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)]

The initial attraction of orthodontic mini-implants was the possibility of them providing reliable anchorage, independent of the dentition and requiring no more patient compliance than standard fixed appliance treatment. More recently it has been recognized that OMIs provide anchorage in all three dimensions and consequently[(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]

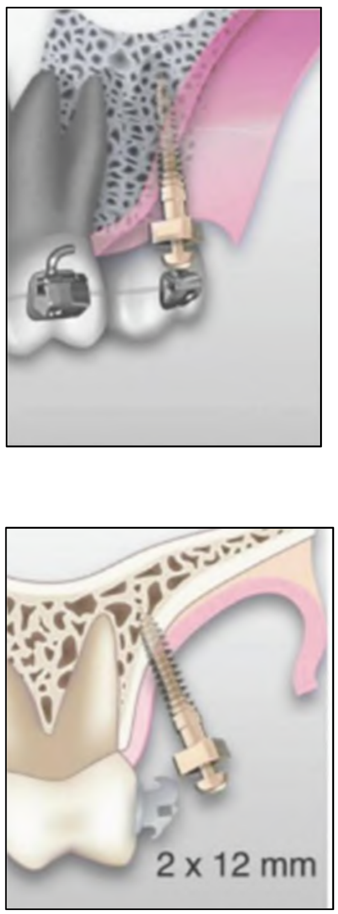

Figure 7.1a; IZC

(Infrazygomatic Crest Implant)

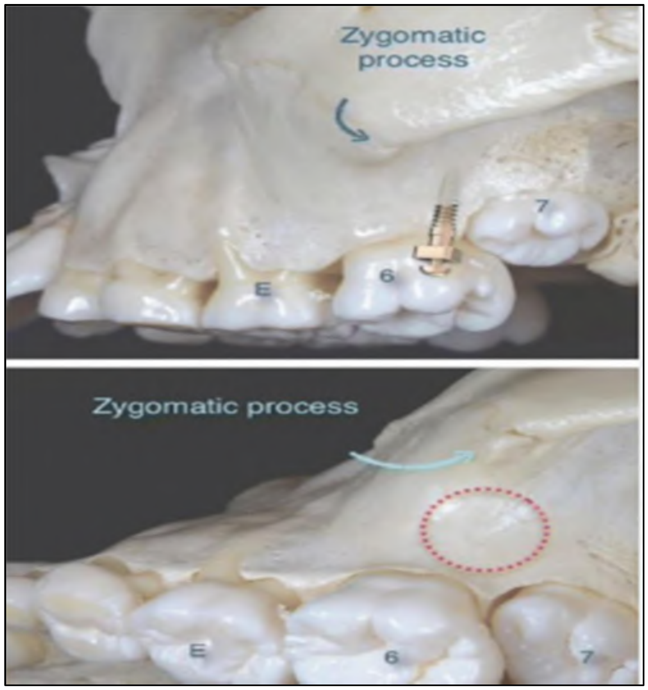

Figure 7.1b; Infra-Zygomatic Crest, Mini Screw

Figure 7.2 Buccal Shelf, Mini Screw

Extra Radicular Bone Screws and Their Difference with Micro-Implants

Although both extra-radicular bone screws (IZC, BS) and micro-implants are categorized as temporary anchorage devices, micro-implants are typically placed inside the radicular spaces between teeth, whereas bone screws are positioned outside of these spaces in the infra-zygomatic regions of the maxilla and the buccal shelf regions of the mandible. Nonetheless, both of them are employed as skeleton anchors.(Figure 7.3)[5]

Bone screws are often bigger in size, ranging from 10 to 14 mm in length and a minimum diameter of 2 mm, but 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 clinical circumstance it has to be utilised for. Depending on the anatomic site and the clinical scenario, bone screws can be purchased with either a short or long collar, similar to how a micro-implant can have either a short or long head. Like micro-implants, their head forms can also vary, with the typical shape being mushroom-shaped.

Figure 7.3; Bone Screw Specifications:

Infra-Zygomatic Crest, BSS

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

The majority of micro-implants on the market are constructed of an alloy of titanium, aluminum, and vanadium (Ti6 Al4 Va), and bone screws are also offered with comparable compositions, although the preferred material 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

With the exception of minimal bleeding, inserting bone screws virtually ever results in problems. If high-quality, pure stainless steel screws are used, screw tip breakage is never an issue. Gingival overgrowth on the screw and early screw loosening are the two most frequent complications connected to bone screws. Maintaining good dental hygiene is essential to preventing complications caused by gingival expansion. With bigger heads on screws, gingival overgrowth is far less common. If a screw becomes prematurely loose, it is best to replace it at a different location.

Because of their bigger size and implantation locations with outstanding cortical bone quality, bone screws are significantly more stable and successful than micro-implants.

NANOTECHNOLOGY IN TEMPRORY ANCHORAGE DEVICES

The method of modifying matter at the nanoscale is known as nanotechnology. It has guaranteed positive outcomes in a variety of medical specialties, including dentistry.

In the far future, the notion of nanotechnology may be used to dentistry and orthodontics. Nanorobots with particular motility mechanisms will traverse through the periodontium to directly modify it, increasing orthodontic tooth movement. This method can also be used to reduce root resorption while receiving orthodontic treatment.

Tads have insertion sites within the bone, and if they function as independent anchorage, they directly improve orthodontic anchorage; if not, they do so indirectly by supporting and bolstering the anchoring teeth.[(6)] As a biologic barrier against microorganisms, healthy peri-implant tissue is essential. With the insertion of tiny screws, tissue irritation, mild infection, and peri-implantitis might develop.[(7)]

Peri-implantitis is an inflammation of the mucosa that surrounds the implant, and it is characterized by increasing mobility, loss of bone support that is clinically and radiographically visible, bleeding upon probing, suppuration, and infiltrations of epithelia. An increase of 30% in failure rate has been linked to inflammation of the soft tissue around the implant.[(8)]

With very little alterations to their functional properties, nanotechnology may be used to create a temporary anchoring device that can lower the incidence of pain and suffering. It is possible for surface modifications to include pharmacologically active pre-incorporated antibacterial agents or compounds, such as antibiotics, antiseptics, metal ions, or organic molecules. This could transform the implant from a passive, pharmacologically inert medical device to something more akin to a drug agent, with unpredictable long-term effects and difficult regulatory issues.[9]

NANOPARTICLES IN TEMPORARY ANCHORAGE DEVICES

TADs are now produced with flat titanium surfaces. Mini screw placement and orthodontic loading both have the potential for stability and patient safety complications. Pain, inflammation, infection, and peri-implantitis are frequent soft tissue problems, along with aphthous ulceration, soft tissue covering of the tiny screw head and auxiliary, and others. Hence, it is crucial to reduce the discomfort and risk of peri-implant infection associated with the placement of temporary anchoring devices. This can be done by making surface alterations utilizing pharmacologically active compounds.

Traditionally, "contact killing" and "drug eluting" have been the two major approaches suggested for efficient antibacterial surface treatment. Metals (such as silver, zinc, copper, etc.), non-metal elements (such as iodine, selenium), organic chemicals (such as antibiotics, anti-infective peptides, chitosan, and other substances), and their mixtures can all be used in antibacterial surface technologies. Silver is the most prevalent metal employed in biomedical applications.[10]

Another intriguing technique focuses on titanium alloy alteration, which is a widely used alloy.

It has been extensively studied and demonstrated in vitro that titanium dioxide films have anti-infective properties, either alone or in combination with other chemicals. Because of their antiinfective qualities, nonmetal elements like oxygen, hydrogen, chlorine, or iodine are frequently used in biomedicine. Staphylococcus aureus and Staphylococcus epidermidis adhesion to titanium or titanium alloy implant discs has been found to be prevented by selenium bonded covalently to those surfaces without impacting osteoblast viability.[11]

TADs SUPPORTED FROG APPLIANCE (Figure 7.4)

One of the most typical situations seen in orthodontic clinics is class II malocclusion. Mandibular retrognathism rather than maxillary prognathism, horizontal development pattern, skeletal deep bite, retroclination of upper incisors, and large soft tissue chin are clinical signs of Class II Div.2 malocclusion.[12] The available treatments include orthognathic surgery, growth modification, and orthodontic concealment. Premolar extraction or distalization of the maxillary molars might be used for camouflage.

Molar distalization has been achieved via a variety of methods.[12] Temporary anchorage devices (TADs) are preferred because they lessen the need for patient cooperation while minimizing unintended tooth movement and accomplishing planned tooth movement.

The components of a frog appliance kit are a screw, a premade spring, and a screwdriver. The frog screw should be positioned between 10 and 12 millimeters from the occlusal surface. This produce bodily movement of the molars because the appliance approximately at the center of resistance of the molars. The anterior portion of the frog appliance is soldered to the miniscrew cap, and lingual sheaths are soldered to the lingual surface of the upper first molar bands. The upper first and second molar bands were cemented using a multi-cure glass ionomer orthodontic band cement at the time of appliance insertion. The ends of the distalizing spring were then inserted into the lingual sheaths of the molar bands, the anterior part of the appliance was adjusted in TAD, and the spring was then inserted into the posterior part of the appliance.

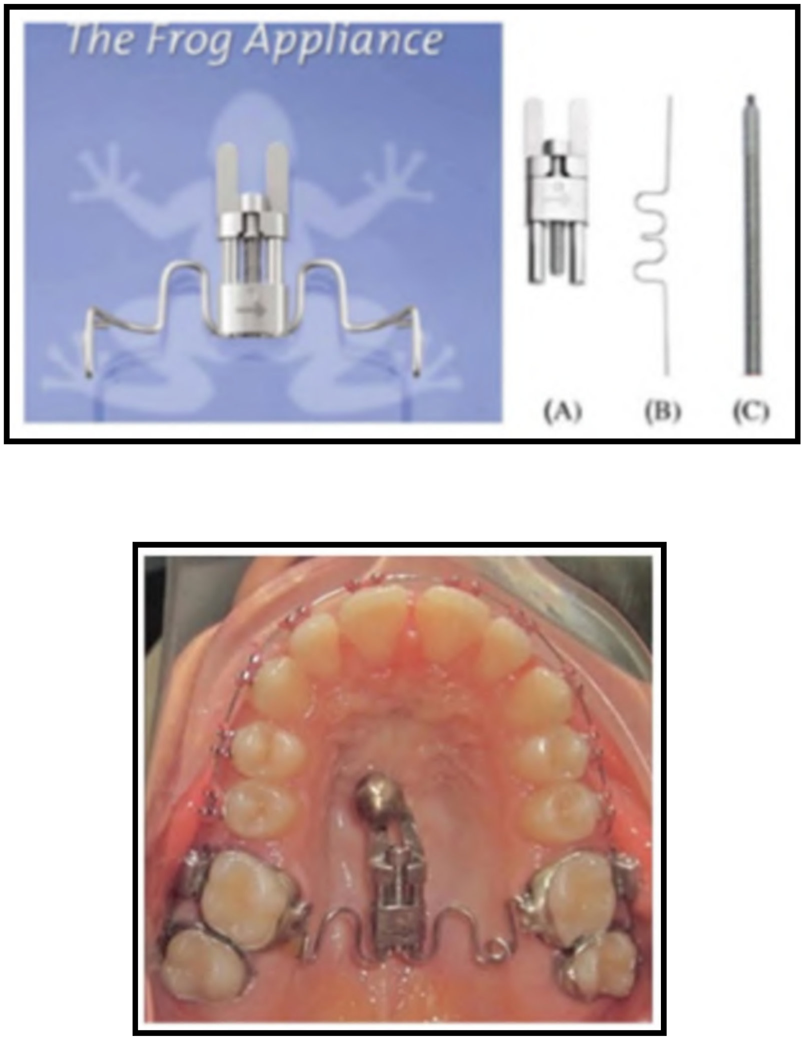

Figure 7.4: Frog Appliance

Palatal appliance, skeletal anchoring, hygienic movement in three dimensions, the ability to gauge the degree of distalization, ease of activation, and adjustable arms are some of the benefits of the frog appliance (not solder to bands).(13)

MAXILLARY PROTRACTION THROUGH SKELETAL ANCHORAGE IN GROWING PATIENTS.

A maxillary protraction face mask is typically used for early treatment of skeletal Class III patients. Due to the forces being delivered mostly to the teeth for 12 to 16 hours per day for 9 to 12 months, this treatment produces a positive overjet through the combination of dentoalveolar and skeletal movements. Adverse dentoalveolar consequences like (proclination of the maxillary incisors, mesialization and extrusion of maxillary molars and retroclination of mandibular incisors) frequently accompany this orthopaedic therapy's results. Temporary anchoring devices (TADs), which are frequently employed in orthognathic surgery and fracture treatment, have become more popular in recent years. In recent studies, skeletal anchorage devices have been offered applications in orthopaedic therapies. They have been successfully employed in orthodontics to produce numerous motions, such as dental intrusion, open bite correction, molar distalization,[14]. TADs as skeletal anchorage are used in skeletal class III patients with hypoplasia of the maxilla determined by cephalometric analysis and soft tissue profile evaluation, in addition to presenting molar class III and negative overjet. (Figure 7.5)

Figure 7.5: Class III Correction By Tads

These patients must be between the ages of 9 to 14 years in a pre-pubertal period. [15] Skeletal anchorage, which uses two titanium plates fixed with small implants implanted in the zygomatic process of the maxilla and two side plates between the lower canine and right and left, as well as the use of intermaxillary elastics, is an alternate treatment. As a result, the maxilla advance, facial aesthetics improve, and dentoalveolar side effects are diminished.[16]

MAXILLARY DISTALIZATION WITH TADs

Temporary anchoring devices (TADs) are now a standard part of orthodontic treatment mechanics in the modern era. These tiny skeletal anchors, also known as mini-implants or mini-screws, have widened the range of non-surgical, non-extraction, and non-compliance treatment protocols by providing "absolute" anchorage and reducing the side effects of conventional orthodontic mechanics.[17]

One increasingly common application of TADs is to provide anchorage for maxillary molar distalization. Although distalization of maxillary posterior teeth is not a novel therapeutic strategy, there were a number of significant unexpected consequences previous to the use of skeletal anchorage, including dental tipping, bite opening, and anterior anchorage loss. In an effort to effectively distalize using dental anchorage, many appliances have been developed and used, including the Distal Jet appliance, Pendulum appliance, Carriere® appliance, and Cetlin appliance.

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

The first premolar is stabilised by this system's inter-radicular TADs on the palate during distalization, and the first molar is stabilised during retraction.

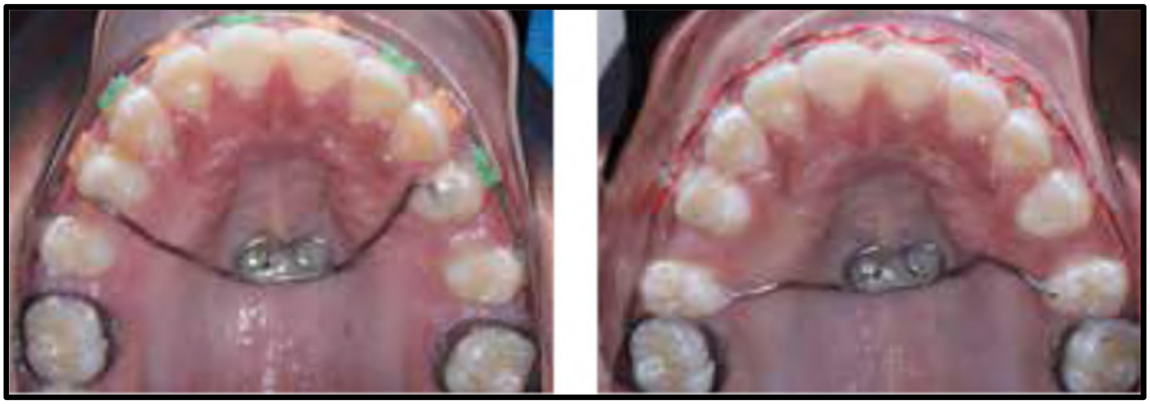

Figure 7.6: Stage Mid Palatal TADS Based Stabilization

As no lab tools are required and the TAD can be reused and repositioned on the same patient after sterilisation, this distalization device is both easy to use and economical. The biggest drawback is the lengthy amount of "doctor-time" required at the chairside to create, bond, and remove and replace the TAD.

Technique Two: TAD-Based Distal Jet (Figure 7.7)

The foundation of this method is a modification of the common tooth-borne distal jet device (Allesee Orthodontic Appliances). The main source of anchoring is provided by the placement of two palatal TADs. Wires were bonded to the palatal surface of the first premolars in early appliance designs. Nevertheless, TAD anchoring is now the only option preferred.

Figure 7.7: Mid Palatal TAD Supported Distal Jet

THE SPIDER SCREW

Many traditional anchorage systems are dependent on patient cooperation and, consequently, they have unpredictable success rates. Titanium miniscrews may be an ideal anchorage system that fulfills the clinical needs of the orthodontist. Some of their benefits include dependability, are well accepted by patients, can be immediately loaded, are simple to insert and remove, and conform to the anchorage needs of the orthodontist.

The Spider Screw (HDC Company, Sarcedo, Italy, hdc goldnet.it) is a self-tapping, commercially pure titanium miniscrew. The screw can be loaded immediately with forces in the range of 50 to 300 *g*. Complete osseointegration is neither expected nor desired with this anchorage system. The Spider Screw anchorage system can be used to support a variety of orthodontic tooth movements in clinical situations involving mutilated dentitions, poor cooperation, or extraction cases requiring maximum anchorage. This system is available in either 1.5- or 2.0-mm diameters. The 1.5-mm diameter screw comes in 6.0-, 8.0-, or10.0-mm lengths, while the 2.0-mm diameter screw comes in 7.0-, 9.0-, or 11.0-mm lengths. Spider Screws are dispensed in prepackaged, sterile, mono-use envelopes. Both diameters are available in three different transmucosal designs to accommodate the soft tissues— low profile, low profile flat, and regular (Figure 7.8). The low profile screw has a longer transmucosal collar combined with a flat head and is utilized in the thick soft tissues of posterior segments, the low profile flat screw has the same head combined with a short collar and is indicated in the thin tissue of the patient's anterior segments, and the regular design has an intermediate length with a raised head, and when combined with a resin core can be used as a temporary prosthetic abutment[18].

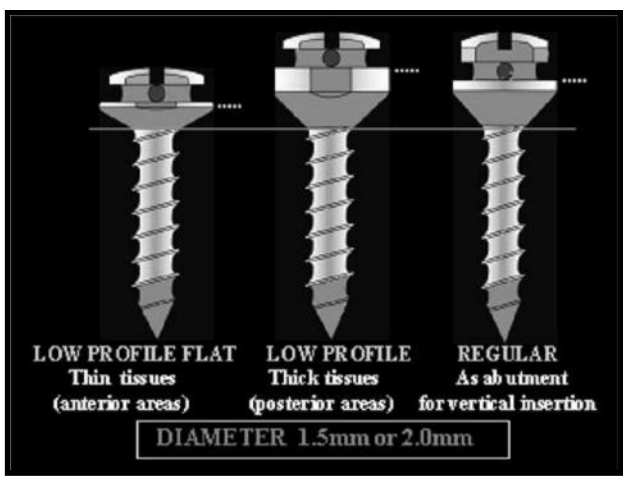

Figure 7.8 Different Heights Of Spider Screw Head And Collar

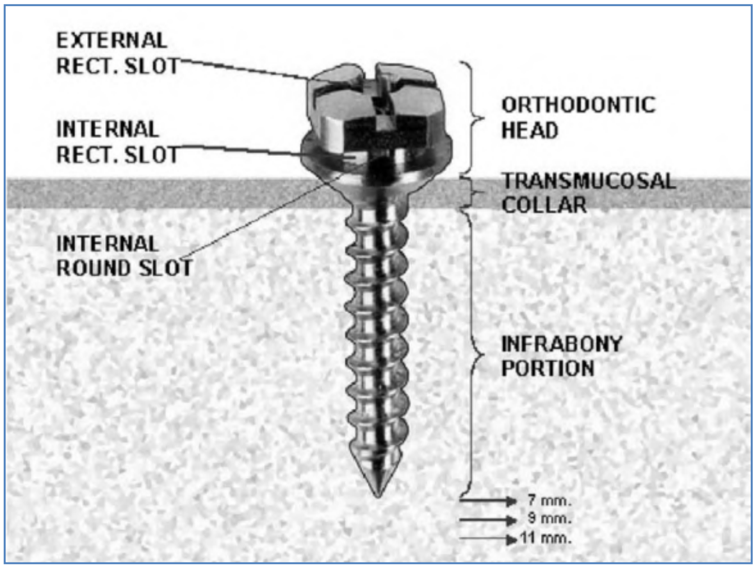

Figure 7.9 Spider Screw Characteristics

The head of the Spider Screw is designed with internal and external rectangular slots 0.021 × 0.025 inch in size. It also has a round internal vertical slot 0.025 inch in diameter (Figure 7.9). The extramucosal head of the screw is small enough to avoid soft tissue irritation yet large enough to accommodate orthodontic attachments

Complications

One possible complication is inflammation of the peri-implant tissues, especially in areas of frenum tissue or muscle tissue. These problems can be controlled with proper oral hygiene and topical application of a 0.2% chlorhexidine rinse. Sometimes, insertion of the miniscrew high in the vestibule creates mucosal complications. In these cases, the clinician should attempt to use anchorage mechanics that requires minimal adjustments at the orthodontic head of the screw. In the event of miniscrew mobility, it can be replaced with a longer and larger miniscrew. If this is not sufficient, another site for placement should be chosen. If, during insertion of the miniscrew, the periodontal ligament is inadvertently invaded, the patient will show symptoms of pain on percussion or mastication. If a root is contacted during insertion, the patient will develop sensitivity to hot and cold. In these cases, the miniscrew should be removed and anti-inflammation therapy and possible antibiotic therapy should be initiated. Presently, there is only one study on factors influencing the stability of the titanium screw. The results of this study showed that there are three critical factors. The first is screw diameter; the second is peri-implant soft tissue inflammation, and the third is bone quality. According to this same study, in presence of poor bone quality, it s suggested to use a longer screw with thicker diameter and apply reduced forces to test the screw's stability before applying larger forces. In all cases, the control of inflammation seems to be an extremely important factor. To minimize inflammation, one must avoid the frenum and insert the miniscrews in areas with keratinized gingiva thus increasing natural tissue resistance and facilitating the patient's ability to maintain good peri-implant hygiene. Finally, select a screw with a proper collar length compatible with the thickness of the soft tissues in the area[19]

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