e-ISSN: 2637-0611

Available online at
https://journal.uitm.edu.my/ojs/index.php/COS

Compendium of Oral Science 12 (2) 2025, 32 - 51

Compendium of Oral Science

Orthodontic Mini Implant, a Narrative Review

Suzanne Husun Reginald Iggan[1], Muhamad Nizam Muhamad Subra[2], Nor Amlizan Ramli[3], Maryati Md Dasor[2*]

[1]*Ministry of Health, Malaysia*
[2]*Centre of Paediatric Dentistry and Orthodontics Studies, Faculty of Dentistry, Universiti Teknologi MARA Sungai Buloh Campus, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia*
[3]*Faculty of Pharmacy, Universiti Teknologi MARA (UiTM), Bandar Puncak Alam,Selangor, Malaysia*

ARTICLE INFO

Article history:
Received 02 April 2024
Revised 19 June 2024
Accepted 11 September 2024
Online First
Published 01 September 2025

Keywords:
mini-implant
orthodontics
overview
surface-treated mini-implant
anchorage

DOI:
10.24191/cos.v12i2.8826

ABSTRACT

Introduction: The refinement in anchorage management in recent years has magnified the superiority of the mini-implant (MI). Behind the vast clinical literature and low failure rates (Alharbi et al., 2018a), there is a steep learning curve. The lack of updated information on MI focused on understanding the multifactorial success has led to a new area in developing MI research for surface treatment and clinical application.

Objective: This comprehensive review aims to address the different variables contributing to MI success.

Methods: The articles were identified electronically (PubMed, Scopus, Google Scholar), ranging from 2018 to date. The articles were independently reviewed by two reviewers (SHR and MMD). Randomised clinical trials (RCT), longitudinal studies, cohort, and case/control studies, both retrospective and prospective, were all included. The following search terms were used: mini-implant orthodontics; mini-implant design; surface treated mini-implant; mini-implant success; mini-implant clinical application; mini-implant complications.

Conclusions: The application of MI in orthodontics is bounded by biological factors, geometry, and operational factors. Surface modifications of MI are performed in various ways to increase the primary stability, and the clinical application of MI has expanded in complex cases to mimic surgical correction. The known risks and complications of MI provide sufficient knowledge to negate any problems encountered in clinical situations. It is critical to recognise that MI has its pearls and pitfalls, and we must constantly refine our understanding and clinical applications to maximise the success rate of MI use.

[2*] Corresponding author. *E-mail address*: maryatidasor@uitm.edu.my

1. INTRODUCTION

Mini-implant (MI), is one of the latest innovations in orthodontics that involved important changes in the way anchorage is managed. One of the most common factors that impedes the achievement of ideal orthodontic treatment outcome is the unwanted tooth movement(Roberts-Harry & Sandy, 2004). Unwanted or unplanned tooth movement resulted from anchorage loss will ultimately cause downward revision of the orthodontic therapy that may affect the outcome. For as long as orthodontics has been in practice, selecting the most suitable way to preserve anchorage during treatment has been one of the most perplexing factors for orthodontists. Orthodontic auxillaries have evolved from headgear to transpalatal arch (TPA), Nance appliance, and Lingual holding arch, most of which had served and worked well but the advent of the MI in orthodontics has been revolutionary. MI is a small biocompatible device inserted into the bone to gain maximum anchorage [2]). The success of MI has been well established since it was first reported by Kanomi in 1997 and significantly effective as a mode of anchorage as postulated by recent works (Alharbi et al., 2019a; Nor et al., 2019; Sandler et al., 2014; Yassir et al., 2022) with preservation of 2.20mm of space more than the conventional anchorage reinforcements (Alharbi et al., 2019b).This type of anchorage has proven its ability to provide maximum anchorage with low adverse effects and positive patient acceptance (T. C. K. Lee et al., 2008; Zawawi, 2014).Different terms such as mini screws, microimplant or temporary anchorage device (TAD have been used interchangeably in literature although the latter covers a broader spectrum of bone anchorage). In relatively short time, we have observed that MI is used frequently in modern orthodontics, and in parallel, creativity in clinical application has increased tremendously, explained by the high number of article publications. The usage of MI has expanded from the common correction of malocclusion to the correction of skeletal discrepancies such as camouflage of the prognathic maxilla or mandible. However, it is not a panacea in orthodontics, as systematic reviews have shown the overall failure rates for MI from 13-15% (Cunha et al., 2017; Papageorgiou et al., 2012; Ramírez-Ossa et al., 2020).Therefore, it is prudent to have a recent and well-organized overview to simplify the MI in orthodontics.

2. MATERIALS AND METHOD

We identified relevant articles via an electronic search on the PubMed, Scopus, and Google Scholar to obtain articles of MI. Randomised clinical trials (RCT), longitudinal studies, cohort, or case/control studies both retrospective and prospective were all included without any restrictions to the year of publication. We referred to older articles for the history and background publication due to the rapid evolution of MI but focused on the recent from the year 2018 to 2024 for the recent findings. The articles obtained were independently reviewed by two reviewers (SHR, MMD). The following keywords were used: mini-implant orthodontics; mini-implant design; surface treated mini-implant; mini-implant success; mini-implant clinical application; mini-implant complications

3. LITERATURE REVIEW

3.1 Mini-implant material

The MI is usually made of titanium alloy (Ti-6Al-4V), titanium (Ti), and stainless steel (SS) which are manufactured with a smooth machined surface that is not designed for full osseointegration (Migliorati et al., 2012) The most popular MI are those made from pure titanium and titanium alloy. Titanium alloy MI is best suited to small diameter MI, whereby it reduces the fracture risk upon insertion and removal at the difference of only 4.09Ncm in comparison to SS MI(Barros et al., 2021). Most studies found no difference in terms of success for both SS and Ti (Mecenas et al., 2020).

https://doi.org/10.24191/cos.v12i2.8826

3.2 Mini implant geometry

Essentially, the MI geometry is one of the three key determinants of MI success, in addition to the host and the operation. There have been constant changes in the geometry although it may have been a just a derivative to the existing design, but this suggests that design aspect is one of the key determinants for success. Selection of the MI, such as length, diameter, thread, and shank design, plays an important role in the primary stability of MI.

3.2.1 Length

The increased length of the MI increases the stability, is the perception, however it is dependent on the thickness of the cortical plate and trabecular bone density (Pan et al., 2019a). The stability is augmented by the increase of contact with the cortical bone, in case if the thickness is insufficient to provide stability, longer implant is needed to gain additional stability from cancellous bone (Ntolou et al., 2018). The length of the MI is classified as short, medium, and long as explained in Table 1 (Cunha et al., 2017). The success rate is the highest for the medium and short MI (0.80-0.92)(Alharbi et al., 2018b). But the length of MI to be used also depends on the anatomical region of insertion (Mohammed et al., 2018), refer to Table 2 for recommended insertion sites and geometry of MI.

Table 1. Size classification (Cunha et al., 2017)

Classification		Diameter (mm)
Diameter	Small	1.0-1.3
	Medium	1.4-1.9
	Large	2.0-2.5
Length	Short	5.0-8.0
	Long	8.5-15

Table 2. Recommended size for different insertion sites (J. H. Park, 2020)

Site	Diameter	Length	Insertion site
1. Maxillary buccal			
i. Interadicular	1.2-1.5mm (preferably 1.5mm)	7-8mm	Distance from the alveolar crest; 5-8mm, between the maxillary permanent first molar and the second premolar. 5–11mm, between the maxillary first and second premolars 5–11mm, between the maxillary first premolar and the canine 5mm or more, in the maxillary anterior portion from canine to canine
ii. Infrazygomatic crest	1.5mm (although 1.3-1.4mm can suffice)	5-6mm	Miniscrews in this area can be placed 14–16mm above the occlusal plane at 55–70° from the maxillary occlusal plane
2. Maxillary Palatal			
i. Interadicular		10-12mm length	Distance from the alveolar crest; 2-8mm, between the maxillary first molar and second premolar 2-5mm, between the maxillary first and second molars 5-11mm, between the maxillary first and second premolars 5-11mm, between the maxillary first premolar and canine
ii. Roof of palate and midpalatal area	1.5-1.8mm	6mm	5mm posterior to the incisive foramen and 3-6mm from the midsagittal suture or raphe.
3. Mandible buccal aspect			
i. Interadicular	1.5mm	5-7mm (if narrow band of attached gingiva, 10-12mm)	Distance below the alveolar crest; 2mm, between the mandibular second and first molars (best zone) 11mm, between the mandibular second premolar and first molar (second best zone) between the mandibular second and first premolar. 11mm, between the mandibular first premolar and the permanent canine
ii. Posterior portion of the mandible	1.5-2mm	5,10,14mm	This area includes the retromolar pads, the external oblique ridge, and the anterior portion of the ramus.
iii. Anterior portion of the mandible	1.2mm-1.3mm		The thickness of the bones decreases towards the midline with limited attached gingiva. Alternatively, cortical anchorage to the symphysis is found to be optimal at 6-11mm apical to cementoenamel junction and 0-60° to the occlusal plane (S. Zhang et al., 2022)

Further assessment of the insertion site in the maxillary can be facilitated by using the orthopantomogram, in which the interradicular width, shape of the sinus, and proximity to the sinus determine the final placement of the MI (Miyazawa et al., 2021). Recent study suggested that, saw tooth sinus appearance predisposes MI to perforation. For funnel-like sinus, the height of placement from alveolar crest should be 6.5-8mm and >8mm if the sinus is non depressed (Miyazawa et al., 2021)

https://doi.org/10.24191/cos.v12i2.8826

3.2.2 Diameter

The diameter of the MI usually refers to the external diameter of the MI. It is classified as small, medium, and large. Systematic review (Papageorgiou et al., 2012) found comparable failure rates for MI of small and large diameter: 10.9 % (95% CI 7.7–15.3) and 14.3 % (95% CI 7.4-25.8). Meanwhile, they found that MI with medium diameter had failure rate of 12.7 % (95% CI 8.1–19.3). Diameter greater than 1.6mm does not confer additional benefit in terms of success rate; however, it has a higher risk of failure due to the risk of contact with the root or periodontal ligaments, which may lead to MI failure (Mohammed et al., 2018; Papageorgiou et al., 2012). Smaller MI carries the risk of MI fracture due to the torsional force or torque during the placement. When the MI is placed in the interradicular aspect, the arbitrary key for the determination of size is based on the distance between the roots. The summary of the ideal diameter based on anatomical sites is summarized in Table 2.

3.2.3 Thread and shank design – (1) self-tapping/ self-drilling (2) pitch, thread angle

The most frequently overlooked is the thread and shank design, despite being designed specifically to maximise the mechanical overlocking of MI and bone. Self-tapping necessitates a pilot drill on the bone and self-drilling are placed without any bone drill as it is designed to displace the bone by its own thread, presumably to have a higher risk of failure due to creating of heat. A recent meta-analysis confirms that the differences between the failure rates of both are not significant (Alharbi et al., 2018b; Papageorgiou et al., 2012).

3.2.4 Head and transgingival collar design

Discussion of the head and connecting elements design often correlates with the clinical applications. Manufacturers designed versatile MI head in such a way that it tackles the unexpected changes in the mechanics during the treatment such as changes in connection to from the ligatures to the elastics or even arch wire (Table 3). Round head is preferable as it minimizes the risk of soft tissue ulceration. Transgingival collar designs to facilitate soft tissue seal while keeping the bacterial invasion at minimum (Prabhu & Cousley, 2006)

Table 3. Types of head designs and connecting elements (Ludwig et al., 2000)

Connecting elements	Head design
a. Ball head b. Hole c. Single slot d. Cross-slot	a. Small head b. No head c. Fixation head d. Bracket head e. Hook head f. Double head g. Joint head h. 0.22” cross-slot i. Button j. Hexagonal

3.3 Efforts to improve biomechanical stability

The overall stability of the MI is the net value of the primary and secondary stability. MI being a temporary anchorage device relies mainly on the primary stability that is achieved purely by the mechanical interlocking. This brings about modifications to achieve early biomechanical retention. Surface modifications can be classified based on methods, subtraction, or addition, and based on the topography of the modification such as micro level, macro level, and nano level (Cicciù et al., 2019 In addition to the

https://doi.org/10.24191/cos.v12i2.8826

surface modification, a technique called as low-level laser therapy on several aspect of the MI insertion is introduced to enhance primary stability by modulating inflammatory processes and stimulate soft and hard tissue repair (Costa et al., 2021) , although the secondary stability is still debatable (Michelogiannakis et al., 2022)

3.4 Surface modifications

Surface modification aims to increase primary stability and eventually achieve a certain degree of osseointegration but still allows removal with minimal bony defect (Jang et al., 2018). When the surface of the MI is treated, it increases its roughness and surface area. Different MI surface modifications modify the roughness governs cell interactions, allowing adhesion, proliferation, and differentiation (Table 4)(Att et al., 2009; Cicciù et al., 2019; Jang et al., 2018; Rupp et al., 2018).

Table 4. Surface modifications

Topography level	Examples of surface modifications
1. Micro-roughned modification	1. **Sandblasting**(Velasco-Ortega et al., 2019) - Sandblasting with abrasive particles to obtain macroroughness ensues adhesion because of mechanical interlocking & biological integration (F.Rupp et al., 2017) 2. **Acid etched surface** (SLA)(C. Park et al., 2020) - Treatment with hydrochloric acid or sulphuric acid to obtain micropits and remove oxide layer 3. **Anodic oxidation** (E. J. Oh et al., 2014; Traini et al., 2018) - Increase thickness of the TiO_2
2. Molecular	4. **TiO2 nanotube** (Li et al., 2018) - Enables local drug delivery to enhance osseointegration and prevent bacterial action 5. **Functional peptides** (X. Chen et al., 2017) - Mi coated with GL13K peptide enables osseointegration (in vivo study) 6. **Fluoride treatment** (Berglundh et al., 2007) - Treatment with fluoride reduce the time for osseointegration **7. Hydroxyapatite or other calcium phosphorus** - Deposit biological coatings such as hydroxyapatite (W. Nicholson, 2020)

3.5 Patient factor

3.5.1 Hard tissues: Cortical bones

The thickness and the density of cortical bones are the most important predictive parameter in MI primary stability (di Stefano et al., 2021) .These two aspects vary at different anatomical sites (Farnsworth et al., 2011; Tepedino et al., 2020) and age (G. T. Kim et al., 2020; Meursinge Reynders, Ronchi, Ladu, Van Etten-Jamaludin, et al., 2012).At the buccal region the thickness also increases from premolar to molar region in the mandible and in maxilla, at first molar and second molar region(Liu et al., 2017; Pan et al., 2019b). An excessive thickness of cortical bone especially in mandibular does not guarantee successful placement due to excessive heat and risk of necrosis (Mohammed et al., 2018). However, the likelihood of MI failure is higher in cortical bone with a thickness less than 1mm compared to that with a thickness of 1mm or greater (Motoyoshi et al., 2009; Pan et al., 2019b). A mapping study by Lyu et al 2020 (Lyu et al., 2020), shows the thickest hard tissue is found palatally at the level of the upper first premolar. Another mapping studies confirmed that at the same vertical level among interdental sites, the palatal bone was the thickest between the first and second premolars, followed by that between the canine and the first premolar, the second premolar and the first molar, and the first and second molars (J. A. Lee et al., 2021).

https://doi.org/10.24191/cos.v12i2.8826

3.5.2 Hard tissues: Trabecular bones

Trabecular bone thickness does not affect primary stability as much as cortical bone, but density contributes to stability in the presence or absence of cortical bone [47]. This may require a longer MI to engage in the trabecular bone (Cousley, 2020)

3.5.3 Soft tissue

Multiple studies have reached unanimous conclusions about the impact of soft tissue due to varying mobility of the mucosa at different heights pertaining to the buccal alveolus and infrazygomatic crest (Baumgaertel, 2014; H. J. Kim et al., 2006). Attached mucosa is the ideal site because it has limited movement that prevents movements by soft tissue, which may stimulate surrounding tissue and evoke periimplantitis or wrapping of opposing tissues such as the cheek (Baumgaertel, S., & Tran, 2012). In addition, it often causes soft tissue proliferation that covers the MI, which causes pain and discomfort (Kuroda & Tanaka, 2014). Non-keratinized soft tissue should be avoided (Alharbi et al., 2018a). Thickness of the soft tissue at the area of insertion should also be considered, because it affects the amount of contact between the MI and the bones(Parmar et al., 2016). Thin, soft tissue presents with lower risk than thick, soft tissues. However, thick, soft tissue can be compensated with longer MI (Baumgaertel, 2014) . The types of soft tissue and thickness are summarized in the Table 5 below.

Table 5. Types of soft tissue and different thickness affecting the MI

Soft tissue types		Details
Types of tissue	Non-keratinized tissue	1. Movable 2. Stimulate surrounding tissue causing proliferation of soft tissue covering the head of MI 3. May evoke peri-implantitis
	Attached gingiva (keratinized tissue)	1. Ideal for the placement of MI 2. Limited movement
Thickness of soft tissue	Thick, soft tissue	1. Reduce the contact length of the MI and the cortical bone.
	Thin, soft tissue	1. Ideal for MI placement

3.5.4 Age

Patients under the age of 18 years have been reported to have more failures than those over 18 years of age (Alharbi et al., 2018b). Amongst the reasons are higher rate of bone turnover and reduced cortical bone density in those younger patients compared to patients above 20 years. A study using CBCT confirmed that the thickness of cortical bone is positively correlated with age (Centeno et al., 2022) .MI are more successful in adolescents at the palatal site due to the developing dentition on the buccal segment and the palatal bone is of the same thickness in late mixed dentition and permanent dentition. However, it is advisable to be cautious and the loading force to be maintained as low force (e.g. 50g) for the initial six weeks after insertion (J. H. Park, 2020)

https://doi.org/10.24191/cos.v12i2.8826

3.6 Other factors

Systemic diseases related to bone metabolism is affecting the stability of the MI, however there is no specific restrictions with regards to MI if good oral hygiene is maintained (Cousley, 2020). Besides looking at the stability of the MI, we should also be concerned about the effect of the MI on the patient. The risks factors for implant are listed below.

1. Systemic disease that affects MI stability	**1.** Risk of infective endocarditis (ADA guidelines 2008) **2.** Poorly controlled diabetes due to poor wound healing (*2. Poorly Controlled Diabetes Due to Poor Wound Healing (Cianciola LJ, Park BH, Bruck E. 1982.Pdf*, n.d.),however recent studies proof that diabetes patient has similar success as healthy patients (N. H. Oh et al., 2014) **3.** Juvenile idiopathic arthritis if the wrist joint is affected, it may affect the oral hygiene regime (Skeie et al., 2019)
2. Medications	Bisphosphonates, immunomodulators, antiepileptics, anticoagulant, platelet anti-aggregation medications
3. Habits	Heavy smoker (>10 cigarettes per day) (Alharbi et al., 2018b; Y. Chen et al., 2009; Sánchez-Pérez et al., 2007)

3.7 Operational factor

3.7.1 Insertion torque

The most ideal insertion torque should be between 5Ncm to 10Ncm at the alveolar region (Motoyoshi et al., 2006). High insertion torque does not confer additional stability but instead it may lead to tissue necrosis and predispose the MI to failure. Low torque on the other hand equates to the low stability of MI. Across the literatures, the recommended insertion torque may be different based on the thickness and density of the cortical bone (Motoyoshi et al., 2006)

3.7.2 Insertion angulation

The degree of insertion of MI is a debatable topic, as many literatures achieved different results. To simplify, it can be classified as perpendicular or oblique in relation to the occlusal plane perpendicular as discussed in the Table 6 below (Golshah et al., 2021; Pickard et al., 2010; Wilmes et al., 2008)

Table 6. Insertion angulation of MI

	Oblique	**90° or perpendicular**
Cortical bone contact	More at a smaller angle, increasing the contact to 1.5x	Less bone contact
Root contact	Reduce the possibility of contacting the roots.	Increase the risk of root contact.
Application	Used in narrow spaces, with curved roots.	Can be used in large interadicular space. It avoids sinuses, but if sinus is low, it precludes placement.
Resistance	Less	More (perceived as more stable to resist force)

3.7.3 Loading protocol

Much debate has previously arose when comparing immediate versus delayed loading. At present, there is no difference in failure rate between immediate and delayed loading (Luzi et al., 2009; Migliorati et al., 2016; Papageorgiou et al., 2012; J. N. Zhang et al., 2019) , the amount of force upon loading such as 100g for early loading and regular force for delayed loading at 200g affects the success rate(Q. Zhang et al., 2011).In fact, immediate loading increases the osseointegration due to more compression area mineralizes significantly faster than the tension area and may cause microdamage which increases the bone remodeling rate and results in more woven bone formation that stabilizes the orthodontic loading (Huja et al., 1999; Luzi et al., 2009; Migliorati et al., 2016; Papageorgiou et al., 2012; Reynders et al., 2009).

3.7.4 Insertion method

Stent fabrication has evolved in tandem with the clinical application of MI. Several methods for accurately placing the MI have been introduced, including wire guides, three-dimensional (3D) tooth-borne stents, and mucosa-borne guides. The latest technologies can combine cone beam computed tomography (CBCT) and digital study models. The apical deviation upon insertion was used to compare the guides, and the results show that 3D guides are significantly more accurate than manual wire guides(Jedlí Nski et al., 2021). However, there are no significant differences in failure rates(Aboshady et al., 2022).

3.7.5 Others

Another aspect for discussion is the operator related factor (Luzi et al., 2009; Papageorgiou et al., 2012).The failure rates are primarily caused by incorrect insertion techniques (Pellegrino et al., 2020) followed by insufficient irrigation(Gehrke et al., 2018; Möhlhenrich et al., 2020) , excessive or insufficient placement torque or wiggling movements (Cho et al., 2013). Clinical experience may affect the success rates of implant, extensive reduction from 24% to 2-4% failure rate noted after placement of 54 to 72 of MI (Papageorgiou et al., 2012). \

3.8 Stability

Primary stability is defined as the biomechanical stability upon MI insertion usually represented by mostly clinical perception based on the cutting resistance of the MI during its insertion and measured by different means as discussed in the Table 7 below.

https://doi.org/10.24191/cos.v12i2.8826

Table 7. Quantification method of primary and secondary stability of MI

Stability	Methods for quantification
Primary stability	a) Maximum insertion torque (Doe et al., 2020; Matys et al., 2018) b) Periotest value (Hosein et al., 2017; Meursinge Reynders, Ronchi, Ladu, van Etten-Jamaludin, et al., 2012) c) Pull out test (Jubhari et al., 2020) d) Resonance frequency measurement (Hosein et al., 2019; Sennerby & Meredith, 2008)
Secondary stability	a) Total percentage of implant to bone divided by total implant surface (Choi & Hwang, 2020) b) Bone-to-implant contact (BIC) ratio (Hwang et al., 2019; Traini et al., 2018; Velasco-Ortega et al., 2019) c) Removal torque(Gansukh et al., 2016; Jang et al., 2018) d) Periotest value (Hosein et al., 2017; Meursinge Reynders, Ronchi, Ladu, van Etten-Jamaludin, et al., 2012) e) Resonance frequency (Hosein et al., 2019; Sennerby & Meredith, 2008)

3.9 Clinical applications in general

The clinical application of MI uncovers a wide spectrum as it allows controlled movement in three dimensions and is tabulated below in Table 8. Many movements that were thought to be impossible in the past has been executed using MI.

Table 8. Clinical applications

Transverse	Anteroposterior	Vertical
1.Expansion of the maxilla. Eg: MARPE(Brunetto et al., 2022; J. J. Park et al., 2017) 2.Correction of asymmetry ((Kottemann, 2020)	1. Protraction of molar 2. Distalisation of molars (Bayome et al., 2021) 3. Retraction of anterior segment (Barthélemi et al., 2019)	1. Intrusion of teeth. Eg : Correction of the gummy smile [86] 2. Extrusion of impacted teeth (Cruz, 2019; Migliorati et al., 2021)

4. SUCCESS AND FAILURES

Several systematic reviews (Table 9) had shown the overall failure rates for MIs with further exploration of the potential factors contributing to their failure (Cunha et al., 2017; Papageorgiou et al., 2012; Ramírez-Ossa et al., 2020). The most recent systematic review in 2020 demonstrates failure rate is at 15.08% (Sheibaninia, 2020).

Table 9. MI success and failure rates

Systematic Review and metanalysis	Success / Failure Rates
Papageorgiou et al 2012	13.5% overall
Cunha et al 2017	0.86 (95% CI 0.83-0.89) * success rates
Alharbi 2018	9.2% in maxilla, 13.5% in mandible buccal sites
Ramirez-Ossa et al 2020	9.6% in the maxilla 12.3% in mandible
Sheibaninia et al 2020	15.08% overall

https://doi.org/10.24191/cos.v12i2.8826

4.1 Complications

As in any other procedure, complications may occur in soft tissues, hard tissues, and the MI itself.

1.	**Complication of hard tissues**	a.	Trauma to the cementum, periodontal ligaments but no serious consequences due to repairing mechanism.(Alves et al., 2013)
		b.	Bony defect upon removal, but healing will take place within 7 weeks (S. J. Kim et al., 2019)
2.	**Complication of soft tissues**	a.	Peri-implantitis and soft tissue hypertrophy commonly resulted from MI placement at the non-keratinized tissue (Kuroda & Tanaka, 2014)
		b.	Inflammation of the soft tissue surrounding the MI placement is the most common complication encountered after its insertion.
		c.	Ulcer on the adjacent buccal mucosa due to frictions, to avoid this the head can be covered with composite (Mohd Ali et al., 2021)
3.	**MI fracture**	a.	MI fracture has also been reported because of the insertion torque. Ideally it should be between 5-10Ncm (Motoyoshi et al., 2006). MI inserted in mandible or mid-palate is predispose to fracture
		b.	MI fracture at the neck during removal because it is subjected to concentrated mechanical force. Prevented by controlling the axis of the screwdriver during removal.(Kuroda & Tanaka, 2014)
4.	**MI failure**	a.	Fail after a week due many factors related to host, geometry and operator. But most failure is due to contact to adjacent root and screw placement in mandible (Papageorgiou et al., 2012)
5.	**Pain and discomfort**	a.	8% of patients reported pain 1 day after insertion (Migliorati et al.,2021)

4.2 Patient acceptance

The merits of each invention synthesis in terms of effectiveness are not only important for clinicians or healthcare providers. Patients' acceptance is one of the domains in determining the relevance of orthodontics outcomes. When comparing the conventional method of anchorage, patients reported less discomfort (Zawawi, 2014)and would recommend it to their friends (Sandler et al., 2014). In terms of acceptance, majority of patients accepted MI as treatment options. However, recently a study shows that, patients exposed to MI on social networking services are more likely to accept them as an orthodontic treatment option compared to patients who are not exposed to M

5. CONCLUSION

In this article, we discussed about general features, clinical applications and complications of MI. MI has significantly contributed to the biomechanics and to a more predictable movement of orthodontic teeth. Some of the clinical applications mimic surgical corrections in orthodontics that were thought impossible in the past. MI is the most significant inventions of our time and most likely to stay. Therefore, clinicians should embrace this shift in modern orthodontic practice.

ACKNOWLEDGEMENTS/FUNDING

The authors would like to acknowledge the support of Universiti Teknologi Mara (UiTM), for providing the facilities and financial support on this research.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Suzanne Husun Reginald Iggan carried out the research, wrote and revised the article. **Maryati Md Dasor** provided the central research idea and provided the theoretical framework. **Saraswathy Devi Sinniah and Muhamad Nizam Muhamad Subra** supervised the article progress.

REFERENCES

Aboshady, H., Abouelezz, A. M. A., Fotouh, M. H. A., & Elkordy, S. A. M. (2022). Failure Rate of Orthodontic Mini-screw after Insertion using 3D Printed Guide versus Conventional Free Hand Placement Technique: Split Mouth Randomized Clinical Trial. *Open Access Macedonian Journal of Medical Sciences*, *10*(D), 6–13. https://doi.org/10.3889/oamjms.2022.7616.

Alharbi, F., Almuzian, M., & Bearn, D. (2018a). Miniscrews failure rate in orthodontics: Systematic review and meta-analysis. *European Journal of Orthodontics*, *40*(5), 519–530. https://doi.org/10.1093/ejo/cjx093.

Alharbi, F., Almuzian, M., & Bearn, D. (2018b). Miniscrews failure rate in orthodontics: Systematic review and meta-analysis. *European Journal of Orthodontics*, *40*(5), 519–530. https://doi.org/10.1093/ejo/cjx093.

Alharbi, F., Almuzian, M., & Bearn, D. (2019a). Anchorage effectiveness of orthodontic miniscrews compared to headgear and transpalatal arches: a systematic review and meta-analysis. *Acta Odontologica Scandinavica*, *77*(2), 88–98. https://doi.org/10.1080/00016357.2018.1508742.

Alharbi, F., Almuzian, M., & Bearn, D. (2019b). Anchorage effectiveness of orthodontic miniscrews compared to headgear and transpalatal arches: a systematic review and meta-analysis. In *Acta Odontologica Scandinavica* (Vol. 77, Issue 2, pp. 88–98). Taylor and Francis Ltd. https://doi.org/10.1080/00016357.2018.1508742.

Alves, M., Baratieri, C., Mattos, C. T., de Souza Araújo, M. T., & Maia, L. C. (2013). Root repair after contact with mini-implants: Systematic review of the literature. *European Journal of Orthodontics*, *35*(4), 491–499. https://doi.org/10.1093/ejo/cjs025.

Att, W., Hori, N., Takeuchi, M., Ouyang, J., Yang, Y., Anpo, M., & Ogawa, T. (2009). Time-dependent degradation of titanium osteoconductivity: An implication of biological aging of implant materials. *Biomaterials*, *30*(29), 5352–5363. https://doi.org/10.1016/j.biomaterials.2009.06.040.

Barros, S. E., Vanz, V., Chiqueto, K., Janson, G., & Ferreira, E. (2021). Mechanical strength of stainless steel and titanium alloy mini-implants with different diameters: an experimental laboratory study. *Progress in Orthodontics*, *22*(1). https://doi.org/10.1186/s40510-021-00352-w.

Barthélemi, S., Desoutter, A., Souaré, F., & Cuisinier, F. (2019). Effectiveness of anchorage with temporary anchorage devices during anterior maxillary tooth retraction: A randomized clinical trial. *The Korean Journal of Orthodontics*, *49*(5), 279. https://doi.org/10.4041/kjod.2019.49.5.279.

Baumgaertel, S. (2014). Hard and soft tissue considerations at mini-implant insertion sites. *Journal of Orthodontics*, *41*, S3–S7. https://doi.org/10.1179/1465313314Y.0000000104.

Baumgaertel, S., & Tran, T. T. (2012). Buccal mini-implant site selection: the mucosal fallacy and zones of opportunity. *JCO, 46*(7), 434–436.

Bayome, M., Park, J. H., Bay, C., & Kook, Y. A. (2021). Distalization of maxillary molars using temporary skeletal anchorage devices: A systematic review and meta-analysis. *Orthodontics and Craniofacial Research*, *24*(S1), 103–112. https://doi.org/10.1111/ocr.12470.

Berglundh, T., Abrahamsson, I., Albouy, J. P., & Lindhe, J. (2007). Bone healing at implants with a fluoride-modified surface: An experimental study in dogs. *Clinical Oral Implants Research*. https://doi.org/10.1111/j.1600-0501.2006.01309.x.

Brunetto, D. P., Moschik, C. E., Mompell, R. D., Jaria, E., Franzotti, E., Anna, S., & Moon, W. (2022). Mini-implant assisted rapid palatal expansion (MARPE) effects on adult obstructive sleep apnea (OSA) and quality of life: a multi-center prospective controlled trial. *Progress in Orthodontics*. https://doi.org/10.1186/s40510-021-00397-x.

Centeno, A. C. T., Fensterseifer, C. K., Chami, V. de O., Ferreira, E. S., Marquezan, M., & Ferrazzo, V. A. (2022). Correlation between cortical bone thickness at mini-implant insertion sites and age of patient. *Dental Press Journal of Orthodontics*, *27*(1), e222098. https://doi.org/10.1590/2177-6709.27.1.e222098.oar.

Chen, X., Zhou, X. C., Liu, S., Wu, R. F., Aparicio, C., & Wu, J. Y. (2017). In vivo osseointegration of dental implants with an antimicrobial peptide coating. *Journal of Materials Science: Materials in Medicine*, *28*(5). https://doi.org/10.1007/s10856-017-5885-8.

Chen, Y., Kyung, H. M., Zhao, W. T., & Yu, W. J. (2009). Critical factors for the success of orthodontic mini-implants: A systematic review. *American Journal of Orthodontics and Dentofacial Orthopedics*, *135*(3), 284–291. https://doi.org/10.1016/j.ajodo.2007.08.017.

Cho, I.-S., Baek, S.-H., & Kim, Y. H. (2013). Effects of wobbling angle on the stability measures of orthodontic mini-implants during insertion and removal procedures. *Angle Orthodontist*, *83*(6), 1009–1014. https://doi.org/10.2319/021513-134.1.

Cicciù, M., Fiorillo, L., Herford, A. S., Crimi, S., Bianchi, A., D'Amico, C., Laino, L., & Cervino, G. (2019). Bioactive titanium surfaces: Interactions of eukaryotic and prokaryotic cells of nano devices applied to dental practice. *Biomedicines*, *7*(1). https://doi.org/10.3390/biomedicines7010012.

Costa, A. C. de F., Maia, T. A. C., de Barros Silva, P. G., Abreu, L. G., Gondim, D. V., & Santos, P. C. F. (2021). Effects of low-level laser therapy on the orthodontic mini-implants stability: a systematic review and meta-analysis. In *Progress in Orthodontics* (Vol. 22, Issue 1). https://doi.org/10.1186/s40510-021-00350-y

Cousley, R. (2020). *The orthodontic Mini-Implant Clinical Handbook*.

Cruz, R. M. (2019). Orthodontic traction of impacted canines: Concepts and clinical application. *Dental Press Journal of Orthodontics*, *24*(1), 74–87. https://doi.org/10.1590/2177-6709.24.1.074-087.bbo.

Cunha, A. C., da Veiga, A. M. A., Masterson, D., Mattos, C. T., Nojima, L. I., Nojima, M. C. G., & Maia, L. C. (2017). How do geometry-related parameters influence the clinical performance of orthodontic mini-implants? A systematic review and meta-analysis. *International Journal of Oral and Maxillofacial Surgery*, *46*(12), 1539–1551. https://doi.org/10.1016/j.ijom.2017.06.010.

di Stefano, D. A., Arosio, P., Capparè, P., Barbon, S., & Gherlone, E. F. (2021). Stability of dental implants and thickness of cortical bone: Clinical research and future perspectives. a systematic review. In *Materials* (Vol. 14, Issue 23). https://doi.org/10.3390/ma14237183.

Doe, Y., Ida, H., Seiryu, M., Deguchi, T., Takeshita, N., Sasaki, S., Sasaki, S., Irie, D., Tsuru, K., Ishikawa, K., & Takano-Yamamoto, T. (2020). Titanium surface treatment by calcium modification with acid-etching promotes osteogenic activity and stability of dental implants. *Materialia*, *12*, 100801. https://doi.org/10.1016/j.mtla.2020.100801.

Farnsworth, D., Rossouw, P. E., Ceen, R. F., & Buschang, P. H. (2011). Cortical bone thickness at common miniscrew implant placement sites. *American Journal of Orthodontics and Dentofacial Orthopedics*, *139*(4), 495–503. https://doi.org/10.1016/j.ajodo.2009.03.057.

Gansukh, O., Jeong, J. W., Kim, J. W., Lee, J. H., & Kim, T. W. (2016). Mechanical and Histological Effects of Resorbable Blasting Media Surface Treatment on the Initial Stability of Orthodontic Mini-Implants. *BioMed Research International*, *2016*. https://doi.org/10.1155/2016/7520959.

Gehrke, S. A., Aramburú Júnior, J. S., Pérez-Albacete Martínez, C., Ramirez Fernandez, M. P., Maté Sánchez de Val, J. E., & Calvo-Guirado, J. L. (2018). The influence of drill length and irrigation system on heat production during osteotomy preparation for dental implants: an ex vivo study. *Clinical Oral Implants Research*, *29*(7), 772–778. https://doi.org/10.1111/clr.12827.

Golshah, A., Gorji, K., & Nikkerdar, N. (2021). Effect of miniscrew insertion angle in the maxillary buccal plate on its clinical survival: a randomized clinical trial. *Progress in Orthodontics*, *22*(1). https://doi.org/10.1186/s40510-021-00370-8.

Graber. (2007). *Orthodontics Current Principles and Techniques*.

Hosein, Y. K., Jeffrey Dixon, S., Rizkalla, A. S., & Tassi, A. (2017). A Comparison of the Mechanical Measures Used for Assessing Orthodontic Mini-Implant Stability. *Implant Dentistry*, *26*(2), 225–231. https://doi.org/10.1097/ID.0000000000000514.

Hosein, Y. K., Jeffrey Dixon, S., Rizkalla, A. S., & Tassi, A. (2019). A novel technique for measurement of orthodontic mini-implant stability using the Osstell ISQ device. *Angle Orthodontist*, *89*(2), 284–291. https://doi.org/10.2319/011518-46.1.

Huja, S. S., Katona, T. R., Burr, D. B., Garetto, L. P., & Roberts, W. E. (1999). Microdamage adjacent to endosseous implants. *Bone*, *25*(2), 217–222. https://doi.org/10.1016/S8756-3282(99)00151-9.

https://doi.org/10.24191/cos.v12i2.8826

Jang, T. H., Park, J. H., Moon, W., Chae, J. M., Chang, N. Y., & Kang, K. H. (2018). Effects of acid etching and calcium chloride immersion on removal torque and bone-cutting ability of orthodontic mini-implants. *American Journal of Orthodontics and Dentofacial Orthopedics*, *154*(1), 108–114. https://doi.org/10.1016/j.ajodo.2017.10.032.

Jedlí Nski, M., Janiszewska-Olszowska, J., Mazur, M., Ottolenghi, L., Grocholewicz, K., & Galluccio, G. (2021). Guided Insertion of Temporary Anchorage Device in Form of Orthodontic Titanium Miniscrews with Customized 3D Templates—A Systematic Review with Meta-Analysis of Clinical Studies. *Coatings, 11*(12), 1488. https://doi.org/10.3390/coatings11121488.

Jubhari, E. H., Dammar, I., Launardo, V., & Goan, Y. (2020). Implant coating materials to increase osseointegration of dental implant: A systematic review. *Systematic Reviews in Pharmacy*, *11*(12), 35–41. https://doi.org/10.31838/srp.2020.12.6

Kim, G. T., Jin, J., Mangal, U., Lee, K. J., Kim, K. M., Choi, S. H., & Kwon, J. S. (2020). Primary stability of orthodontic titanium miniscrews due to cortical bone density and re-insertion. *Materials*, *13*(19), 1–12. https://doi.org/10.3390/ma13194433

Kim, H. J., Yun, H. S., Park, H. do, Kim, D. H., & Park, Y. C. (2006). Soft-tissue and cortical-bone thickness at orthodontic implant sites. *American Journal of Orthodontics and Dentofacial Orthopedics*, *130*(2), 177–182. https://doi.org/10.1016/j.ajodo.2004.12.024

Kim, S. J., Ha, Y. D., Kim, E., Jang, W., Hwang, S., Nguyen, T., Ko, C. C., Choi, Y. J., Kim, K. H., & Chung, C. J. (2019). Dynamics of alveolar bone healing after the removal of orthodontic temporary anchorage devices. *Journal of Periodontal Research*, *54*(4), 388–395. https://doi.org/10.1111/jre.12640

Kottemann, W. J. (2020). The use of TADs with clear aligners for asymmetry correction. *Temporary Anchorage Devices in Clinical Orthodontics*, *52*, 555–562. https://doi.org/10.1002/9781119513636.ch52.

Kuroda, S., Sugawara, Y., Deguchi, T., Kyung, H. M., & Takano-Yamamoto, T. (2007). Clinical use of miniscrew implants as orthodontic anchorage: Success rates and postoperative discomfort. *American Journal of Orthodontics and Dentofacial Orthopedics*, *131*(1), 9–15. https://doi.org/10.1016/J.AJODO.2005.02.032.

Kuroda, S., & Tanaka, E. (2014). Risks and complications of miniscrew anchorage in clinical orthodontics. *Japanese Dental Science Review*, *50*(4), 79–85. https://doi.org/10.1016/J.JDSR.2014.05.001.

Lee, J. A., Ahn, H. W., Oh, S. H., Park, K. H., Kim, S. H., & Nelson, G. (2021). Evaluation of interradicular space, soft tissue, and hard tissue of the posterior palatal alveolar process for orthodontic mini-implant, using cone-beam computed tomography. *American Journal of Orthodontics and Dentofacial Orthopedics*, *159*(4), 460–469. https://doi.org/10.1016/j.ajodo.2020.01.019.

Lee, T. C. K., McGrath, C. P. J., Wong, R. W. K., & Rabie, A. B. M. (2008). Patients' perceptions regarding microimplant as anchorage in orthodontics. *Angle Orthodontist*, *78*(2), 228–233. https://doi.org/10.2319/040507-172.1.

https://doi.org/10.24191/cos.v12i2.8826

Li, T., Gulati, K., Wang, N., Zhang, Z., & Ivanovski, S. (2018). Understanding and augmenting the stability of therapeutic nanotubes on anodized titanium implants. *Materials Science and Engineering C*, *88*(March), 182–195. https://doi.org/10.1016/j.msec.2018.03.007.

Liu, H., Wu, X., Yang, L., & Ding, Y. (2017). Safe zones for miniscrews in maxillary dentition distalization assessed with cone-beam computed tomography. *American Journal of Orthodontics and Dentofacial Orthopedics*, *151*(3), 500–506. https://doi.org/10.1016/j.ajodo.2016.07.021.

Ludwig, B., Baumgaertel, S., & Bohm, bern hard. (2000). *Mini-Implant in Orthodontic.pdf*.

Luzi, C., Verna, C., & Melsen, B. (2009). Guidelines for success in placement of orthodontic mini-implants. *Journal of Clinical Orthodontics : JCO*, *43*(1), 39–44.

Lyu, X., Guo, J., Chen, L., Gao, Y., Liu, L., Pu, L., Lai, W., & Long, H. (2020). Assessment of available sites for palatal orthodontic mini-implants through cone-beam computed tomography. *Angle Orthodontist*, *90*(4), 516–523. https://doi.org/10.2319/070719-457.1.

Matys, J., Flieger, R., Tenore, G., Grzech-Leśniak, K., Romeo, U., & Dominiak, M. (2018). Er:YAG laser, piezosurgery, and surgical drill for bone decortication during orthodontic mini-implant insertion: primary stability analysis—an animal study. *Lasers in Medical Science*, *33*(3), 489–495. https://doi.org/10.1007/s10103-017-2381-9.

Mecenas, P., Espinosa, D. G., Cardoso, P. C., & Normando, D. (2020). Stainless steel or titanium mini-implants? *The Angle Orthodontist*, *90*(4), 587–597. https://doi.org/10.2319/081619-536.1.

Meursinge Reynders, R. A., Ronchi, L., Ladu, L., Van Etten-Jamaludin, F., & Bipat, S. (2012). Insertion torque and success of orthodontic mini-implants: A systematic review. *American Journal of Orthodontics and Dentofacial Orthopedics*, *142*(5), 596-614.e5. https://doi.org/10.1016/j.ajodo.2012.06.013.

Michelogiannakis, D., Jabr, L., Barmak, A. B., Rossouw, P. E., Kotsailidi, E. A., & Javed, F. (2022). Influence of low-level-laser therapy on the stability of orthodontic mini-screw implants. A systematic review and meta-analysis. *European Journal of Orthodontics*, *44*(1), 11–21. https://doi.org/10.1093/ejo/cjab016.

Migliorati, M., Cevidanes, L., Sinfonico, G., Drago, S., Dalessandri, D., Isola, G., & Biavati, A. S. (2021). Three dimensional movement analysis of maxillary impacted canine using TADs: a pilot study. In *Head and Face Medicine* (Vol. 17, Issue 1). https://doi.org/10.1186/s13005-020-00252-0.

Migliorati, M., Drago, S., Gallo, F., Amorfini, L., Dalessandri, D., Calzolari, C., Benedicenti, S., & Silvestrini-Biavati, A. (2016). Immediate versus delayed loading: Comparison of primary stability loss after miniscrew placement in orthodontic patients - A single-centre blinded randomized clinical trial. *European Journal of Orthodontics*, *38*(6), 652–659. https://doi.org/10.1093/ejo/cjv095.

Migliorati, M., Signori, A., & Silvestrini Biavati, A. (2012). Temporary anchorage device stability: An evaluation of thread shape factor. *European Journal of Orthodontics*, *34*(5), 582–586. https://doi.org/10.1093/ejo/cjr026.

Miyazawa, K., Shibata, M., Tabuchi, M., Kawaguchi, M., Shimura, N., & Goto, S. (2021). Optimal sites for orthodontic anchor screw placement using panoramic images: risk of maxillary sinus perforation and contact with adjacent tooth roots during screw placement. *Progress in Orthodontics*, *22*, 46. https://doi.org/10.1186/s40510-021-00393-1.

Moghaddam, S. F., Mohammadi, A., & Behroozian, A. (2021). The effect of sandblasting and acid etching on survival rate of orthodontic miniscrews: a split-mouth randomized controlled trial. In *Progress in Orthodontics* (Vol. 22, Issue 1). https://doi.org/10.1186/s40510-020-00347-z.

Mohammed, H., Wafaie, K., Rizk, M. Z., Almuzian, M., Sosly, R., & Bearn, D. R. (2018). Role of anatomical sites and correlated risk factors on the survival of orthodontic miniscrew implants: a systematic review and meta-analysis. *Progress in Orthodontics*, *19*(1), 1–18. https://doi.org/10.1186/s40510-018-0225-1.

Mohd Ali, N. D., Al-Jaf, N. M., & Norman, N. H. (2021). The orthodontic mini implants covers and their effect on the oral health related quality of life: A randomised controlled trial. *International Medical Journal*, *28*(3), 352–356.

Möhlhenrich, S. C., Heussen, N., Modabber, A., Kniha, K., Hölzle, F., Wilmes, B., Danesh, G., & Szalma, J. (2020). Influence of bone density, screw size and surgical procedure on orthodontic mini-implant placement – part A: temperature development. *International Journal of Oral and Maxillofacial Surgery*. https://doi.org/10.1016/j.ijom.2020.07.004.

Motoyoshi, M., Hirabayashi, M., Uemura, M., & Shimizu, N. (2006). Recommended placement torque when tightening an orthodontic mini-implant. *Clinical Oral Implants Research*, *17*(1), 109–114. https://doi.org/10.1111/j.1600-0501.2005.01211.x.

Motoyoshi, M., Inaba, M., Ono, A., Ueno, S., & Shimizu, N. (2009). The effect of cortical bone thickness on the stability of orthodontic mini-implants and on the stress distribution in surrounding bone. *International Journal of Oral and Maxillofacial Surgery*, *38*(1), 13–18. https://doi.org/10.1016/j.ijom.2008.09.006.

Nor, N. F. M., Sinniah, S. D., & Dasor, M. M. (2019). Comparison of three methods of orthodontic anchorage: A prospective study. *Journal of International Dental and Medical Research*, *12*(1), 185–191.

Ntolou, P., Tagkli, A., & Pepelassi, E. (2018). Factors related to the clinical application of orthodontic mini-implants. *Journal of International Oral Health*, *10*(3), 103–110. https:// 10.4103/jioh.jioh_28_18.

Oh, E. J., Nguyen, T. D. T., Lee, S. Y., Jeon, Y. M., Bae, T. S., & Kim, J. G. (2014). Enhanced compatibility and initial stability of Ti6Al4V alloy orthodontic miniscrews subjected to anodization, Cyclic precalcification, And heat treatment. *Korean Journal of Orthodontics*, *44*(5), 246–253. https://doi.org/10.4041/kjod.2014.44.5.246.

Oh, N. H., Kim, E. Y., Paek, J., Kook, Y. A., Jeong, D. M., Cho, I. S., & Nelson, G. (2014). Evaluation of stability of surface-treated mini-implants in diabetic rabbits. *International Journal of Dentistry*, *2014*. https://doi.org/10.1155/2014/838356.

Pan, C. Y., Liu, P. H., Tseng, Y. C., Chou, S. T., Wu, C. Y., & Chang, H. P. (2019a). Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. *Journal of Dental Sciences*, *14*(4), 383–388. https://doi.org/10.1016/j.jds.2019.06.002.

Pan, C. Y., Liu, P. H., Tseng, Y. C., Chou, S. T., Wu, C. Y., & Chang, H. P. (2019b). Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. *Journal of Dental Sciences*, *14*(4), 383–388. https://doi.org/10.1016/j.jds.2019.06.002.

Papageorgiou, S. N., Zogakis, I. P., & Papadopoulos, M. A. (2012). Failure rates and associated risk factors of orthodontic miniscrew implants: A meta-analysis. *American Journal of Orthodontics and Dentofacial Orthopedics*, *142*(5), 577-595.e7. https://doi.org/10.1016/j.ajodo.2012.05.016.

Park, C., Lim, J. H., Tallarico, M., Hwang, K., Choi, H., Cho, G., Kim, C., Jang, I., Song, J., Kwon, A. M., Jeon, S. H., & Park, H. (2020). *Coating of a Sand-Blasted and Acid-Etched*. 1–11.

Park, J. H. (2020). *Temporary Anchorage Devices in Clinical Orthodontics*.

Park, J. J., Park, Y. C., Lee, K. J., Cha, J. Y., Tahk, J. H., & Choi, Y. J. (2017). Skeletal and dentoalveolar changes after miniscrew-assisted rapid palatal expansion in young adults: A cone-beam computed tomography study. *Korean Journal of Orthodontics*, *47*(2), 77–86. https://doi.org/10.4041/kjod.2017.47.2.77.

Parmar, R., Reddy, V., Reddy, S. K., & Reddy, D. (2016). Determination of soft tissue thickness at orthodontic miniscrew placement sites using ultrasonography for customizing screw selection. *American Journal of Orthodontics and Dentofacial Orthopedics*, *150*(4), 651–658. https://doi.org/10.1016/j.ajodo.2016.03.026.

Pellegrino, G., Bellini, P., Cavallini, P. F., Ferri, A., Zacchino, A., Taraschi, V., Marchetti, C., & Consolo, U. (2020). Dynamic navigation in dental implantology: The influence of surgical experience on implant placement accuracy and operating time. An in vitro study. *International Journal of Environmental Research and Public Health*, *17*(6). https://doi.org/10.3390/ijerph17062153.

Pickard, M. B., Dechow, P., Rossouw, P. E., & Buschang, P. H. (2010). Effects of miniscrew orientation on implant stability and resistance to failure. *American Journal of Orthodontics and Dentofacial Orthopedics*, *137*(1), 91–99. https://doi.org/10.1016/j.ajodo.2007.12.034.

Prabhu, J., & Cousley, R. R. J. (2006). Current products and practice: Bone anchorage devices in orthodontics. *Journal of Orthodontics*, *33*(4), 288–307. https://doi.org/10.1179/146531205225021807.

Ramírez-Ossa, D. M., Escobar-Correa, N., Ramírez-Bustamante, M. A., & Agudelo-Suárez, A. A. (2020). An Umbrella Review of the Effectiveness of Temporary Anchorage Devices and the Factors That Contribute to Their Success or Failure. *Journal of Evidence-Based Dental Practice*, *20*(2), 101402. https://doi.org/10.1016/j.jebdp.2020.101402.

Reynders, R., Ronchi, L., & Bipat, S. (2009). Mini-implants in orthodontics: A systematic review of the literature. *American Journal of Orthodontics and Dentofacial Orthopedics*, *135*(5), 564.e1-564.e19. https://doi.org/10.1016/j.ajodo.2008.09.026.

https://doi.org/10.24191/cos.v12i2.8826

Roberts-Harry, D., & Sandy, J. (2004). PRACTICE Orthodontics. Part 9: Anchorage control and distal movement. *British dental journal volume*, *196*(5). https://doi.org/10.1038/sj.bdj.4811031.

Rupp, F., Liang, L., Geis-Gerstorfer, J., Scheideler, L., & Hüttig, F. (2018). Surface characteristics of dental implants: A review. *Dental Materials*, *34*(1), 40–57. https://doi.org/10.1016/j.dental.2017.09.007.

Sampson, A., Figueiredo, D. S. F., Jeremiah, H. G., Oliveira, D. D., Freitas, L. R. P., Chahoud, M., Soares, R. v, & Cobourne, M. T. (2021). The effect of social media on patient acceptance of temporary anchorage devices. *The Angle Orthodontist*, *91*(3), 363–370. https://doi.org/10.2319/071020-618.1.

Sánchez-Pérez, A., Moya-Villaescusa, M. J., & Caffesse, R. G. (2007). Tobacco as a Risk Factor for Survival of Dental Implants. *Journal of Periodontology*, *78*(2), 351–359. https://doi.org/10.1902/jop.2007.060299.

Sandler, J., Murray, A., Thiruvenkatachari, B., Gutierrez, R., Speight, P., & O'Brien, K. (2014). Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm multicenter randomized clinical trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, *146*(1), 10–20. https://doi.org/10.1016/j.ajodo.2014.03.020.

Sennerby, L., & Meredith, N. (2008). Implant stability measurements using resonance frequency analysis: Biological and biomechanical aspects and clinical implications. *Periodontology 2000*, *47*(1), 51–66. https://doi.org/10.1111/j.1600-0757.2008.00267.x.

Sheibaninia, A. (2020). Failure Rate and Associated Factors with Use of Mini-Screws in Orthodontic Treatments: A Systematic Review and Meta-analysis. *International Journal of Pharmaceutical and Phytopharmacological Research (eIJPPR), 10*(4), 22–27.

Skeie, M. S., Gil, E. G., Cetrelli, L., Rosén, A., Fischer, J., Åstrøm, A. N., Luukko, K., Shi, X., Feuerherm, A. J., Sen, A., Frid, P., Rygg, M., & Bletsa, A. (2019). Oral health in children and adolescents with juvenile idiopathic arthritis - A systematic review and meta-analysis. *BMC Oral Health*, *19*(1). https://doi.org/10.1186/s12903-019-0965-4.

Tepedino, M., Cattaneo, P. M., Niu, X., & Cornelis, M. A. (2020). Interradicular sites and cortical bone thickness for miniscrew insertion: A systematic review with meta-analysis. *American Journal of Orthodontics and Dentofacial Orthopedics*. https://doi.org/10.1016/j.ajodo.2020.05.011.

Traini, T., Murmura, G., Sinjari, B., Perfetti, G., Scarano, A., D'Arcangelo, C., & Caputi, S. (2018). The surface anodization of titanium dental implants improves blood clot formation followed by osseointegration. *Coatings*, *8*(7). https://doi.org/10.3390/coatings8070252.

Velasco-Ortega, E., Ortiz-García, I., Jiménez-Guerra, A., Monsalve-Guil, L., Muñoz-Guzón, F., Perez, R. A., & Gil, F. J. (2019). Comparison between sandblasted acid-etched and oxidized titanium dental implants: In vivo study. *International Journal of Molecular Sciences*, *20*(13). https://doi.org/10.3390/ijms20133267.

W. Nicholson, J. (2020). Titanium Alloys for Dental Implants: A Review. *Prosthesis*, *2*(2), 100–116. https://doi.org/10.3390/prosthesis2020011.

Wilmes, B., Su, Y. Y., & Drescher, D. (2008). Insertion angle impact on primary stability of orthodontic mini-implants. *Angle Orthodontist*, *78*(6), 1065–1070. https://doi.org/10.2319/100707-484.1.

Yassir, Y. A., Nabbat, S. A., McIntyre, G. T., & Bearn, D. R. (2022). Which anchorage device is the best during retraction of anterior teeth? An overview of systematic reviews. *Korean Journal of Orthodontics*, *52*(3), 220–235. https://doi.org/10.4041/kjod21.153.

Zawawi, K. H. (2014). Acceptance of orthodontic miniscrews as temporary anchorage devices. *Patient Preference and Adherence*, *8*, 933–937. https://doi.org/10.2147/PPA.S66133.

Zhang, J. N., Lu, H. P., Bao, X. C., Shi, Y., & Zhang, M. H. (2019). Evaluation of the long-term stability of micro-screws under different loading protocols: A systematic review. *Brazilian Oral Research*, *33*, 1–13. https://doi.org/10.1590/1807-3107BOR-2019.VOL33.0046.

Zhang, Q., Zhao, L., Wu, Y., Wang, H., Zhao, Z., Xu, Z., Wei, X., & Tang, T. (2011). The effect of varying healing times on orthodontic mini-implant stability: A microscopic computerized tomographic and biomechanical analysis. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*, *112*(4), 423–429. https://doi.org/10.1016/j.tripleo.2010.10.042.

Zhang, S., Wei, X., Wang, L., Wu, Z., Liu, L., Yan, X., Lai, W., & Long, H. (2022). Evaluation of Optimal Sites for the Insertion of Orthodontic Mini Implants at Mandibular Symphysis Region through Cone-Beam Computed Tomography. *Diagnostics*, *12*(2), 285. https://doi.org/10.3390/diagnostics12020285.