Mini-implants are anchorage reinforcement products that are safe, minimally intrusive, and can be used to supplement orthodontic anchorage. Mini-implants are exempt from the traditional extraoral anchorage's compliance requirements. Mini-implants work better than traditional implants in as they are implanted into the bone, traditional intraoral anchorage designs. To address orthodontic malocclusion in the anteroposterior, vertical, and transverse dimensions, mini-implants can be inserted at various places in the maxilla and mandible.[(1)]

Titanium mini-screws have become extremely common in orthodontics during the past 20 years and are frequently used as a source of absolute intraoral anchorage, expanding the potential goals and range of orthodontic therapy. Another benefit is the potential for providing quick loading, which shortens the overall length of orthodontic therapy.[(2)] TADs give more consistent outcomes when compared to other anchorage mechanisms.

A novel type of orthodontic anchoring that uses orthodontic mini-implants (OMIs), also known as mini-screw implants and temporary anchorage devices, has emerged at the beginning of the twenty-first century (TADs). The average body (endosseous) dimensions of these modified bone screws are 1.5–2 mm in diameter and 6–10 mm in length. When opposed to dental implants, their surfaces are polished and smooth. They therefore rely on mechanical retention within the cortical layers of the alveolar and palatal bones rather than osseointegration.[(3)]

There have been many significant developments in orthodontics over the course of its century-long history, but few can compare to the therapeutic effect produced by micro-implants and the new orthodontic bone screws for the ***buccal shelf (BS) and infra-zygomatic crest (IZC).***(Figure 7.1a, 7.1b and 7.2) In the last ten years, the notion of absolute anchorage has been revitalised by the use of micro-implants and extra-radicular bone screws in orthodontics. An experienced physician may use it as an additional tool in their toolbox to meet new clinical difficulties and transition even surgical situations that are on the verge of becoming nonsurgical without sacrificing the outcomes attained.[(4)]

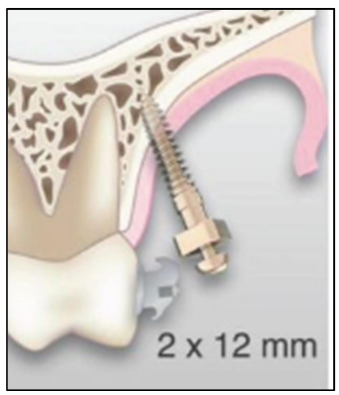

Figure 7.1a; IZC

(Infrazygomatic Crest Implant)

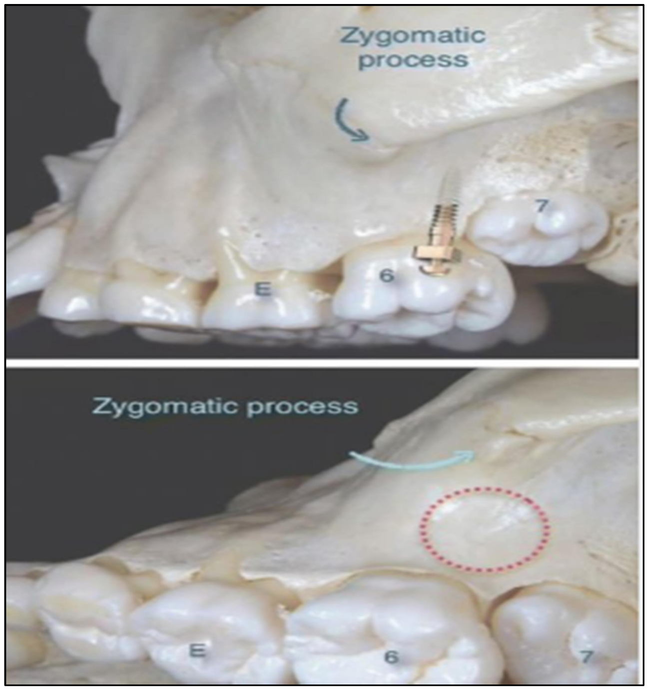

Figure 7.1b; Infra-Zygomatic Crest, Mini Screw

Figure 7.2Buccal Shelf, Mini Screw

Extra Radicular Bone Screws and Their Difference with Micro-Implants

Although both extra-radicular bone screws (IZC, BS) and micro-implants fall under the category of temporary anchorage devices, their placement locations differ. Micro-implants are typically inserted within the radicular spaces between teeth, whereas bone screws are positioned externally in areas such as the infra-zygomatic regions of the maxilla and the buccal shelf regions of the mandible. Nonetheless, both serve as skeletal anchors (see Figure 7.3) (5).

Bone screws are often larger in size, ranging from 10 to 14 mm in length with a minimum diameter of 2 mm. In contrast, the average size of a micro-implant varies between 6 and 11 mm in length and 1.3-2 mm in diameter, depending on the specific clinical application. Bone screws can be acquired with either short or long collars, much like micro-implants, depending on the anatomical site and clinical scenario. Similarly, their head shapes can vary, with the mushroom-shaped head being the most common design, similar to micro-implants.

Figure 7.3; Bone Screw Specifications:

Infra-Zygomatic Crest, BSS

BONE SCREWS AND MICRO-IMPLANTS USE DIFFERENT TYPES OF MATERIALS.

Most micro-implants available on the market are made from an alloy known as Ti6Al4V, consisting of titanium, aluminum, and vanadium. While bone screws with similar compositions are available, the preferred material for bone screws is pure stainless steel.Bone screws are often implanted in IZC and BS regions, which have DI (>1250 HU) grade bone, necessitating more fracture resistance.(Table 7.1)

The ideal material is stainless steel since it has stronger fracture resistance than Ti alloy.

Properties	Stainless steel	Titanium alloy
Elastic modulus (Gpa)	193	100
Yield strength (Mpa)	170-1210	795
Tensile strength (Mpa)	480-1300	860
Ductility (%)	12-40	10

Table 7.1: Comparison of properties of stainless steel and titanium alloy

COMPLICATIONS AND SUCCESS RATE OF BONE SCREWS AS COMPARED TO MICRO-IMPLANTS

Inserting bone screws rarely leads to issues, typically resulting in only minor bleeding. When using high-quality, pure stainless steel screws, there is no concern about screw tip breakage. The most common complications associated with bone screws are gingival overgrowth on the screw and early screw loosening. Effective dental hygiene is crucial in preventing complications related to gingival enlargement. The risk of gingival overgrowth is significantly reduced when screws have larger heads. If a screw becomes loose prematurely, it is advisable to replace it at a different location.

Due to their larger size and placement in areas with excellent cortical bone quality, bone screws offer significantly greater stability and success rates compared to micro-implants.

NANOTECHNOLOGY IN TEMPRORY ANCHORAGE DEVICES

Nanotechnology, the process of manipulating matter at the nanoscale, has shown promise across various medical disciplines, including dentistry. In the distant future, nanotechnology could revolutionize dentistry and orthodontics. Nanorobots equipped with specific mobility mechanisms may navigate the periodontium to directly enhance orthodontic tooth movement. Additionally, this approach could potentially mitigate root resorption during orthodontic treatment.

Temporary Anchorage Devices (TADs) have insertion sites within the bone, and they enhance orthodontic anchorage either directly, when functioning independently, or indirectly, by providing support to anchoring teeth (6). The preservation of healthy peri-implant tissue is crucial as a biological defense against microbial invasion. However, the insertion of tiny screws may lead to issues such as tissue irritation, mild infections, and the development of peri-implantitis (7).

Peri-implantitis is an inflammation affecting the mucosal tissue surrounding an implant, characterized by symptoms such as increased mobility, visible loss of bone support both clinically and on radiographs, bleeding upon probing, suppuration, and epithelial infiltrations. Research has shown that soft tissue inflammation around the implant can lead to a significant 30% increase in implant failure rates (8).

Nanotechnology offers the potential to develop temporary anchoring devices with minimal alterations to their functional properties, aiming to reduce patient discomfort. Surface modifications may involve the incorporation of pharmacologically active antibacterial agents or compounds, such as antibiotics, antiseptics, metal ions, or organic molecules. This innovation could transform implants from passive, pharmacologically inert medical devices into something resembling drug agents, potentially introducing unpredictable long-term effects and raising complex regulatory concerns (9).

NANOPARTICLES IN TEMPORARY ANCHORAGE DEVICES

Modern TADs are manufactured with flat titanium surfaces. The placement of mini-screws and orthodontic loading both present the potential for stability and patient safety issues. Common soft tissue problems include pain, inflammation, infection, and peri-implantitis, as well as issues like aphthous ulceration, soft tissue covering of the small screw head, and other complications. Therefore, it is imperative to minimize discomfort and the risk of peri-implant infection related to the installation of temporary anchoring devices. This can be achieved by implementing surface modifications using pharmacologically active compounds.

Historically, two primary strategies, namely "contact killing" and "drug eluting," have been proposed as effective methods for antibacterial surface treatment. Antibacterial surface technologies can utilize a range of materials, including metals like silver, zinc, copper, non-metal elements like iodine and selenium, organic compounds like antibiotics, anti-infective peptides, chitosan, and various combinations thereof. Among metals, silver is the most commonly utilized material in biomedical applications (10).

Additionally, there is a notable approach centered on modifying titanium alloys, a widely employed alloy in various applications.

Extensive in vitro research has shown that titanium dioxide films possess intrinsic anti-infective properties, either independently or when combined with other substances. In biomedical applications, non-metallic elements such as oxygen, hydrogen, chlorine, or iodine are often utilized due to their anti-infective attributes. For instance, covalently bonded selenium on the surfaces of titanium or titanium alloy implant discs has been observed to prevent the adhesion of bacteria like Staphylococcus aureus and Staphylococcus epidermidis, without causing any adverse effects on osteoblast viability (11)

.TADs SUPPORTED FROG APPLIANCE(Figure 7.4)

One of the most common issues encountered in orthodontic practices is Class II malocclusion. Clinical indicators of Class II Div.2 malocclusion include mandibular retrognathism rather than maxillary prognathism, a horizontal development pattern, a skeletal deep bite, retroclination of upper incisors, and the presence of a prominent soft tissue chin (12). Treatment options include orthognathic surgery, growth modification, and orthodontic camouflage. Camouflage methods may involve premolar extraction or distalization of the maxillary molars.

Various techniques have been employed to achieve molar distalization (12). Temporary Anchorage Devices (TADs) are favored for this purpose as they reduce the reliance on patient cooperation, minimize unintended tooth movement, and facilitate planned tooth movement.

A frog appliance kit consists of three main components: a screw, a pre-fabricated spring, and a screwdriver. To ensure effective treatment, it's essential to position the frog screw at a distance ranging from 10 to 12 millimeters from the occlusal surface. This placement facilitates the desired bodily movement of the molars since the appliance is positioned approximately at the center of resistance for the molars.

In the construction of the frog appliance, the anterior section is soldered to the miniscrew cap, and lingual sheaths are attached to the lingual surface of the upper first molar bands. When inserting the appliance, the upper first and second molar bands are affixed using a multi-cure glass ionomer orthodontic band cement.

. Subsequently, the ends of the distalizing spring are inserted into the lingual sheaths of the molar bands, followed by the adjustment of the anterior part of the appliance onto the Temporary Anchorage Device (TAD). Finally, the spring is inserted into the posterior part of the appliance to complete the assembly.

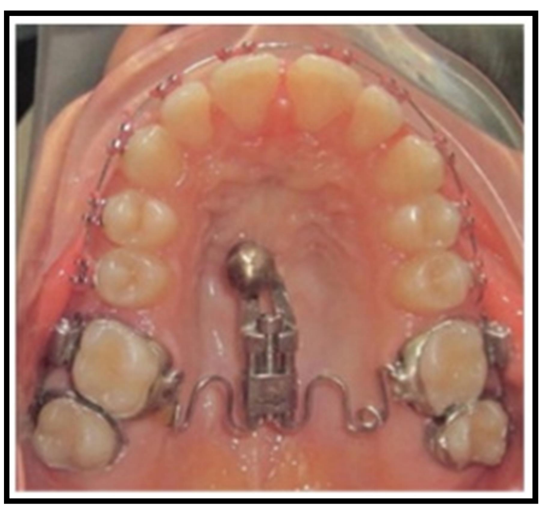

Figure 7.4: Frog Appliance

The frog appliance, when not soldered to bands, offers several advantages, including palatal placement, skeletal anchorage, hygienic movement in three dimensions, the capacity to measure distalization degree, straightforward activation, and the presence of adjustable arms (13)

MAXILLARY PROTRACTION USING SKELETAL ANCHORAGE IN GROWING PATIENTS.

A maxillary protraction face mask is commonly employed for the early treatment of patients with skeletal Class III malocclusions. This treatment involves applying forces primarily to the teeth for 12 to 16 hours daily over a span of 9 to 12 months, resulting in a positive overjet due to both dentoalveolar and skeletal adjustments. However, adverse dentoalveolar effects, such as maxillary incisor proclination, mesialization and extrusion of maxillary molars, and retroclination of mandibular incisors, often accompany the outcomes of this orthopedic therapy.

In recent years, there has been a growing trend toward the The utilization of Temporary Anchoring Devices (TADs) is a common practice in orthognathic surgery and the treatment of fractures. These devices have found increased popularity and applications in orthopedic therapies, including orthodontics. They have demonstrated successful outcomes in various orthodontic maneuvers, including dental intrusion, correction of open bites, and molar distalization (14).

Temporary anchorage devices (TADs), employed as skeletal support, are used in the management of skeletal Class III patients. Diagnosis is made through cephalometric analysis and soft tissue profile assessment, and patients typically exhibit maxillary hypoplasia, a molar Class III relationship, and a negative overjet (see Figure 7.5).

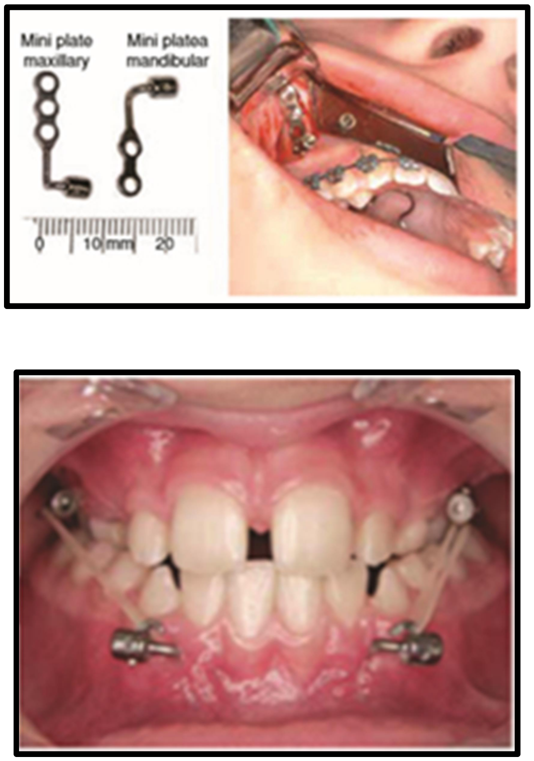

Figure 7.5: Class III Correction By Tads

To be eligible for this approach, patients should fall within the age range of 9 to 14 years, during the pre-pubertal phase (15). An alternative treatment method involves employing skeletal anchorage, this approach involves using two titanium plates attached to small implants inserted into the maxillary zygomatic process, along with two side plates positioned between the lower canines on both the right and left sides.

In conjunction with the use of intermaxillary elastics, this approach leads to advancements in the maxilla, enhancement of facial aesthetics, and a reduction in dentoalveolar side effects (16).

MAXILLARY DISTALIZATION WITH TADs

Temporary Anchoring Devices (TADs) have become an integral component of contemporary orthodontic treatment methods. These diminutive skeletal anchors, often referred to as mini-implants or mini-screws, have expanded the scope of non-surgical, non-extraction, and non-compliance treatment approaches by offering "absolute" anchorage and mitigating the adverse effects associated with conventional orthodontic techniques..[17]

An increasingly prevalent utilization of TADs involves offering anchorage support for the distal movement of maxillary molars. While the distalization of maxillary posterior teeth is not a new therapeutic approach, there were several notable unforeseen outcomes before the adoption of skeletal anchorage. These issues encompassed dental tipping, heightened bite opening, and anterior anchorage loss. In an effort to attain successful distalization with dental anchorage, several appliances have been developed and utilized, including the Distal Jet appliance, Pendulum appliance, Carriere® appliance, and Cetlin appliance.

Technique One: Two-Stage Stabilizing Wire (Figure 7.6)

The inter-radicular Temporary Anchorage Devices (TADs) on the palate secure the first premolar during the distalization phase, while the first molar is stabilized during retraction..

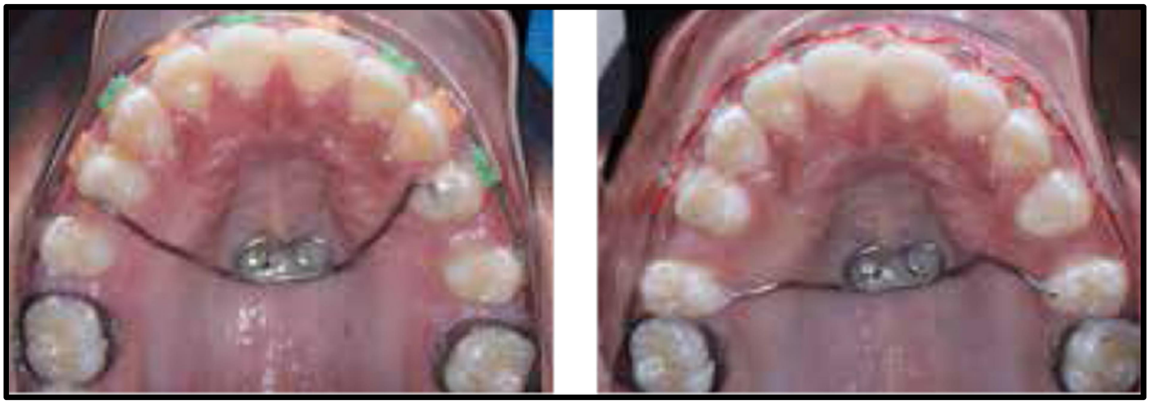

Figure 7.6: Stage Mid Palatal TADS Based Stabilization

Since it doesn't necessitate laboratory tools and can be sterilized, reused, and repositioned in the same patient, this distalization device is not only user-friendly but also cost-effective. However, its major drawback is the significant amount of "doctor-time" needed at the chairside for TAD creation, bonding, removal, and replacement.

Method Two: TAD-Powered Distal Jet (Figure 7.7)

This method is based on a modification of the traditional tooth-borne distal jet device, particularly the Allesee Orthodontic Appliances.The primary method of anchorage relies on the placement of two palatal Temporary Anchorage Devices (TADs). In previous appliance designs, wires were connected to the palatal surface of the first premolars. However, TAD anchoring is now the sole preferred option.

Figure 7.7: Mid Palatal TAD Supported Distal Jet

THE SPIDER SCREW

In such situations, it is advisable to remove the miniscrew and commence anti-inflammatory treatment, as well as consider potential antibiotic therapy. As of now, there is only one study available that delves into the factors affecting the stability of titanium screws.

The findings from this study highlight three crucial factors. The first factor is the screw diameter, the second is inflammation of the peri-implant soft tissues, and the third is the quality of the underlying bone. In accordance with the same study, it is advised that in cases of low bone quality, one should consider employing a longer screw with a larger diameter and initially applying reduced forces to evaluate its stability before applying greater forces. Across all scenarios the effective management of inflammation becomes an exceptionally crucial consideration.

To minimize inflammation& to ensure proper peri-implant hygiene and bolster the natural tissue's resilience, it is crucial to steer clear of the frenum and insert the miniscrews in areas with keratinized gingiva.

Finally, it is crucial to select a screw with an appropriate collar length that aligns with the thickness of the surrounding soft tissues in the area.

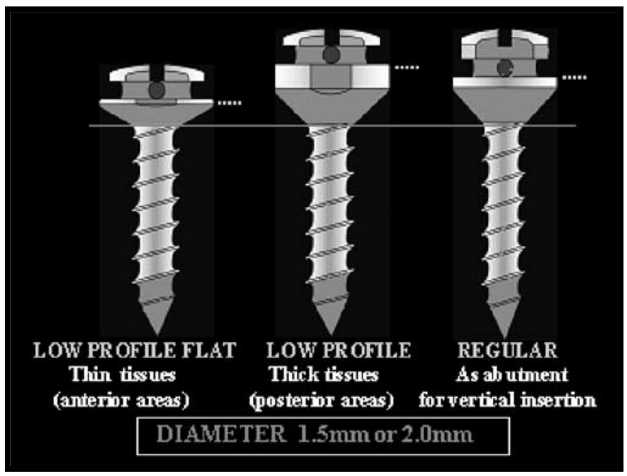

Figure 7.8 Various Heights Of Spider Screw Head And Collar

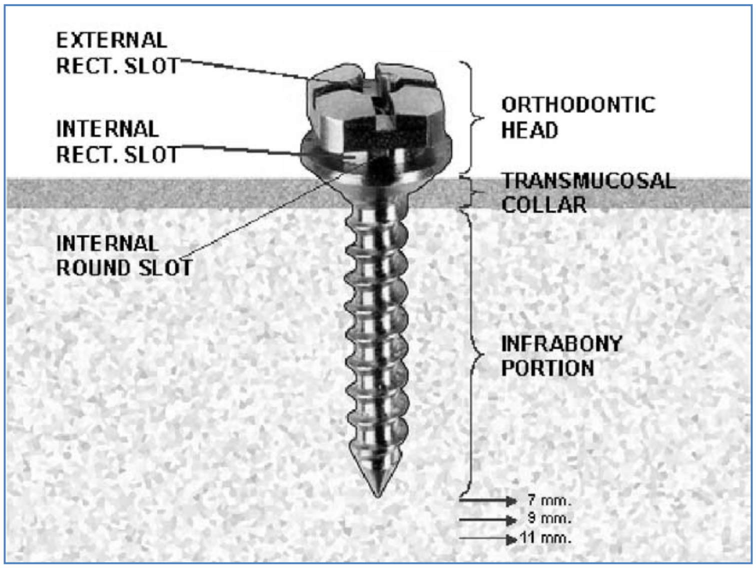

Figure 7.9 Characteristics of Spider Screw

The head of the Spider Screw contains both internal and external rectangular slots, each measuring 0.021 × 0.025 inches. Additionally, it includes a circular internal vertical slot with a diameter of 0.025 inches (refer to Figure 7.9). The extramucosal aspect of the screw head is compact to prevent irritation of soft tissues, yet sufficiently spacious to accommodate orthodontic attachments

Complications

One potential challenge arises from inflammation within peri-implant tissues, especially in areas that involve the frenum or muscle tissue. Effective management of these issues involves maintaining proper oral hygiene and applying a topical chlorhexidine rinse 0.2%. Occasionally, Placing the miniscrew too high in the vestibule can result in mucosal complications. In such cases, the clinician should aim to utilize anchorage mechanics that require minimal alterations at the orthodontic head of the screw.

If miniscrew mobility becomes an issue, it can be resolved by Replacing it with an extended and larger miniscrew.

If this proves insufficient, an alternative site for placement should be considered. In cases where inadvertent invasion of the periodontal ligament occurs during miniscrew insertion, patients may experience pain upon percussion or while chewing. Contact with a root during insertion can result in the patient developing sensitivity to hot and cold stimuli.

In such situations, it is advisable to remove the miniscrew and commence anti-inflammatory treatment, as well as consider potential antibiotic therapy. The steadfastness of titanium screws.

The first factor is the screw diameter, the second is inflammation of the peri-implant soft tissues, and the third is the quality of the underlying bone. According to the same study, When faced with low bone quality, it is advisable to opt for a longer screw with a larger diameter and to initially apply reduced forces to evaluate its stability before proceeding with greater force applications .Across all scenarios, the effective control of inflammation becomes a critically significant factor to address.

To minimize inflammation, it is essential to steer clear of the frenum and position the miniscrews in areas with keratinized gingiva to prevent complications, thereby improving the inherent tissue resilience and supporting the patient in maintaining optimal peri-implant hygiene. Finally, it is crucial to Choose a screw with a collar length that matches the thickness of the adjacent soft tissues in the region.

(19)

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