



Failure of miniscrews installed in maxilla and mandible: a systematic review and meta-analysis

Falha de mini-implantes instalados em maxila e mandíbula: uma revisão sistemática e meta-análise

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ABSTRACT

Objective: The aim of this systematic review was to compare the clinical failure rate of orthodontic miniscrews in maxilla and mandible. **Material and Methods:** Randomized controlled trials of patients in orthodontic treatment, which required miniscrews for orthodontic intervention reporting the failure rate of miniscrews in the maxilla and mandible were searched in Pubmed database. Two authors independently reviewed all identified titles and abstracts for eligibility. Comparison between failures in maxilla and mandible were estimated using pairwise meta-analysis to calculate the relative risk (RR) of failure and the 95% confidence intervals using a random-effect model. The reports of randomized trials were assessed for bias using the Cochrane risk of bias tool. **Results:** Four studies fulfilled the eligibility criteria. 299 patients with a total of 628 miniscrews installed were included in the analysis. The analysis showed a 0.55 RR (95% CI 0.23–1.29) and $I^2 = 85\%$. All studies had an unclear risk of bias regarding to the two following items: allocation concealment, blinding of participants and personnel. All studies had a low risk of bias with regard to incomplete outcome data and selective reporting. The results did not demonstrate statistical difference between risk of failure of miniscrew between maxilla and mandible. **Conclusion:** The results of the meta-analysis showed that miniscrews installed in maxilla presents reduced risk of failure. A tendency of higher number of failures in mandible was also demonstrated. However, results should be interpreted with caution because of the very low quality of included studies and the differences among methodologies.

KEYWORDS

Meta-analysis; Orthodontic anchorage procedures; Review.

RESUMO

Objetivo: A presente revisão sistemática objetivou comparar a taxa de falha clínica de mini-implantes ortodônticos instalados em maxila e mandíbula. **Materiais e Métodos:** Ensaios clínicos controlados e randomizados que reportaram a taxa de falha de mini-implantes instalados em maxila e mandíbula de pacientes necessitando tratamento ortodôntico foram pesquisados na base de dados do Pubmed. Dois autores revisaram independentemente os títulos e resumos identificados com base nos critérios de elegibilidade. Comparações entre as falhas na maxila e mandíbula foram estimadas utilizando meta-análise pareada para cálculo do risco relativo (RR) de falha e dos intervalos de confiança de 95%, usando um modelo de efeito aleatório. Os reportes dos estudos incluídos foram avaliados quanto ao risco de viés seguindo os critérios da Cochrane para ensaios clínicos randomizados. **Resultados:** Quatro estudos preencheram os critérios de elegibilidade. No total, 299 pacientes e 628 mini-implantes instalados foram incluídos na análise. A análise apresentou um RR 0,55 (IC 95% 0,23-1,29) e $I^2 = 85\%$. Todos os estudos apresentaram um risco claro de viés em relação aos dois itens seguintes: ocultação de alocação, cegamento dos participantes e profissionais. Todos os estudos apresentaram um baixo risco de viés no que diz respeito a dados de desfecho incompletos e reporte seletivo. Não foi demonstrada diferença estatisticamente significativa entre mini-implantes instalados em maxila e mandíbula. **Conclusão:** Os resultados da meta-análise demonstraram um menor risco de falhas em mini-implantes instalados na maxila e uma tendência para maior número de falhas na mandíbula. Contudo, os resultados devem ser interpretados com cautela, dadas a baixa qualidade dos estudos incluídos e as diferenças entre suas metodologias.

PALAVRAS-CHAVE

Meta-análise; Procedimento de ancoragem ortodôntica; Revisão.

INTRODUCTION

Several forms of orthodontic anchorage have been described in the literature. When treating severe occlusion problems, the indication of temporary anchorage devices (TADs) may optimize results with simpler mechanics or reducing the treatment time [1]. Miniscrews (MS) are devices installed on maxilla or mandible that provide support to orthodontic movements based on skeletal anchoring. Among all temporary skeletal anchorages those are the ones that best suit the characteristics required for this type of anchorage when conventional anchorage cannot be achieved or is insufficient to promote the desirable orthodontic movements. Thus, among the desirable characteristics of MS are their reduced size, easy placement, resistance to applied orthodontic forces, ability to receive immediate loading, use in conjunction with various orthodontic mechanics, easy installation, easy removal and low cost [2,3]. It is a consensus in orthodontic literature that some dental movements may be considered more complex, such as dental intrusion due to loss of vertical dimension or absence of the opposing teeth, retraction of the anterior teeth or even distalization of posterior teeth [4]. However, even representing one of the main innovations in the clinical orthodontic practice over the last 20 years, one of the most frustrating complications of MS is their loss during use as absolute anchorage [5].

Several factors could influence the success of MS as site of installation, geometry-related parameters, initial torque, installation technique and patient-related factors, which are the main subjects of interest regarding this type of anchorage device [6]. Despite that, the interpretation of published studies draw attention to the lack of clarity and poor quality of the methodology of most studies. Issues related to patient acceptance, rate and severity of the adverse effects of the MS and the variables that influence success were presented without reliable data. In addition, there is no report in the literature comparing the success of MS in maxilla and mandible based on randomized controlled trials. The aim of this study was to compare the success rates of orthodontic MS installed in maxilla and mandible of patients undergoing orthodontic treatment through a systematic review and meta-analysis of randomized clinical trials.

MATERIALS AND METHODS

This systematic review was based on Cochrane Handbook Guidelines for Intervention Systematic Reviews [7] and followed the four phases of Flowchart based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [8].

Studies selection criteria

Types of studies: Randomized controlled clinical trials (RCTs) reporting the success rate of miniscrews in maxilla and mandible were included. Retrospective and non-randomized prospective studies, animals and in-vitro studies, systematic reviews or studies that did not present data from MS success rate in mandible and maxilla were excluded.

Types of participants: Patients in orthodontic treatment, which required MS for orthodontic intervention.

Intervention: Studies that evaluated general success rate of MS in mandible and maxilla. RCTs could present the randomization according to different systems, lengths, geometries and time of loading.

Sources of information and bibliographic research

Electronic searches: Electronic searches were performed without language restriction and were limited to the period between 1984 and 2018 within Pubmed database. The search was limited to that time because the first reporting of MS was in 1983. The literature search strategy is available in Supplemental material.

Study selection criteria: The results of searches were uploaded in EndNote X7 software (Thomson Reuters, USA) for duplicates removal and article selection. Two researchers (SHBS and ABLQ) assessed the titles and abstracts following the inclusion criteria. The studies were classified as: I) include, II) exclude or III) uncertain. The complete articles of studies judged as uncertain or include were obtained for verifying eligibility. Inconsistencies were solved through discussion between the researchers and in case of disagreement, the opinion of another specialist was obtained. In the event of identification of the same study in different articles, the article with longer follow-up time was included. In additional, a hand

search was made in two published systematic reviews in this topic [9,10].

Data collection process

A standardized table was elaborated and used for data extraction. The following data were extracted: Author and year of publication; number of patients, gender, age, number of MS installed in each arch, number of failures, MS dimensions, region of the arch (buccal or lingual) and time of follow-up, time of load (immediately or delayed) and MS brand.

The data extraction was performed by one researcher and reviewed by another (SHBS and VPN).

Evaluation of effectiveness

The primary outcome evaluated was the number of MS failures.

Evaluation of the risk of bias

The risk of bias of randomized studies was evaluated with the Cochrane risk of bias tool, considering the judgement of the random sequence generation, allocation concealment, blinding of participants and personnel, blinding of the outcome assessment, incomplete outcome data, selective reporting [11]. The evaluation was completed by one researcher and reviewed by another researcher. Publication bias was not assessed due the small number of included studies.

Data synthesis

A table was created to summarize included studies. When enough data were available, comparisons between failures in maxilla and mandible were estimated using pairwise meta-analysis to calculate the relative risk (RR) of failure considering 95% confidence intervals with a random-effect model. The statistical heterogeneity was evaluated with the Chi2 test and the I2 statistic. A forest plot was used to present the results of meta-analysis. A summary finding was created presenting the results of meta-analysis, the total number of MS installed, total number of participants and the quality of evidence.

Evidence evaluation

The evidence was interpreted according to the Grading of Recommendations Assessment,

Development and Evaluation (GRADE) approach. [12] The assessment involves consideration within study risk of bias, directness of evidence, heterogeneity, precision of treatment estimates and risk of publication bias.

RESULTS

The PRISMA flow diagram is presented in Figure 1. Four studies [13-16] fulfilled the eligibility criteria and were included in the quantitative synthesis. Table I presents the characteristics of included studies, patients and miniscrews.

Regarding the patients observed in included studies, 208 were female and 91 were male, with 370 MS installed in maxilla and 258 in mandible (n=628). All studies were conducted in universities, three studies presented a follow-up of 6 months, except one presenting 15 months of follow-up. When considering load protocol, only one study applied delayed load.

Several characteristics related to MS macrogeometry were also reported by authors. Different brands, shapes, lengths and diameters were used among the included studies, where two studies used AbsoAnchor miniscrews, with different measures and different load forces. Also, only one study installed MS in buccal and lingual sites, the other three installed only at buccal site.

Results of the meta-analysis is presented in Figure 2. The analysis showed a RR of 0.55 (95% CI 0.23–1.29) and I2=85%. However, although no statistically significant difference was found, it is possible to verify that installing MS in maxilla reduces the risk of failure in 45%.

Risk of bias and GRADE assessment

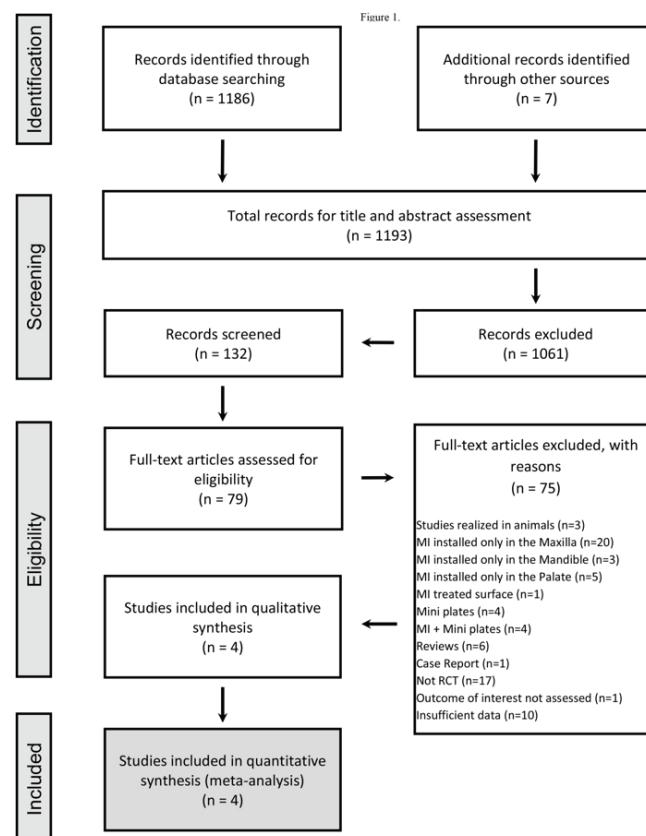
All studies had an unclear risk of bias regarding the following items: allocation concealment, blinding of participants and personnel and a low risk of bias with regard to incomplete outcome data and selective reporting (Figure 3). Based on the GRADE assessment, the evidence was classified as very low because of the limitations in the design and implementation, indirectness of evidence and imprecision of the results related to a wide confidence interval of the estimate (Table II).

Table I - Characteristics of included studies.

Author/ year	Number of participants Female (F) Male (M)	Age of included patients	Clinical Setting	Total number of MS* (failure)	MS Maxilla (failure)	MS Mandible (failure)	MS dimensions (mm)	Number buccal/ lingual/	Applied Force	Follow-up (months)	Immedi- ately or Delayed loaded	MS Brand
Wiechmann et al, 2007	49 36 (F) 13 (M)	26.9 mean age range (13-46)	University	133 (31)	90 (12)	43 (19)	Diam: 1.1 and 1.6 mm Length: 5, 6, 7, 8 and 10 mm	57 (Buccal) 55 (Lingual)	100/200 g	6	Immediately	AbsoAnchor and Dual Top
Suzuki et al, 2013	105 75 (F) 30 (M)	20.9 mean age range 13.1–32.4	University	186 (27)	122 (8)	64 (19)	Diam: 1.3 mm Length: 5, 6 and 7 mm	Only buccal	50-100 g	6	Immediately	AbsoAnchor
Yoo et al, 2014	132 89 (F) 43 (M)	25.3 mean age range 17-33	University	227 (42)	110 (23)	117 (19)	1.5 x 7 mm	Only buccal	200-250 g	15	Immediately	Biomaterials Korea
Garfinkle, 2008	13 8 (F) 5 (M)	14.8 mean age range (12-18)	University	82 (24)	48 (14)	34 (10)	1.6 x 6 mm	Only buccal	150-250 g	6	Delayed	Osteomed

Table II - Summary findings and quality assessment.

Clinical situation: Miniscrews installed in maxilla and mandible Population: Patients undergoing orthodontic treatment requiring miniscrew intervention				
Outcome	Relative risk (CI 95%)	Number of miniscrews	Number of participants	Quality of evidence (GRADE)
Failure of miniscrew	0.55 (0.23 - 1.29)	628	299 patients (4 studies)	Very Low

**Figure 1** - Flowchart of study selection.

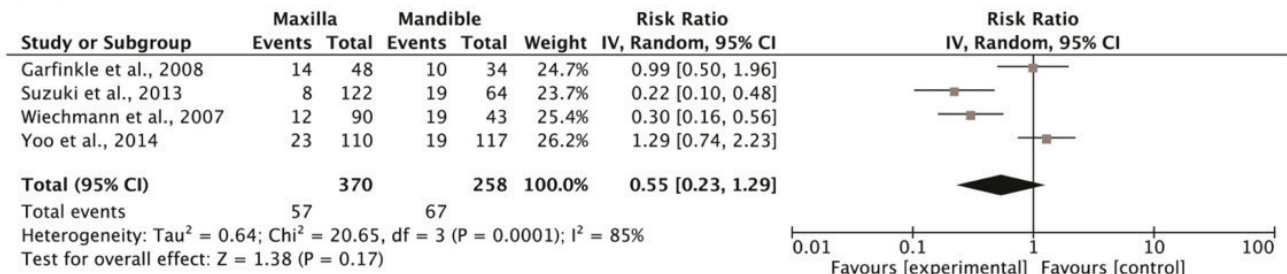


Figure 2 - Forest plot comparing the risk ratio of failure in maxilla and mandible.

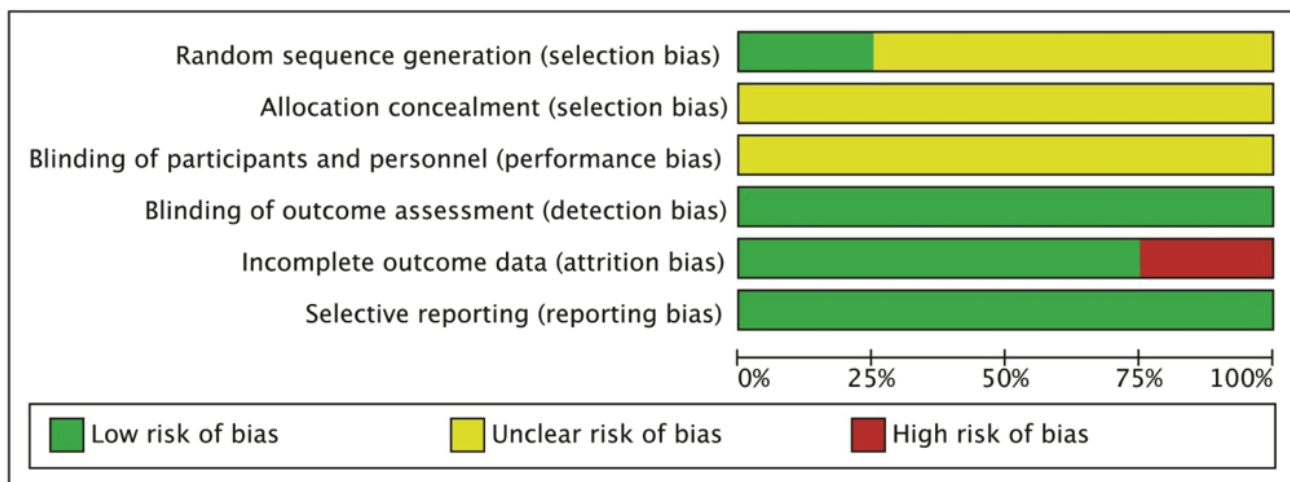


Figure 3 - Review authors' judgements about each risk of bias item presented as percentages across all included studies.

DISCUSSION

This study compared the failure rates of orthodontics MS installed in maxilla and mandible. Our results did not present statistical significance between the maxilla and the mandible; however, it is possible to verify that installing MS in maxilla reduces the risk of failure in 45%. An important factor to be considered related to the placement location of MS is the range of attached gingiva. If the MS is installed in a free gingival area, the movement of the surrounding peri-implant tissue may cause local inflammation, edema, leading to mobility and loss of the TAD [17]. Thus, a possible explanation for the higher unfavorable result in MS installed in the mandible could be the lack of an adequate attached gingival area. Also, the results could be related to the cortical bone present in mandible, where vascularization may be insufficient, resulting in bone necrosis and

loss of MS [18].

The results of a recent systematic review demonstrated a minimal effect of jaw of insertion on the failure rate but with a clear tendency of higher number of failures in mandible. Our systematic review corroborates the previous study. Yet, the study of Alharbi et al., [11] included different study designs and we included only randomized controlled trials that assessed the performance of MS under ideal and controlled circumstances. Also, considering the systematic reviews in that topic, our study is the first to use the GRADE approach to define the quality of body of evidence. Although it seems that including four studies to perform a meta-analysis would be insufficient, the number of MS tested was high, which may present a clear performance result for the studied outcome.

Several factors described in the

literature could affect the success or failure of the MS. Two recent systematic reviews [9,10] demonstrated that the implant geometry parameters, properties of the insertion site, the type of gingivae and smoking habit could influence the clinical performance of MS. From our included studies, two of them assessed different MS lengths [14,15] and only one compared different diameters [14]. Despite MS length data being reported as a variable, it was not addressed as an outcome in Wiechmann et al. [16] study, and success rates favored 6-7 mm MS over 5 mm in the Suzuki et al. [15] study. Moreover, regarding the diameter, the comparison between 1.1 and 1.6 mm MS resulted in higher success for larger diameter devices (87% vs 69.6%). However, is important to state that different brands were used for this comparison and assumptions of the best choice for MS diameters should be carefully considered based on this.

Another comparison tested was the site of MS placement, where buccal and lingual/palatal MS were evaluated for success rates at Wiechmann et al. [16] study. As results, lingually placed MS presented the lower survival rates when compared with the buccal MS in the same jaw. Although randomization was carried out in all included studies, some factors assessed were not randomized, like the buccal/lingual placement site of MS. Therefore, we encourage the conduction of well-designed clinical trials, especially considering the randomization of any outcome of interest, since there are several systematic reviews about this topic and few clinical studies with reliable data to support this evidence.

The high heterogeneity demonstrated could be related to the included studies, as they present different methods such as testing different MS systems, lengths, geometries and loading protocols. In addition, the evidence was classified as very low with most studies included presenting unclear risk of bias related to randomization aspects, making difficult to reach solid implications for clinical practice. Thus, no differences in the risk of failure of MS

between maxilla and mandible were observed. However, the estimative showed that installing MS in maxilla reduces the risk of failure, what could lead to longer retention and less time to achieve desirable orthodontic movement. Nonetheless, the results of the meta-analysis should be interpreted with caution because of the very low quality of included studies, a high heterogeneity and a wide confidence interval.

Beyond that, included studies have important limitations related to design, conduction and reporting. Further researches comparing the success of MS in mandible and maxilla with longer follow-up and considering risk factors are still necessary. Also, better reporting related to randomization process and blinding of participants and personnel are essential.

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