary segments, correcting intercuspation, and dental asymmetries combined with midline shifts [7].
- Stabilizing teeth (e.g., canines or molars) during treatment with Class II or Class III elastics, if the action of the elastics is to be confined to the mandible.
- Bilateral or unilateral maxillary expansion in adults.

Infrazygomatic implants
Anatomy of infrazygomatic crest: Infra zygomatic crest is a pillar of cortical bone at zygomatic process of maxilla.

Design and sizes
IZC bone screws are available in two sizes commonly (manufacturer specific) – 12 and 14 mm in length and 2 mm in diameter [8]. When the soft tissue in the buccal vestibule is thick as in most clinical situations, the preferred choice is a 14 mm screw. Orthodontic bone screws of 12 mm length are preferred in cases of thin soft tissue at the vestibule.

Site for placement
Some authors prefer bone screws to be placed in the 1st and 2nd molar region, while others prefer a more anterior placement, closer to the MB root of the 1st molar.
The preferred site for placement of bone screws in the maxilla

is the infra-zygomatic crest which lies higher and lateral to the 1st and 2nd molar region.

Insertion Method

- For placement of bone screws in the IZC (1st and 2nd molar region) – initial point of insertion is inter-dentally between the 1st and the 2nd molar and 2 mm above the muco-gingival junction in the alveolar mucosa.
- The self-drilling screw is directed at 90° to the occlusal plane at this point.
- After the initial notch in the bone is created after couple of turns to the driver, the screw tip engages and penetrates ~1mm bone cortex, buccal to the molar roots.
- The bone screw driver direction is changed by 55°–70° toward the tooth, downward, which aid in bypassing the roots of the teeth and directing the screw to the infra-zygomatic area of the maxilla.
- The bone screw is screwed in till only the head of the screw is visible outside the alveolar mucosa.

Force application: Immediate loading is possible and a force of up to 220-340 g can be taken up by a single bone screw.

Indications

- Retraction of the entire upper dentition to correct Class II malocclusion.
- Excessive gingival exposure.
- Skeletal asymmetry.
- Maxillary canine-lateral incisor transposition.
- Scissor bite.
- Space closure.
- Posterior intrusion.
- Molar and even maxillary dental arch distalization.

Buccal shelf implants

Anatomy of buccal shelf area: Mandibular buccal shelf is a buccal alveolar bone of mandible.

Design and sizes of buccal shelf implants: Bone screws in the buccal shelf area are available in two sizes commonly (manufacturer specific) – 10 mm and 12 mm in length and 2 mm in diameter. Buccal shelf area in the Indian population is mostly found to be thin and deep; therefore, the preferred choice will be a 12-mm screw [9].

Site for placement

The most favourable overall anatomic relationship for a buccal shelf bone screw placement is buccal to the distobuccal cusp of mandibular 2nd molar [10].

Insertion method

- For placement of bone screws in the BS area of mandible (2nd molar region), initial point of insertion is buccal 4mm buccal to distobuccal root of lower 2nd molar.
- Make an indentation with the explorer.
- The self-drilling screw is directed at 90° to the occlusal plane at this point.
- After the initial notch in the bone is created after couple of turns to the driver, the bone screw driver direction is changed by 60°– 75° toward the tooth, upward, which aid in bypassing the roots of the teeth and directing the screw to the buccal shelf area of the mandible.

Indications

- Class III compensatory treatment.
- Retraction and/or canine distalization in cases of excessive mandibular crowding.
- Mesial movement of molar.
- Intrusion of posterior teeth.
- Correction of occlusal plane asymmetries and midline deviation.
- Anchorage for cantilever use in mandibular impacted canine traction.
- Orthognathic surgery preparation in Class II cases.

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