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REVIEW ARTICLE **OPEN ACCESS**

Temporary Anchorage Devices in Orthodontics – A Review Article

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ABSTRACT
Temporary anchorage devices (TADs) have transformed modern orthodontic biomechanics by providing reliable skeletal anchorage independent of patient compliance. These temporary implants, commonly in the form of Mini screws, are inserted into alveolar bone to facilitate controlled and predictable tooth movement. This review summarizes the materials, anatomical placement sites, biomechanical considerations, clinical technique, advantages, and limitations associated with TADs. Mini screws are predominantly fabricated from medical-grade titanium alloys, due to their superior strength and biocompatibility. Common placement sites include maxillary and mandibular interradicular areas, palatal region, buccal shelf, retromolar area, and infra-zygomatic crest. Success is influenced by cortical bone thickness, root proximity, bone depth, and soft tissue characteristics. Appropriate case selection, radiographic assessment, and careful selection of screw length and diameter are essential to enhance primary stability and reduce complications. TADs can withstand orthodontic forces of 300–800 g and significantly improve anchorage control in procedures such as en-masse retraction and Class II correction. Despite potential complications, their high success rate and versatility make them an indispensable adjunct in contemporary orthodontic practice.

KEYWORDS : *Skeletal anchorage; stability; Mini-implants; Orthodontic biomechanics.*

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INTRODUCTION

Temporary anchorage devices (TADs) represent one of the most significant advancements in modern orthodontics. These devices provide a reliable source of skeletal anchorage by being temporarily fixed into the alveolar bone, thereby enabling controlled and predictable tooth movement without relying on patient cooperation or auxiliary anchorage appliances.

According to Cope [1], the introduction of TADs marked a paradigm shift in orthodontic biomechanics by allowing clinicians greater precision and consistency in treatment outcomes. Subsequent research has validated both the safety and clinical effectiveness of these devices. A meta-analysis conducted by Papageorgiou et al. [2] reported low failure rates for orthodontic Mini screws and identified multiple biological and mechanical factors influencing their success. [2] Furthermore, Poggio et al. [3] described specific "safe zones" in the maxillary and mandibular arches, emphasizing optimal placement areas that minimize complications and enhance primary stability. [3]

Beyond routine orthodontic applications, TADs have proven particularly valuable in complex treatment scenarios such as the correction of Class II malocclusions. Papageorgiou et al. [2] highlighted the role of skeletal anchorage in facilitating demanding orthodontic movements. In addition, Antoszewska-Smith et al. [4], through a systematic review and meta-analysis, demonstrated that the use of TADs significantly improves anchorage control during en-masse retraction, leading to more efficient and predictable treatment outcomes.

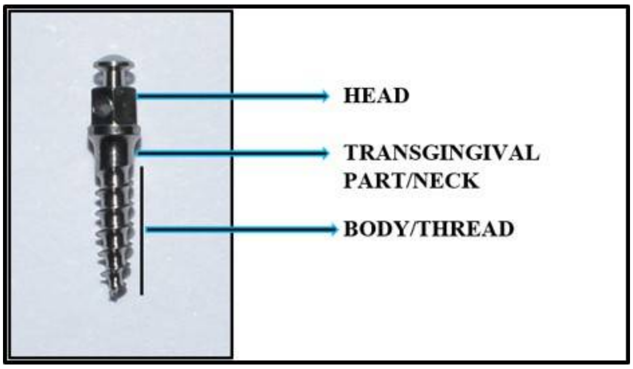

Fig 1. Components of a Miniscrew / TAD

MATERIALS USED FOR IMPLANTS

Conventional orthodontic Mini screw implants (MSIs) are manufactured from a variety of materials, including:

- Titanium alloy
- Titanium-coated stainless steel
- Commercially pure bioinert titanium
- Stainless steel

Among these, medical-grade Titanium alloy is the most commonly utilized due to its excellent biocompatibility and mechanical strength. Grade V Titanium alloy (Ti-6Al-4V), composed of Titanium, aluminum, and vanadium, is considered the material of choice. Compared with commercially pure Titanium, this alloy demonstrates superior strength while maintaining high biocompatibility [5].


Fig 2. TADs with different head designs

SITES FOR TAD PLACEMENT

An accurate understanding of anatomical placement sites is essential for achieving optimal outcomes with temporary anchorage devices.

3.1 Maxillary Buccal Alveolar Bone

The maxillary buccal region is the most frequently used site for TAD placement. Adequate inter-radicular space is typically available between the first premolar and first molar, making this area favorable for Mini screw insertion. For improved primary stability, placement is often recommended in the apical region where the cortical bone is thicker. However, this advantage may be offset by reduced inter-radicular distance.

Placement in movable mucosa, although providing increased inter-radicular space, may lead to soft tissue irritation and postoperative discomfort. [7]

3.2 Maxillary Palatal Alveolar Bone

The palatal cortical bone is generally thicker and denser than its buccal counterpart. Studies have shown that the densest palatal inter-radicular bone is located between the first and second premolars, whereas the greatest cortical thickness is observed between the canine and first premolar. [8]

3.3 Mid-Palatal Suture

Due to the presence of dense cortical bone, pilot drilling is recommended before Mini screw insertion in the mid-palatal region. Longer screws are often required because of the increased thickness of palatal mucosa. In growing individuals, placement approximately 1–2 mm lateral to the mid-palatal suture is preferred, as the suture itself consists of under-ossified bone and soft tissue.

Mandibular Buccal Alveolar Bone

In the mandible, inter-radicular space increases from the cervical region toward the apex and is most pronounced between the first and second premolars. Cortical bone thickness also tends to increase from the anterior to posterior region, with the greatest inter-root distance commonly observed between the first and second molars.

Despite the denser cortical bone of the mandible, Park et al. reported a lower success rate for mandibular TADs compared to maxillary placements. [9]

Buccal Shelf Area

The mandibular buccal shelf provides a dependable alternative when inter-radicular placement is limited. This extra-alveolar site allows the insertion of larger-diameter Mini screws parallel to the roots, thereby reducing the risk of root damage. High success rates of approximately 93% have been reported, regardless of whether the screw is placed in attached gingiva or movable mucosa. [10]

Retromolar Area

The retromolar region is another viable site for TAD placement and has demonstrated high success rates. However, caution is necessary, as lingual displacement of screws in this area may pose a risk to the lingual and inferior alveolar nerves. [6]

Infrazygomatic temporary anchorage devices (IZ-TADs)

Have become an important adjunct in modern orthodontics for managing demanding anchorage requirements. These Mini screws are placed in the extra-alveolar region of the infrazygomatic crest of the maxilla, where dense cortical bone provides superior primary stability. IZ-TADs enable absolute anchorage and facilitate complex tooth movements such as maxillary posterior intrusion, en-masse anterior retraction, correction of Class II malocclusion, and management of vertical maxillary excess. Their extra-radicular placement reduces the risk of root damage and allows immediate application of orthodontic forces. Clinically, the use of infrazygomatic anchorage has expanded non-extraction and non-surgical treatment options in borderline skeletal cases. Nevertheless, careful case selection and precise placement technique are essential to minimize complications such as soft-tissue irritation or Mini screw failure. Overall, IZ-TADs provide a reliable and versatile means of enhancing biomechanical control in orthodontic treatment.

Table 1: Recommended dimensions of orthodontic mini-implants at different anatomical sites

Site/Region	Diameter (mm)	Length (mm)
Maxillary interradicular	1.6	8–10
Mandibular interradicular	1.2–1.6	6–8
Infra-zygomatic	1.3–1.8	8–12
Palatal/ Mid palatal	1.2–1.6	6–10
Retromolar area	1.5–2.0	6–10

FACTORS AFFECTING IMPLANT SITE SELECTION

The selection of an appropriate site for Mini screw placement is influenced by several anatomical and biomechanical factors. Ideally, the implant should be positioned within the available bone volume while avoiding adjacent anatomical structures. Sites with fewer anatomical limitations generally offer a higher success rate and reduced complication risk [7].

Cortical Bone Thickness

Cortical bone thickness is one of the most critical determinants of Mini screw stability. Insufficient thickness may result in inadequate mechanical retention, whereas excessive thickness can increase insertion torque and risk bone damage. An optimal cortical bone thickness of approximately 1.0–1.5 mm has been associated with the highest success rates [11].

Proximity to Dental Roots

The closeness of a Mini screw to adjacent dental roots significantly influences its success. Numerous studies have demonstrated increased failure rates when screws are placed too near the roots. The use of anatomical averages, orthodontic root divergence, surgical guides, and three-dimensional imaging can help minimize this risk [3, 12, 13].

Bone Depth

Bone depth refers to the distance between the cortical plate providing retention and opposing anatomical boundaries. While monocortical engagement is usually sufficient for orthodontic purposes, bicortical engagement may be advantageous in orthopedic applications such as rapid palatal expansion. Although nasal cavity perforation is often asymptomatic, sinus perforation may lead to complications due to impaired drainage [7].

Soft Tissue Considerations

Attached gingiva is the preferred soft tissue for Mini screw placement, as it is firm and immobile, reducing inflammation and improving peri-implant stability [14].

TECHNIQUE OF MINI-SCREW PLACEMENT

Case Selection Criteria

Prior to Mini screw insertion, a comprehensive medical history should be obtained, with particular attention to systemic conditions and medications affecting bone metabolism. Radiographic evaluation is essential to assess bone quality, inter-radicular space, root angulation, and crestal bone height. Informed consent should be obtained, and any existing periodontal disease or gingival inflammation must be addressed through appropriate oral hygiene measures and prophylaxis.

Mini screw Placement

Screw Length

Mini screws are available in lengths ranging from 5 to 12 mm. The selection depends on bone quality, bone quantity, and soft tissue thickness. A minimum bone-screw contact of 4 mm in the mandible and 6 mm in the maxilla is recommended. Consequently, typical lengths range from 5–7 mm in the mandible and 7–8 mm in the maxilla. Longer screws (10–12 mm) are preferred in areas with thick soft tissue, such as the palate.

Screw Diameter

Mini screw diameters vary from 1.2 to 2.7 mm. The diameter should be selected based on available inter-radicular space, ensuring at least 1 mm of surrounding bone. A diameter of 1.5 mm is commonly used, while narrower screws (1.2 mm) are preferred in areas with limited space, such as between mandibular incisors. Although diameter plays a key role in stability, screws exceeding 2 mm may increase the risk of root damage and instability [15].

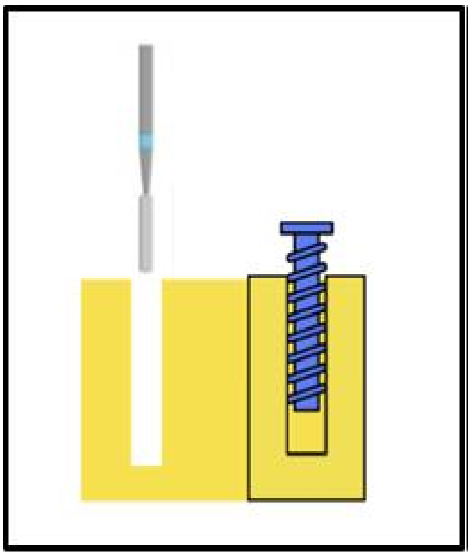

Fig 3. Self-tapping Mini screw

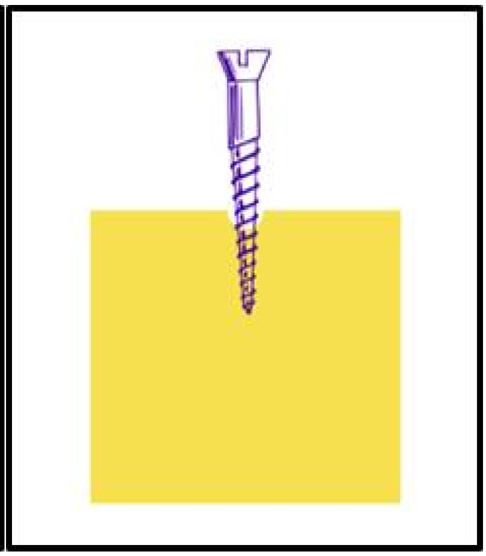

Fig 4. Self-drilling Mini screw

BENEFITS AND LIMITATIONS OF MINI-SCREWS

Mini-Screws

Force Application

Mini screws are capable of withstanding orthodontic forces ranging from 300 to 800 g, making them suitable for a wide range of tooth movements.

Advantages

- Cost-effective
- Simple placement and removal
- Provides reliable skeletal anchorage

LIMITATIONS

Root Damage: Accidental contact with dental roots during insertion is a recognized risk. The use of surgical guides and CBCT imaging can significantly reduce this complication. Minor cementum or dentin damage often heals following immediate screw removal; however, pulpal involvement may lead to irreversible injury [16, 17].

Screw Fracture: Predrilling and the use of appropriate screw diameters are essential in areas with dense cortical bone to prevent fracture.

Ingestion or Aspiration: Loosening of Mini screws during mastication or sleep poses a risk of ingestion. Although most ingested screws pass spontaneously, precautionary measures are necessary [18].

CONCLUSION

Temporary anchorage devices have revolutionized contemporary orthodontic practice by offering a reliable, non-compliance-dependent method of anchorage control. Their versatility allows clinicians to perform complex tooth movements with greater precision, efficiency, and predictability. The success of TADs is multifactorial and depends on appropriate case selection, thorough understanding of anatomical structures, careful site selection, and adherence to proper clinical techniques.

Mini screws, owing to their minimal invasiveness, ease of placement and removal, and cost-effectiveness, have become the most widely used form of skeletal anchorage. Advances in imaging modalities and biomechanical protocols have further enhanced their clinical success and expanded their applications, including management of challenging malocclusions and borderline surgical cases.

Despite certain limitations and potential complications, the high success rates and clinical benefits of TADs outweigh their drawbacks. With continued research and technological advancements, TADs are expected to play an even more integral role in the future of orthodontics, contributing to improved treatment outcomes and patient satisfaction.

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