

Stability of Mini Implants in the Periodontum during Orthodontic Treatment

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Abstract

In orthodontic treatment, forces are used to perform tooth movements depending on the magnitude, direction and duration, generating cellular and vascular responses in the periodontium. Orthodontic movement involves inflammatory responses resulting from this damage repair process. With the introduction of mini implants in orthodontic treatment, it allows us to obtain better control over the patient's movements by decreasing the load on the teeth such as in case of retraction, intrusions of a tooth or sector and mesializations. Unfortunately, it has been reported that between 13.4% and 20.1% of IMs loosen and fail shortly after placement. Sufficient primary stability is one of the determining factors [1]. The stability of the mini-implant can be influenced by the way of placement or direction of the implant, bone quality, loading force, adhesion and bacterial proliferation. The **objective** of this study is to evaluate the stability of mini-implants in the periodontium during orthodontic treatment. **Methodology:** it is a bibliographic systematic review work, qualitative design through the systematic review of articles. Using the PudMed, Scielo, Dialnet and some university repositories databases. **Conclusions:** The primary stability of mini-implants is considered the most important criterion to evaluate the success rate of orthodontic mini-implants

Keywords: mini-implante; ortodoncia; periodoncia; mini-implant; micro-implat; orthodontic; periodontics

Introduction

One of the most significant advances in recent years in Orthodontics is the introduction of skeletal anchorage with mini-implants [2]. When implants began to be used in orthodontics due to their excellent anchorage, initially the osseointegration process was expected and this generated difficulty in removing the dental implant after completing the orthodontic treatment and another requirement was to have an edentulous area with sufficient bone for the implant. anchorage [3], later titanium screws with smaller dimensions called mini orthodontic implants were introduced and can be placed in unconventional sites such as the alveolar bone of adjacent teeth without damaging the roots and without requiring time for osseointegration, and offers a stable anchorage even in critical conditions [4].

Despite the clinical advantages of mini-implants, there are some disadvantages, such as the risk of root damage, perforation of the nasal floor or maxillary sinus, dental ankylosis, and lack of space for insertion [5].

The primary stability of mini-implants is the most important criterion for evaluating the success rate of mini-implants in orthodontics. It is defined as the result of the mechanical stability of the mini-implant with the surrounding bone, which is related to several factors: quality and quantity of cortical bone, operator technique and screw diameter [6].

Thin bone is associated with a higher risk of failure. There are studies where it was revealed that the thickness of the alveolar bone progressively increased in the distal part ($P < 0.001$), regardless of sex, age and facial pattern. The proximity of the second molar to the ramus and, consequently, the incidence of greater masticatory forces may be responsible for this greater bone dimension [7]. Previous

studies have reported greater buccal bone thickness in hypodivergent patients, but the small sample size decreases statistical power and increases the possibilities of type II error in these studies. Another relevant factor is that bone thickness was measured only in one region of the root, without considering spatial changes of the inferior alveolar nerve. The study carried out by Mascarenhas et al. revealed that the vertical facial pattern and age did not affect the region of the second molar, which is the region with the greatest bone thickness, which agrees with what was found by Arango et al. It also showed that there was no difference between men and women, consistent with the findings of previous studies [7].

Factors related to operator technique include placement method, root proximity, and mini-implant loading. The insertion torque of 5 to 10 N cm was considered optimal for the success of the mini-implant [8].

The mini implants available are made from a grade 5 titanium alloy, this material has replaced commercially pure titanium (cp Ti) this has improved biocompatibility, but is more prone to fracture [9].

Another factor to consider in the installation of dental implants is that it promotes the activation of the molecular mechanisms involved in bone remodeling for osseointegration and can also trigger a cascade of inflammatory reactions by stimulating the production of cytokines and chemokines, contributing to the establishment of a unique biochemical environment [10]. The action of these pro-inflammatory cytokines and factors related to osteoclastogenesis has an important role in the development and severity of peri-implantitis, one of the main causes of loss of dental implants. [10].

The evaluation of these mediators involved in inflammation is essential to increase the stability of temporary anchorage devices in orthodontics [10].

In addition to the insertion angle, there are still questions about the stability and mechanical stresses around mini implants due to the impossibility of accurate measurements that can be obtained from patients. For this reason, there have been several investigations in dentistry that require the use of laboratory animals [11]. Different investigations have shown that it is difficult to experimentally determine the tensions and displacements of mini-implants, at different insertion angles with the use of an animal model through in situ measurement, in addition to the difficulty in controlling the study parameters and variations in the samples [11]. The length of time the mini-implant will be used must be taken into account. Carvalho et al [12] mention that a more stable osseointegration can be generated around the orthodontic mini-implants when they are left in the mouth for a long time and without use. in orthodontic movements.

Methodology

A systematic review was carried out through a bibliographic, descriptive, qualitative, non-experimental study of the literature to discuss in detail the stability of mini-implants in the periodontium during orthodontic treatment.

For this, the information was reviewed with a universe of 48 articles in some literature databases: PubMed, Scielo, latindex, Dialnet and some university repositories produced from 2018 to 2023, including base articles from 2010, 2011 and 2014. To collect the data, the search keywords in Spanish were used: mini-implant, orthodontics, periodontics, and their respective translations into English mini-implant, orthodontic periodontics.

For the selection of studies, 33 articles that met the inclusion criteria were included: written in English and Spanish, from experimental studies and bibliographic reviews.

Literary Review

As described previously, there are various factors that influence the stability of the mini-implant during orthodontic treatment. Among the most relevant in this research, the following topics have been taken.

Composition of Mini Implants

The material used is commercially pure titanium (Ti cp), but certain amounts of Aluminum (Al) and Vanadium (V) are added to provide stability, low toxicity, resistance, toughness and the elastic modulus of the mini-implant [3, 13] and surgical stainless steel have been used as raw material for mini-implants [14]. Biomaterials have some specific characteristics, such as biocompatibility and corrosion resistance, to be used in the human body. Mini implants must have a specific mechanical resistance, resistance to corrosion in the physiological environment in which they will be inserted [14]. The use of surface treatment of mini-implants with sandblasting followed by acid etching to remove contaminants is also suggested to create surface roughness and promote the assimilation of osteoblasts on the surface of the mini-implant, resulting in a improved contact between the bone and the mini-implant and better clinical stability [15]. In the study conducted by Ravi et al. where they implemented the use of sandblasting followed by acid etching, it was observed that the mini-implants with treatment on their surface needed greater touch when being removed from the oral cavity, this could demonstrate that the secondary stability of the mini-implant can be improved with the adequate surface treatment [15].

Insertion site selection

The choice will depend on the movements we want to perform, but it is also necessary to know a Roberts W classification Performing a macro classification taking into consideration bone density [16]. Misch is based on the following characteristics: type 1 (dense uniform dense bone), type 2 (dense trabecular bone core and a thin layer of surrounding dense bone), type 3 (dense trabecular bone surrounding the layer of cortical bone) and type 4 (Dense trabecular bone) cortical layer surrounding low density bone) [16] Type 4 bone is not recommended because it is associated with a high failure rate between 35% and 50% [16].

The most frequent insertion sites are: a) External oblique line of the lower jaw (Shelf), b) Infrazygomatic ridge, c) Hard palate and d) Vestibular interradicular space [16]. The insertion area of mini implants most used in clinical practice is the alveolar ridge; however, root injury is a risk. To avoid root damage and ensure good stability of the mini-implants, some authors have proposed insertion angles between 30 and 45°. Other authors suggest insertion angles between 60 and 70° because there is more space available near the apical region, while others favor 90° placement because it reduces stress concentration and increases the probability of stabilization of the mini-implant [10].

Insertion

Mini implants have undeniable advantages in orthodontics. They allowed a review of the principles of anchorage and biomechanics used in orthodontic treatment [17]. The use of mini-implants has some limitations and disadvantages that are related to the age of the patient, the quality of the bone tissue, the characteristics of the oral mucosa, the place of implantation, the state of health of the organism, etc. The quality of the patient's oral health [17].

The approximate failure rate in the literature is 10%. In addition to the factors mentioned above, the stability of the mini-implant depends on the mechanical interlocking of the threads and bone tissue and not on osseointegration [17].

The mini-implant is a temporary anchorage device, therefore, primary stability is adequate for treatment success [18]. For maximum effectiveness, it is expected that they remain immobile when orthodontic force is applied [17]. It has been reported in the literature that most mini-implant losses occur in the first week after implant insertion [17]. A relationship between the growth pattern and the thickness of the alveolar cortical bone must also be considered, and whether this has an effect on the use of mini-implants [19]. since the thickness of the cortical bone is considered a decisive factor for the initial stability of mini-implants. It is estimated that a greater thickness of the alveolar cortical bone is related to a greater probability of initial stability and, therefore, a better success rate [19].

In a study carried out by Menendez et al. in 2020 determined based on a specific sample, it can be concluded that the growth pattern has an influence on the cortical thickness of the alveolar bone in specific areas of the maxilla and mandible, but this fact may not influence the stability and success rate of mini-implants in the posterior maxillary buccal region [19].

To place the mini-implant, the place of insertion must be determined, which will depend on the type of movement we wish to perform. It is necessary to evaluate radiographically and study models to obtain a general and three-dimensional vision of the chosen site. After our choice, the patient is anesthetized in the selected area, since the soft tissues are important. In general, local anesthesia is sufficient. (twenty).

The mini-implant is then applied directly with a manual screwdriver. This possibility gives the doctor the sensitivity of the structures through which the screw passes and allows him to change direction in case the patient experiences slight pressure on the adjacent teeth and avoid damage to the dental structures. The mini implant must be placed so that only the head is visible in the mouth [20]. Once the insertion is completed, an intraoral x-ray is performed to verify that the entire process has been carried out correctly [20]. Primary stability is defined as the stability of the mini-implant immediately after insertion and which depends mainly on mechanical interlocking with the cortical bone [21, 22], but over time secondary stability is also expected to be obtained and this is based in bone remodeling around the mini-implant and is responsible for the clinical stability of the implant during orthodontic treatment [15]. Osseointegration is not necessary for mini-implants, if they present a certain degree of mobility it is not inconvenient for the use of the device [21]. In different articles they mention that the insertion torque is also a factor during the surgical procedure, which affects the stability of the mini-implant. It has been demonstrated that reduced torques have better osseointegration than those with high insertion torque, which is why it is preferable. always a low torque [23].

Complications in the insertion of mini-implants

Among the main causes we have: fracture of the device, damage to anatomical structures such as tooth roots or nerve structures, local irritation with or without superinfection such as mucositis and peri-implantitis, penetration into the nasal passages or maxillary sinus, rejection of the device, pain during placement, displacement of the mini-implant during mechanics, pain during chewing [23]. In tooth movement, it is not common to have injuries to the roots of teeth and due to the small size of the mini-implants they are placed between them, avoiding complications [23]. This has allowed the complications to not be so relevant anymore. whether due to not being reported or due to their few symptoms [23]. We should note that during the insertion of the mini-implant there may be bacteremia, this refers to the presence of viable bacteria in the bloodstream and can occur in dental procedures and common daily activities such as brushing teeth, the use of dental floss and chewing [24].

Generally, primary bacteremia is temporary and benign; the host is able to eliminate bacteria in the bloodstream [24]. Although bacteremia is likely to cause infection and sepsis when immune mechanisms fail due to systemic problems in the host [24]. As reported in different articles, antibiotic prophylaxis is necessary in high-risk interventions, such as dental extraction (40%), periodontal surgery (58%) [14, 15] and intraligamentary injections (97%), but bleeding is not decisive for detect bacteremia since it could be found in procedures without bleeding [24]. In a study carried out by Feizbakhsh et al., they investigated the probability that bacteremia may occur, in patients susceptible to infective endocarditis, after the placement of the mini implant in orthodontic treatment. In the article it mentions the possibility that orthodontists should consider antibiotic prophylaxis for patients at high risk of endocarditis, although the study was carried out in healthy patients taking all surgical protocols, one patient in the study group of 30 people presented bacteremia [24].

Biomechanics of mini implants

Currently Biomechanics, with finite element (3D) study, to determine the correct stress in the periodontal ligament. In this way, with the intention of simplifying the application of the concepts of Biomechanics for the treatment of complex malocclusions, instead of segmental mechanics and using the numerous accessory devices of the classic segmented arch technique, it is possible to apply mechanical multivector provided by a sophisticated system of forces using extra-alveolar mini implants [25].

The authors also mention the existence of three critical factors for the mechanics to be considered statically determined and can be studied through finite elements: 1) use of a rectangular arch (full-size) with torque control during retraction; 2) relative constant force

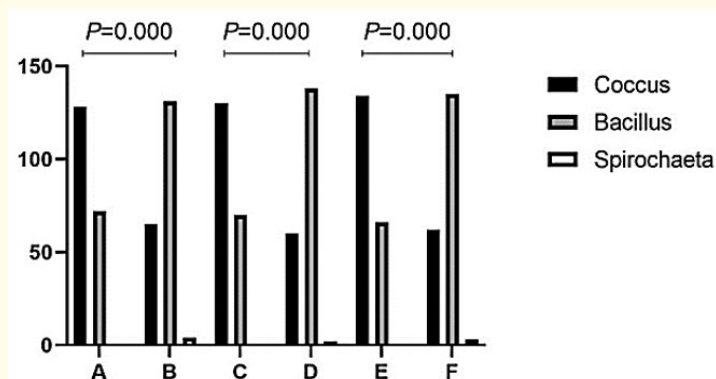
from superelastic NiTi springs; and 3) force applied directly to the arch [25]. The force applied to the mini-implant, which has been used in most mini-implants in immediate or early loading, is 100 to 200 g of load [18]. Sidhu et al, in 2020 carried out a study where the stress pattern caused by the mini-implant in the alveolar bone of the jaw was evaluated, using different angulations and retraction forces, they were able to observe that increasing loads cause stress levels and horizontal loads of 250 g have the maximum stress levels, it is below the levels that can cause overloaded bone resorption and loss or failure of the mini-implant [18].

The loading protocols depend on the need of the professional, but the latter must be progressive in the loading on the mini-implant since a surgical procedure and an incorrect loading protocol potentiated by patient factors (habits and hygiene) will influence a greater probability of a positive or negative scenario in mini-implants [23].

Factors that affect the Mini-implant after insertion

The main components of fixed orthodontic treatments decrease the self-cleaning capacity of the tongue and cheeks, leading to an increase in the production of bacterial plaque and therefore changing the qualitative and quantitative profile of the microbial flora [26]. This change in bacterial flora may only be a transient effect and depends entirely on the state of oral hygiene maintenance [26]. With the advancement of modern orthodontics, anchorage plays an important role in obtaining favorable treatment results [24].

In the study carried out by Huang et al [27], they determined that the supragingival and subgingival bacterial composition around the mini implants was similar to that of natural teeth. In the periphery of the implants, a variety of bacteria similar to natural periodontal microorganisms can be detected, and in the pathological development of peri-implantitis it is similar to periodontitis [27]. The periodontal status between mini-implants and dental implants is not defined, the situation of the dental plaque around the mini-implants and its bacterial composition, it has been reported that the more plaque is found on the surface of the mini -implant, the stronger or more severe the inflammatory response of the surrounding soft tissue is [27]. In the study carried out by Huang et al., they were able to isolate 3 most common oral flora bacteria, both supragingival and subgingival in the presence of mini-implant, orthodontic and normal without appliances [27], cocci, bacillus and spirochetes, although the difference was very few among them, the proportion of spirochetes in the subgingival plaque of the mini-implants was (4%) greater than in the supragingival plaque, which increases the destructive effect on the soft tissue around the mini-implants [27]. After insertion of the mini-implant, a space is formed between the mini-implant and the surrounding soft tissue creating a soft tissue pocket at the periphery of the mini-implant and the depth of the pocket varies depending on the location of the device [27].



Bacterial composition in different sites: A, Supragingival (mini-implant); B, Subgingival (mini implant); C, Supragingival (orthodontic); D, Subgingival (orthodontic); E, Supragingival (normal); F, Subgingival (normal).

Table taken from: Investigation of periodontal status and bacterial composition around mini-implants Rui Huang et al.,2023, <https://www.sciencedirect.com/science/article/abs/pii/S0889540623000707>

It has also been observed that after the insertion of the mini-implant, traumatic lesions may appear in the soft tissues, among the most common found are: aphthous ulcerations or oral ulcers in the alveolar, buccal, labial mucosa or in the frenulum [28], these lesions are self-limiting and can heal without major complications. A healing abutment, a wax pellet and an elastic spacer can be used on the head of the mini implant for recovery [28]. In other cases, mini-implants become trapped due to excessive growth of soft tissue around the implant. This would require excision of the soft tissue to expose the implant head, which is a minor surgical operation [29]. The inflammatory response increases in the periodontal tissues around the mini-implant along with the increase in microbial colonization of the mini-implants after placement in the oral cavity and results in a production of pro-inflammatory cytokines that regulate the immune response [10]. The evaluation of the mediators involved in inflammation is necessary to increase the stability of temporary anchorage devices in orthodontics. Damião et al [10] in their study concluded that a greater amount of the proinflammatory cytokine IL-6 is found in failed implants and this could be associated with the loss of stability of the mini implant.

Inflammation around the mini-implant in the regions of the palate, buccal fold and ascending ramus, this inflammation has been associated with failure of the mini-implant, however these cases have been related to patients with poor oral hygiene, the inflammation can occur even if the placement procedure is performed carefully [28].

Maintenance of Mini-implants

Patients with fixed orthodontics present malocclusion and crowding. Added to this, those with orthodontic appliances will cause problems with hygiene. Furthermore, the presence of these devices in the mouth causes the pH and bacterial flora of the mouth to change and dental plaque that is difficult to clean accumulates [30]. Therefore, daily mouth washing and the use of antimicrobial agents are necessary to control and eliminate bacterial plaque and limit gingivitis and periodontitis. Among the antimicrobials used to reduce the microbial load in the mouth are different types of toothpastes, mouthwashes and gels [30].

However, different studies have revealed the corrosion behavior of mini-implants when they come into contact with mouthwashes [31]. Any solid material in a chemical environment results in loss of structural integrity, change of structural characteristics, and loss of material substance [32].

Mouthwashes such as chlorhexidine gluconate and sodium fluoride are frequently used in orthodontic patients as antibacterial agents to prevent soft tissue inflammation or white spot lesions on enamel [13]. Abboodi et al. In their study they showed that fluoridated mouthwashes could cause cracking and pitting corrosion on the surface of mini-orthodontic implants after 28 days of immersion in the rinse [13]. Mandsaurwala et al found that chlorhexidine mouthwash could cause release of metal ions after 45 days of immersion [13]. A biomaterial chitosan, obtained from crustaceans, is being used as a mouthwash due to its antibacterial effects and biocompatibility [13].

Setyari et al. conducted a study of 4 groups immersed in 0.2% chlorhexidine gluconate (MINOSEP®, PT Minorock Mandiri, Indonesia), 0.2% sodium fluoride (Pepsodent Expert Protection Pro Complete, PT Unilever, Indonesia) and), 1.5% chitosan (KITOBETM, CV EcoShrimp, Indonesia) and distilled water (Aqua Pro Injection Sterile, PT Ikapharmaindo Putramas, Indonesia) [13]. As a result, the mini-implants immersed in chitosan and distilled water showed more samples with smooth surfaces and no signs of corrosion [13]. Utami et al, had the same results where they did not increase the toxicity in the 1.5% chitosan solution [13]. This, added to the oral environment, will generate more accelerated corrosion. It is important to note what type of mouthwash should be used when patient to improve the stability of the mini-implant. You can use other mouthwash options such as propolis rinse which is an alternative to chlorhexidine, which does not have the side effects on mini-implants [30]. The antimicrobial and therapeutic properties of propolis have allowed it to be used in oral hygiene. Therefore, to prove the medicinal effects of propolis, numerous scientific studies have been conducted on its effects [30]. Benefits of other types of components such as chamomile both in pastes and rinses from commercial brands available on the market. Always taken into consideration the best to avoid increasing corrosion of the mini-implants.

Removal of the Mini-implant

Once the use of the device in the mouth is finished, it must be removed, the implications of osseointegration in the extraction of mini-implants, in addition, removing the device can damage the surrounding bone [15], it can also increase the possibility of fracture during removal of the device, due to excessive osseointegration, which may influence its resistance to fracture [33].

Discussion

Orthodontic forces are a topic of extensive research because to carry out tooth movements, forces are used that depend on the magnitude, direction and duration, generating cellular and vascular responses in the periodontium, in a way that involves inflammatory responses resulting from this process. repairing the damage.

The authors refer to the importance of prior analysis of the teeth of each patient; as well as the measurement between the dental roots and correct application and control of the forces applied throughout the treatment with the mini-implant during the respective movements.

Starting from the general objective of this research, which aims to evaluate the stability of mini-implants in the periodontium during orthodontic treatment, evidence was obtained that shows us that Orthodontic forces cause significant changes and that the stability of the mini -implant can be influenced by the way it is placed or directed, the quality of the bone, the loading force, adhesion and bacterial proliferation.

(Beatriz & Lilibeth, 2020) & (Chin-Yun Pan, 2019) & (Haddad R, 2019) They mention that it is necessary to radiographically evaluate and study models to obtain a general and three-dimensional view of the chosen site and avoid damage to the dental structures.

According to, (Chin-Yun Pan, 2019) & (Adelina Popa, 2022) & (Chau Miyakawa, 2021) & (Carolina Carmo de Menezes, 2020) & (Eto, V., et al. 2023) agreed in their literature that The thickness of the cortical bone is a decisive factor for the initial stability of mini-implants and is important for the success of a mini-implant because insufficient thickness of the cortical bone causes inadequate primary stability.

Authors such as (Vasu Kumar, 2021) & (Marcela Cristina Damião Andruccioli M. A., 2019) & (Mahboobe Dehghani, 2019) state that when placing fixed orthodontics they decrease the self-cleaning capacity of the tongue and cheeks, which leads to an increase in the production of bacterial plaque and, therefore, the qualitative and quantitative profile of the microbial flora, the pH and the bacterial flora of the mouth changes and dental plaque that is difficult to clean accumulates.

(Van Mai Truong, 2022) & (Vasu Kumar, 2019) Among the problems that we see in the use of mini-implants is that the inflammation around it in the regions of the palate, the buccal fold and the ascending ramus, is has associated this inflammation with these related cases in patients with poor oral hygiene, inflammation can occur even if the placement procedure is performed carefully.

Masood Feizbakhsh et., al. (2022) & (Mahboobe Dehghani et., al. 2019) They mention in the article the possibility that orthodontists should consider antibiotic prophylaxis for patients at high risk of endocarditis, since they took two blood samples from the patients for aerobic cultures and anaerobic just before and 30-60 seconds after placement of the mini-implant and one patient was positive for aerobic and anaerobic bacteria after placement.

Conclusions

Through the bibliographic review, and its respective analysis and reflection, we can conclude the following:

- It is necessary before placing mini-implants to take a history and analysis of the teeth and their pulp vitality, as well as the quality of the bone, the load force.
- So that there is no interruption of blood flow through the periodontal ligament, the ideal forces will be 26g per cm².

- Insertion torque of 5 to 10 N cm was considered optimal for the success of the mini implant.
- Implant stability is associated with the distance from the mini-implant to the alveolar crest bone, along with the distance to the alveolar crest, age and MI site were significant predictors of failure.
- The primary stability of mini-implants is considered the most important criterion to evaluate the success rate of orthodontic mini-implants, although secondary stability is also expected, but not complete osseointegration since this would be detrimental at the time of implantation. remove the device.
- The type of force that presented the greatest appearance of apical lesions during Orthodontic treatments were intrusive forces.
- Root proximity was not associated with failure of mini-implants.
- Acid solutions and fluorine decrease the stability of the passive protective oxide layer typically formed on titanium-based surfaces, thereby decreasing their corrosion resistance.
- Cortical bone stress had the lowest value when the mini-implant had an insertion angle of 30° and the highest value when the implant had an insertion angle of 120°.
- During the course of orthodontic treatment, regular oral prophylaxis should be performed, because there is a significant increase in plaque accumulation, inflammation, and gingival recession.

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