LITERATURE REVIEW

FACTORS INFLUENCING FAILURES IN THE USE OF MINI-IMPLANTS: A LITERATURE REVIEW

FATORES QUE INFLUENCIAM INSUCESSOS NO USO DE MINI-IMPLANTES: UMA REVISÃO DE LITERATURA

LUÍZA TRINDADE VILELA[1], BRUNA CAROLINE TOMÉ BARRETO[2], MARGARETH MARIA GOMES DE SOUZA[3]

ABSTRACT

Temporary anchorage devices or mini-screws are becoming increasingly relevant in the clinical management of orthodontic treatments. However, despite the expressive clinical results obtained, some intercurrences may affect the anchorage during the treatment. Failures may be associated with factors related to the professional, the patient or the screw. Furthermore, there are factors that can contribute to the clinical success in the use of these devices, such as the appropriate selection of the length of the mini-screws, the choice of suitable areas for insertion of the device, such as areas of attached gingiva, besides the knowledge about bone density, aiming to contribute to primary stability, practice of good oral hygiene habits or even the use of self-drilling devices. Thus, the present study aimed to review the scientific literature available on mini-implants. Scientific articles were selected using PubMed, Scopus, Web of Science, Cochrane Library, Embase, BVS, Opengrey, Google Scholar and Catalog of Theses and Dissertations. After applying the selection criteria, 32 articles were selected to compose this work. It is concluded that the use of mini-screws maintains ideal anchorage control, in order to avoid undesirable tooth movements, and the clinical success of temporary anchorage devices in Orthodontics is undeniable. However, it has been proven that complications whose etiology may vary between professionals, patients, or the screw itself are capable of affecting the device during orthodontic treatment, leading to failure of the mini-screws.

Keywords: Orthodontics; Mini-implant; Mini-screw; Micro-implants.

RESUMO

Os dispositivos de ancoragem temporária ou mini-implantes adquirem cada vez mais relevância no manejo clínico dos tratamentos ortodônticos. Entretanto, apesar dos resultados clínicos expressivos obtidos, algumas intercorrências podem acometer a ancoragem no decorrer do tratamento. Os insucessos podem estar associados a fatores relacionados ao profissional, ao paciente ou ao próprio parafuso. Outrossim, existem fatores que podem contribuir para o sucesso clínico na utilização destes dispositivos, como a seleção apropriada do comprimento do mini-implante, a escolha de áreas adequadas para inserção do dispositivo, além de conhecimentos acerca da densidade óssea, de forma a contribuir para a estabilidade primária, a prática de bons hábitos de higiene bucal ou ainda a utilização de dispositivos autoperfurantes. Assim, o presente estudo propôs-se a revisar a literatura científica disponível acerca de mini-implantes com artigos científicos selecionados utilizando as bases de dados PubMed, Scopus, Web of Science, Cochrane Library, Embase, BVS, Opengrey, Google Scholar e Catálogo de teses e dissertações. Após aplicados os critérios de seleção, 32 artigos foram selecionados para compor este trabalho. Conclui-se que a utilização dos mini-implantes mantém o controle ideal da ancoragem, de modo a evitar movimentações dentárias indesejáveis, sendo inegável o sucesso clínico dos dispositivos de ancoragem temporária na Ortodontia. Entretanto, é comprovado que complicações cuja etiologia pode variar entre profissional, paciente ou o próprio parafuso são capazes de acometer a ancoragem no decorrer do tratamento ortodôntico, de modo a implicar falhas e insucesso dos miniparafusos.

Palavras-chave: Ortodontia; Mini-implante; Miniparafuso; Micro-implante.

[1] MSc and PhD student in Orthodontics - PPGO/UFRJ - Department of Pediatric Dentistry and Orthodontics, Federal University of Rio de Janeiro (UFRJ), Brazil.
[2] Specialist, MSc and PhD student in Orthodontics - PPGO/UFRJ - Department of Pediatric Dentistry and Orthodontics, Federal University of Rio de Janeiro (UFRJ), Brazil.
[3] Specialist, MSc, PhD and Professor of Orthodontics, Department of Pediatric Dentistry and Orthodontics, Federal University of Rio de Janeiro (UFRJ), Brazil.

How to cite this article: Vilela LT, Barreto BCT, Souza MMG. Factors influencing failures in the use of mini-implants: a literature review. Nav Dent J. 51(1): 41-46.
Received: 26/06/2023
Accepted: 29/01/2024

INTRODUCTION

In recent years, the use of mini-screws has resulted in a revolution in orthodontics, in which anchorage control is becoming more important in the clinical management of treatments (1) and an alternative to conventional methods (1,2). The ease with which the screws can be inserted and removed, their low cost, and the minimal need for patient cooperation (3) have made mini-implants popular, and their use has led to a significant reduction in anchorage loss rates in orthodontics (4).

Anchorage control is extremely important during orthodontic treatment. It avoids undesirable tooth movements resulting from the reaction of the forces applied to carry out the orthodontic movement (4,5).

Mini-screws are considered a safe, reliable, and efficient anchoring method (1). However, despite the significant clinical results obtained through its use, various complications can affect the anchorage during orthodontic treatment (4,6). The etiology of failure in this temporary anchorage may be associated with factors related to the professional, the patient or the screw (1,6). On the other hand, there are factors that can contribute to clinical success in the use of these devices, such as the appropriate choice of mini-implant length (5,7), the selection of more appropriate areas for insertion of the device, such as areas of attached gingiva (7), as well as knowledge about bone density (8, 9), the practice of good oral hygiene habits (3,9,10) or the use of self-drilling devices (11).

This study aimed to review and analyze the available scientific literature on using mini-implants to clarify the conditions that may influence these orthodontic devices' clinical success or failure rate. For this reason, identifying this etiology is extremely important to minimize clinic failures and help increase success rates.

LITERATURE REVIEW

The eligibility criteria were established based on studies that evaluated the factors that interfere with the clinical success of temporary anchorage devices in orthodontics. Observational, interventional, review, and case series studies were included. Expert opinions, editorials, and letters were excluded though.

The scientific literature was reviewed in electronic databases: PubMed, Scopus, Web of Science, Cochrane Library, Embase, BVS, Opengrey, Google Scholar and Catalog of Theses and Dissertations in May 2023. The search strategy was initially developed for MEDLINE (PubMed), using MeSH terms, entry terms, and free terms where possible. The combination of terms included was: "Orthodontics", "Mini-implant", "Mini-screw", "Micro-implants" and "Mini implants success rate" and their derivatives, adapted according to each database and for each language, as well as adjusted for the other databases according to their syntax rules.

To improve the searches, the Boolean operators "OR" and "AND" were combined. No restrictions were placed on the date of publication or language. Two authors (L.T.V. and B.C.T.B.) independently assessed the title and abstract of all the articles retrieved from the databases. The duplicates were then removed manually. Observational, interventional, review, and case series studies were included, excluding those with expert opinions, editorials, and letters. A total of 55 articles were selected for full reading. After reading, 32 articles met the criteria for this review. Articles that did not meet the eligibility criteria were excluded at this stage. In the event of disagreement between the authors, a third author (M.M.G.S), an expert in the field, was consulted.

A total of 12,381 articles were retrieved (PubMed = 428, Scopus = 793, Web of Science = 962, Cochrane Library = 234, Embase = 869, BVS = 1, Opengrey = 0, Google Scholar = 9,050 and Catalog of Theses and Dissertations = 44). Of these, 32 articles were selected to make up this review, after removing duplicates, reading titles, abstracts and reading in full.

Table 1 shows the selected studies and their respective themes regarding the etiology of mini-implant failure.

Professional-related factors

It is essential for the clinician to plan the appropriate site for inserting the mini-implant to guarantee the effectiveness and success of the intervention. Therefore, knowledge about bone density in specific areas of the oral cavity can be extremely useful (12). Mainly to avoid damage to adjacent tissues or root injuries due to improper insertion of mini-screws (3). Van Mai Truong *et al*. state that the professional must understand the insertion and removal procedures in full, as well as mastering the characteristics of the anatomical structures and the inherent characterization of the screw, to maximize the success and effectiveness of the procedure (8). According to Kim *et al*., when evaluating mini-implant insertion methods, success rates were similar among all age groups of patients regardless of the technique used (13).

There is a learning curve about the successful insertion of temporary anchorage devices. At the same time, the failure rates related to orthodontic mini-implants are inversely proportional to the increase in clinical experience (14).

TABLE 1. ARTICLES USED AND THEIR RESPECTIVE THEMES REGARDING CLINICAL SUCCESS USING MINI-IMPLANTS.

Author, Year, and Type of Study.	Professional related factors.	Patient-related factors.	Screw-related factors.
Apel *et al*. (2009) - Clinical trial		■	
Baek *et al*. (2008) - Clinical trial		■	
Casaña-Ruiz *et al*. (2020) - Systematic review and meta-analysis		■	
Chaddad *et al*. (2008) - Clinical trial			■
Chen *et al*. (2007) - Clinical trial		■	
Chin *et al*. (2007) - Clinical trial			■
Chugh *et al*. (2013) - Literature review	■	■	
da Cunha *et al*. (2015) - Experimental study		■	■
Dalessandri *et al*. (2014) - Meta-analysis		■	
Garfinkle *et al*. (2008) - Clinical trial	■	■	
Giudice *et al*. (2021) - Systematic review		■	
Holm *et al*. (2012)		■	
Kim *et al*. (2012) - Clinical trial	■		
Knutson *et al*. (2013) - Experimental study			■
Kravitz *et al*. (2007) - Literature review		■	■
Leo *et al*. (2016) - Literature review	■	■	■
Malik *et al*. (2023) - Literature review		■	
Marquezan *et al*. (2014) - Experimental study		■	
Manni *et al*. (2011) - Experimental study		■	■
Melo *et al*. (2016) - Clinical trial		■	
Mohammed *et al*. (2018) - Systematic review and meta-analysis		■	
Papadopoulos *et al*. (2011) - Meta-analysis		■	
Papadopoulos *et al*. (2007) - Literature review	■	■	
Papageorgiou *et al*. (2012) - Meta-analysis		■	
Pithon *et al*. (2013) - Clinical trial			■
Reynders *et al*. (2009) - Systematic review	■	■	■
Romano *et al*. (2015) - Clinical trial		■	
Severo *et al*. (2015) - Literature review	■	■	■
Suzukia *et al*. (2011) - Clinical trial			■
Truong *et al*. (2022) - Literature review	■		
Tsai *et al*. (2016) - Clinical trial		■	
Wu *et al*. (2009) - Clinical study		■	

Patient-related factors

In general, mini-screws are biologically compatible with the patient's body, but it is essential that professionals understand the need for them and carry out a meticulous assessment, taking into account each individual's biological environment (1), careful technique, and accurate planning (15).

The choice of anatomical location should minimize any risk of root contact or the insertion of screws in areas with nerves or vessels (1). Mohammed *et al*. points out a greater risk of failure in mini-screws that came into contact with the roots (16). This unwanted event also had a higher incidence in the posterior region of the arches, equally affecting the maxilla and mandible (17).

Regarding the bacterial flora, the screws are placed transgingivally so that they are accessible to numerous types of microorganisms in the oral cavity, especially bacteria associated with periodontitis and peri-implantitis. In patients with poor oral hygiene, these bacteria can penetrate the tissues through the devices, triggering infections of soft and/or mineralized tissues (18). The patient's peri-implant tissues can be affected by irritation or inflammation, resulting in mini-screw failure, especially in patients with poor oral hygiene (4,19). Kravitz and Kusnoto equated the importance of home hygiene care for mini-screws with the importance of proper placement of the device by the orthodontist (9). In the study by Apel *et al*., bacterial analyses were carried out to investigate the clinical failure rate of mini-screws, and no significant differences were identified in the total quantity or species composition between the mini-screws in the clinically successful group and those characterized by failure. However, the species Actinomyces viscosus was found in 100% of cases and Campylobacter gracilis in 75% of stable screws, while both species were rarely detected in failed temporary anchorage devices (12.5%) (18). Furthermore, Melo *et al*. pointed out that factors such as smoking habits and craniofacial pattern did not affect the success of temporary anchorage devices (20).

No difference in mini-implant failure rates was observed based on the patient's age group (20,21). On the other hand, Chen *et al*. observed that mini-implants inserted in younger patients have a higher risk of failure (22), and Dalessandri *et al*. noted that the effectiveness of mini-screws is greater when used in individuals over 20 years of age (19). Meanwhile, Wu *et al*. showed a higher failure rate in elderly patients (10).

Bone density is a fundamental factor when installing temporary anchorage devices (9,12), since areas of low bone density may indicate the need for longer mini-implants to improve retention.

In areas of high bone density, pre-drilling can act as a preventative measure against possible screw fractures (12). Besides, Cunha *et al*. stated that the mechanical performance of temporary anchorage devices is highly dependent on the quality of the bone substrate (23). It should be noted that areas of greater bone density require adequate irrigation to prevent bone overheating during device installation (12). Considering bone properties, Marquezan *et al*. reported that cancellous bone plays a fundamental role in the primary stability of mini-screws, whether in the presence or absence of cortical bone. In addition, the primary stability of the anchorage device is directly dependent on the bone mineral density of the recipient site (24).

According to Holm *et al*., the increase in cortical bone density generates a significant increase in the maximum insertion torque, which increases the primary stability of the mini-implant (25). When it comes to the ideal position for inserting temporary anchorage devices, the highest success rate is found in the inserted gingiva (85.4%), followed by insertion in the mucogingival line (84.2%) (26). Moreover, Kravitz and Kusnoto stated that the absence of inserted gingiva at the mini-implants insertion site is a potential risk factor (9). When considering the distinctions between the placement of the temporary anchorage device on the right and left side, no significant differences were observed in the failure rates of the mini-implant on the insertion side (21). These results corroborate the findings of studies by Baek *et al*. (27). Manni *et al*. compared the success rate of mini-screws when inserted in the maxilla and mandible. They concluded that the highest success rate (86.9%) occurred in the maxilla, compared to 76.1% of devices inserted in the mandible (26). Similarly, the study by Papageorgiou *et al*. highlights that the highest failure rates were found in mini-implants inserted in the mandible (19.3%) (21). These results corroborate those found by Dalessandri *et al*, Chen *et al*, Melo *et al* and Casaña-Ruiz *et al* (19,20,22,28).

Screw-related factors

Pithon *et al*. evaluated the length of the mini-implant and its interferences. They reported that the length of the screw does not influence the fracture resistance during bending of the device. However, increasing the length of the screw, despite not generating an increase in mechanical strength, can effectively contribute to reinforcing initial stability (5).

Surface characteristics do not influence the survival rates of immediately loaded mini-implants (29). However, Knutson and Berzins suggest that the corrosion of orthodontic mini-screws contributes to tissue inflammation, becoming one of the agents that interfere with the clinical success of the devices. Furthermore, the authors point out that exposing screws to fluoride reduces polarization resistance and increases the corrosion current of the devices (30).

Mini-implants' geometry is a fundamental factor that directly influences the distribution of stresses on the bone. Excessive stress between the bone's interface and the device is a major cause of mini-screw failures (9,23).

Regarding the types of mini-implants, self-drilling devices have numerous advantages over pre-drilled ones. The first devices provide the simplest surgical procedures for placement and offer greater primary stability compared to pre-drilled mini-screws. Self-drilling mini-implants are less resistant to osseointegration because they are temporary anchoring devices that require easy removal with a low risk of fracture (11).

The literature shows that success rates are over 80% and that the adverse effects of mini-implants include biological damage, inflammation, painful symptoms, and discomfort (31).

The skeletal anchorage system presents miniplates as an alternative to mini-implants as a resource for anchorage control. These are pure titanium or titanium alloy anchorage plates temporarily implanted in the maxilla or mandible as absolute orthodontic anchorage. They have excellent mechanical strength and promote effects on the bone surface, contributing to a higher anchorage value and better stability of the miniplates, among other temporary anchorage devices. However, miniplates are expensive and require a more invasive surgical procedure than mini-implants, since it requires a flap opening (32-34).

DISCUSSION

Wu *et al*., Papageorgiou *et al*., Chen *et al*. and Melo *et al*. state that the failure rate of mini-implants was not significantly affected by the age or sex of the individual (10, 20-22). However, when considering the sexes, Manni *et al*. point out that there are differences and the success rate is higher in males (88%) when compared to females (26). Malik *et al*. confirm that, like bone quality, gender is a determining factor and impacts clinical practice, with the success of temporary devices being greater in females (35). In a systematic review, Casaña-Ruiz *et al*. noted that the gender variable has been the subject of controversy, since some studies report that the gender of patients does not interfere with the failure of treatment with mini-implants, while other studies have attributed a higher success rate to male individuals, due to the greater bone density of men (28).

According to the findings of Papadopoulos *et al*., the patient's role in orthodontic treatment with a temporary anchorage device is limited to cooperation in maintaining adequate and effective oral hygiene (3). About patient adherence to treatment, Wu *et al*. emphasized the importance of collaboration in preventing inflammation around the screws for the treatment to be successful (10). Wu *et al*. also showed that hygiene habits can affect the risk of losing a mini-screw (10).

According to Pithon *et al*. regarding the length of the mini-implant and its respective interferences, the length of the screw does not influence the resistance to fracture during bending of the device. However, a screw with a longer length can help to reinforce initial stability (5). However, in line with the findings of Manni *et al*., the length of the mini-screw is relevant, with a device 1.3 mm wide and 11 mm long being considered the best performing (26).

In a systematic review, Reynders *et al*. reported that most studies show success rates of over 80% and that the unfavorable consequences include biological damage, inflammation, painful symptoms, and discomfort (31). Papadopoulos *et al*. corroborate these findings, pointing out that orthodontic mini-screws used for anchorage purposes have a success rate of 87.7%. Melo *et al*. corroborate the previous findings (20).

Van Mai Truong *et al*. emphasize the importance of the professional knowing and mastering the procedures for inserting and removing the devices, as well as the characteristics of the anatomical structures and the characterization of the screw, to carry out an effective and satisfactory procedure (8). These findings are corroborated by the study by Honsali *et al*. evaluating a digitally assisted mini-implant insertion system, which highlights the importance of investigating and knowing the screw insertion area and considering factors inherent to the individual, such as ethnicity, sex, and anatomical characteristics (36).

CONCLUSION

Mini-screws have transformed orthodontic anchorage, acquiring greater relevance in the clinical management of treatments with significant success. However, complications caused by the professional, the patient or the screw itself can affect the device in orthodontic treatment. The clinician needs to know the specific areas of the oral cavity where the mini-screws will be inserted, the inherent characteristics of the anatomical structures, to carry out good planning, as well as to master the knowledge of the screw to maximize the success of the procedure. It should be noted that there is a learning curve for professionals about the success of temporary anchorage devices. Mini-screws are compatible with the body, but the patient's cooperation in maintaining proper oral hygiene over the long term is essential to minimize the risk of losing the device or the risk of infection. There is controversy over whether the length of the mini-implant contributes to the procedure's success. However, it is well known that the geometry of the mini-screws is a fundamental factor that has a direct influence on the distribution of stresses on the bone and, consequently, on the device's success.

The authors declare that there are no conflicts of interest.

Corresponding author:
Luíza Trindade Vilela
Rua Prof. Rodolpho Paulo Rocco, 325 - Cidade Universitária da Universidade Federal do Rio de Janeiro, Rio de Janeiro – RJ, Brazil, Post Code 21941-617
Email: luizavilela@ortodontia.ufrj.br

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