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Mini Implants in Orthodontics

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ABSTRACT;

In orthodontic treatment teeth are moved to desired position, during this movement some undesirable movement also occurs. To prevent such undesirable movement anchorage units are used. The introduction of skeletal anchorage in the form of temporary anchorage devices (TADs) or miniscrews has greatly benefited orthodontists in finding a way of anchorage control with minimum patient compliance and without a complicated clinical insertion and removal procedures. The mini-implant placement guide was fabricated using rectangular 0.017 x 0.025/0.019 × 0.025 stainless steel (SS) archwire, the wire was bent vertically distal to second premolar along the long axis. The vertical length of the wire is according to the desired length for micro-implant insertion, which is generally 6-7 mm apical to the alveolar crest. After the vertical bend,3-4 mm horizontal bend (which is an interradicular space between two roots) is given in the interradicular space between 2nd premolar and 1st molar. A CBCT is taken to confirm the correct position of template guide. The point of mini-implant insertion site is just at the middle of the horizontal bend, which can be readily marked using a marker or a micromotor burr. This micro-implant placement guide is simple in design, easy to fabricate, inexpensive, supportive and can be used with a variety of mini-screws.This article provides comprehensive information about Temporary Anchorage Devices (TAD's).

Keywords: *Orthodontic Implants, mini implants, micro implants, Temporary anchorage devices, TAD's, Anchorage unit.*

INTRODUCTION;

The concept of skeletal anchorage is not new. Basal bone anchorage was suggested more than 60 years ago as an alternative to increasing the number of teeth to achieve conventional anchorage. Because of the limitations of headgear, clinicians sought other means of anchorage **[1].** For example, orthopedists have used stainless steel bone screws for leg lengthening since before 1905.In 1945, research into the concept of using a pin or screw attachment to the ramus was initiated not only for moving teeth, but also for "exerting a pull on the mandible **[2].**

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One study involved placing Vitallium screws(Dentsply) in dogs. Using basal bone for anchorage, tooth movement was successful; however, it was found that an effective force could be maintained for no longer than 31 days[1,3]. The loss of all screws was attributed to infection from communication between the Vitallium screw and the oral cavity. Nonetheless, the authors concluded that "anchorage may be obtained for orthodontic movement in the future **[3,4].**

Since 1969, when Branemark et al **[5]** introduced dental implants for tooth replacement and prosthetic rehabilitation, osseointegration has remained the singular goal. In the last 25 years, dental implants have been used successfully in combined management of orthodonticrestorative patients, particularly in partially edentulous adults . Osseointegrated dental implants are used for orthodontic anchorage and then later serve as abutments for tooth replacement. This type of anchorage is very effective in treating patients with hypodontia, congenially missing teeth, or periodontal disease, who lack sufficient teeth for conventional anchorage. Additionally, implants have been used for presurgical tooth movement, space opening/closing, and generally as a means to achieve better functional, biologic, and esthetic results in multidisciplinary treatment **[3.4] (FIG. 1 A-F, FIG. 2 A-I)**.

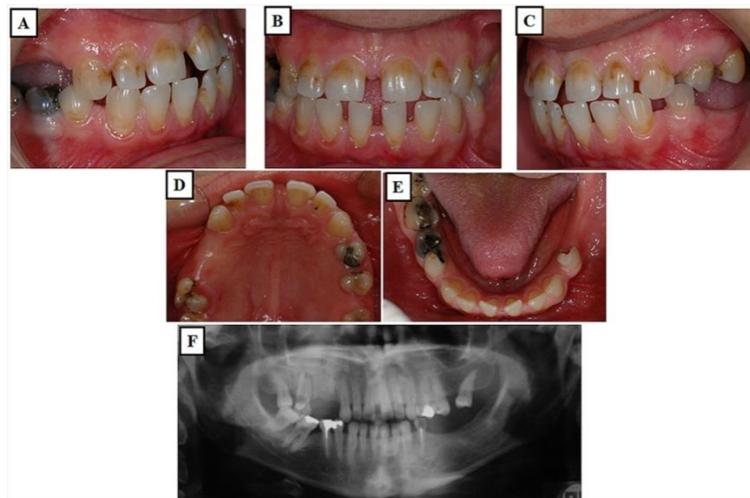

Figure1 A-F: *Clinical case of a patient with multiple missing teeth requiring orthodontic treatment prior to prosthetic rehabilitation.*
(A–C) *Frontal and lateral intraoral views showing generalized spacing and tipping due to tooth loss.*
(D, E) *Occlusal views of the maxillary and mandibular arches with visible edentulous spaces.*
(F) *Panoramic radiograph confirming the extent of tooth loss.*
To allow for proper prosthetic planning, orthodontic space closure was indicated as part of the interdisciplinary treatment approach.

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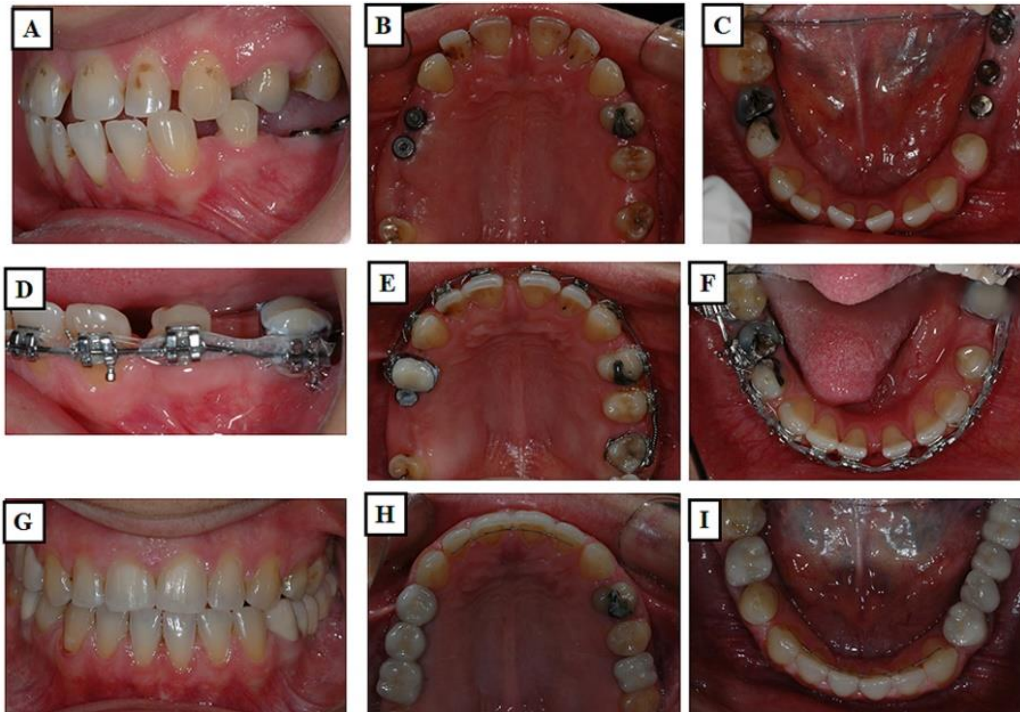

Figure 2 A-I: *Interdisciplinary treatment of a patient with multiple missing teeth requiring orthodontic space management before prosthetic rehabilitation.*
(A–C) *Initial intraoral views showing malocclusionand edentulous spaces.*
(B, C) *Implant fixtures were placed in the correct prosthetic positions prior to orthodontic treatment.*
(D–F) *Fixed appliance therapy initiated five months after implant placement; the implants were used as stable anchorage units during space closure and alignment.*
(G–I) *Final occlusal outcome following successful interdisciplinary treatment.*

In 1978, Sherman3 placed six vitreous dental implants into the extraction sites of mandibular third premolars in dogs and loaded them with orthodontic forces. Only two of the six implants were considered successful. Later on, Roberts and co-workers **[4]** investigated the osseous adaptation of rigid endosseous implants to continuous loading: titanium implants with an acid-etched surface were screwed into the femur of rabbits and were found to be useful as a source of firm osseous anchorage for orthodontics and dentofacial orthopaedics. They concluded that endosseous implants could be used as a firm osseous anchorage for orthodontics and dentofacial orthopaedics **[1,4,5]**.

Orthodontic miniscrew implants have been designed to circumvent the limitations posed by restorative dental implants. These smaller bone screws are significantly less expensive, are easily placed and removed, and can be placed in almost any intra-oral region, including between the roots of the teeth. Some basic questions remain, however, concerning the limitations of miniscrews. Specifically, what is the maximum amount of lateral or shear force

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that can be applied to these miniscrews before they fail? How does a force that is applied immediately after the miniscrew is placed affect the maximum holding power of the implant? To what extent does the total length literature. of screw engaged in bone affect the maximum shear force the implant can withstand? These are questions ? **[3,5,6]**.

For orthodontic purposes, however, standard implants of 3.25 to 7.0 mm in diameter were less than ideal. They required multiple-stage surgical procedures and a waiting period of 4 to 6 months for osseointegration before orthodontic loading could be activated. Lack of adequate bone to place the large-diameter dental implants restricted their use in some patients. In others, anatomic limitations (soft tissue, sinus, nerves, unerupted teeth inchildren, etc) were problems. Another disadvantage of osseointegrated implants involved the need to place them in edentulous areas, retromolar regions, along the palatine suture, or pterygoid areas.6-8 Finally, dental implant surgical protocols were invasive, expensive, uncomfortable for patients, and lengthy, and they excluded children under the age of 16 years **[6] (FIG 3)**

In preparation for implant placement, good orthodontic records (panoramic, periapical, and cephalometric films, casts, etc) are required along with clinical findings and a definitive orthodontic treatment plan to determine the optimal position for implant placement. Site selection is critical and requires careful consideration of the hard and soft tissues, accessibility, patient comfort, and biomechanical needs. The actual implant placement is atraumatic, nonpainful, and requires minimal anesthesia **[6,7].**

All types of skeletal anchorage (including miniscrews) are, by definition, implants. It is important, however, to differentiate miniscrews from typical dental implants **[1,3,5]**.

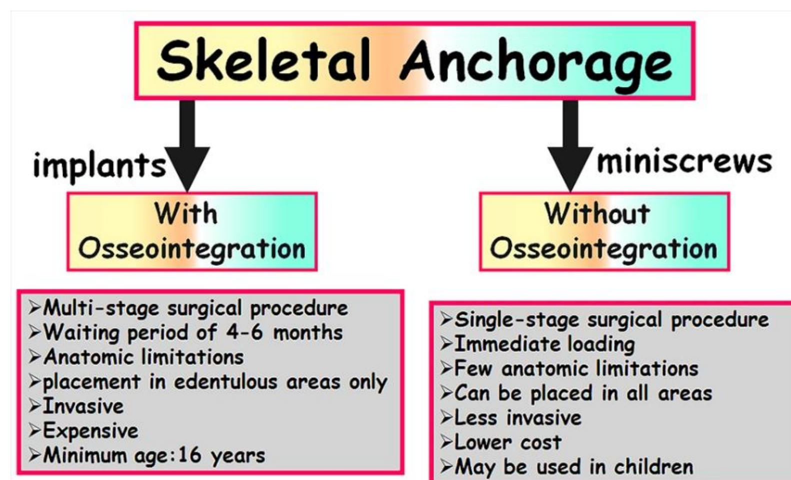

Figure 3:*Comparison between skeletal anchorage systems: osseointegrated implants versus non-osseointegrated miniscrews. Key differences include surgical protocol, loading time, anatomical requirements, cost, and patient age suitability.*

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More than 30 different terms for skeletal temporary anchorage screws are in use in the international literature. The most common of these are mini-implant, mini-pin, miniscrew, or TAD (temporary anchorage device) .The term "miniscrew" appears to provide the most accurate (and most palatable) description of these "miniature screws," especially when discussing their use with prospective patients . There are also more than 30 manufacturers of miniscrew systems , with the number of different screws offered per system ranging from two to 154 **(FIG 4)**. It can be an overwhelming and perplexing process to sort through all of these options and select those devices that are needed for daily practice. The following is an overview of the most important decision-making criteria for choosing a miniscrew system **[1,3,5,6]**.

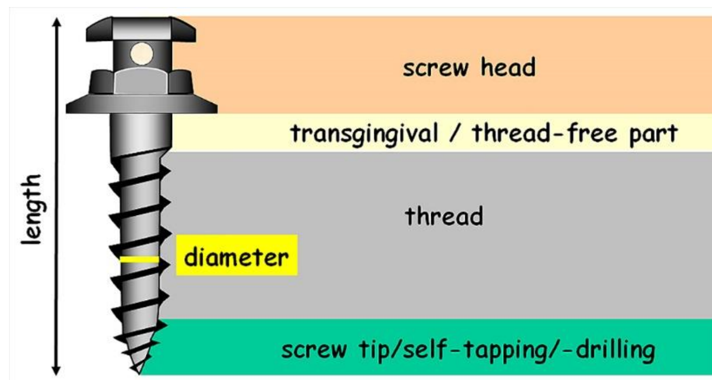

Figure 4:*Structural components of an orthodontic miniscrew, illustrating the screw head, transgingival (thread-free) section, threaded body, and self-tapping or self-drilling tip. The diagram also defines key geometric parameters, including overall length and outer thread diameter, both critical for clinical application and primary stability.*

The stability of a miniscrew in the bone depends primarily on its diameter, and not on its length. The diameter of available miniscrews varies between 1.2 mm and 2.3 mm. In this case, "diameter" is the outside diameter of the threads. For safe and secure primary mechanical stabilization, a minimum amount of bone is required around the shank of the miniscrew . Although there is no definitive answer as to the amount of bone required, it appears that from between 0.5 mm to 2 mm is necessary for stabilization to reduce premature loss. The amount of bone between the roots of teeth, therefore, defines the maximum diameter of screw that can be used in a particular site. In short, the total distance between roots should be at least 1 mm greater than the diameter of the chosen miniscrew to provide adequate bone support **[5,7,8]. (FIG 5 A, B)**

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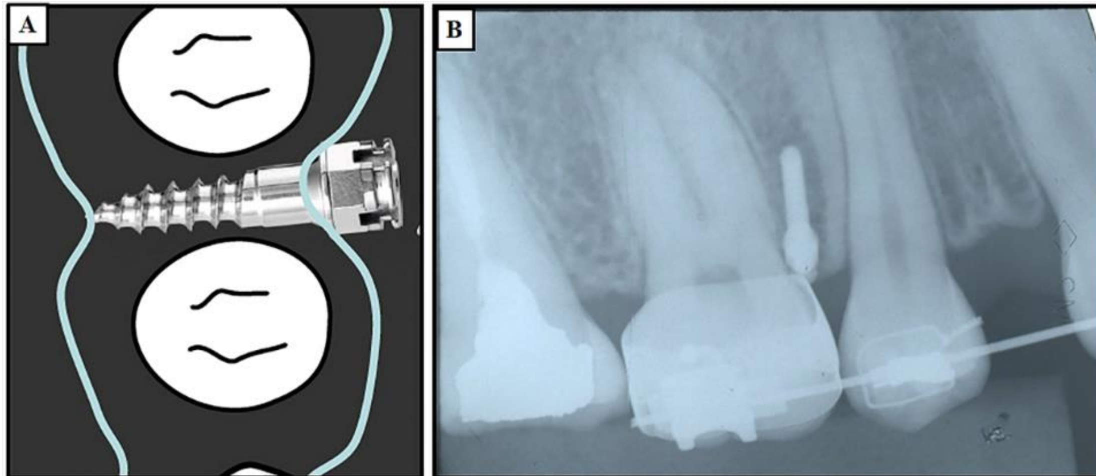

Figure 5 A, B:*To avoid root damage and ensure primary stability, the distance between adjacent tooth roots should be at least 1 mm greater than the outer diameter of the inserted miniscrew.*

The length of the various miniscrews on the market ranges from 5 mm to 14 mm. Typically, the length of the miniscrew refers only to the shaft or shank (the threaded section) . As with the diameter, the selection of the length of a miniscrew is dependent upon the amount of bone available. Depending on the region, the total thickness of the alveolus is between 4 mm and 16 mm **[5,7,8,9].**

The length of a screw, however, is of secondary importance when it comes to secure anchorage—the diameter is much more critical. Various investigations have shown that the thickness of the cortical plate plays the most important role in miniscrew stability.For example, FEM analyses have demonstrated that the typical orthodontic load is applied only in the region of the cortical bone **[7.9,10] (FIG 6)**.

When selecting the length of a miniscrew, the depth of the gingiva must also be considered. The average depth of the gingiva is about 1.25 mm except in a few locations such as the retromolar region. The ratio between the length of the head (the part of the miniscrew outside the bone) and the length of the threaded shaft (the part of the screw inside the bone) should be at least 1:1. Consequently, Poggio et al recommended miniscrews lengths of 6 mm to 8 mm, and Costa suggested that miniscrews should be from 6 mm to 10 mm. On the basis of these investigations, it would appear that longer screws are unnecessary except in unusual circumstances. This has also been confirmed by numerous, anecdotal clinical experiences **[8,10,11,12].**

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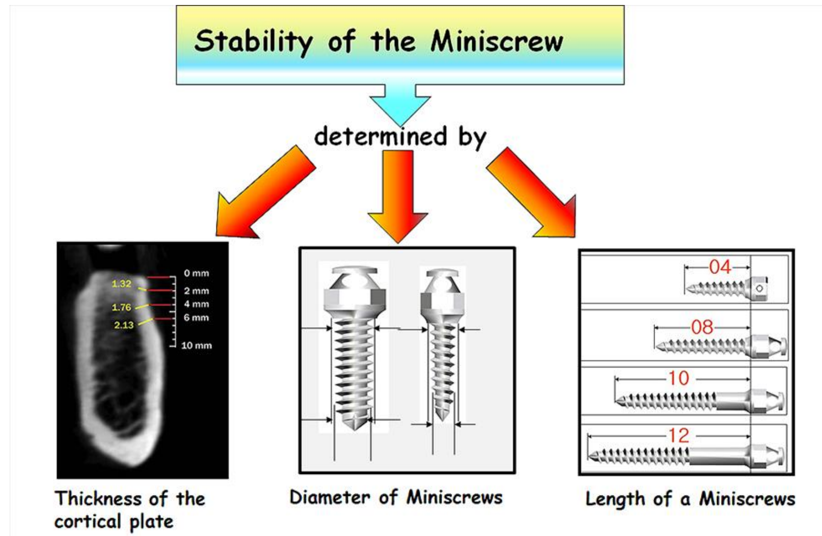

Figure 6:*Key factors influencing the primary stability of orthodontic miniscrews: cortical bone thickness, screw diameter, and screw length.*

TYPES OF ANCHORAGE;

The miniscrew implants can provide 2 different types of anchorage: direct and indirect anchorage means that they are connected through bars or wires to the reactive unit, whereas direct anchorage means that they directly receive the reactive forces by acting as an anchor unit. **[6,10,11,12] (FIG 7, 8)**

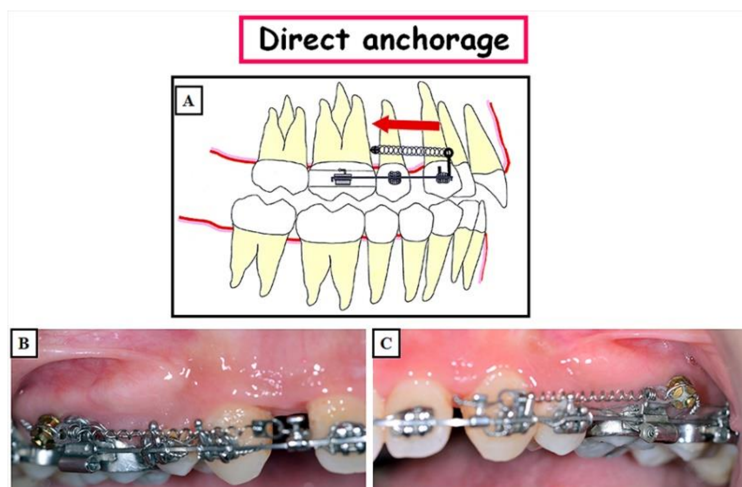

Figure 7 A-C ***:****Direct anchorage using miniscrews for anterior tooth retraction. (A) Schematic illustration, (B, C) Clinical intraoral photographs showing direct force application from the miniscrew to the anterior segment.*

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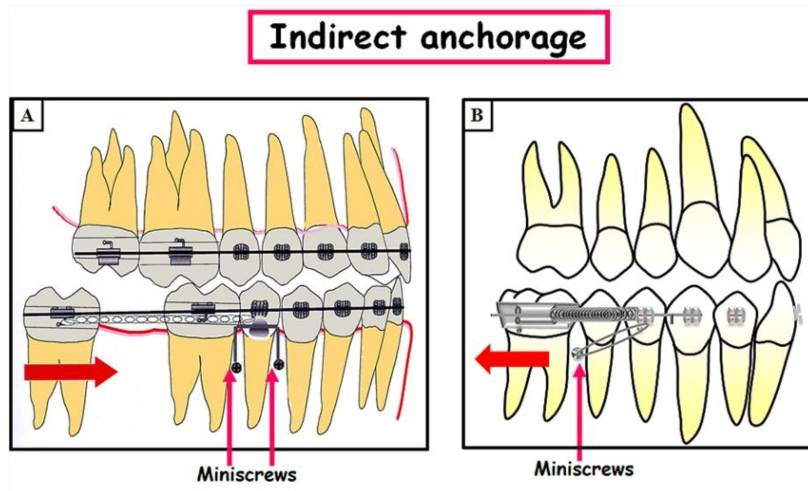

Figure8 A, B:*Illustration of indirect anchorage: the reactive units are stabilized via miniscrews, allowing anchorage reinforcement during tooth movement.*

-Head Design

The most frequent is the button like design with a sphere or a double sphere like shape or a hexagonal shape. With a hole through the head or neck of the screw, usually 0.8 mm in diameter, this design is mostly used for direct anchorage. Further a bracket like design and a hook like design is also available which can be used both for direct and indirect anchorage. **[6,10]**

-Thread design

The thread body can be either conical as in miniscrew anchorage system or parallel tapering only at the end as in orthodontic mini-implant. They are available in different lengths but it is that suggested 4 to 6 mm as safe in most regions. Most miniscrew implants have a thread diameter ranging from 1.2 to 2.0 mm and a length from 4.0 to 12.0 mm although some of them are also available at lengths of 14 or even 21 mm. **[10,13] (FIG 4)**

-CLASSIFICATION [6,10,13,14]

Implants can be broadly classified under the following:

BASED ON THE LOCATION

Subperiosteal

In this design, the implant body lies over the bony ridge. This type has had the longest history of clinical trials but a decreased long-term success rate; probably due to the fact that the chances of getting it dislodged are high. Also, the complexity of their designs requires a precise casting procedure. The subperiosteal design currently in use for orthodontic purposes is the ‘Onplant’. **[6,13,14,15]**

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ENDOSSEOUS

These are partially submerged and anchored within bone. These are the most popular and the widely used ones. Various designs and compositions are available for usage in specific conditions. The endosseous implants are also the most commonly employed types for orthodontic purposes. Based on the Configuration Design Root form implants: These are the screw type endosseous implants and the name has been derived due to their cylindrical structure. **[6,13,14,15,16]**

TRANSOSSEOUS

In this particular variety, the implant body penetrates the mandible completely. These have enjoyed good success rate in the past. However, they are not widely used because of the possible damage to the intrabony soft tissue structures, like the nerves and vessels. Even in the field of orthodontics, transosseous implants have not been used. **[6,13,14,15,16]**

SCREW DESIGNS THESE INCLUDE:

1. Dentos absoanchor implant system
2. Aarhus implant
3. Spider screw, the OMAS system, the Leone miniimplant.

BLADE/PLATE IMPLANTS PLATE DESIGNS THESE INCLUDE:

1. Skeletal anchorage system (SAS).
2. Graz implant-supported system.
3. Zygoma anchorage system.

ACCORDING TO THE COMPOSITION

 Stainless steel

 Cobalt-chromium-molybdenum (Co-Cr-Mo)

 TITANIUM:

– Alpha

– Beta

– Alpha-Beta phase (most commonly used)

– Ti-6Al-4V

 Ceramic implants

 Miscellaneous, such as vitreous carbon and composites.

ACCORDING TO THE SURFACE STRUCTURE

 Threaded or Non threaded .

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The root form implants are generally threaded as this provides for a greater surface area and stability of the implant.

 Porous or Nonporous

The screw type implants are usually nonporous, whereas the plate or blade implants (non threaded) have vents in the implant body to aid in growth of bone, and thus, a better interlocking between the metal structure and the surrounding bone.

CONTRAINDICATION

 Absolute Contraindications

 Severe systemic disorder, e.g. osteoporosis

 Psychiatric diseases, e.g. psychosis dysmorphia

 Alcoholics and drug abusers. Relative Contraindications

 Insufficient volume of bone

 Poor bone quality

 Patients undergoing radiation therapy

 Insulin dependent diabetes ï Heavy smokers.

Sites of Mini-Implants Placement:**[6,17,18]**

a.In Maxilla

1.Anterior maxilla

Studies have shown that the preferable site for mini-implant placement is the anterior palate. Due to the following reasons:

1. Thick cortical bone available in this region
2. Presence of sufficient amount of attached gingiva
3. Site of placement – away from the roots
4. Doesn't hinder orthodontic tooth movement

The optimal site for the placement of mini implants in the labial aspect of anterior maxilla is 6mm from the alveolar crest between central and lateral incisors. The location becomes safer with the placement being more anterior and apical.

2. Posterior maxilla

The available sites for the placement of mini-implants in

the inter-radicular region of posterior maxilla in the order of maximum safety to the least are as follows:

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1. 2-8 mm from the alveolar crest in the palatal side, between the maxillary first molar and second premolar.

2. 2-5 mm from the alveolar crest in the palatal side, between the maxillary first and second molar.

3. 5-11 mm from the alveolar crest in both the buccal or palatal side, between the first and second premolar.

4. 5-11 mm from the alveolar crest in both the buccal or palatal side, between the canine and first premolar.

5. 5-8 mm from the alveolar crest in the buccal side, between the first molar and second premolar **(FIG 9 A-E)**.

b. In mandible

***1**. Anterior mandible*

The optimal site in the mandibular anterior region for miniimplant placement is 6mm from the alveolar crest between the lateral incisor and canine.

2.Posterior mandible

The available sites for the placement of mini-implants in the inter-radicular region of posterior mandible in the order of maximum safety to the least are as follows:

1. 2-11 mm from the alveolar crest in the buccal side between the first and second molar.

2. 2-11 mm from the alveolar crest in the buccal side between the first and second premolar.

3. 11 mm (over 8mm due to root proximity) from the alveolar crest in the buccal side between the first molar and second premolar.

4. 11 mm (over 8mm due to root proximity) from the alveolar crest in the buccal side between the canine andfirst premolar.**[6,17,18]**

This article provides comprehensive information about Temporary Anchorage Devices (TAD's).

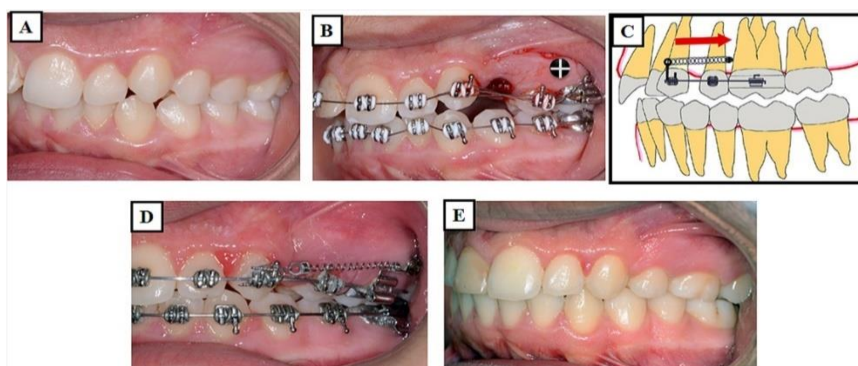

Figure 9 A-E:*Unilateral extraction treatment in a patient with left-sided Class II malocclusion and right-sided Class I occlusion.*

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(A) Initial situation showing Class II relationship on the left side.
(B) Clinical photo after unilateral extraction of the upper left first premolar.
(C) Schematic illustration of asymmetric space closure using miniscrew-supported anchorage.
(D) Ongoing retraction phase with fixed appliance and temporary anchorage device.
(E) Final occlusion demonstrating Class I canine and Class II molar relationship on the left side, with midline correction

PLACEMENT SITES; [6,19]

Miniscrews are used in place of traditional appliances such as headgear and lingual arches in cases where absolute anchorage is necessary. From a biomechanical standpoint, miniscrews allow more bodily tooth movement during space closure by placing the force vectors closer to the center of resistance of the teeth. The sites most often utilized for MAS insertion in the maxilla include:

 Infrazygomatic Crest Area Recommended microimplant size: Diameters of 1.3 and 1.4 mm and a length of 5 to 6 mm.

Maxillary Tuberosity Area Recommended microimplant size: Diameters of 1.3 and 1.5 mm and a length of 7 to 8 mm.

 Between the Maxillary First Molar and Second Premolar Buccally Recommended micro implant size: Diameters of 1.3 and 1.6 mm and a length of 6 to 7 mm.

Between the Maxillary First Molar and Second Premolar Palatally Recommended microimplant size: Diameters of 1.3 and 1.6 mm and a length of 10 to 12 mm.

Mid-Palatal Area Recommended microimplant size: Diameters of 1.5 and 1.8 mm and a length of 5 to 6 mm.

Mandible Retromolar Area Recommended microimplant size: Diameters of 1.4 and 1.6 mm and a length of 5 to 10 mm.

Between the Mandibular First Molar and Second Premolar Bucally Recommended microimplant size: Diameters of 1.3 and 1.6 mm and a length of 5 to 7 mm.

Extraction spaces In our experience, the most useful locations are the interradicular spaces, either buccal or lingual, between the second premolars and first molars in both arches, or the buccal space between the upper lateral incisor and canine.

Placement technique;

Prior to placing the implant an intra-oral peri-apical or a panoramic radiograph of the region is essential to evaluate the inter-radicular space available; ideally, a minimum of 2 mm is required . Radiographic stents or guides such as twisted brass wire can be used as an aid to positioning . However, they only give a two-dimensional image, which indicates the correct implant insertion point, but offer no guidance to the drilling angle. This is best determined by direct vision as drilling proceeds.

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A minimal amount of dental anaesthetic (about0.3 ml) is given into the mucosa adjacent to the proposed implant placement site. The underlying bone has no innervation and profound anaesthesia of theadjacent teeth and periodontal ligaments (PDL) is contra-indicated. Any approximation of the drill or implant to the PDL will elicit pain, which will, in turn, alert the dentist to redirect the implant. This important feedback from the patient would not be possible with profound anaesthesia.

Wherever possible, the implant head should protrude through the attached gingiva and not the unattached alveolar mucosa. Insertion through alveolar mucosa tends to create more bleeding, is more traumatic and requires an initial incision to be made through the mucosa with a scalpel to prevent entanglement of the bur . For this reason and in order to take advantage of the increased apical inter-radicular space, the implant is placed at an angle of about 45u to the buccal/labial bone.

The implants come in various lengths (5–12 mm) and diameters (1.2–2 mm). It is the authors' experience that 1.5 mm is the optimal diameter to use. Thinner implants risk breakage and thicker implants make root contact more probable. In the mandible, where the bone is generally denser, a 6–8 mm length is optimal, while in the maxilla an 8–10 mm length is preferred. **[6]**

To prevent the pilot twist drill slipping on the surface of the cortical bone, first pierce the cortical bone at right angles with a #2 round bur and then change the inclination of the drill to 45u to allow oblique drilling with the pilot drill. The pilot hole is drilled with a 1.2 mm twist drill, generally supplied with the implant kit, at y600 rpm to just short of the implant length. Self-drilling implants are available, although in our opinion the risk of going off course during placement is higher. While some clinicians prefer the self-drilling screw, we believe that the force required to place a self-drilling screw in bone reduces the tactile feel for the operator and may increase the risk of root contact. A gently drilled pilot hole, in our experience, offers better tactile feedback and placement precision. However, as yet there is no scientific evidence to support either technique. **[5-8]**

The sterile implant is removed from its package with the handpiece driver attached to the handpiece. It is carried to the mouth without being touched by hand, placed into the pilot hole and driven, with the handpiece at y??? r pm, three-quarters ofthe way and, if access permits, it driven to its full depth with a hand driver. Using a hand driver to do the final tightening of the implant offers better tactile feedback as to the tightness and stability of the implant (FIG. 10a-e). The implant needs only to be tightened to a torque value of 7–10 Ncm, which is achieved with mild finger tightening; achieving primary stability is essential. A post-operative radiograph should be taken to assure correct positioning of the implants . **[6]**

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ROLE IN ORTHODONTICS;

For many years, Anchorage has been always an integral part of treatment mechanics in Orthodontics & Dentofacial Orthopaedics. Various extraoral and intraoral devices have been attempted in the scientific literature to prevent anchorage loss, but

until the advent of TADS, no practical solutions were found. The 20th century witnessed the emergence of different skeletal anchorage devices, such as prosthetic implants, palatal implants, micro-implants, mini-plate screws, and onplants.

Because they are small, simple to insert and can be removed easily, can be loaded

right away, and can offer absolute anchorage for many forms of orthodontic treatment mechanics with little to no patient compliance, orthodontic implants, also known astemporary anchorage devices (TADs), have grown in popularity in late 1900.

Teeth are subjected to stresses and moments as the orthodontic treatment progresses. All of these forces result in opposing reciprocal forces. For the therapy to be successful and to prevent unintended tooth movements, these pressures must be

directed. The anchorage protocols are now in place. Orthodontics is very concerned with anchor management techniques or modalities. The primary objective of orthodontic treatment is to reposition teeth in the desired direction while enhancing the patient's aesthetic appearance.**[21]**

Planning the anchorage requirements and assessing the needs for their execution

can be a time-consuming and labor-intensive process. Orthodontic professionals have suggested several strategies to overcome the challenges associated with anchorage, such as utilizing extraoral anchorage, employing opposing anchors, and increasing the number of teeth in anchorage units."

The extraoral anchorage is a little difficult to use and can hurt the patient and

require patient compliance which affects the patients' willingness to use it. The term

'absolute anchorage' refers to the stability of the anchorage unit, which is a challenge in conventional orthodontic mechanics. "Absolute or infinite anchorage is a term used to describe the absence of movement in the anchorage unit caused by the reaction forces that are applied to move teeth. This kind of anchorage can only be achieved by utilizing ankylosed teeth or dental implants as anchors, which rely on the bone to restrict movement. With the emergence of mini-implants, it has become feasible to achieve absolute anchorage of the skeleton. Mini-implants provide maximum anchorage while minimizing adverse side effects." **[22]**

The effects of microimplantassisted rapid palatal expansion (MARPE) on the nasomaxillary complex—a finite element method (FEM) analysis.

"Mini implants are presently utilized in orthodontics as temporary anchorage

devices (TADs), which are temporarily fixed to the bone to enhance anchorage. The

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objective is either to support the reactive unit's teeth or to eliminate the need for the reactive unit entirely."."TADs can be attached to the bone either biochemically or mechanically. In terms of implants, limitless anchorage is defined as exhibiting no movement (zero anchorage loss) due to reactive pressures. The introduction of skeletal anchorage systems and TADs into orthodontic treatment has made it possible to achieve limitless anchorage." **[23]**

The osseo-integrated implant (endosteal) was the first one to be used for thepurpose of orthodontic anchorage. Although they have a limited scope for use in

orthodontics, they did a good job of supplying the orthodontic anchorage. In essence, they were used to fill edentulous areas that weren't present in typical orthodontic cases. **[24]**

One of the downsides of endosteal implants was the lengthy waiting period required for implant integration, which typically took around 3 to 4 months before loading could take place. Even the implant's size and the installation process had issues.

The size is substantial, and the placement's surgical technique is challenging.(5)

These issues and complications were resolved by non-osseointegrated micro implants utilized in orthodontics. In addition, they were mechanically stabilized cortical implants. Micro screws are ones that are less than 2mm wide while mini screws are those that are 2mm wide or wider. The first small screw system was made by Oleus, LomesMondeal, and HDC Italy.

Additionally, Dentos Inc. in Degu, Korea, produced the original miniscrew or

microimplant anchorage known as the Abso Anchor. A screw with various lead shapes is an added benefit. Depending on the mechanism, these head types enable the screw to be employed in a variety of applications.

"Conventional dental implants have some limitations, including:

- They can only be placed in edentulous or retromolar areas.
- The direction of force application is limited since a dental implant is situated on the alveolar ridge, and it is too large for horizontal orthodontic traction.
- The surgery required for dental implants is complex, and patients may experience discomfort during the initial healing period. Oral hygiene can also be challenging for patients with dental implants."

Advantages of the mini implant [26,27]

- Mini-implants for orthodontic anchorage can be placed in any area of alveolar bone, including apical bone, since they are small enough.
- The surgical procedure is simple and can be performed by an orthodontist or general dentist. It is a minor surgery, and the healing process is rapid.
- The mini implant can be easily removed after orthodontic traction."
- "Conventional dental implants are typically 3.5-5.5mm in diameter and 11-21mm long, while mini implants are only 1.2mm in diameter and 6mm long, making them much more

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suitable for orthodontic purposes. The screw is small enough to be inserted between the mesial and distal roots of a molar, allowing for molar intrusion."

• Shorter or even no waiting period (for miniscrews), it is suggested that a waiting period for bone healing and osseointegration before loading is unnecessary because the primary stability (mechanical retention) of the miniscrews is sufficient to sustain a regular orthodontic loading.

• No need for laboratory work

• Easier removal after treatment

• Low cost. **(FIG 3)**

Anatomic considerations in placement of the implants[27]:

• "The thickness and density of the cortical bone, which are crucial for retaining the miniscrew, can vary among patients and implant sites. Sites with thick, dense cortical bone are considered the most stable for mini-screw implants. In the mandible, the retromolar area and the buccal side of the posterior region are suitable sites that meet these criteria. In the maxilla, the midpalatal suture area is considered the most favorable site for implantation due to the thin soft tissue and dense bone.". **[28]**

• "Whenever possible, mini-screws should be implanted in the zone of attached gingival above the mucogingival junction. This area is less likely to have soft tissue impingement, reducing the likelihood that the soft tissue will cover the screw or that the screw will become dislodged, and making it easier for the patient to maintain good oral hygiene."

•Before placing the implant, it is important to determine the number, position, and parallelism of the proximal roots. Panoramic and periapical radiographs can be utilized for this purpose."

"When placing the mini-screw in the mandible, it is important to avoid the

mandibular canal and the mental foramen. Similarly, in the maxilla, the incisive canal and the greater palatine nerve and artery should be considered, although they are generally far from the implant site and rarely pose a problem."

Complications that may arise after implantation of mini-screws include

□□Inflammation of the soft tissue surrounding the screw, which is the most common cause of mini-screw failure.

□□When the mini-screws are implanted below the mucogingival junction on movable mucosa, applying elastic force can be challenging due to the soft tissue covering the screw head. Care must be taken during the operation to avoid damaging adjacent roots, nerves, and blood vessels. **[29]**

□□Occasional miniscrew fracture can occur, but this can be prevented by using screws with a diameter of 2mm or more **(FIG 10 A, B)** .

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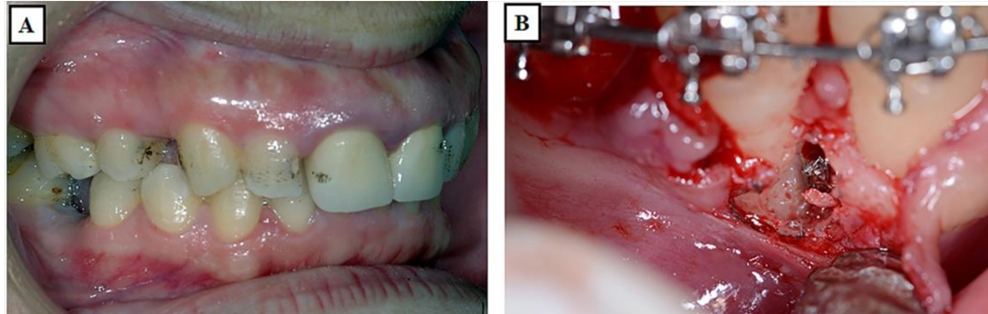

Figure:Clinical case showing an extraction site in the region of the first molar (tooth 46). ***(A)*** Intraoral view prior to miniscrew insertion in the edentulous space. ***(B)*** Intraoperative image after fracture of the screw during insertion; the fractured fragment remained embedded in the cortical bone.

Effect of Orthodontic forces on Mini-implants:

o J.W. Liou, Betty C.J.Pai et al. **[30]** Conducted a clinical cephalometric study in order to evaluate the behaviour of miniscrews under orthodontic loading.

o Sixteen adult patients were included in this study, where miniscrews (diameter-2mm, length-17mm) were used for maxillary anchorage. The miniscrews were inserted directly on the maxillary zygomatic buttress to facilitate en masse anterior retraction. After two weeks of miniscrew insertion, nickel-titanium closed-coil springs were placed for retraction with a force of approximately 400 grams. Cephalometric radiographs were taken immediately before force application (T1) and 9months later (T2). The cephalometric tracings at T1 and T2 were superimposed for the overall best fit on the structures of the maxilla, cranial base, and cranial vault to determine any movement of the mini screws. The mini screws were also evaluated clinically for their mobility (0: no movement, 1: <0.5mm, 2:0.5-1mm, 3 :> 1.0mm). The mobility of all mini screws was 0 atT1 and T2. **[5-13]**

On average, the mini screws showed a significant forward tipping of 0.4mm at the screwhead.

□□However, in 7 out of the 16 patients, the miniscrews were extruded and tipped forward by a range of -1.0 to 1.5mm.

□□Miniscrews are a stable anchorage but do not remain absolutely stationary Miniscrews provide stable anchorage but are not completely stationary during orthodontic loading. Unlike endosseous implants, miniscrews do not provide absolute anchorage. The movement of miniscrews could be due to various factors, such as fixture size, magnitude of orthodontic force, depth of miniscrew insertion, bone quality and quantity at the implant site, and waiting period. Among these factors, the waiting period may play a determining role in the displacement of miniscrews. **[31]**

Microfracture or microcrack of the peri-implant microcallus and strong bone

remodeling and resorption on the tension and compression side may occur, which can ultimately result in the displacement of the miniscrew.

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It has been suggested that a waiting period is not necessary for miniscrews

because of their primary stability (mechanical retention) is sufficient to sustain normal orthodontic loading and this would not compromise the clinical stability of the miniscrews.

Liou and Pai**[32]** suggested that the miniscrews used in the study were not fully osseointegrated and instead had a layer of fibrous tissue between them and the surrounding bone. This allowed the miniscrew to be extruded and tipped in the direction of the orthodontic force, similar to a tooth and its periodontal ligament. The fibrous tissue compressed, and the threads of the miniscrew mechanically locked into the surrounding bone. This hypothesis can explain why some miniscrews were displaced but still appeared clinically stable. However, there was no histological evidence to support this hypothesis.

•The average forward tipping of the screw head by 0.4mm may not have a significant clinical impact on the displacement. Miniscrews are commonly utilized as temporary fixtures for orthodontic treatment and are removed after completion. It is not essential for the miniscrews to remain completely stationary during orthodontic loading, as long as the desired treatment outcomes are achieved. **[33]**

• However, the displacement of miniscrews could potentially cause harm to adjacent vital organs such as dental roots, nerves, and blood vessels, making it a serious concern. Therefore, miniscrews should be placed in a site that is not adjacent to any vital organ. A suitable implant site for miniscrews could be a non-tooth bearing area that has no foramen or pathway for any major nerves and blood vessels. In cases where miniscrews are placed in a tooth-bearing area, a clearance of 2mm between the miniscrew and dental root is recommended for safety purposes.

CLINICAL APPLICATION IN ORTHODONTICS;

(A) Intrusion of Anterior Teeth

A case study on the use of avitallium implant for anchorage when invading the

upper anterior teeth was reported by Creekmore in 1983. Immediately below the front nasal spine, The vitallium screw was placed. The researchers implemented a 10-day unloading period before attaching an elastic thread between the screw's head and the archwire. **[6]**

Over the course of one year, the results showed 6 mm intrusion and 25 degrees of lingual torque.

(B) Mandibular Anteriors

Extrusion of posterior teeth or intrusion of anterior teeth are two nonsurgical

approaches for treating deep bites. When extrusion of posterior teeth is not desired, it is necessary to intrusion of anterior teeth in patients with excessive incisal display and to rectify deep bite in adult patients.

Temporary anchorage devices (TADs) can be used to facilitate the intrusion of

anterior teeth, particularly in cases where there is a deep bite or excessive overbite. The use of TADs for intrusion can provide absolute anchorage, allowing the orthodontist to move the

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teeth in a controlled and predictable manner without any reciprocal movement of other teeth or structures in the mouth. To intrude anterior teeth using TADs, the orthodontist will first place the TADs into the bone between the roots of the teeth that need to be intruded. The TADs serve as an anchor point for a spring or elastic band that is attached to the teeth being intruded. **[6,17]**

The orthodontist will then apply a continuous and controlled force to the teeth

over a period of several weeks or months. The force will cause the teeth to move

gradually, allowing the bone to remodel around the roots of the teeth and enabling the teeth to be intruded.

One advantage of using TADs for anterior intrusion is that it can be done without

the need for other orthodontic appliances, such as headgear or braces. This can reduce treatment time and improve patient comfort. Additionally, using TADs for anterior intrusion can help to avoid unwanted side effects, such as tipping or rotation of adjacent teeth. **[5]**

In summary, TADs can be an effective tool for facilitating the intrusion of anterior teeth in cases where there is a deep bite or excessive overbite. By providing absolute anchorage, TADs allow orthodontists to achieve precise and predictable tooth movements with minimal discomfort to the patient. **[20]**

Gummy smile

Temporary Anchorage Devices (TADs) are widely used to treat a gummy smile,

and they have been found to be a popular and successful method. However, one of the main drawbacks of this approach is the possible extrusion of posterior teeth, which can lead to an increase in lower anterior facial height, especially when combined with a continuous archwire. **[14]**

The "gummy" smile is characterised by a full smile that exposes 2mm or more of

the maxillary gingiva. Gummy smiles can arise from different causes, including

overgrowth of the maxilla in the vertical direction, a short upper lip, overactive levator muscles, passive eruption of the upper front teeth, and gingival hyperplasia. Treatment options to correct a gummy smile can vary depending on the underlying cause. Some options include headgear therapy, crown lengthening procedures, surgical techniques like Lefort 1 osteotomy with superior impaction, botulinum toxin injections, skeletal anchorage system-assisted intrusion, and various loop mechanics.

Utilizing a standard continuous arch wire for treating a gummy smile with TADs

can lead to unintended extrusion of posterior teeth. However, using a TAD-assisted segmented arch wire for maxillary anterior intrusion and retraction is a great way to treat a gummy smile successfully while preventing posterior extrusion.

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Retraction of anterior teeth

TADs (temporary anchorage devices) are a common orthodontic treatment

method for retraction of anterior teeth, which is used to address dental malocclusions such crowding or tooth protrusion. The TADs are tiny, temporary screws inserted into the jawbone to act as anchors for the stresses of orthodontic treatment. **[15]**

The TADs are positioned carefully in the jawbone during retraction and joined to

the teeth with orthodontic wires or elastic bands. The anterior teeth can be moved back into place using the TADs as a solid anchor. By doing so, the orthodontist can get the best outcomes possible without needing to rely on the patient's cooperation or heavy external appliances like headgear.

The appearance and functionality of a patient's teeth can be greatly enhanced by

retraction of anterior teeth with TADs, which is a minimally invasive and successful treatment approach. With the use of TADs, orthodontists can move teeth with more control and accuracy, completing treatments more quickly and with better results. **[15-17]**

One of the significant challenges in cases of tooth extraction is the loss of anchorage in the posterior region, which can impact the curve of Spee and cause a deep bite. To address this issue, mini screws can be used as a reliable skeletal anchor for anterior retraction, whether en masse or segmental retraction is being performed. **[6]**

Correction of a canted occlusal plane

An orthodontic treatment method called "correction of a canted occlusal plane"

includes levelling out an unbalanced or slanted occlusal plane. The incisal margins of the upper front teeth and the occlusal surfaces of the back teeth form a theoretical plane known as the occlusal plane.

When the occlusal plane is uneven, slanted, or sloping, it is said to have a canted

occlusal plane, which results in an unbalanced bite and an asymmetrical appearance of the teeth and face. This can be brought on by a number of things, including skeletal irregularities, dental wear, missing teeth, and jaw asymmetry.

Depending on how severe the issue is, orthodontic treatment for a canted occlusal plane may combine techniques including braces, TADs, and jaw surgery. TADs offer secure anchorage for more accurate tooth movement while braces can be utilized to move teeth into the proper position. Jaw surgery could be necessary in some situations to fix skeletal irregularities and enhance face symmetry. **[6-9]**

Canted occlusal plane correction is crucial for the function and health of the jaw

and teeth as well as for aesthetic reasons. The distribution of forces when chewing is improved by a balanced occlusal plane, which lowers the incidence of tooth wear, gum disease, and temporomandibular joint disorders (TMD).

It was difficult to cure a canted occlusal plane with traditional orthodontics. In

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addition, micro implants provide skeletal anchorage to allow teeth on the canted side to erupt. **[4-8]**

Correction of dental midline

The ideal alignment of the dental midline with the face midline is when it splits the upper and lower teeth into left and right halves.

When the dental midline is out of alignment with the facial midline, it results in anasymmetrical grin and face, which is known as a dental midline discrepancy. This may be brought on by a number of things, including tooth loss, dental crowding, or skeletal irregularities. **[6-13]**

Temporary anchorage devices (TADs) can be utilized to provide stable anchorage for accurate tooth movement to correct a dental midline discrepancy. To direct the teeth into the proper position, TADs are inserted in the jawbone strategically and joined to orthodontic wires or elastic bands. Teeth can move more predictably and precisely thanks to the stable anchor provided by TADs.

TADs can be used to address dental midline abnormalities, and they provide a

number of benefits, such as shorter treatment times, increased precision, and better control over tooth movement. The use of TADs also lessens the requirement for other orthodontic devices, like as headgear or elastics, which can be uncomfortable or bothersome for the patient. **[15-22]**

Intermaxillary elastics are typically used to repair dental midlines when patient

cooperation is crucial. The bite of elastics can intensify as a result of vertical force, which is one of its main drawbacks. Miniscrews could therefore be a practical substitute. The head of a screw can be positioned either buccally or lingually, and the line of force is directed more occlusally with an enhanced horizontal vector at the crown borders . **[5-11]**

Molar Mesialization

The orthodontic treatment method known as molar mesialization with TADs

(temporary anchorage devices) includes advancing the molars towards the front of the mouth. When there is not enough room for further teeth to erupt or when the molars have moved backward, resulting in a malocclusion, molar mesialization may be required. **[6]**

TADs are tiny, temporary screws that are inserted into the jawbone to give

orthodontic pressures a secure anchor. TADs are carefully positioned in the jawbone during molar mesialization and attached to the molars with orthodontic wires or elastic bands. The TADs serve as an anchor, enabling the molars to migrate forward in a precise and regulated manner. **[6-12]**

Molars have occasionally shifted mesially to close extraction spaces. The difficult

process of mesialization of the molar can also result in problems including anterior anchorage loss and molar tipping. Following the initial phase, insertion of a mini screw can help engage

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a full-sized archwire and prevent mesial crown tipping of the molars during space closure in extraction cases. By positioning the mini screw at the midpoint of the space, the force vectors are closer to the center of resistance of the molar. This provides a stable skeletal anchorage for anterior retraction, which can prevent posterior anchorage loss and minimize changes to the curve of Spee and overbite. **[36] (FIG 11 A, B)**

Faster treatment timeframes and better control of tooth movement are two

benefits of molar mesialization with TADs. Additionally, it does away with the need for additional orthodontic devices like elastics or headgear, which can be uncomfortable or bothersome for the patient.

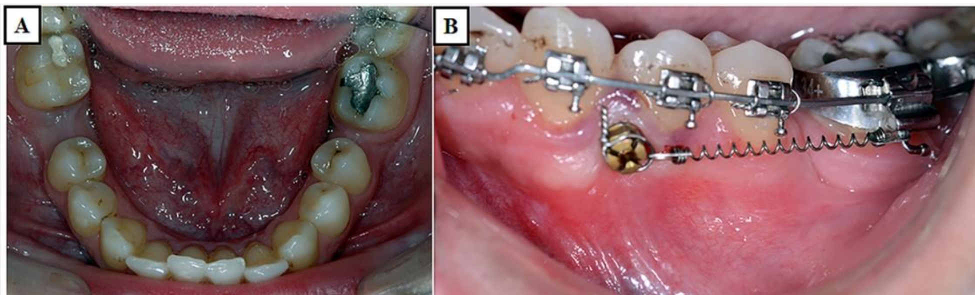

Figure 11 A, B:*Clinical case with an extraction space in the region of the first molar (tooth 36).*
(A) Occlusal view showing the edentulous site in the lower left quadrant.
(B) Insertion of a miniscrew for maximum anchorage to facilitate mesialization of the second molar using direct anchorage.

To find out if molar mesialization with TADs is the best solution for your particular orthodontic needs, it is crucial to speak with a knowledgeable orthodontist. Because every case is different, the ideal treatment strategy for getting the best results requires a thorough review. A safe and efficient treatment option that can dramatically enhance the functionality and appearance of your smile is molar mesialization using TADs. **[6-11]**

Molar distalization[6,28]

When there is crowding, a malocclusion, or a need to provide more room for other teeth, molar distalization may be indicated.

TADs are tiny, temporary screws that are inserted into the jawbone to give orthodontic pressures a secure anchor. TADs are positioned carefully in the jawbone during molar distalization and attached to the molars with orthodontic wires or elastic bands. The TADs serve as an anchor, enabling the molars' precise and controlled migration backward.

For the treatment of molar distalization, there are numerous fixed and removable prostheses available, although numerous investigations of distalization reveal anterior anchorage loss. The TAD system is thought to be the best option for molar distalization. Palate is the best location for placing. If the tiny implant is less than 2mm, the palatal anchorage will not be stable enough.

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The use of TADs for molar distalization has a number of benefits, including quicker treatment timeframes and better control over tooth movement. **[6]** Additionally, it does away with the need for additional orthodontic devices like elastics or headgear, which can be uncomfortable or bothersome for the patient.

Intermaxillary anchorage

Elastics or anterior repositioning devices are used to do Class II correction (i.e.

Jasper Jumper, Bite Fixer, etc.). These types of mechanics have a lot of negative side effects, including opening of the bite and excessive anterior movement (proclination and protrusion) of the lower incisors, to mention a couple. **[6,17]**

Molar Intrusion [37]

It is quite challenging to accurately put the microscrews between the first and

second molar roots without affecting the teeth's roots during implantation or intrusive motions. Furthermore, in cases when there is not enough room for the screw placement, the intrusion force may need to be relatively strong and multiple screws may be required. For the aforementioned reasons, it is advised to only employ miniscrews in instances of straightforward molar intrusion of one or two teeth. **[42-54]**

When prosthodontic treatment of a missing molar has been delayed, the

traditional treatment has been to reduce the crown length of the tooth opposite the extruded tooth or to adjust the path of intrusion. Intrusion by subapical osteotomy or extraction of extruded molar are more aggressive alternatives.

The orthodontic treatment should aim to intrude or upright the extruded or tilted teeth to restore the original occlusal plane and minimize any further damage to the teeth. **[44-60]**

Intrusion of teeth using conventional orthodontic methods often results in

extrusion of the anchorage tooth due to the law of action and reaction. Despite efforts, efficient molar intrusion is difficult to achieve.

Moreover, extrusion of adjacent teeth may lead to clockwise rotation of the

mandible, causing anterior open bite or retrusion of the chin. Therefore, alternative methods such as TADs may be considered for efficient and effective molar intrusion.

Mini-screws can be used to obtain absolute anchorage in order to obtain tooth

movement. Their simple design makes them comfortable to the patient; side effects, such as extrusion of adjacent teeth are minimized, so that results are more reliable; and the implantation technique is relatively simple as is controlling the direction and amount of force. **[20]**

Young-Chel Park et al**[38]**utilized miniscrews to achieve intrusion of extruded

molars. They implanted two mini-screws mesiodistally to the tooth to be intruded on the palatal side. On the buccal side, an L-type mini-plate was implanted at the zygomatic crest**(19)**, with one end exposed through the buccal vestibule. Lingual buttons were attached

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to the tooth, and an intrusion force was applied using elastic thread or power chain. The retention of the intruded molar was accomplished with restorations in the opposite arch. If there isn't enough space to carry out molar intrusions, an open-coil spring can be used

after passively bracketing the premolars and second molars. Once adequate space is obtained, the teeth to be intruded can be intruded using power chains.

The amount of force to be used to cause intrusion: For molar intrusion, Umemori

et al recommended an initial force of 500g. Kalra et al suggested 90gms per tooth for molar intrusion in growing children. Melson and Fiorelli used 50gms buccolingually to intrude maxillary molars in adult patients.

Young-Chel Park et al. have used mini-screws in order to cause intrusion of the

extruded molars and concluded that by simply implanting mini-screws and controlling the direction and amount of force can obtain successful molar intrusion. **(FIG 12 A-D)**

Considering the number and the surface area of posterior tooth roots, it is

reasonable to apply intrusion forces 2 to 3 times greater than those applied on anterior teeth. **[38-43]**

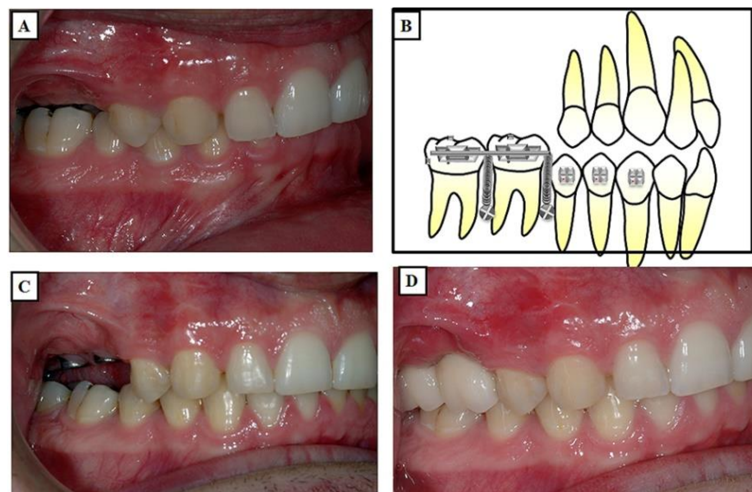

Figure 12 A-D:*Orthodontic intrusion of mandibular molars prior to prosthetic rehabilitation.*
(A) Initial situation showing supraeruption of the lower molars following the loss of teeth 16 and 17.
(B) Schematic illustration of miniscrew-assisted intrusion of the mandibular molars.
(C) Clinical progress after active intrusion phase.
(D) Final result after successful intrusion and implant-supported restoration in the upper right quadrant.

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Molar Alignment

Mini screws can also be useful in situations where traditional orthodontic

mechanics cannot be used, such as when there are multiple missing teeth. For example, an upper third molar can be straightened using a fixed sectional wire and a palatal mini screw as skeletal support to prevent excessive protrusion of the molar. **[6,21,39] (FIG 13 A-E)**

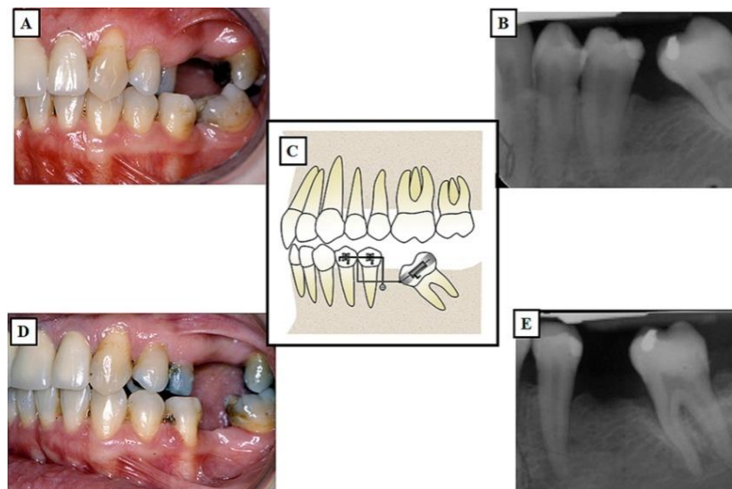

Figure 13 A-E:*Molar uprighting in a patient with loss of teeth 36 and 37. (A, B) Clinical and radiographic presentation showing mesial tipping of the mandibular second molar due to prolonged edentulism. (C) Schematic illustration of orthodontic uprighting mechanics using miniscrew and auxiliary springs. (D, E) Clinical and radiographic outcome after successful uprighting, enabling space reopening and prosthetic planning.*

Extrusion of Impacted Canine

To prevent anchorage loss and canting of the occlusal plane during the alignment

of an impacted canine, various treatment approaches have been proposed. A few authors have suggested attaching auxiliary components to the primary archwire, like Kilroy springs. Archwires with superelastic overlays have been suggested by others. In order to bring an impacted canine into occlusion and prevent anchorage loss and canting of the occlusal plane, several treatment options have been proposed. One method is to use miniscrews to apply strong forces without relying on other teeth for support. Depending on whether the impacted canine is palatally or lingually positioned, the miniscrew can be positioned to provide the optimal force vector, and can even be adjusted as the canine is extruded. **[40-52]**

Correction of Molar Crossbites

Through-the-bite elastics are necessary for scissors bite correction with traditional orthodontic mechanics; nevertheless, if these elastics are utilized, undesired posterior tooth

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extrusion may result. But during buccal crossbite treatment, the same type of uprighting and intrusion is seen when micro-implants are employed. **[41]**

MARPE –miniscrew assisted rapid palatal expansion[42]

The application of orthopaedic forces or a surgical intervention is required for the treatment of the constricted maxillary arch in order to achieve expansion. Individuals who have little to no growth left may be reluctant to have surgery, which led to efforts to address these deficits without undergoing surgery, which served as the inspiration for the creation of MARPE. The MARPE appliance, developed by Dr. Won Moon et al., **[43]** is a creative modification of the RME appliance and a breakthrough in the treatment of transverse malocclusion. Since its creation, this has demonstrated to be a practical and effective nonsurgical choice for young people.

A maxillary skeletal expander (MSE) with four miniscrews parallel to the

midpalatal suture was created by Mac Ginnis et al. **[44]**based on Lee's experiments. The device had two posterior screws with a length of 9mm, two anterior screws with a diameter of 1.5 to 1.8 mm and a length that could be adjusted depending on the anatomical thickness of the patient's palate. **[44-60]**

STABILITY OF MINI-IMPLANTS;

Miyawaki et al **[45]**analyzed the success rate of 3 different screw sizes and a miniplate design. Their sample consisted of 51 patients who had 134 different implants used for conserving anchorage. The implants were in the form of screws (134 in number) of 1.0, 1.5 and 2.3 mm diameter as well as 17 miniplates. On 1 year after placement, they drew the following conclusions:

A. The implant screws of 1 mm diameter had a high failure rate and are not recommended for clinical use as orthodontic anchors.

B. Implant screws of 1.5 and 2.3 mm diameter had reasonable success rates—84 and 86% respectively, and therefore could be used in majority of the cases.

C.The miniplates had the best stability (96%), but the surgical intervention and patient discomfort was greater when compared to miniscrews. Miniplates have been recommended in high angle patients.

D. Peri-implant hygiene is one of the major factors which could affect the stability of these implants

REASONS FOR MINI-IMPLANTS FAILURE1

Before mini-implant placement, it is advisable that a 3D analysis be carried out on the site by means of periapical radiographs, particularly by bisection and interproximal techniques, and occlusal radiograph with periapical film. Volumetric computed tomography with its several evaluation slices may replace conventional radiography. **[46-60]**

The more cervical a mini-implant is placed, the higher the risk of loss. The more apical a miniimplant is placed, the better its prognosis will be.

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Interdental alveolar bone crests are flexible and deformable. For this reason, they have little mobility to offer and may not provide the ideal absolute anchorage. The more cervical the structures, the more delicate they are, thus offering less mechanical interlocking for mini-implant placement. **[17,46-54]**

Alveolar bone crests of triangular shape are more deformable, whereas those of rectangular shape are more flexible.

The bases of alveolar processes of the maxilla and the mandible are not flexible, for this reason, they are more likely to receive mini-implants.

CONCLUSIONS;

Osseointegrated implants can now be used as absolute anchorage units in orthodontics. They are very useful in cases were the compliance of patient is poor. The continuing development of orthodontic implants has led to the production of smaller designs which are easy to insert and remove, and do not require a long healing period prior to loading. In the future, as developments occur in implant technology, they may have a significant role as anchorage reinforcement aids and make headgear obsolete. However, there is a need for high quality research in this area.

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