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Research Article

A COMPREHENSIVE OUTLOOK TO TEMPORARY ANCHORAGE DEVICES IN ORTHODONTICS: FROM THEORY TO PRACTICE

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Abstract

Temporary Anchorage Devices (TADs)are small titanium implants that provide stable anchorage for precise tooth movement in orthodontics. By eliminating reliance on adjacent teeth or external appliances, TADs offer a more predictable and efficient solution, overcoming limitations of traditional methods. Factors like implant material, dimensions, placement torque, and osseointegration are critical to their success. TADs can be loaded early after placement, enhancing treatment speed. While they offer significant benefits, careful technique and risk management are essential. Future advancements promise to improve TAD efficacy and application further.

Keywords: Temporary Anchorage Devices (TADs), Orthodontic Anchorage, Mini-screw.

INTRODUCTION

The orthodontic treatment relies primarily on anchorage, which denotes the resistance to unwanted tooth movement during orthodontic treatment procedures.(1) The traditional approach to anchorage was based on the use of adjacent teeth and appliances like headgear or the use of extraoral forces (1). These approaches have numerous limitations, such as patient compliance and discomfort. The discovery of Temporary Anchorage Devices (TADs) has revolutionized the field of orthodontics.(2) It is a small, minimally invasive implant that provides anchorage for different types of tooth movements without depending on other teeth or external appliances.(2)

Orthodontic implants: Orthodontic implants are small titanium devices that help in the efficient movement of teeth.(3,4) They act as Temporary Anchorage Devices (TADs), providing a stable anchor point for the attachment of braces or other orthodontic appliances. (3,5) The main function of orthodontic implants is to facilitate effective and precise tooth movement without relying on the other teeth for support.(6) They are typically removed after the completion of treatment (5).

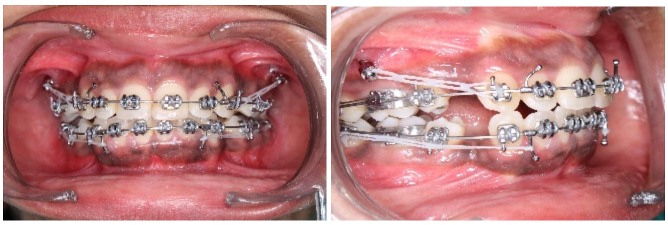

Figure 1. Orthodontic mini-implants (Infra-zygomatic screws

Parts of orthodontic implants:

The orthodontic mini-implant is made from titanium alloy grade V (Ti-6Al-4V) and consists of four components (1).

Figure 2. Orthodontic mini-implants (Infra-zygomatic screws)

Head: It is a slot for attaching the orthodontic archwire.

Neck: Serves as an isthmus between the head and platform, designed for the attachment of an elastic, NiTi coil spring, or other accessories.

Platform: Available in three sizes (1mm, 2mm, and 3mm) to accommodate varying soft tissue thicknesses at different implant sites.

Body: It has a parallel shape and is self-drilling, with a wide diameter and deep thread pitches. This offers improved mechanical retention, reduced loosening and breakage, and stronger anchorage.

Material considerations for orthodontic implants: key properties

The implant material must exhibit exceptional physical and mechanical properties.(1) The ideal implant material should fall into three categories: bio-resistant, bio-inert, and biologically active.(7) The material of choice is titanium due to its resistance to allergic or immunological reactions.(8)

The ideal implant material

Titanium is highly favoured in orthodontic implants due to its excellent biocompatible properties. (9)

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Table 1. Classification of orthodontic implants: (1,3,6)

According to the site of placement/ anchorage components	Subperiosteal implant, Transosteal implant, Endosteal/ Endosseous implant
According to surface texture	Treaded, Perforated
According to the form	Solid, Hollow, Vented
According to the spray coating of hydroxyapatite or plasma-sprayed titanium	Coated, non-coated
Based on head type	Small head type, Long head type, Circle head type, Fixation head type, Bracket head type
According to implant morphology	Plate design, Skeletal anchorage implant, Graz implant supported system, Zygoma anchorage system, Screw design, Orthosystem implant, Straumannortho implant, Aarhus implant, Mini implant system, Micro- implant, C – implant, Spider screw, Implant disc
Based on the ORLUS system	Standard type, Wide collared type, long collared type

It is non-reactive, reducing the risk of allergic responses and ensuring long-term stability, and has proven to resist tumour growth, making it a reliable choice for orthodontic applications.(10)

Tailored implant dimensions: ensuring maximum stability and load resistance

The bone-implant interface plays animportant role in determining the implant's load capacity.(11) It comes in a variety of sizes, ranging from 6 mm in length, 0.6 mm radius (small implants), 6-15 mm length, 1.5-2.5 mm radius (traditional dental implants), all made to enhance anchorage and stability.(12)

Implant shape: Impact on Bone integration and stress distribution: It directly influences the bone-to-implant contact area, essential for the transmission of stress and thereby provides stability. (13)A well-designed implant reduces surgical complexity and improves the success rate of the implant.(14)

Osseo integration: The key to Implant success: It is the process by which bone integrates with the implant. (15) A rougher surface typically enhances the stability by improving the bone-implant interface, leading to better initial fixation and long-term success (15,16).

Balancing surgical simplicity and performance: The Design Challenge:

The design of orthodontic implants strikes a balance between minimizing surgical complexity and adequate primary stability. A well-designed implant provides support for effective tooth movement (17).

Orthodontic Anchorage:

It is defined as the ability to resist unwanted tooth movements, provided by other teeth, the palate, head, or neck, or implants in bone.(18)

Classification of Orthodontic Anchorage: (18,19)
Orthodontic Anchorage

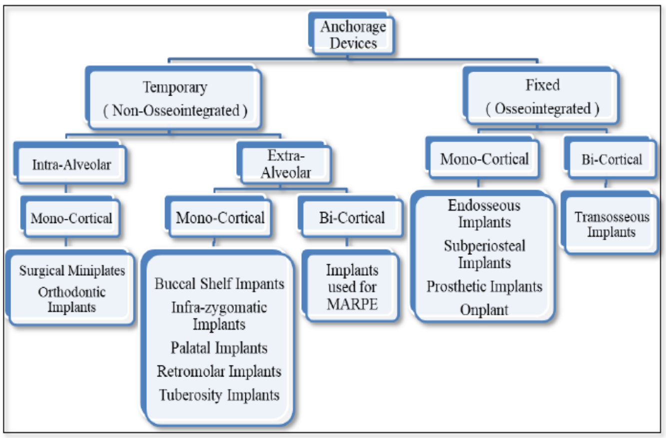
- Intra- oral anchorage
  Intra-arch
  Inter-arch
  Extra-dental

- Extra-oral anchorage

Significance of Orthodontic Anchorage Systems: (20,21)

- Control of tooth movement by providing a stable base for an anchor.
- Prevention of undesired tooth movement during orthodontic force application.
- Increases the speed and predictability of the treatment.
- Minimize the patient's discomfort by controlling the forces applied to the teeth.
- Adaptable to various treatment needs for both traditional and advanced methods (eg, Mini-implants, TADs)(22)
- Essential for treating severe malocclusions and complicated cases requiring tooth repositioning.

Classification of Anchorage Device: (1)



Flowchart 1: AJ Classification System for Anchorage Device

Temporary Anchorage Devices:
Definition:

Temporary Anchorage Devices (TADs) are temporary, small-scale implants that are placed in the oral cavity to provide anchorage for orthodontic treatment.(23) They are made of titanium and other biocompatible materials that can be inserted into bone and soft tissues. (9)TADs have been widely used in the field of orthodontics in the field of orthodontics due to their ability to reduce patient compliance and improve treatment outcomes (24).

Classification of Anchorage Device:(23,25)

- **Skeletal Anchorage Devices:** Mini screws, miniplates, and micro implants placed in bone.
- **Dental Anchorage Devices:** Devices that rely on the support of existing teeth.
- **Placement Classification:** Can be intraosseous (implanted into the bone) or extra osseous (placed on the gum or tooth surfaces).

History of TADs: (26–29)

600 AD – Mayans	• Used jawbone portions as implants to replace missing teeth.
1809 – Maggiolo	• First attempt to stabilize tooth roots using gold prosthetic tubes. • Procedure caused severe gum infections.
Late 19th Century – Dr. Hartman	• Advocated using metal pins to secure dentures to the jaw. • Early step towards refining tooth anchorage systems.
1909 – Greenfield	• Patented a design for manufactured teeth with retainers in the alveolar bone. • Experimented with iridium-platinum alloys bonded with gold for securing dental prostheses.
1930s – Strock Brothers	• Introduced Vitallium (chromium-cobalt alloy) in orthopedic and dental implants. • Pioneered infection control for implant procedures.
1938 – P.B. Adams	• Patented a cylinder-shaped device integrated with bone and mucosal band for support.
1940s – Orthodontists	• Explored anchoring devices into bone for more efficient orthodontic treatments.
1990s – Titanium Mini Screws	• Developed titanium mini screws for minimal-invasive dental anchorage. • Costa and colleagues introduced screws that could be placed without a flap, offering predictable outcomes.
Today – Modern TADs	• Revolutionized orthodontics with efficient, less invasive solutions for tooth alignment.

Principles of Anchorage:

These are essential for successful orthodontic treatment, and TADs provide a means of optimizing these principles (30, 31). It allows the orthodontist to apply force in a specific, controlled direction, significantly enhancing the treatment outcome compared to traditional anchorage methods.(32)

Mechanism of action of temporary anchorage devices:

Biomechanics: The biomechanics of TADs are based on their capacity to provide stable, localized anchorage for orthodontic treatments.(33) When force is applied to a specific tooth, the TADs serve as a stationary support, preventing unnecessary movement of adjacent teeth or structures.(31,32)The applied force is transferred directly to the target tooth via wires or elastics, allowing precise movement without affecting the neighbouring teeth (34,35).

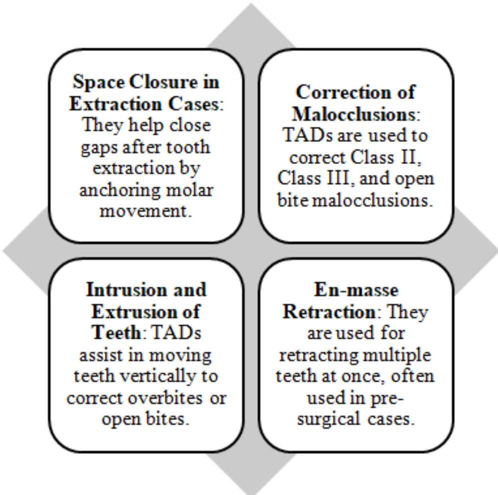
- **Absolute Anchorage:** TADs offer absolute anchorage, meaning they provide an anchor that resists movement, allowing other teeth to be moved without any reciprocal movement of the anchor teeth. This is especially useful when complex tooth movements are required, such as distalization of molars or intrusion of anterior teeth.
- **Relative Anchorage:** In cases where movement of both anchor and moved teeth is required, TADs help achieve controlled and predictable tooth movement by balancing forces across different groups of teeth. This allows for greater precision in aligning teeth and optimizing occlusion.

Applications of Temporary Anchorage Device: (36–38)

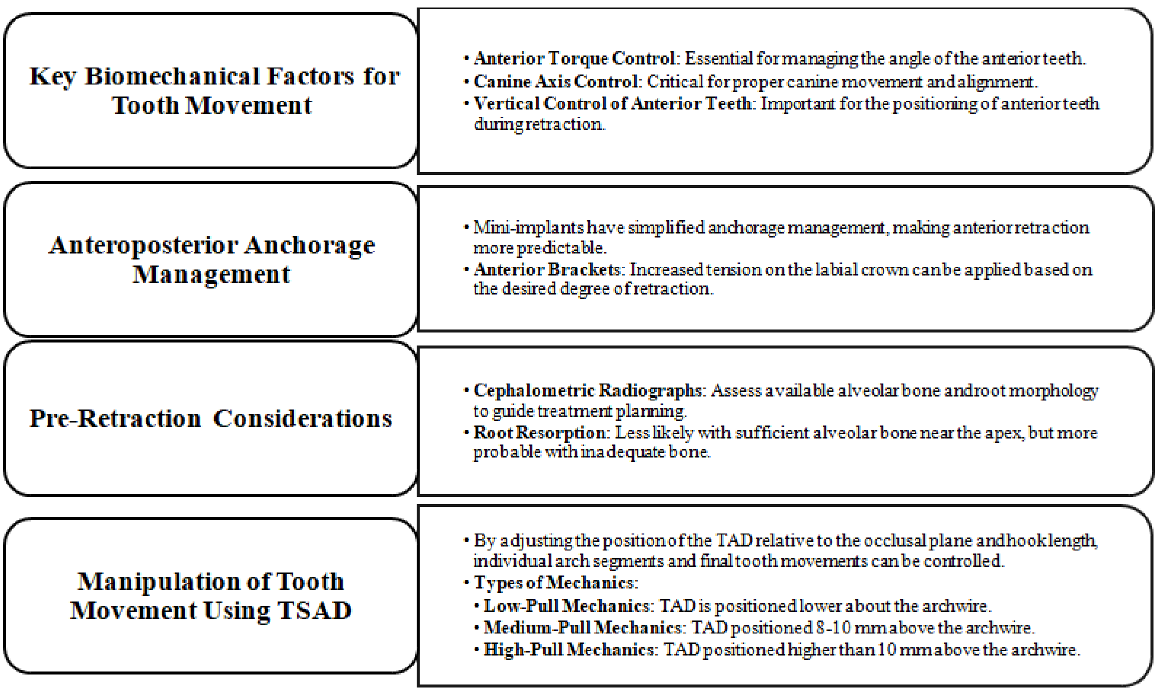
- **Improved Precision and Control:** TADs provide a fixed point of anchorage in the bone, which is more stable than tooth-based anchorage. This allows for more precise control over tooth movement, especially in difficult cases where traditional methods would be ineffective.

- **Eliminating the Need for External Devices**: Unlike traditional skeletal anchorage systems such as headgear or functional appliances, TADs do not require bulky or uncomfortable external components. This makes them more comfortable and aesthetically pleasing for patients.
- **Facilitating Complex Movements:** TADs are particularly beneficial in complex orthodontic movements such as molar distalization, intrusion of teeth, and space closure. They can be used in conjunction with other orthodontic devices, such as braces, to move teeth in three-dimensional directions, which would not be possible with traditional methods alone.
- **Permanent Stability:** Once placed, TADs provide stable anchorage throughout the duration of treatment, and they can be removed easily once treatment goals are achieved, making them an efficient and temporary solution for skeletal anchorage.

Role of TADs in Providing Skeletal Anchorage: (25,39)



Biomechanics and Tooth Movement with TADs:(40–45)



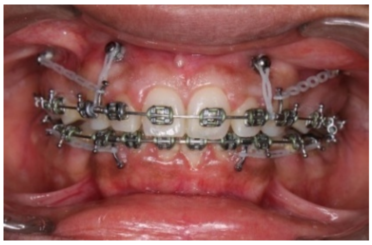


Figure 3. Temporary Anchorage Device for Intrusion

Techniques for TADs placement:(46)

Implant stability and placement Torque: The success of TADs is influenced by the implant Placement Torque (IPT), especially in the buccal alveolar bone. Studies have shown that, for 1.6 mm TADs, successful IPTs range from 5-10 Ncm, with a max of 20 Ncm recommended to prevent fractures (47).

Immediate vs. Delayed Load Application: Buchter et al. stated that mini-implants can be loaded after a short healing period (up to 3 weeks) without compromising stability, as long as the tipping moment at the bone rim does not exceed 90 Ncm.(48)

Effect of Pilot Hole Size on Stability: A smaller hole increases the fracture risk, whereas a larger hole reduces stability. The ideal size for 2.0 mm minis crews is 1.3 mm, especially in dense bone (49, 50).

Flap vs. Non-Flap Surgery: Flap is needed when using a miniplate or to prevent mucosa from covering screw threads during insertion (48).

Site of insertion of TADs: The site and direction of insertion of TADs are important for their stability and effectiveness. Common sites for TAD insertion include interradicular spaces (especially between the second premolar and first molar), the anterior paramedian region of the palate, the buccal shelf in the mandible, the infrazygomatic crest in the maxilla, and occasionally the retromolar area.

Site selection depends on bone density, proximity to vital structures, and the desired direction of orthodontic force. (51)

Direction of insertion of TADs: The direction of insertion varies based on the anatomical location. In interradicular areas, TADs are usually placed at an oblique angle of 30–45 degrees to the long axis of the teeth to maximize bone contact and avoid root damage. Palatal TADs are generally inserted perpendicularly or at a slight angle, taking advantage of the thick cortical bone. In the buccal shelf and infrazygomatic regions, screws are inserted perpendicularly or slightly obliquely to achieve optimal stability in dense cortical bone. Proper planning of the site and angle of insertion ensures minimal complications and maximum anchorage efficiency during orthodontic treatment (51).

Table 2. Indications and Contraindications of TADs: (52–54)

Indications	Contraindications
• Absolute Anchorage	• Systemic Bone Diseases.
• Failed Headgear	• Pre-Skeletal Development
• Missing teeth	• Bone Reshaping Areas
• Difficult tooth movements	• Inadequate Bone Thickness
• Anterior/Posterior intrusion	• Demand for experienced clinicians
• En Masse Distalization	• Ethical considerations
• Molar up righting	
• Molar Distalization	
• Adult Orthodontics	
• Orthopedic Traction	

Risk factors for TAD Placement:(52)

Complications of TADs:(55)

Soft tissue injuries:

- Improper placement of TADs in the gingival region may lead to chronic irritation, inflammation, or hyperplasia.
- Mechanical irritation from TADs may lead to soft tissue ulcerations and discomfort.

Placement-related injuries:

- Accidental engagement with the root during insertion can lead to root resorption and pulp necrosis.
- In the maxillary region, involvement of the sinus may lead to breach in the maxillary sinus region, and in the mandible, improper angulation can affect the inferior alveolar nerve.

Post-placement injuries: Peri-implantitis around the TAD can occur due to poor oral hygiene and biomechanical overloading.

- The surrounding tissue may overgrow and engulf TAD, complicating removal and risk of infection.

Damage from adjuncts: Forces applied via coils and elastics may cause soft tissue laceration or irritation if improperly directed.

- Adjunctive orthodontic components, like brackets or wire, may impinge on soft tissues when positioned too close to TADs

Hard tissue trauma:

- Excess torque during placement or poor bone density can cause micro fractures.
- Infections or chronic inflammation may result in bone necrosis or osteolysis around the TAD site.

Biomechanical errors in TAD therapy:

- Overloading the TAD by applying excessive orthodontic forces can lead to loosening or failure of the TAD.
- Incorrect vector of force application can result in undesired tooth movement or TAD displacement.

Future of TADs: Innovations and Advancements:(37,56)

- **Miniaturization and Design-**Future TADs will be smaller and more ergonomic, improving patient comfort and minimizing soft tissue irritation.
- **Smart TADs-**Technology integration could create "smart" TADs with sensors to monitor force application and tooth movement in real time.
- **Material Innovations-**New materials may enhance TADs' biocompatibility, strength, and durability for better performance.
- **Customization and 3D Printing-**3D printing could allow personalized TADs tailored to individual patient anatomy, optimizing treatment outcomes.
- **Improved Techniques-**Future research may introduce refined techniques for optimal TAD placement and biomechanics, ensuring more successful treatments.
- **Multidisciplinary Integration-**TADs could be used across various dental specialties, fostering comprehensive treatment approaches.
- **Patient-Centric Focus-**TADs will focus on patient comfort, with smoother insertion processes and shorter treatment times.

Conclusion

TADs have transformed orthodontic treatment by providing stable and predictable anchorage for complex tooth movements. Proper implant selection, placement, and torque are key to their success. While TADs reduce treatment time and improve outcomes, skilled placement is necessary to avoid complications. Innovations in TADs will continue to enhance their effectiveness, expanding treatment options and improving patient care in orthodontics.

Conflicts of interest: Nil

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