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Advances in Orthodontic Anchorage with the Use of Mini-Implant Techniques

A Project Submitted to
The College of Dentistry, University of Baghdad,
Department of Orthodontics in partial fulfillment for the Bachelor of Dental Surgery

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Certification of the Supervisor

I certify that this project entitled **"Advances in orthodontic anchorage with the use of mini-implant techniques"** was prepared by **Sarah Ismael Atyah** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor degree in dentistry.

Supervised by
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Signature:

Date:

Dedication

I would Like to Dedicate This Work To My

Father and Mother

I Know That All Word Can Not

Describe Your Support , Your Sacrifice

and Your Endless Love

Thank You For Every Pray, Every Tear

And Every Effort You Do For Me.

Sarah Ismael

ACKNOWLEDGMENT

First and foremost, praises and thanks to Allah Almighty for giving me all these blessing, to be able to studying and working for myself.

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Title	Meaning
TAD	Temporary anchorage device
OMI	Orthodontic mini implant
ANS	Anterior nasal spine
Mm	Millimeter
ASTM	American society for testing and material
ELI	Extra low interstitial
G	Gram
TMA	Titanium molybdenum alloy
D	Density
DJR	Double j retractor
MAS	Mini-screw Anchorage System
LA	Local anesthesia
Fig	Figure
MARPE	Miniscrew assisted rapid palatal expansion
RPE	Rapid palatal expansion

INTRODUCTION

Orthodontics is the branch of dentistry concerned with the growth of the face, development of occlusion and the prevention and correction of occlusal anomalies/ abnormalities **(Phulari, 2017).**

Controlling the reaction force during orthodontic treatment is necessary to avoid undesirable movements of the teeth; Even though many biomechanical alternatives have been developed to moderate anchorage, the use of Temporary Anchorage Devices (TADs) is currently one of the most popular among orthodontists **(Barthélemi *et al*.,2019).**

Anchorage has been a vital topic since the origin of orthodontics; In the orthodontic process, gentle, constant pressure is applied to the teeth that need to be moved against the other teeth, which serve as the anchoring unit; The anchoring teeth must be completely stable; The introduction of temporary anchorage devices to the orthodontic field has made it possible to overcome conventional anchorage and its limitations; Mini implants have widened the horizon of the orthodontic field; Skeletal anchorage has, to a large degree, replaced conventional anchorage in a situation where anchorage is considered either critical, insufficient, or likely to result in undesirable side effects **(Umalkar *et al*., 2022).**

Skeletal anchorage in the form of temporary anchorage devices (TADs) or miniscrews, has changed the scenario of anchorage control providing maximum anchorage with minimum patient compliance and without a complicated clinical procedure **(Sharma and Soni, 2023).**

Orthodontic miniscrews offer several advantages over traditional anchorage devices and can be a valuable tool in achieving optimal orthodontic results; miniscrews provide a stable anchor point that allows for more precise control of tooth movement, This can help to reduce treatment time and achieve more accurate results.

Aim of Study

This study aim to identify mini-implants and its clinical application in orthodontics field as well as the advantages and complications associated with this type of temporary but absolute skeletal anchorage.

CHAPTER ONE

REVIEW OF LITERATURE

1.1. Anchorage in Orthodontics

Every type of tooth movement, irrespective of the (fixed or removable) orthodontic appliance involved, generates an equal and opposite reactive force, as first described by Newton's third law of motion; Anchorage (reinforcement) comprises a myriad of clinical approaches to reduce the negative effects of this reactive force, which manifests clinically as anchorage loss; Mesial movement of the first molar teeth, during active retraction of the anterior teeth, is a classic example of such unwanted anchorage loss; Fortunately, the start of the twenty- first century has seen the emergence of a new form of orthodontic anchorage, utilizing orthodontic mini-implants (OMIs), also known as mini-screw implants anchorage devices (TAD) **(Cousley and Sandler, 2015).**

Orthodontic treatment is an orthodontic method that pushes the jaw or teeth to reach the ideal position. During the treatment, a certain reacting force will be generated that must be borne by the orthodontic anchorage; Therefore, the orthodontic anchorage is of great significance in orthodontic treatment **(Zhang *et al.*, 2022).**

1.2. Temporary Anchorage Device and Skeletal Anchorage System

Temporary skeletal anchorage, were developed to help correct more severe occlusal and dentofacial discrepancies that were treated with orthognathic surgery alone previously; These techniques have allowed the orthodontist to move teeth against a rigid fixation, allowing for more focused movements of teeth and for orthopedic growth modification; using a rigid fixation have allowed for greater interaction between the orthodontist and the oral and maxillofacial surgeon, and have vastly enhanced the treatment planning for the orthodontist in today's society **(Jones *et al.*,2020).**

1.3. History of Mini-Implants

Orthodontics implants was first mentioned in an article by Gainsforth and Higley in 1945 which was about augmentation of anchorage; They used vitallium screws; The implants were immediately loaded and used for canine retraction in the upper arch; Unfortunately all implants were lost. **(Jasoria *et al*, 2013).**

In **1970, Linkow** used an implant for replacing a missing molar, to retract upper anteriors and the results were quite encouraging.

Toward the end of 1980s, Creekmore described the use of vitallium implants for providing anchorage for upper anterior teeth intrusion; The screws were inserted just below the ANS; Within a years-time 6 mm of intrusion was demonstrated **(Creektnore and Eklund, 1983).**

(Roberts *et al.*,1989) placed a two stage endosseous implant in the retromolar area of the mandible, as a source of rigid anchorage in order to translate 2nd molars 10 to 12 mm; Over a three-years period the endosseous implant remained rigid (osseointegerated).

(Roberts *et al.*, 1994) used an anchorage implant (3.76 ×7mm standard Branemark fixture) in the retro- molar area about 5 mm distal to the mandibular 3rd molar for space closure; closing loops were placed by which about 0.8 mm of space was closed.

More recently, mini-plates and palatal implants have been developed specifically for use in orthodontics. The mini plate implants have been used for space closure and distalization of maxillary molars; Because these new devices still have many of the same limitations, most orthodontists have turned to mini-screws; they have found that small screws work well for orthodontic anchorage purpose **(Jasoria *et al.*, 2013*).***

Kanomi in 1997, first described mini implant; He successfully used mini-implant to intrude the mandibular incisors; The implant was placed between the mandibular central incisors, 2 to 3 mm form the root apex.

Various case reports showed the usage of implants (1.2 mm diameter, 6-12 mm in length) in uprighting of molars **(Park *et al,* 2002);** Bae et al, 2002 inserted microimplants of the same dimensions between the maxillary 1st and 2nd premolars, for retraction of the maxillary anterior teeth **(Wang and Liou, 2008).**

1.4. Principal Design Features of Mini-Implants

1.4.1. Mini-Implant Shape

A) Head It is the orally accessible part of the mini-screw implant that holds the springs and rubber bands in place; It has a special spot that is designed in such particular ways that engage the mini-screw driver for implant placement; For acquiring varieties of anchorage and avoiding soft tissue irritation, different types of heads are available. Button-like design with a sphere or double sphere-like shape or a hexagonal shape is found to be the most commonly used design; The screw head also comes with a hole or collar to give different attachments **(Muhamad and Nezar,2014; Nausheer *et al*.,2020)**

B) Neck the neck of the screw, also known as the transmucosal portion, passes through the mucosal part and secures the screw to the head. Variable neck lengths are provided in a way that suits different mucosal thicknesses; To prevent plaque or debris accumulation over the neck surface, it must be smooth and well-polished. Most of the failures of implants at this point are due to its crucial junction with mucosa, as various inflammation issues start from this part of the implant **(Nausheer *et al*., 2020)**.

C) Screw this part provides retention by being embedded in cortical or medullary bone; The thread of the screw around the shank or main body of the TAD has a cutting edge that facilitates insertion; The number of stresses and torque required for the insertion of TAD is determined by none other than the cutting edge and the angle; Thread design may be conical as in mini- screws or parallel tapering at its end point only as in implants in orthodontics; The length of TAD is defined by its thread's body length, ranging from 5 and 12 mm in length according to anatomic requirements; The

whole mini-screw length can be judged by the length of the whole parts of the implant, i.e., head, neck, and screw **(fig.1) (Nausheer *et al*., 2020)**.

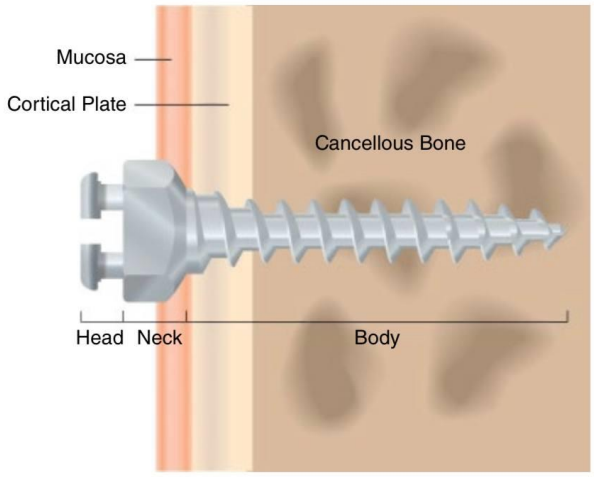

Figure 1: The three principal sections of a mini-implant: the head superficial to the tissues, the neck traversing the mucosa, and the threaded body within the cortical and cancellous bone (Cousley, 2020).

1.4.2. Mini-Implant Standards:

A) Mini- Implant Material

According to **(Sripradha and Pandian, 2018)** Mini-implants are manufactured from a biocompatible titanium alloy composition, "Wrought Titanium-6 Aluminum-4 Vanadium ELI (Extra LowInterstitial)", according to the ASTM F136-02 standards specification; The Orthodontic Mini Implant (OMI) is made of implant steel the alloy exhibits a well-documented level of biological inertness being characterized as:

- Corrosion free.
- Non Toxic.
- Strong.
- Having a low module of elasticity .
- Anti-magnetic.

B) Mini-Implant Dimension

The relationship between length and diameter is inversely proportional, if the length decreased, diameter must be increased **(Giancotti *et al.*, 2002).**

Diameter plays a greater role in their retention, Diameter should be approximately of 1.5-1.3 mm **(Giancotti *et al*., 2004).**

Length give stability, it should be long enough to support the intended movement, it shouldn't be too long because a long screw easily impact on a root or on other delicate anatomic structures, the best length of thread portion of screw shouldn't exceed 2-12mm **(Chung *et al.*, 2007).**

Screw pitch is a term used for the distance between two threads; Threads positioned wide apart have a high pitch, while threads positioned nearer have a low pitch; a screw having a higher pitch than normal is inserted quickly and fast **(Nausheer *et al.*, 2020).**

1.5. Classification of Orthodontic Mini-Implant (Melsen and Costa, 2000; Wilmes *et al.*, 2008)

Orthodontic implants are alloplastic material devices which are surgically inserted into or onto jaw bone, they are classified as:

1) Based on Location

- Subperiosteal: they lies over the bony ridge.
- Transosseous: These implant body penetrates the mandible completely.
- Endosseous/ Endosteal: are those implants that are partially submerged and are anchored within bone.

2) According to the surface structure

- Threaded or Non-threaded.
- Porous or Non Porous.

1.6. Types of Mini-Implants Anchorage

In general, two different types of anchorage must be distinguished: direct and indirect. Determining the type of anchorage that is more favorable depends on the following clinical or radiological factors: local bone quality, available space (in particular for inter-radicular insertion) and mucosal thickness. Furthermore, the expected load on the mini-implant should be taken into consideration **(ludwig *et al.*, 2008).**

In a direct anchorage situation, the active unit is attached to the TAD and bypasses anchorage to the other teeth **(fig.2 A);** In the second approach called indirect anchorage, the traditional teeth comprising the anchorage or reactive unit are tied to the TAD; that is, the unit to be moved is not attached directly to the TAD **(Fig.2 B) (Soni and Sharma, 2022).**

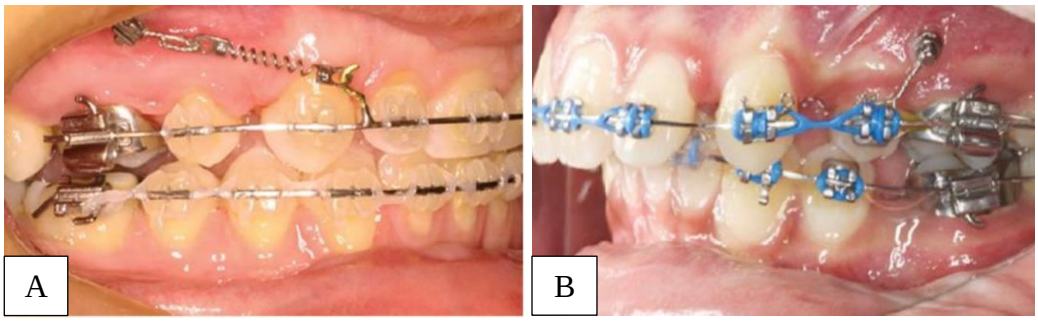

Figure 2: A. direct anchorage; B. indirect anchorage (Soni and Sharma,2022).

1.7. Indications for Placement of Mini-Implants (Johns, 2021)

Common Indications for mini-implants in orthodontics are as follow:

1. Retract and align anterior teeth.

2. In first molar extraction sites they are used for closing the edentulous spaces.

3. Intrude or extrude teeth.

4. Protract or retract teeth of one arch.

5. Stabilizing the teeth with less bone support.

1.8. Contraindications for Placement of Mini-Implants (Cousley, 2020)

There are no absolute medical contraindications which specifically apply to orthodontic mini-implants. Conditions, such as diabetes mellitus and immunosuppression, which are relative contraindications to orthodontic treatment in general must be considered in terms of soft tissue hyperplasia and infection risks. However, if the patient has good oral hygiene then comprehensive treatment may proceed as normal. Older, especially female, patients with osteoporosis may present problems in terms of reduced bone support and hence mini-implant stability, but this can be accounted for in terms of insertion site and force application considerations. The increasing number of older patients on bisphosphonate drug treatment (according to **Jeffery *et al.*, 1996** bisphosphonate used for increase bone mineral density) may limit orthodontic treatment, because of osteonecrosis risks.

1.9. Clinical Applications of Mini-Implant

Previously, in the case of malocclusion owing to skeletal discrepancy in adults, the amount of tooth movement was limited since there was no reliable skeletal anchorage device; The only way to treat this type of cases was by repositioning the maxilla and mandible via orthognathic surgery, but most patients are reluctant to undergo surgery owing to the risk and expenses incurred. However, with the current introduction and use of miniscrews as temporary anchorage devices, the entire dental arch can be relocated to a target position without surgery, thus broadening the scope of non-surgical orthodontic treatment compared to the past **(Choi *et al.*,2020).**

Mini-screws are used as temporary anchorage devices (TAD) to produce various dental movements, including anterior retraction, canine retraction, distalization, molar uprighting, protraction **(Chang *et al.*, 2019; Hasan *et al.*,2021);** In addition, mini-screws can be used in the application of dentofacial orthopedics such as rapid palatal expansion and Class II and III correction (Fig.3) **(Aslan *et al.*, 2013).**

Figure 3: Miniscrews used in the application of dentofacial orthopedics with the placement of four mini-screws between the inter-radicular areas of the maxilla. (Aslan *et al*., 2013).

These applications include:

A- Intrusion

- **Intrusion of Posterior Teeth**

Intrusion of the permanent maxillary molar can be achieved on a continuous arch wire with a single buccal mini-implant placed bilaterally **(fig.4)** with improvement in facial aesthetics, especially in the vertical plane. This method may be beneficial in patients with borderline vertical discrepancy treated with conventional friction mechanics during space closure after first premolar extractions **(Felicita and Wahab, 2022).**

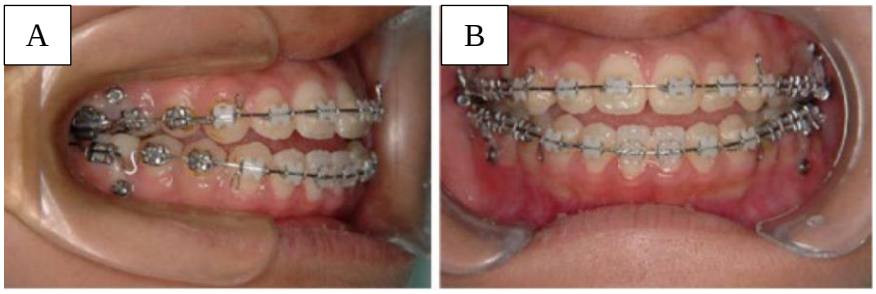

Figure 4:A.B Mini-screw implant to achieve intrusion of over-erupted posterior teeth (Kaku *et al*., 2009).

- **Intrusion of Anterior Teeth**

Deep bite is known as one of the most common malocclusions, and its treatment and retention are often challenging; The use of mini-screws has been suggested as an ideal method for the intrusion of incisors in deep-bite patients **(Bardideh *et al.*,2023).**

The mini-screws should be placed as close to the midline of the anterior arch as possible; between the maxillary central and lateral incisors and between the maxillary lateral incisors and canines area on both left and right sides **(Fig.5) (Sosly *et al.*, 2020).**

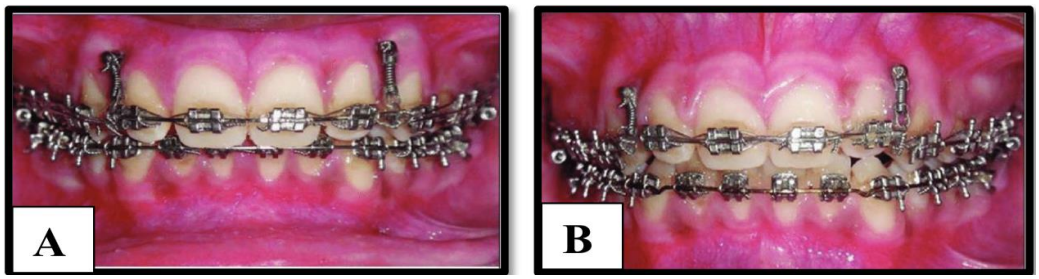

Figure 5: A) Temporary anchorage device for intrusion of incisors, B) Postintrusion (Park *et al*., 2003).

B- Space closure

Generally, miniscrews are best suited to use as indirect anchorage during retraction of the anterior teeth or protraction of the posterior teeth In this way, the miniscrew is used to avoid undesirable movement of anchorage teeth, while conventional mechanics are used to close the space created **(Fig.6). (Maino *et al.*, 2005).**

Figure 6: The use of a miniscrew as indirect anchorage during the distalization of the premolars and canine (Maino *et al.*, 2005).

When direct anchorage is preferred for space closure, the direction and point of force application becomes crucial; Segmented arches may be preferred for canine distalization to provide a more appropriate force application point.. Miniscrews can be used as direct anchorage when retracting the anterior teeth; Open coils/elastic

chains are applied directly between the miniscrew placed between the second premolar, the first molar and the hooks on the arch wire **(Maino *et al.*, 2005; Aslan *et al.*, 2013).** Therefore, the point of force application is close to the center of resistance of the anterior teeth, so that the anterior segment may slide bodily with minimal tipping; 150 g of force is used for retraction **(Park *et al.*, 2005).**

C- Molar Distalization

During molar distalization with conventional intraoral appliances, tipping and extrusion can occur in conjunction with the distal movement; In addition, reactive forces on the anterior anchoring teeth occur in the form of mesialization of upper anterior teeth and premolars and increased overjet **(Keles *et al.*, 2003 ;Carano *et al.*, 2005 ; Kircelli *et al.*, 2006)**, Miniscrew-supported appliances are effective in molar distalization with distal movement of premolars with minimal anchorage loss and distal tipping of the molar teeth **(Mohamed *et al.*,2018).**

- **Maxillary molar distalization**

Maxillary molar distalization is a commonly employed effective treatment strategy, which is useful not only for patients with Class II malocclusion but also for resolving crowding caused by maxillary arch length discrepancy **(Park *et al.*,2022)** , when bone screws placed it in the palate or in the infrazygomatic process away from the roots **(Fig. 7)** The entire arch usually can be distalized **(Rosa *et al.*,2023).**

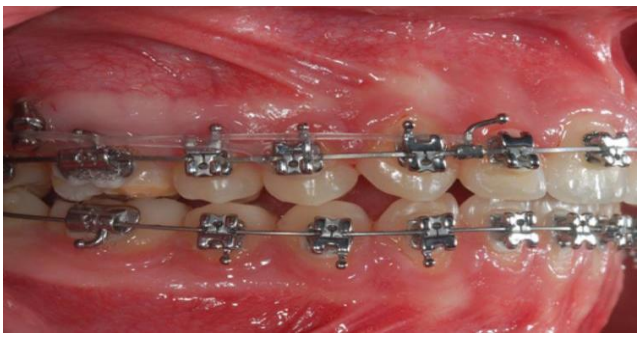

Figure 7: Total arch distalization (Rosa *et al.*,2023).

- **Mandibular Molar distalization**

Placing miniscrews at the retromolar pad area for lower molar distalization was found to be a simple and effective method for correcting anterior cross bite and mandibular anterior crowding or protrusion, without the need for patient compliance **(fig.8) (Safavi *et al.*,2016).**

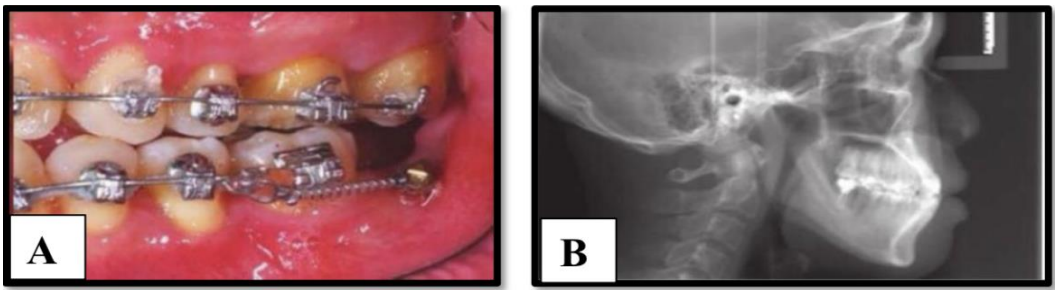

Figure 8: moving the entire mandibular arch distally can correct the crossbite (A) Pre-treatment dental appearance, with crowding. (B) cephalometric radiograph showing the protrusion of the lower incisors(proffit *et al.*, 2013).

D- Retraction of Mandibular and Maxillary Anterior Teeth

Treatment of a Class III skeletal discrepancy in adolescence or adulthood often involves orthognathic surgery or compensatory orthodontic therapy that may include extractions, depending on the severity of bone discrepancy **(Hakami *et al.*, 2018).**

One example of such treatment is mandibular arch retraction supported by temporary microscrews, which has proven effective in treating Class III malocclusions with predictable force application (fig.9) **(Camci *et al*.,2017).**

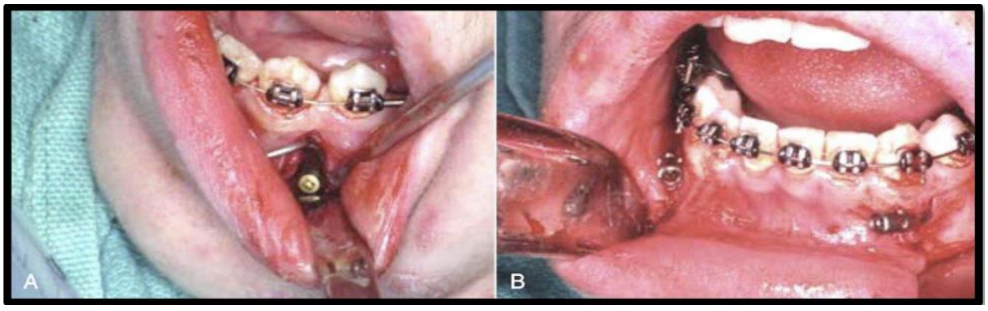

Figure 9: A, placement of screw to hold a bone anchore in mandible.B,anchore in place bilaterally (Proffit et al., 2013).

Successful orthodontic resolution of bimaxillary dentoalveolar protrusion depends on successful retraction of anterior dentition, which also involves acquiring proper buccolingual inclination and vertical position of anterior teeth; When maximum anchorage is required during retraction of the anteriors, TADs are inserted in the midpalatal area; In the early days, a miniscrew was placed when retracting an anterior portion using a C-lingual retractor **(fig.10 A);** Moreover, the combination of Double J Retractor (DJR) with the proper position of miniscrew is expected to allow bodily-like parallel retraction of anterior teeth **(fig.10 B) (Soni, 2022).**

Figure 10: A C-lingual retractor with miniscrew (Kim, 2014). B, using Double J Retractor with palatal miniscrews for anterior teeth retraction. (Jang *et al.*, 2010).

E- Uprighting

Uprighting is generally needed when second molars are impacted and the first molar tips mesially because of early premolar extraction. Uprighting vectors with intrusion are very hard to accomplish; therefore, absolute anchorage is required. Mini-screws can be used as direct anchorage to prevent reactive forces on adjacent teeth that may result in negative side effect For second molar uprighting, a miniscrew can be placed in the buccal inter-radicular area of the second premolar and first molar; this area is the most reliable mandibular buccal cortical site , for first molar uprighting, the mini-screw can be placed mesially in the area between the second and first premolars; (6-to 8-mm) mini-screws are preferable and (0.17 × 0.25 inch) TMA wires preferred for preparing sectional arches with tip-back bending; Once the wire

has been engaged by the mini-screw's head, intrusion and distalization **(Fig 10)** forces are applied to the molar **(Aslan *et al*., 2013).**

Figure 11: Uprighting of second molar with a miniscrew implant and elastomeric chain. radiograph after the uprighting of second molar, with the miniscrew placed distally (musilli *et al*., 2010).

F- Additional Uses

One of the dilemmas facing orthodontists is how to maintain space during the retention period, when a patient has completed orthodontic treatment, but is too young for placement of an osseointegrated implant with a prosthesis for long-term restoration; Pontics can be fabricated to fit onto a TAD and utilized for several years while the patient continues growth and passive eruption of the teeth; Another uses of TADs is with expansion appliance anchorage in patients who were once thought to be past the age at which the palate can be expanded; Sutural separation has been documented in these patients at a more advanced age than was once thought possible —again expanding the boundaries of traditional orthodontics **(Shirck et al., 2011).**

Miniscrew-assisted rapid palatal expansion (MARPE) is a relatively new method introduced to counter the side effects associated with RPE **(Choi *et al*., 2016: Mehta *et al*., 2022)** MARPE appliance consists of an expansion screw anchored to miniscrews (mini-implants) inserted into the palate **(mehta *et al*., 2021; Arqub *et al*., 2021) (fig.12).**

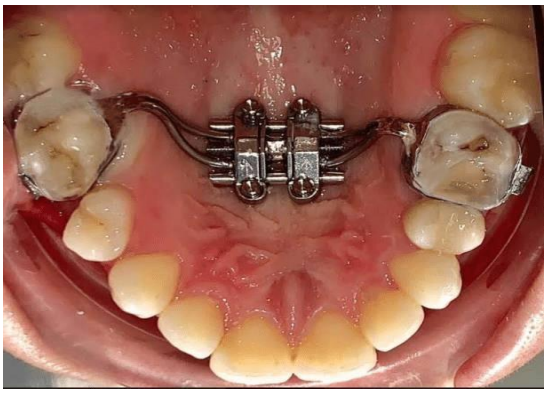

Figure 12: Miniscrew-assisted rapid palatal expander (MARPE) device (Bud *et al.*, 2021).

1.10. Sites for Placement of Mini-Implants

When absolute anchoring of the implant is necessary, mini-screws are employed instead of standard appliances such as lingual arches; The most prevalent locations for mini-screw anchorage system (MAS) insertion in the upper jaw or maxilla are the incisive fossa, canine fossa, infra-zygomatic ridge, pre-maxillary region, or mid-palatal region; The most typical locations for mini-screw in the lower jaw or mandible are symphysis, canine fossa, anterior external oblique ridge, retro-molar area, or sub-maxillary fossa. TADs can be sited in extra alveolar bone, but this will cause force on the center of resistance of the tooth; The buccal or lingual inter-radicular gaps between the second bicuspids and molars in both arches, and buccal spaces between the upper anterior in both arches, are considered as most beneficial areas in our experience **(Nausheer *et al.*,2020).**

1.11. Mini-Implant Stability

The stability of an Orthodontics mini-implants is difficult to evaluate and is often measured in terms of mobility; It is generally defined by two major components **(Paik *et al*, 2009);** primary stability achieved by mechanical bonding between the bone and the mini-implants; and secondary stability achieved through continuous bone remodeling around the implant, thus leading to osseointegration **(Hong *et al.*, 2011).**

Primary stability of a mini-implant depends on a number of factors, primarily including the place where the implant itself is inserted, its proximity to the root,

geometric design of the mini-implant, soft tissue condition, operating techniques, and the strength and the duration of the applied orthodontic forces; The bone quality at the implant insertion point is important for primary stability; thus, the increase in the cortical bone thickness increases the value of the pulling force significantly **(Redžepagić-Vražalica *et al*.,2021).**

Primary stability can be improved by increasing the diameter and length of the miniscrew; However, the extent to which the diameter and length can be increased is limited by proximity to the adjacent tooth roots and risk of root contact **(Lim *et al.*,2008; Dalessandri *et al.*,2014).**

To compensate for this limitation, tapered miniscrews have been developed. The tapered shape increases primary stability by applying a compressive force to the cortical bone while reducing the risk of root contact; In a clinical study, tapered miniscrews showed higher initial stability than cylindrical miniscrews **(Yoo *et al.*,2014).**

1.12. Factors Affecting Mini-Implant Success (Cousley, 2020)

1) Patient (anatomical) factors:

- Macro – somatic and general patient factors.
- Mini – insertion site anatomy.
- Micro – bone characteristics.

2) Mini-implant design factors:

- Materials and surface characteristics.
- Dimensions.

3) Clinical factors:

- Insertion technique.
- Force application.

1.13. Complications of Mini-Implants

1.13.1. Complications During Insertion

Complications during insertion of mini implant may include the following

- **Root Contact**

The insertion of orthodontic miniscrews in interradicular regions could lead to iatrogenic root damage **(fig.13).** Among the complications, its outcome could be considered the most serious for the patient's dental health **(Alves *et al.*, 2013);** Potential complications of root injury include loss of tooth pulp sensibility, root resorption, root fracture, osteosclerosis, and dentoalveolar ankylosis **(Gintautait *et al.*, 2018).**

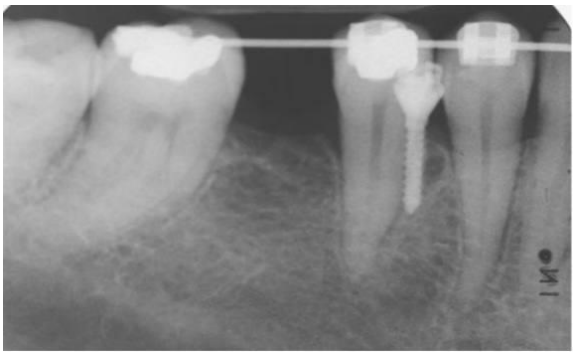

Figure 13: Radiographic image of implant touching tooth root (Mizrahi and Mizrahi, 2006).

- **Perforation of Nasal and Maxillary Sinus Floors**

During orthodontic miniscrew installation, perforation into the nasal cavities and maxillary sinuses **(fig.14)** has been reported **(Motoyosh *et al.*, 2015; jia *et al.*, 2018);** In the palate, distance to the nasal cavity and maxillary sinus was greatest in the region mesial to the first premolar and then the distance started to decrease significantly **(Al Amri *et al.*, 2020);** In the buccal area, perpendicular insertion was safe with minimal risk of sinus or nasal cavity injury, while oblique placement increased the possibility of sinus and membrane penetration **(Al Amri *et al.*,2020; Tavares and Neves, 2022).**

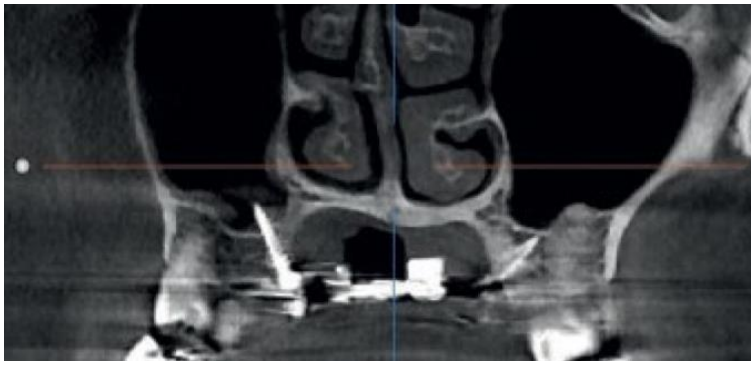

Figure 14 :one month after insertion of mini-implants in palatal alveolar sites. sited distal to the right maxillary first molar and has perforated the maxillary sinus (Cousley, 2020).

- **Miniscrew Fracture**

Increased torque placement could cause miniscrew bending or fracture that not only affects the miniscrew stability but may also requires surgical intervention **(fig.15)**; Miniscrew fracture has been reported and caused a sinus tract, and the fractured tips had to be removed surgically **(McCabe and Kavanagh,2012; Gurdan and Szalma, 2018).**

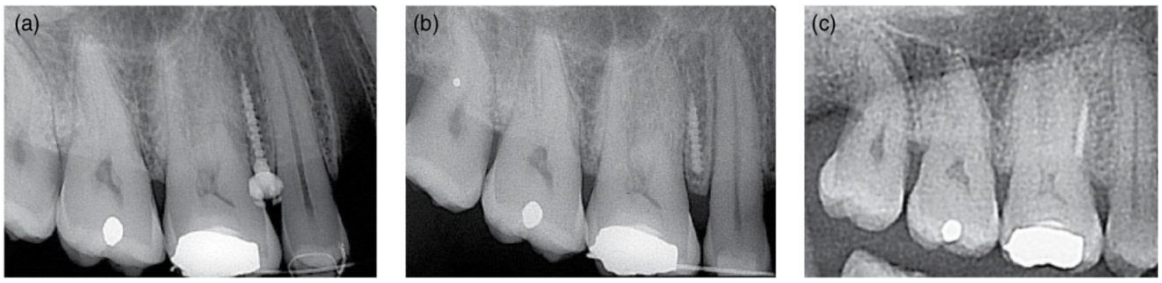

Figure 15: Intraoral radiographs after: (a) insertion of mini-implant mesial to the maxillary first molar, (b) its fracture near the coronal end of the body. (c) Sectional OPG showing retained mini-implant body over five years later. (Cousley, 2020).

1.13.2. Complications after Insertion

Installation of miniscrews may cause pain and discomfort **(Fah and Schatzle, 2014; Ganzer *et al.*,2016;Sreenivasagan *et al.*, 2021)**; Pain intensity and discomfort were not greater than other orthodontic procedures, and some author sreported that patients preferred miniscrews to tooth extraction **(Zawawi, 2014; Ganzer *et al.*, 2016).**

1.13.3. Complications under Loading

Complications under loading of mini implant may include the following

- **Stationary Anchorage Failure**

Many risk factors could affect the stability of miniscrew: patient-related (age and sex), miniscrew-related (diameter, length, and design), location-related (thickness of cortical bone, density of bone, thickness and type of soft tissue, and insertion site), and clinical procedure-related (pre-drilling/ self-drilling, pilot hole, and method of loading) **(Kim *et al*., 2022).**

- **Miniscrew Displacement**

Miniscrews have been affirmed to provide good stationary quality, many studies confirmed that there was a remarkable secondary displacement of the miniscrew under orthodontic loading over time **(Pittman *et al*., 2014; Garg and Gupta, 2015).**

- **Traumatic Soft Tissue Lesion and Soft Tissue Coverage**

Traumatic soft tissue lesions could happen in the form of aphthous ulcerations or canker sores (aphthous ulcer) in alveolar, buccal, labial mucosa, or frenulum **(fig.16) (Kravitz and Kusnoto, 2007; Marquezan *et al*., 2012)**; However, these injuries are self-limiting and able to heal without further complications; Using healing abutment, wax pellet, and elastic separator over the head of miniscrew, with daily use of chlorhexidine, was performed for ulceration prevention and patient comfort improvement. **(Kravitz and Kusnoto, 2007).**

Figure 16:axillary alveolar ulcerative gingivitis after one month with the powerchain in situ, along with generalized gingival hyperplasia resulting from poor oral hygiene (Cousley, 2020).

- **Peri-screw Inflammation**

Inflammation around the miniscrew was reported to occur in the regions of palate, buccal fold **(fig.17)**, and ascending ramus **(Gurdan and Szalma, 2018);** Peri-screw inflammation was associated with miniscrew failure **(Samrit *et al.*,2012; Acocella *et al.*,2012);** In patients with poor oral hygiene, inflammation can happen even if the placement procedure is operated carefully **(Gurdan and Szalma, 2018).**

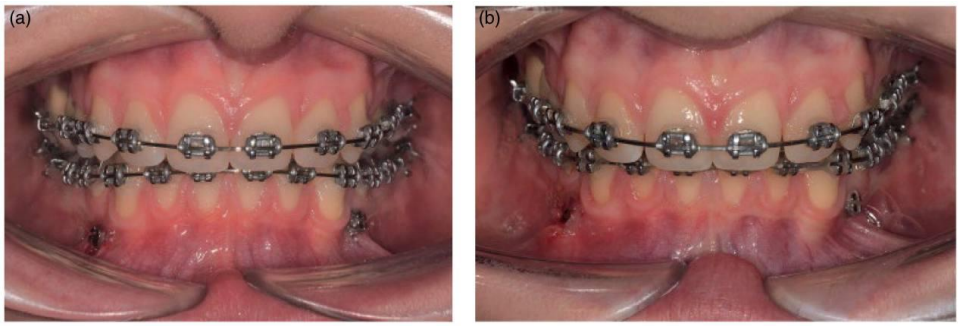

Figure 17: (a) Photograph of lower anterior mini-implants immediately after insertion. (b) Hyperplasia of the loose sulcular mucosa around the right mini-implant one month after insertion (Cousley, 2020).

1.13.4. Complications During Removal

During removal, miniscrew fracture can happen if the torque is over the limit of the miniscrews **(fig.18) (Suzuki, 2011);** For this reason, controlling the removal torque was recommended **(Pauls *et al.*, 2013).**

Figure 18: Broken implant fragment removal (Mizrahi and Mizrahi, 2006).

1.13.5. Complications after Removal

Complication after removal of mini-implants may include:

- **Soft Tissue Scarring**

After orthodontic miniscrew removal, detectable soft tissue scarring may develop at a fairly high rate **(Choi *et al.*,2015; Jung *et al.*,2015);** Even though this scarring was only located at the site of placement and was not considered serious, it might give negative esthetic problems **(Choi *et al.*,2015).**

- **Alveolar Bone Exostoses**

Alveolar bone exostoses have been reported once in the literature as a complication of orthodontic miniscrew; In this case, resective osseous surgery was performed, and orthodontic treatment was continued after one month without recurrence **(Agrawal *et al.*, 2013).**

1.14. Mini-Implant Driving Methods

According to **(Rastogi *et al*, 2011)** There are two methods of mini-implants placement which are:

- **Self-Tapping Method:**

In this method the miniscrews is driven into the tunnel of bone formed by drilling, making it tap during implant driving; This method is used when we use small diameter miniscrews **(Rastogi *et al.*, 2011).**

- **Self-Drilling Method:**

Here the miniscrews is driven directly into bone without drilling; This method can be used when we want to use larger diameter (more than 1.5mm) miniscrew.

Self-drilling miniscrews have been described to shorten operative time, reduce bone damage and patient discomfort comparing to self-tapping miniscrews **(Gupta *et al.*, 2012).**

Self-drilling miniscrews are commonly featured with deep thread and sharp screw tip, and thus might have a better success rate comparing to self-tapping miniscrews **(Migliorati *et al*., 2013).**

1.15. Procedure for Mini-implant Placement

According to **(Cousley, 2020)** the steps of mini-implants placement are as following:

1. Mini-implant Kit Sterilization
2. Superficial Anaesthesia: Either local (LA) or topical anaesthetic agents may be used to achieve superficial anaesthesia.
3. Antibacterial Mouthwash: The patient should rinse the insertion site(s) for one minute using 0.2% chlorhexidine gluconate mouthwash.
4. Soft Tissue Removal: Use a soft tissue punch (mucotome) where the insertion is through either (thick) palatal attached tissue or through unattached/mobile buccal mucosa **(fig.19).**
5. Cortical Perforation: Full pilot drilling (of both cortical and cancellous bone layers) is required for non-drilling mini-implants but not for self-drilling designs.
6. Mini-implant Insertion: The screwdriver **(fig.20)** should be fully engaged onto the mini-implant neck or head (depending on the type of implant design).

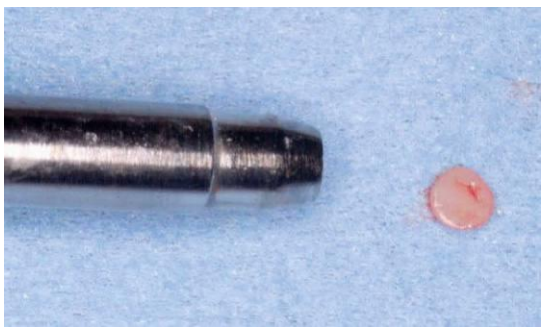

Figure19: The circular piece of excised attached mucosa is seen adjacent to the Infinitas soft tissue punch (mucotome) used to remove it (Cousley,2020).

Figure 20:Freehand manual insertion of a 2.0 mm diameter mini-implant in the right maxillary edentulous molar site (Cousley. 2020).

1.16. Load Bearing Capacity of Mini-Implants

According to **(Deguchi *et al.*,2003)** after a short healing period (maximum 3 weeks) small titanium screws can function as rigid osseous anchorage against ortho-dontic loads for 3 months; The orthodontic load-bearing capacity is closely related to the size and biocompatibility (i.e., bonding strength at the implant-bone interface) of the mini-implants **(Skripitz and Aspenberg, 1998; Schatzle *et al.*,2009).**

Splinting two TADs or placing extra TADs can allow for heavier forces to be applied **(Leung *et al.*, 2008; Holberg *et al.*, 2013)** The use of wider and longer TADs may also be helpful **(Duaibis *et al.*, 2012; Liu *et al.*, 2012);** mini-screws have the ability to withstand force up to 500 g and at the same time remain intact until the end of the treatment **(Raghis *et al.*, 2022).**

CHAPTER TWO

2.1. Discussion and Comments

Anchorage control is one of the most challenging problems in orthodontics. It is achieved with orthodontics miniscrews, which have been used frequently because they prevent unintended tooth movement **(Inchingolo *et al,* 2023).**

Miniscrews have been used more widely for orthodontic anchorage reinforcement due to good stationary quality, various insertion sites, simple placement or removal procedures, light tissue invasion, immediate or early loading allowance, minimal patient compliance, and low cost; the uses of miniscrew have widened the scope of nonsurgical orthodontic therapy **(Jasoria *et al*.,2013; Mohammed *et al*.,2018).**

Clinical success of orthodontic anchorage depends on the stability of the miniscrews used for fixation; The stability of mini-implant is positively associated with bone mineral density at the receptor site: as the bone density increases, the primary stability of dental implants also increases; It's also depends on the pre-drilling diameter, insertion torque, and insertion depth; moreover high successful rate is predictable with increasing the length of miniscrews **(Cousley, 2020).**

Placement of Orthodontics miniscrews is a critical procedure, and even if preventive measures are taken, such as an apical radiograph before screw placement, multiple complications can take place , the orthodontist must be aware about this complications and able to manage it **(Inchingolo et al, 2023).**

Complications can also occur after insertion or even under loading such as fractures, mobility or inflammation of soft tissues at the insertion site; These situations can usually be resolved by inserting another implant (screw fracture; mobility) or applying chlorhexidine to the inflamed site **(Rosa *et al*.,2023).**

Depsite the precence of these complication, the emergence of orthodontic mini-implants provide significant benefits, which make them of a great importance and indispensable in orthodontics approach **(Soni, 2020).**

CHAPTER THREE

3.1. Conclusions

Over the past few decades, conventional anchorage, which is considered either critical or insufficient, has been replaced by skeletal anchorage with minimal invasiveness and desirable properties; These skeletal fixtures would make the outcome more predictable and satisfying for orthodontists and patients; The orthodontist can use the orthodontics mini-implant (OMI) to help with a variety of issues that arise.

When tooth displacement occurs; Despite drawbacks such as root damage, implant infections, and failures in implants, OMI have a significant role in orthodontics due to the benefits of simpler placement and withdrawal, instantaneous placement, and appropriate anchorage. A detailed understanding of the elements that influence micro implant success can aid in obtaining targeted treatment outcomes with little patient chair-side time.

3.2. Suggestions

For future studies we suggest:

- Conducting a survuy among orthodontis to esimate the most probable limitation and complication of mini-implant use.
- Conducting a clinical study to reveal and identify the most applicable type of implantswith the lowest degree of failiure.

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