PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ

ESCOLA DE CIÊNCIAS DA VIDA
PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA
ÁREA DE CONCENTRAÇÃO CLÍNICA ODONTOLÓGICA INTEGRADA

PAOLA MARQUES DE MATTOS

REVISÕES SISTEMÁTICAS E META-ANÁLISES:

ASPECTOS PERIODONTAIS EM DENTES TRACIONADOS ORTODONTICAMENTE E

FATORES DE RISCO ASSOCIADOS A ESTABILIDADE DE MINI-IMPLANTES E MINI-PLACAS

Curitiba
2021

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Tese apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos para obtenção do título de Doutor em Odontologia, Área de Concentração em Clínica Odontológica Integrada (Ênfase em Periodontia).

Orientador: Prof. Dr. Odilon Guariza Filho
Coorientador: Prof. Dr. Cristiano Miranda de Araújo

Curitiba
2021

Dados da Catalogação na Publicação
Pontifícia Universidade Católica do Paraná
Sistema Integrado de Bibliotecas – SIBI/PUCPR
Biblioteca Central
Edilene de Oliveira dos Santos CRB-9/1636

M444r 2021

Mattos, Paola Marques de
Revisões sistemáticas e meta-análises : aspectos periodontais em dentes tracionados ortodonticamente e fatores de risco associados a estabilidade de mini-implantes e mini-placas / Paola Marques de Mattos ; orientador: Odilon Guariza Filho ; coorientador: Cristiano Miranda de Araújo. -- 2021
132 f. : il. ; 30 cm

Tese (doutorado) – Pontifícia Universidade Católica do Paraná, Curitiba, 2021.
Inclui bibliografias

1. Odontologia. 2. Dente impactado. 3. Movimentação dentária. 4. Procedimentos de ancoragem ortodôntica. 5. Implantes. 6. Estabilidade. I. Guariza Filho, Odilon. II. Araújo, Cristiano Miranda de. III. Pontifícia Universidade Católica do Paraná. Programa de Pós-Graduação em Odontologia. IV. Título

CDD. 20. ed. – 617.6

PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ
Escola de Ciências da Vida
Programa de Pós-Graduação em Odontologia

TERMO DE APROVAÇÃO

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Curitiba, 10 de setembro de 2021.

AGRADECIMENTOS

À Deus, por ser tão essencial na minha vida, onipresente.

À minha família, em especial meus pais e irmãs Bianca e Giovanna, e meu namorado Ayrton, por acreditarem em mim e incentivarem sempre a lutar pelos meus sonhos.

Ao orientador deste trabalho de tese Prof. Dr. Odilon Guariza Filho, por todo o auxílio e dedicação durante estes 4 anos de Doutorado.

Ao coorientador Prof. Dr. Cristiano Miranda de Araújo, essencial seu auxílio e coorientação para que a realização desse trabalho fosse possível.

Ao Programa de Pós-Graduação em Odontologia da PUCPR – PPGO, pela concessão da isenção da mensalidade pelo prêmio Marcelino Champagnat para que pudesse cursar o Doutorado, incluindo a coordenadora do programa Prof. Dra.Luciana Alanis Reis de Azevedo e a funcionária da secretaria Neide.

Aos meus colegas de profissão e de doutorado, por todo o companheirismo e apoio constantes.

A todos os que direta ou indiretamente auxiliaram na minha formação moral e profissional.

SUMÁRIO

RESUMO

Objetivo: O objetivo desse trabalho foi responder através da realização de duas revisões sistemáticas as seguintes perguntas: “Como são os aspectos periodontais em dentes tracionados ortodonticamente?” e “Quais são os fatores de risco associados à estabilidade de mini-implantes e mini-placas?”. *Material e Métodos:* Estratégias de busca foram desenvolvidas para cada base de dados eletrônica: PubMed/Medline, LILACS, Scopus, Web of Science, Embase e Cochrane Library; e na literatura cinzenta: Google Scholar, Proquest e Open Grey. Meta-análises de efeitos aleatórios foram realizadas na primeira revisão sistemática, e meta-análises e meta-regressões de efeitos aleatórios foram realizadas para os desfechos de interesse na segunda revisão. *Resultados:* O total de 2.082 e 1.517 artigos foram encontrados, sendo 24 e 7 selecionados respectivamente para a realização da síntese qualitativa das duas revisões sistemáticas. Os dentes impactados apresentaram valores significativamente maiores nos índices gengival e profundidade de sondagem, comparados com os dentes contalaterais não tratados. Quando comparado o risco de a falha entre mini-implantes e mini-placas, é signiticativamente maior nos mini-implantes, e a instalação de dispositivos em mandíbula também apresentou de forma significativa maior risco de falha. *Conclusões:* As evidências encontradas na literatura indicam que dentes tracionados apresentaram piora nos parâmetros periodontais relacionados a índice gengival e profundidade de sondagem, contudo, a profundidade de sondagem deve ser ponderada quanto ao seu significado clínico, devido ao pequeno tamanho de efeito observado. A falha na estabilidade dos DATs está relacionada com o tipo de dispositivo e o local da instalação, com maior risco para utilização de mini-implantes isolados e quando posicionados em mandíbula. O tipo de movimento ortodôntico e higiene ao redor dos dispositivos podem agir como um fator de confusão não relatado pelos estudos incluídos, diminuindo a certeza de evidência deste desfecho.

Palavras-chave: dente impactado, tracionamento, dispositivos de ancoragem temporária, estabilidade.

INTRODUÇÃO GERAL

As revisões sistemáticas são essenciais para toda a comunidade científica, que de outra forma seria confrontada por um volume avassalador de pesquisas para basear suas decisões(1). Em conjunto com a metanálise, são os métodos atualmente mais adequados para sintetizar evidências quanto a eficácia e os efeitos de intervenções. Possibilita uma análise mais objetiva dos resultados, facilitando uma síntese conclusiva sobre determinada intervenção(2). Esse tipo de estudo busca reunir evidências que se enquadrem nos critérios de elegibilidade pré-estabelecidos e responder a uma pergunta de pesquisa específica. A sistematização visa apontar e minimizar o viés dos estudos existentes, utilizando métodos explícitos documentados com antecedência com um protocolo(3).

Impacção dentária é uma condição que pode variar na população em geral entre 0,8 e 3,6%(4,5), estima-se que na faixa etária de 15 a 19 anos, excluindo terceiros molares, 1,65% dos pacientes possuem algum dente impactado(6). A falta de um diagnóstico precoce em relação aos dentes impactados pode trazer sérios danos, como reabsorção dos dentes adjacentes, problemas estéticos, bem como alterações periodontais que podem levar a perda do dente (7,8). Alguns mecanismos ortodônticos podem ser utilizados para que ocorra a erupção espontânea, mas quando esta não ocorre mesmo após o ganho de espaço, pode ser optado pelo tracionamento ortodôntico(9).

O estado periodontal é um indicador de sucesso no tratamento de dentes impactados(10), contudo, algumas complicações podem ser observadas após o tratamento, como recessão gengival, doença periodontal, inflamação gengival e perda óssea alveolar e/ou de gengiva inserida(11). A estrutura anatômica do tecido mole que recobre o dente impactado é um dos principais fatores que determinam a chance de o método de exposição cirúrgico funcionar, pelo fato de que o tratamento ortodôntico-cirúrgico deverá estimular um padrão de erupção natural do dente impactado através da gengiva inserida(12).

Os dispositivos de ancoragem temporária (DATs) são amplamente utilizados na mecânica ortodôntica de forma a expandir o limite da movimentação dentária através da ancoragem esquelética(13-16). Os DATs são uma alternativa de tratamento útil em maloclusões complexas, principalmente com discrepâncias

verticais, como em casos de mordida aberta e extrusões dentárias pela perda do dente antagonista(17-22).

Estudos utilizando mini-placas para ancoragem esquelética têm mostrado a diminuição de efeitos dentários indesejáveis e grandes efeitos esqueléticos(23-26), com diminuição expressiva no tempo de tratamento utilizando em pacientes com maloclusões Classe III de Angle(26). Os mini-implantes também podem fornecer ancoragem esquelética para a movimentação ortodôntica(23,27), apresentando maior facilidade em sua inserção ou remoção, além de menor custo(23,28). Contudo, a estabilidade dos DATs depende do travamento mecânico que ocorre no tecido ósseo, diferente dos implantes dentários cuja estabilidade principal está diretamente relacionada ao processo de osseointegração. Esta estabilidade mecânica possibilita ao dispositivo suportar a movimentação dentária sem necessitar de períodos de cicatrização(13, 29, 30). Alguns fatores de risco podem estar associados a perda da estabilidade, como o tipo de dispositivo, diâmetro do parafuso e presença de inflamação no tecido mole ao redor do dispositivo(31).

Uma meta-análise avaliou os aspectos periodontais profundidade de sondagem e recessão gengival entre caninos impactados por palatina comparados com caninos contralaterais e não encontraram diferença estatística (32). Contudo, não foi encontrado até o presente momento nenhuma revisão sistemática que aborde os parâmetros periodontais envolvendo diferentes grupos de dentes tracionados. Sendo assim, justifica-se a realização de uma revisão sistemática sobre o assunto, uma vez que outros dentes além dos caninos, podem ser acometidos de impacção. Também não foram encontradas revisões sistemáticas que abordaram fatores de risco associados à estabilidade de mini-implantes comparados a mini-placas, apenas revisões envolvendo dados isolados em relação a estes dispositivos (27,31, 33-38), justificando a realização de uma revisão sistemática sobre o assunto. Desta forma, o objetivo desta primeira revisão sistemática foi responder a seguinte questão focada: “Como são os aspectos periodontais em dentes tracionados ortodonticamente?” e o objetivo do segundo estudo foi responder a seguinte questão focada: “Quais são os fatores de risco associados à estabilidade de mini-implantes e mini-placas?”

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ARTIGO 1 – VERSÃO EM INGLÊS (submetido no periódico Clinical Oral Investigations – Qualis A1/IF 3.573)

Periodontal aspects in orthodontically tractioned teeth: systematic review and meta-analysis

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Abstract

Objective: This systematic review aims to answer the following question: “What are the periodontal aspects of orthodontically tractioned teeth?” *Material and methods:* Search strategies were developed for each of the following electronic databases: PubMed/Medline, LILACS, Scopus, Web of Science, Embase, and Cochrane Library. Moreover, a search of gray literature was conducted using Google Scholar, ProQuest, and Open Grey. Random effects meta-analyses were performed for the outcomes of interest. Risk of bias was assessed using the Cochrane Collaboration’s tool for assessing risk of bias and the Meta-Analysis of Statistics Assessment and Review Instrument. The certainty of the evidence was assessed using the GRADE approach. *Results:* A total of 2082 articles were found, 24 of which were selected for qualitative synthesis. Gingival index analysis showed a significant difference between impacted and contralateral teeth, with higher values of this index in impacted teeth [MD = 0.25; CI 95% = 0.10 – 0.40; I^2 = 0%]. Impacted teeth showed greater probing depth, with a statistically significant mean difference between groups [MD = 0.14; CI 95% = 0.07 – 0.20; I^2 = 6%]. Most studies had a low risk of bias; however, the certainty of the evidence is still very low due to the design of existing studies. *Conclusions:* Literature evidence indicates that tractioned teeth showed worsening in the periodontal parameters of gingival index and probing depth. Notwithstanding, probing depth should be considered in terms of its clinical significance due to the small effect size observed. *Clinical relevance:* These results provide greater safety to the clinician, revealing important information for establishing the prognosis in these cases.

Keywords: impacted tooth; ectopic eruption; unerupted tooth; traction.

Introduction

Dental impaction is a condition that can affect from 0.8 to 3.6% of the general population [1, 2]. Estimates show that 1.65% of patients in the age group 15-19 years have an impacted tooth, excluding third molars [3]. The most recurrent impacted teeth are, respectively, third molars (16.7%), upper canines (2.8%), lower premolars, and upper central incisors (both with 2.6%). This condition is more frequent in women [3-7]. The main causes of impactions correlate with primary factors, including the degree of root resorption of the deciduous tooth, trauma to the tooth germ, changes following eruption, reduced space in the dental arch, rotation of the impacted tooth, and premature closure of root apexes. Secondary factors such as abnormal muscle pressure, vitamin D deficiency, endocrine disturbances, and fever are also among the causes of impaction [8].

Lack of an early diagnosis of impacted teeth can cause serious damage, including resorption of adjacent teeth, aesthetic problems, and periodontal changes that can lead to loss of the dental element [9, 10]. Dentists can apply orthodontic mechanisms for spontaneous eruption, but when this eruption does not occur even after space is gained, the professionals can choose to apply orthodontic traction [11]. The function of orthodontic treatment is to align the impacted tooth on the dental arch, reducing possible periodontal complications and maintaining the integrity of the supporting tissues [12]. Loss of support leads to the formation of a periodontal pocket, resulting in gingival recession [8].

Periodontal status is an indicator of success in the treatment of impacted teeth [13]. However, some complications may occur after treatment, such as gingival recession, periodontal disease, gingival inflammation, and bone loss in the alveolus and/or inserted gingiva[14]. The anatomical structure of the soft tissue overlying the impacted tooth is one of the main factors that determines whether the surgical exposure method will work, as the orthodontic-surgical treatment should stimulate a natural eruption pattern of the impacted tooth through the gum inserted [15].

A meta-analysis comparing periodontal aspects (probing depth and gingival recession) between palatal impacted canines and contralateral canines found no statistical difference [16]. However, to date, there is no systematic review addressing periodontal parameters involving different groups of tractioned

teeth, nor assessing whether there is heterogeneity between results according to the group of teeth included in the analysis. This justifies a systematic review on the subject since teeth other than canines may be affected by impaction. Thus, this systematic review aims to answer the following focused question: “What are the periodontal aspects of orthodontically tractioned teeth?”

Material and methods

This systematic review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) checklist [17].

Eligibility criteria

For the eligibility of studies to be included/excluded from this review, the acronym “PICOS” was used:

- Population (P) – Patients with impacted teeth
- Intervention (I) – Orthodontic traction
- Comparison (C) – Teeth with normal eruption (contralateral)
- Outcomes (O) – Periodontal aspect (gingival recession, probing depth, plaque index, gingival index, keratinized mucosa width)
- Study design (S) – Randomized, pseudorandomized, or nonrandomized clinical studies, cross-sectional observational studies, cohort or case-control studies

Inclusion criteria

The present study included studies in which the sample consisted of patients undergoing treatment for orthodontic-surgical traction of impacted teeth, regardless of the tooth group. There was no restriction on the type of malocclusion, gender, and age. There was also no restriction on the study language and publication time.

Studies that evaluated the following periodontal parameters were included:

a) Gingival recession: distance between the cementoenamel junction (CEJ) and the gingival margin, with the gingival margin located apically to the

cementoenamel junction being positive, and the gingival margin located coronally to the cementoenamel junction being negative[18].

b) Probing depth: periodontal pockets are measured from the level of the free gingival margin to the bottom of the pocket[8].

c) Periodontal attachment level: measurement that involves the probing depth and the distance between the gingival margin and the cementoenamel junction. In cases of gingival recession, the clinical attachment level should be calculated as follows: clinical attachment level = periodontal probing depth + gingival recession[19].

d) Plaque index: tooth faces are classified with a score from 0 to 3 according to the method described by Silness and Loe [20].

e) Gingival index: tooth faces are classified in the same way as the score from 0 to 3 used to calculate the plaque index [20].

f) Gingival bleeding index: the presence or absence of bleeding is checked after periodontal probing using the method described by Carter and Barnes [21].

g) Keratinized mucosa width: measured from the distance between the gingival margin and the mucogingival junction[3].

Randomized and nonrandomized controlled clinical trials were included. Cohort, case-control, and cross-sectional studies were also included.

Exclusion criteria

The following exclusion criteria were applied:

- Studies in animals or including patients with associated syndromes;
- Studies in which at least one of the variables has not been evaluated;
- Reviews, letters, conference abstracts, expert opinions, case reports, and case series.

Information sources and Search strategy

Appropriate word combinations and truncations were selected and adapted for each database search.

Search strategies were developed specifically for each of the following electronic databases: PubMed/Medline, LILACS, Scopus, Web of Science,

Embase, and Cochrane. In addition, a search of gray literature was conducted using Google Scholar, ProQuest, and Open Grey (appendix 1).

Finally, a manual search of the references of the included studies was performed, and an expert on the subject was consulted to verify any possible publication on the subject. EndNote® software (EndNote® X7 Thomson Reuters, Philadelphia, PA) was used to manage and remove duplicate references.

Selection process

The selection of articles was carried out in two phases. In phase 1, two reviewers (P.M.M. and I.B.B.) independently reviewed the titles and abstracts of all references. All articles that did not meet the inclusion criteria were excluded. In phase 2, the same reviewers performed the complete reading of the selected articles, independently. In case of disagreement, and when this was not resolved through discussion between the first and second reviewers, a third author (C.M.A.) was involved for the final decision.

To blind the reading of references and guarantee independence and confidentiality in both phases, the Rayyan website (http://rayyan.qcri.org) was used. Reviewers were blinded in all evaluations, in which a member of the team (C.M.A.), who did not participate in the selection, acted as moderator.

Data collection process

Two reviewers (P.M.M. and I.B.B.) collected information from the included studies, and this information was discussed. The data collected consisted of: study characteristics (author, year of publication, country, study design), population characteristics (sample size, age), evaluation characteristics (composition of control and experimental groups, surgical technique, number of evaluators, parameters of interest, outcome assessment method, index used for assessment), characteristics of the results (results presented in relation to the outcome), and main conclusions.

In case of missing or incomplete data in the article, attempts were made to contact the authors to obtain pertinent unpublished information. Three attempts were made to contact the first author, the corresponding author, and the last author of the article, and the time interval between attempts was one week. In case of no response, the article was excluded with due justification.

Data items

Mean, standard deviation, and sample size values for each group were extracted from the studies included in the synthesis, when available. For the variable probing depth, in the absence of the mean value, when more than one site was measured, the mean of the values between the measured sites was calculated. When standard deviation values were not reported, and there was no description of any measure of variability that would allow its calculation, the value from the study with the greatest variance within the analysis was then imputed. This produced a more conservative result, decreasing study weight and generating a broader confidence interval.

Assessment of risk of bias

The methodology of the selected observational studies was evaluated using the risk of bias tool Meta Analysis of Statistics Assessment and Review Instrument (MASTARI) [22]. Risk of bias was categorized as “high” when the study had “yes” scores lower than 49%; “moderate” when the study presented between 50% and 69% of “yes” scores; and “low” when the study presented more than 70% of “yes” scores for the risk of bias questions.

For interventional studies, the Cochrane Collaboration’s tool for assessing risk of bias was used [23]. This tool covers seven domains: random sequence generation, allocation concealment, blinding of participants and professionals, blinding of outcome evaluators, incomplete outcomes, selective outcome reporting, and other sources of bias. The judgment as to the possible risk of bias in each of these domains was made based on the information extracted from the study, and they were classified as “high risk” or “low risk” of bias. In case the study did not report enough details, risk of bias was judged to be “not clear” and the authors of the original study were contacted for more information. These judgments were performed by two independent reviewers (P.M.M. and I.B.B). Disagreements were first resolved by discussion; in case of lack of consensus, the third reviewer (C.M.A) was consulted to make a final decision.

Effect measures

As the evaluated outcomes are continuous, reported in the same measurement scale, the mean difference (MD) was calculated.

Synthesis method

A random effects meta-analysis method using the statistical softwares RStudio version 1.2.1335 (Rstudio Inc, Boston, USA) and Stata version 16.0 (Stata Corp LLC, College Station, USA) was performed, with the studies weighted by the inverse variance method. Heterogeneity was calculated by the inconsistency index (I^2), and variance by Tau^2, estimated by the DerSimonian-Laird method; 95% confidence intervals were generated (CI 95%) and the significance level was set at 5%.

When extreme effect sizes were found as a source of heterogeneity within the analysis, the Leave-one-out method was performed, recalculating the global effect estimate k - 1 times, with the respective confidence intervals and I^2 values. This was performed by omitting one study at a time, thus assessing whether the influence of any study has distorted the combined effect estimate [24].

Reporting bias assessment

The graphic evaluation of the existence of publication bias was performed using the funnel plot, in addition to the Egger test to assess the existence of asymmetry in the funnel.

Certainty of evidence

The certainty of the evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tool [25] in all domains of risk of bias, consistency, openness, accuracy, and publication bias. The certainty of evidence was judged as high, moderate, low, or very low.

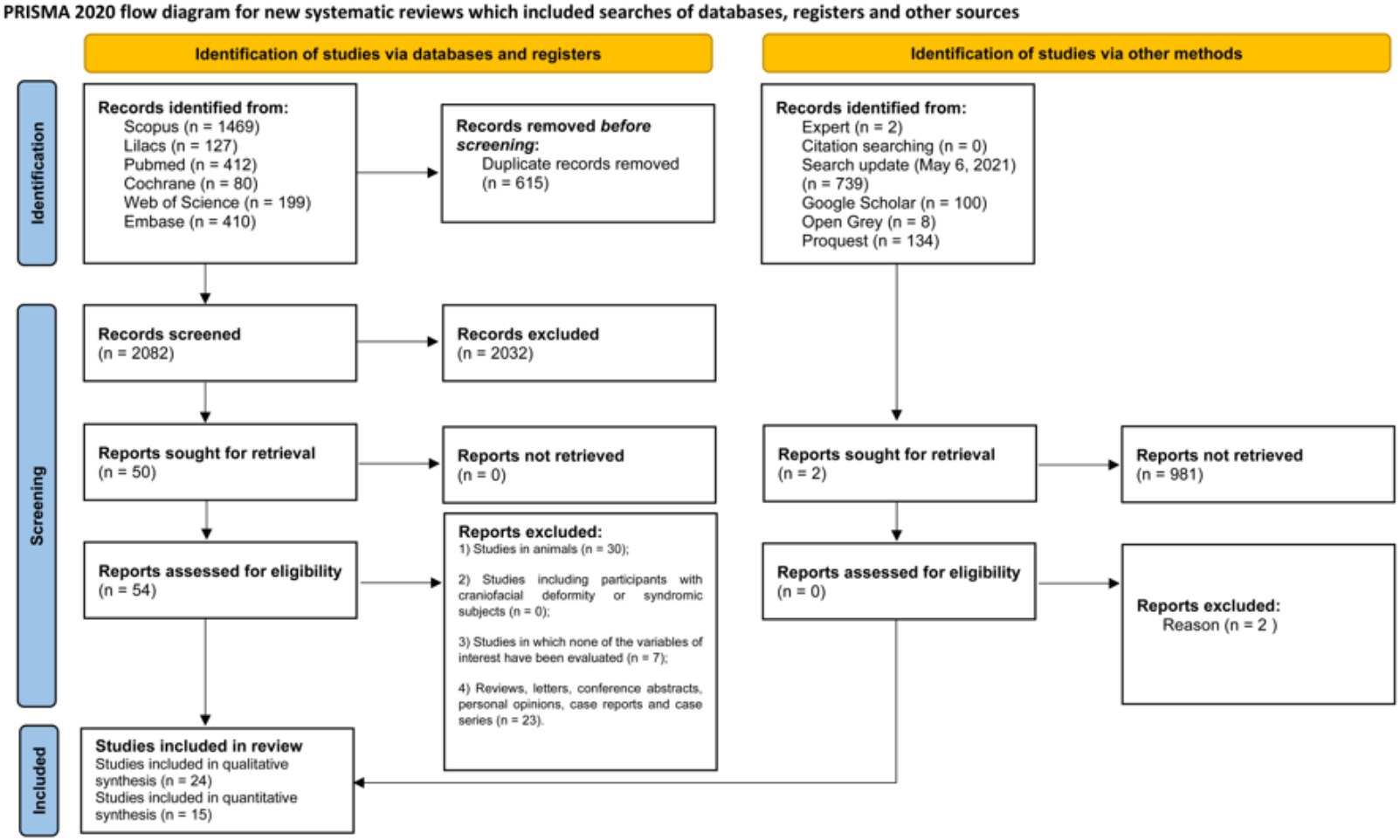
Results

Study selection

Through the elaborated research strategy, a database search was conducted, totaling 2697 articles. Excluding duplicate articles, 2082 articles were

selected for title and abstract reading. Of these articles, 54 were selected for full reading (phase 2), of which 30 were excluded (appendix 2), resulting in 24 articles for qualitative synthesis (Fig. 1).

Figure 1 - Flowchart of literature search and selection criteria



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

1

Study characteristics

Among the articles included, 23 studies were published in English and only 1 article was published in Portuguese, with the following countries as sources: Brazil, Belgium, Canada, Korea, Spain, Israel, Italy, Lithuania, United Kingdom, Sweden, and Turkey, with the year of publication ranging from 1978 to 2019.

Sample sizes ranged from 11 to 271 patients, with ages ranging from 11 to 52 years. The included studies that reported the gender of the samples showed a predominance of females.

As for study design, nineteen articles were classified as observational due to the absence of manipulation of the exposure factor, with 3 longitudinal prospective cohort and 16 cross-sectional studies. In addition to these, five clinical trials were included.

Twenty-one articles included assessed specific groups of dental elements treated orthodontically and submitted to traction; among these, eighteen studies evaluated upper canines and three articles evaluated upper incisors. Three articles evaluated groups of teeth, including maxillary incisors and canines, mandibular canines and premolars, canines and second premolars, and maxillary incisors and canines.

Regarding the type of surgical technique used in the articles included, twelve articles used the closed technique, six articles used the open technique, and six articles compared the closed and open techniques. All characterization data from the included studies are available in table 1.

Table 1 – Characteristics of the included studies (n=24)

Study, Author/Year (Country)	Title	Sample (gender, dental group)	Age (Median or Mean ± SD)	Surgical Technique	Results	Conclusions
Becker, A., et al., 2002 (Israel)	Closes eruption surgical technique forimpacted maxillary incisors: A postorthodontic periodontal evaluation.	21 patients (6 M, 15 F / Upper Central Incisor)	17.5	Closed	PI and GI without statistical significance. There was a statistical difference between the means of PD between and LC and contralateral (p=0.002) and without statistical significance between LI and contralateral. Significantly higher PD was observed on the distobuccal and lingual surfaces when compared to the teeth alone.	It concludes a good long-term aesthetic result from the treatment of incisors impacted by traction in technique, even reporting statistical difference in some periodontal parameters.
Becker, A., et al., 1983 (Israel)	Periodontal status following the alignment of palatally impacted canine teeth	23 patients (9 M, 14 F / upper canine)	12.48±2.21	Closed	PI without statistical significance. There was statistical significance in GI and PD, greater in treated canine.	It is concluded that the parameter that clearly needs more attention is the loss of greater bone support in the treated region, assessed radiographically.

Bollero, P., et al., 2017 (Italy)	Long-term periodontal status f palatally and buccally impacted canines after closed surgical -orthodontic approach	28 patients (14 canines impacted with palatine 6M 8 F / 14 canines impacted with vestibular - 7 M, 7 F)	13.5 ±1.4	Closed	Canines impacted by palatine with PD significantly higher in the mesiopalatine. No statistical significance in KMW, PI, GBI and GR. In canines impacted by vestibular there was a significant increase in KMW. No statistical difference for PD, PI, GBI and GR. The palatal impacted canines showed significantly higher PD in the mid-vestibular region and in all the palatal regions compared to the buccal impacted canines. No statistical difference for KMW, PI and GBI and GR.	It was concluded that after ortho-surgical treatment, there was no statistical periodontal difference after treatment in palatal impacted canines. Canines impacted by paatina showed greater probing depth in the lingual regions than those impacted by vestibular. Despite the statistical significance in some parameters, they did not show great clinical significance.
Caminiti, M.F., et al., 1998 (Canadá)	Outcomes of the surgical exporure, bonding and eruption of 82 impacted maxillary canines	54 patients (82 canines, 60 impacted with palatine and 22 impacted with vestibular /23 M 31 F)	14 years	Open/Closed	Three canines with PD greater than 3mm. The cases presented with approximately 3mm of KMW, only two canines impacted by vestibular presented 1mm of KMW. They evaluated the prevalence of cases, without analyzing the data statistically.	No conclusions about periodontal parameters, no quantitative data collected

Caprioglio, A., et al., 2013 (Italy)	Long-term periodontal response to orthodontic treatment of palatally impacted maxillary canines	33 patients (9 M, 24 F / upper canine impacted of palatine)	16.3±3.9	Closed	There was no clinical statistical difference for PD, only on the buccal aspect of the lateral incisor and the mesiopalatine aspect of the first premolar.	It was concluded that the use of a conservative surgical technique with light orthodontic force contributes to an adequate final periodontal state.
Cercadillo - Ibauguren, I., et al., 2011 (Spain)	Periodontal health and esthetic results in impacted teeth exposed by apically positioned flap technique	15 patients (5 M, 10 F / 12 UC, 2LC, 1UP)	16.8	Open	No statistical difference for PI, GI, GBI and KMW parameters. Significantly higher values for PD teeth in the palate (p=0.031) and lower values for GR (p=0.005).	It was concluded that it is possible to maintain periodontal health using the apically positioned flap technique to expose the impacted tooth.
Chaushu, S., et al., 2003 (Israel)	Periodontal status following surgical-orthodontic alignment of impacted central incisors with an open-eruption technique.	11 patients (4 M, 8F / upper central incisor)	22	Open	Statistical difference in the parameters PI, GI, PD (p=0.01) mesiobuccal (p=0.005), with higher values in tractioned incisors.	It was concluded that orthodontic alignment of LC impacted by open technique is accepted in orthodontic resolution. Negative aesthetic and periodontal effects on the treated tooth must be considered. Long-term stability and post-treatment periodontal health should be monitored.

Chaushu, S., et al., 2009 (Israel)	Periodontal Status of Impacted Maxillary Incisors Uncovered by 2 Different Surgical Techniques	22 patients (open technique group 11 patients 4 M, 7F / closed technique group 11 patients 3 M, 8 F / upper central incisor)	21.5	Open/Closed	No statistical difference in the parameters of interest.	It was concluded that comparing the two surgical exposure techniques, the closed technique produces a superior result in terms of periodontal prognosis and final appearance.
Crescini, A., et al., 1994 (Italy)	Tunnel traction of infraosseous impacted maxillary canines. A three-year periodontal follow-up.	15 patients (upper canine, tractioned group - 7 impacted with vestibular and 8 impacted with palatine - and group of canines not tracted / 4 M, 11 F)	14.8±1.6	Open	T1: significantly higher KMW and PD also in 3 regions (MV, DV, DP) in the pulled canines. T2: PS significantly lower in canines pulled only in the MV region. No statistical difference for KMW. Comparing T1 and t2: There was a significant decrease in PD and KMW in both groups, more pronounced in the traction group (3 regions in the control group did not give statistical significance MV, DV, DP). Assessing the mean created by the decrease in the parameters of the two groups, there was a statistical difference in PD in the MV and DV regions in the KMW.	It was concluded that after the canine traction procedure - impacted both by buccal and palatal - using the repositioned flap and tunnel-type traction, no change in insertion levels, no GR and adequate amount of gingiva can be obtained and maintained in teeth treated for at least 3 years after treatment. Although they showed statistical differences in the PD and KMW parameters, they are clinically insignificant (<1mm).

Crescini, A., et al., 2007 (Italy)	Short- and long-term periodontal evaluation of impacted canines treated with a closed surgical-orthodontic approach	125 patients (31 M, 94F) 58 patients on follow-up (23 M, 35 f M / Upper canine)	16.9±5.9	Open	T1: PD with statistical difference considering the side of the tooth in the pulled canine and with higher values in the interproximal ones ($p<0.0001$). There was a statistical difference in the KMW, greater in the pulled canines ($p=0.0028$). T2: statistically significant difference in the group under traction in the PD, with higher values in the interproximal ones ($p<0.0001$). There was a statistical difference in theKMW, being higher in the traction group ($p=0.0002$).	It was concluded that the combined surgical-orthodontic technique (flap approach associated with direct orthodontic traction towards the center of the alveolar crest) favorably resulted in a correct alignment of the repositioned canine in the dental arch associated with an adequate amount of gingiva and probing depth physiological.
Crescini, A., et al., 2007 (Italy)	Orthodontic and periodontal outcomes of treated impacted maxillary canines.	168 patients (118 UC impacted wih palatine and 50 UC impacted with vestibular / 40 M, 128 F)	17.2±6	Open	PD significantly higher in canines impacted by the palate than by the vestibular one ($P=0.04$). There was no statistical difference inKMW values.	It was concluded that the pretreatment radiographic characteristics assessed on panoramic radiographs are useful indicators for the duration of orthodontic traction, however, they are not valid predictors of the final periodontal status of impacted canines that have been orthodontically repositioned.

Crescini, A., et al., 2007 (Italy)	Pre-treatment radiographic features for the periodontal prognosis of treated impacted canines	168 patients (155 UC impacted with palatine and e 56 UP impacted with vestibular / 40 M, 128 F)	17.39±6.04	Open	PD significantly higher in interproximals ($p<0.0001$). KMW significantly higher in cases of impaction by the palate than by the vestibular ($p=0.0149$).	It was concluded that pretreatment radiographic characteristics aimed at defining the position of the canine on a panoramic X-ray are not valid predictors of the final periodontal status of impacted canines treated by the surgical-orthodontic approach.
Evren, A. D., et al., 2014 (Turkey)	Periodontal status of ectopic canines after orthodontic treatment	30 patients (Upper canine 15 impacted with palatine and 15 impacted with vetibular / 9 M, 21 F)	11.3 ±1.45	Closed/conventional orthodontics techniques	In canines impacted by the palate (treated by the closed technique), PD was significantly higher compared to untreated contralateral ones ($p<0.01$). in the vestibular impacted canines (treated with conventional orthodontic techniques), there was an increase in PI($p<0.01$) ISG ($p<0.01$) and PD compared to the control group ($p<0.05$).	It was concluded that periodontal changes in palatal ectopic canines were in the form of increased probing depth. The buccal ectopic canines, on the other hand, pointed to an increase in the index of plaque and gingival bleeding and greater pocket depths.

Kohavi, D., et al., 1984 (Israel)	Periodontal status following the alignment of buccally ectopic maxillary canine teeth	29 patients (13 unilateral UC impacted with vestibular and 16 bilateral upper canine impacted with vestibular/ 12 M, 17 F)	CS unilaterais 12.72±1.6 / CS bilaterais 12.78±1.47	Closed	In unilateral cases, there was no statistical difference in PI, GI and PD compared to their contralateral ones. In bilateral cases, there was no statistical difference in PI. There was statistical difference in GI and PD, with higher values in the traction group compared to the control group ($p<0.05$).	It was concluded that the orthodontist is advised to be alert to the possibility, although apparently rare, of concluding the case and finding compromised periodontal support.
Landim, F. S., et al., 2010 (Brazil)	Avaliação clínico-radiográfica dos caninos após tratamento orto-cirúrgico	17 patients (ND, canines)	ND	ND	Prediction for females, left side and maxilla in relation to impacted canines. Four patients (23.5% of the sample) had GR associated with hypersensitivity.	It was concluded that orthodontic traction in the studied sample appears to be an effective, safe and reproducible procedure.
Lee, J. Y., et al., 2010 (Korea)	Labially impacted maxillary canines after the closed eruption technique and orthodontic traction: A split-mouth comparison of periodontal recession	54 patients (21 M, 33 F / canines impacted with vestibular)	12.85±3.5	Closed	There was a statistical difference in the variable KMW, smaller in the pulled canine ($p=0.04$). PD with statistical difference only in DP with higher value in the pulled canine ($p=0.04$).	It was concluded that the closed eruption technique exhibited slightly worse periodontal conditions in relation to the alveolar bone and gingiva in the pulled canine.

Odenrick, L. and T. Modeer, 1978 (Sweden)	Peridontal status following surgical-orthodontic alignment of impacted teeth	22 patients (11 patients group open technique, 11 patients group closed technique/ ND / Iincisors and upper canines)	13.6	Open/Closed	Attachment loss, evaluated by the PAL parameter, presented 1 case in the open technique group and 7 in the closed technique group. One patient out of 11 in the closed technique group and 7 out of 11 in the open technique group had GR. In the open technique group, 3 teeth presented on the buccal face and were positioned buccally, 3 on the lingual face of 5 that were positioned lingually. Of 3 cases positioned centrally, 1 presented GR. In the closed technique group, the only case that presented GR had a vestibular position.	It was concluded that the surgical flap technique in combination with orthodontic treatment creates several possible advantages. Most impacted teeth from the open technique group had loss of attachment. However, more studies are needed. to assess the effect of the surgical technique on the soft tissue reaction after the alignment of impacted teeth.
Quirynen, M., et al., 2000 (Belgium)	Periodontal Health of Orthodontically Extruded Impacted Teeth. A Split-Mouth, Long-Term Clinical Evaluation	38 patients (ND / 29 UC, 5 UI, 2 LC, 2 LP)	17-51	Open/Closed	There was no statistical significance in the parameters of interest comparing all teeth pulled with the control group of contralateral. Comparing only unilateral upper canines (n=26), there was a statistical difference in the KMW, which was lower in the traction group (p=0.006).	It can be concluded that the closed eruption technique with conservative periodontal surgery and careful orthodontics is a treatment with excellent long-term results. It should be recommended as the treatment of choice for impacted teeth, at least when its position and absence of ankylosis allow eruption to occur.

Smailiene, D., et al., 2013 (Lithuania)	Posttreatment status of palatally impacted maxillary canines treated applying 2 different surgical-orthodontic methods.	43 patients (upper canines impacted with palatine, 22 group open técnique with spontaneous eruption and 21 closed technique group / 8M, 35 F)	15,81±3.04	Open with spontaneous eruption/closed	PD with statistical difference in the traction group compared to the control in the MV region ($p<0.05$), but no difference between the techniques. No statistical difference between groups and contralateral groups regarding GR.	The post-treatment status of palatal impacted canines after surgical-orthodontic treatment did not differ significantly between the groups treated with 2 different surgical methods, and may be considered acceptable techniques for treatment.
Smailiene, D., et al., 2013 (Lithuania)	Palatally impacted maxillary canines: Choice of surgical-orthodontic treatment method does not influence post-treatment periodontal status. A controlled prospective study	43 patients (upper canines impacted with palatine, 22 group open técnique with spontaneous eruption and 21 closed technique group / 8M, 35 F)	15,81±3.04	Open with spontaneous eruption/closed	Significant PD comparing the tractioned side with the contralateral in the MV region ($P<0.05$), but without statistical significance comparing the techniques. There was no statistical difference between groups and contralaterals in the parameters GR, KMW, GI and GBI.	After surgical-orthodontic treatment of canines impacted by the palate, by open surgery with spontaneous or closed eruption, there were no significant differences in periodontal status. Both treatments are acceptable even though the average time of exposure to the rash.

Capriogio , A., et al., 2019 (Italy)	Effects of impaction severity of treated palatally displaced canines on periodontal outcomes: A retrospective study	271 patients (293 canines impacted eith palatine, ND)	13,8±1.2	Closed	There was no comparison to untreated canines. Significantly higher prevalence of PD less than 2mm (normal) compared to groups with PD greater than or equal to 2mm, or presence of GR. Low prevalence and non-significant SBI.	Little significant values of periodontal changes in the evaluated parameters. They should be limited to canines impacted by the palate, since the vestibular displacement can involve different results as well as treatment options and success rate.
Parkin, N. A., et al., 2013 (United Kingdom)	Periodontal health of palatally displaced canines treated with either na open or closed surgical technique: a randomized controlled trial	62 patients (upper canines, 33 open technique and 29 closed technique, ND)	ND	Open/Closed	No statistical difference in PAL and GR parameters between open and closed groups (P<0.05). Statistical difference in PAL parameters with greater attachment loss in treated canines (P>0.05) and RG, with greater prevalence in treated canines on MV and MP faces.	The exposure and alignment of palatal impacted canines had a small impact on periodontal health. This impact was not influenced by the type of technique and is so small and clinically irrelevant to influence tooth prognosis.
Zasciurinskiene, E., et al., 2008 (Lithuania)	Initial vertical and horizontal position of palatally impacted maxillary canine and effect on periodontal status following surgical-orthodontic treatment	32 patients (10 M, 22 F, upper canine impacted with palatine)	18,2±5.1	Closed	PD significantly higher on the MV face of treated canines (p<0.05). No statistical difference between groups in the RG parameter, prevalence of 18.75% over the sample.	Combined orthodontic-surgical treatment of impacted maxillary canines produces a clinically acceptable periodontal condition.

Crescini, A., et al., 2007 (Italy)	Combined surgical and orthodontic approach to reproduce the physiologic eruption pattern in impacted canines: report of 25 patients	25 patients (9 M, 16 F, upper canine / 13 impacted with vestibular e 12 with palatine)	15,2±2.1	Closed	Statistical difference in PD and KMW parameters, lower at follow-up than at the end of treatment ($P<0.05$). There was no RG in any of the samples observed	The tunnel-type technique can be considered safe and effective in the treatment of impacted canines. The application of this technique can result in optimal dental alignment and healthy periodontium.

Legends: M, Male; F, Female; UI, Upper Incisor; CI, Central Incisor; LI, Lateral Incisor; UC, Upper Canine; LC, Lower Canine; UP, Upper Premolar; LP, Lower Premolar; GI, Gingival Index; PI, Plaque Index; GBI, Gingival Bleeding Index; KMW, Keratinized Mucosa Width; PAL, Periodontal Attachment Level; PD, Probing Depth; GR, Gingival Recession; DV, Dysto Vestibular; DP, Dysto Palatine; MV, Middle Vestibular; ND, Not Described

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Risk of bias

Among the 19 observational studies included, 12 articles had low risk of bias, 5 articles had moderate risk of bias [26-30], and 2 articles had high risk of bias [31, 32]. Of the 5 interventional studies included, two articles presented more than 50% of the domains assessed as being at high risk or lacking information that would provide adequate judgment [8, 33] (appendix 3).

Results of individual studies

Probing depth and gingival recession were the most evaluated parameters, followed by plaque index, gingival index, and keratinized mucosa width.

When considering only the periodontal parameters of the upper incisors, [26, 34, 35], probing depth was significantly greater in the tractioned teeth, with no difference in relation to the gingival and plaque indices ($p > 0.05$). Only one study showed higher values for gingival and plaque indices in central incisors under traction [34].

Similarly, when considering maxillary canines [8, 13, 18, 19, 27-29, 31, 33, 36-43], pulled teeth showed greater probing depth [13, 27, 38-40, 42] in at least one face of the tooth. However, the literature diverged in relation to this outcome, with studies that did not find differences between these teeth and contralateral teeth [18], or with a difference in this variable only on the surfaces of teeth adjacent to the canine [8]. Regarding plaque, gingival bleeding, and gingival recession, statistical nonsignificance prevailed between the groups of treated and untreated canines. Only one study showed a statistical difference in the rates of plaque and gingival bleeding, which were higher in the treated group [38]. The literature also diverged for keratinized mucosa width, with studies showing lower values [13, 28, 29, 36, 38] or even larger values in treated canines [37], and studies that showed no difference between groups [13, 40].

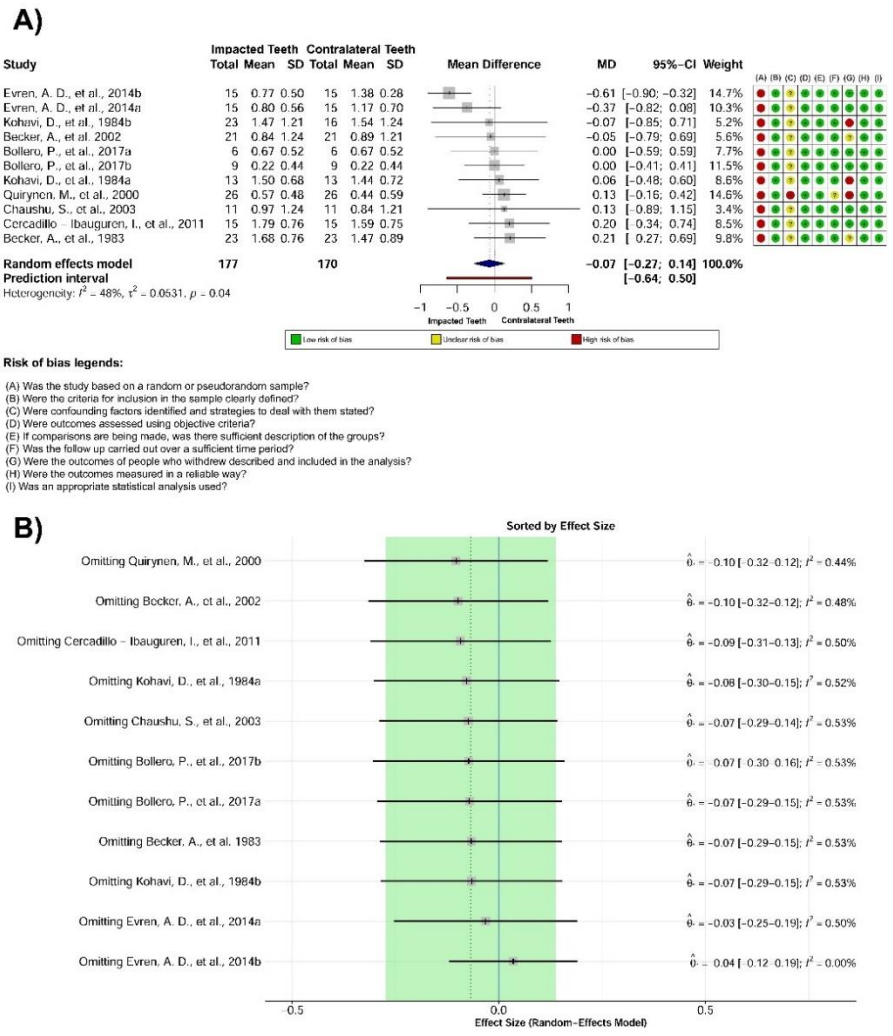
Nonstatistical significance of the periodontal parameters plaque index and gingival index prevailed among the included studies that evaluated mixed groups of teeth [3, 30], and the parameters probing depth and gingival recession had higher values in the treated group [30].

Synthesis of results

Fifteen studies were included in the quantitative synthesis, making it possible to evaluate the following outcomes: plaque index, gingival index, keratinized tissue width, and periodontal probing depth.

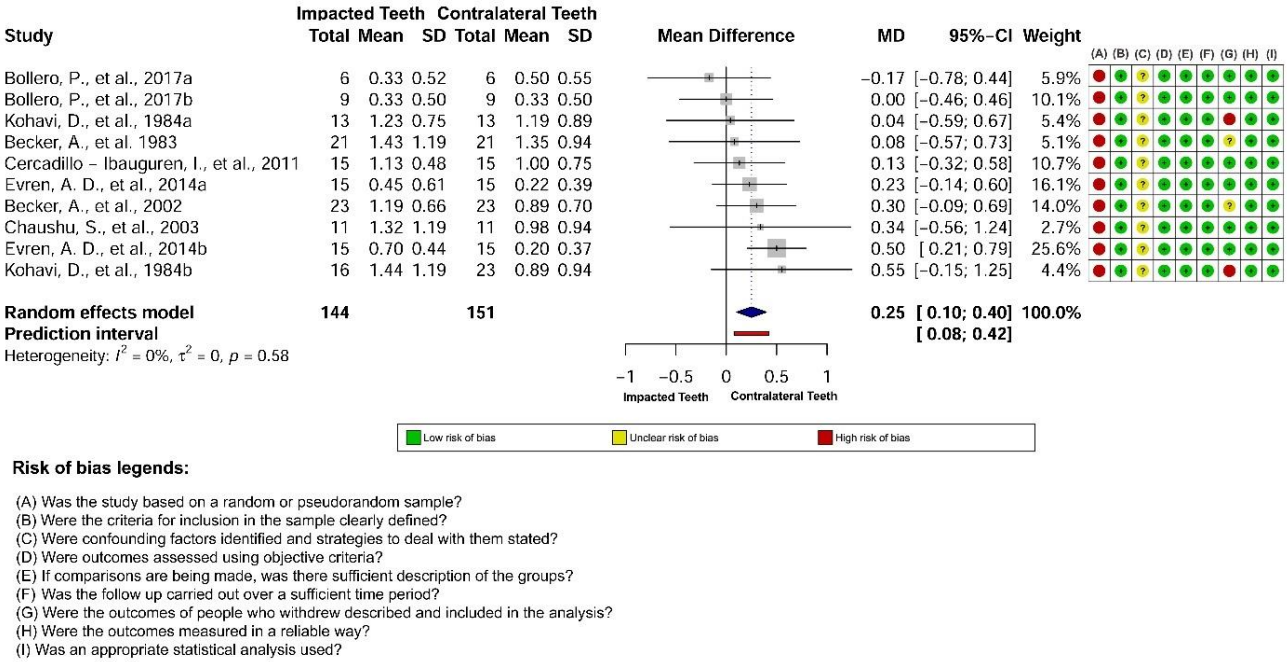
There was no relationship between dental impaction and plaque index [MD = -0.07; PI 95% = -0.64 – 0.50; I^2 = 48%], with no difference for plaque index between impacted and contralateral teeth (Figure 2a). Influence analysis showed that the study by Evren et al. [38] was responsible for the observed heterogeneity (I^2 = 48%). However, even with the removal of this study from the analysis, the values remained without statistical significance (p > 0.05) (Figure 2b), denoting robustness of the analysis.

Figure 2 – Comparison of the plaque index between tractioned teeth and their contralateral counterparts: a) Forest plot showing the risk of bias for each included study; b) influence analysis.



The gingival index differed significantly between impacted and contralateral teeth [MD = 0.25; CI 95% = 0.10 – 0.40; I^2 = 0%]. Even including more than one group of teeth submitted to the traction procedure, there was no heterogeneity between the observed effect sizes, demonstrating similar values regardless of the type of tooth (p = 0.58; Tau^2 = 0.00). Thus, impacted teeth had higher gingival index scores than contralateral teeth, denoting a worse gingival condition (Figure 3). The analysis demonstrated robustness, with a narrow prediction interval [PI 95% = 0.08 – 0.42], even with the inclusion of studies that measured different groups of teeth. Therefore, this was not a confounding factor capable of altering the effect size.

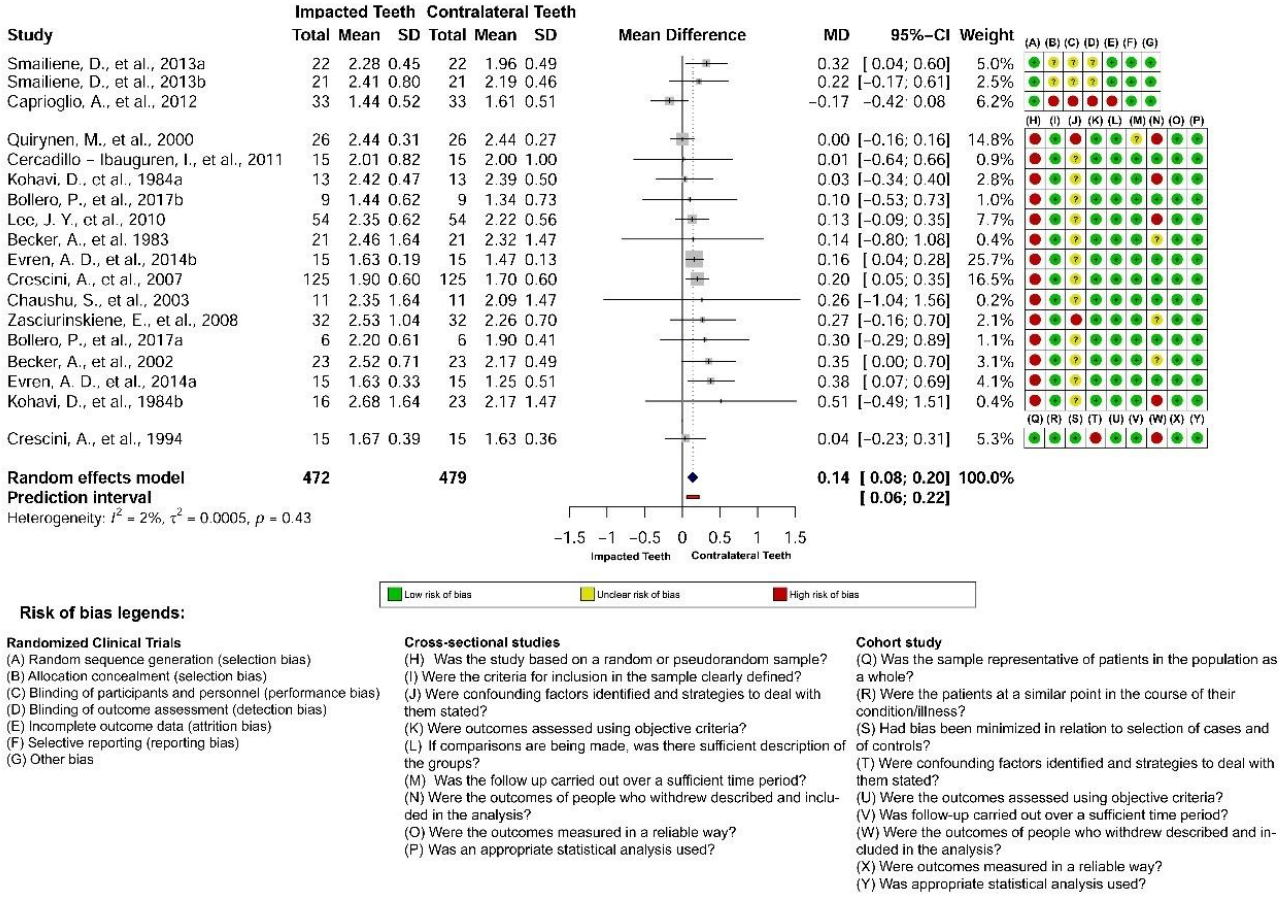
Figure 3 – Comparison of the gingival index between tractioned teeth and their contralateral counterparts, showing the risk of bias for each included study.



In the same sense, when assessing periodontal probing depth, impacted teeth showed greater probing depth, with a statistically significant mean difference between groups [MD = 0.14; CI 95% = 0.08 – 0.20; I^2 = 2%]. Likewise, the variance observed between the effects was close to zero, with no significant

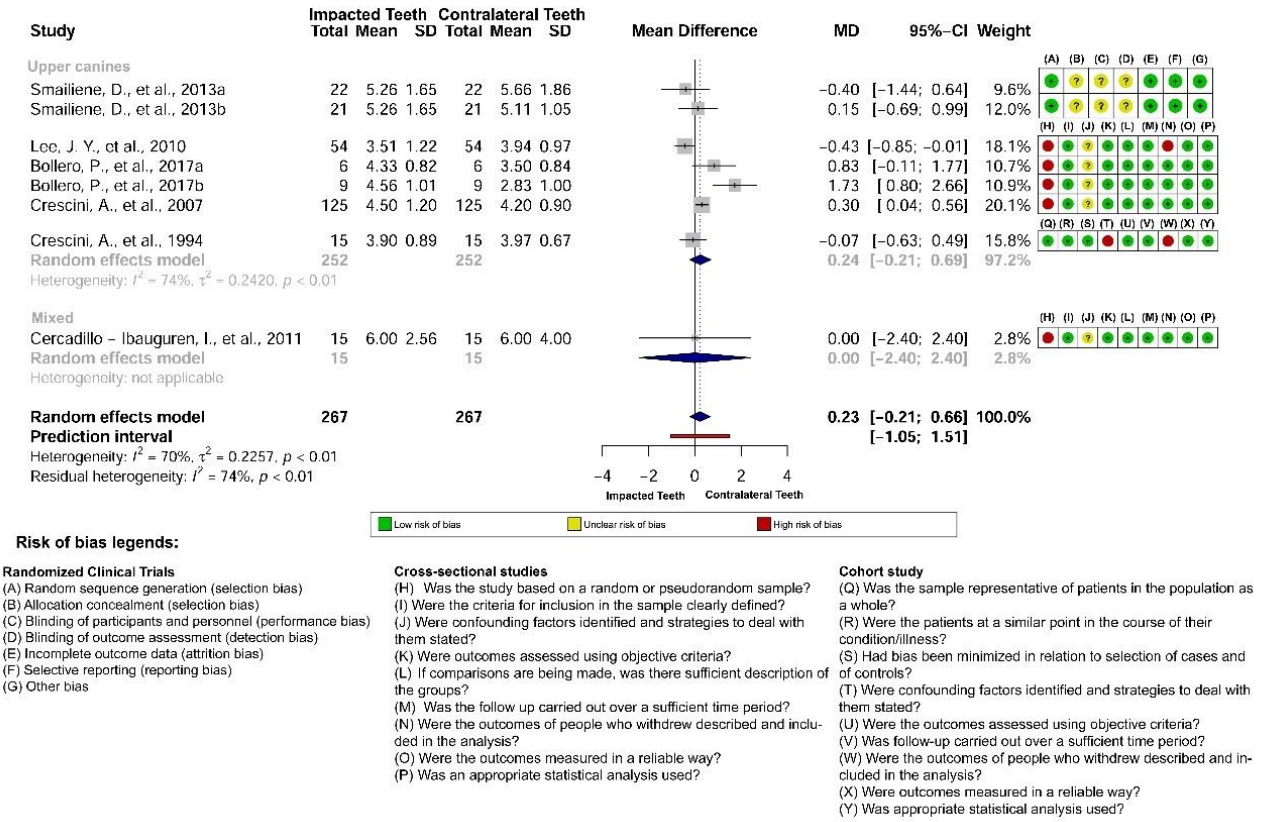
heterogeneity, regardless of the type of teeth included in the analysis (p = 0.38; Tau^2 = 0.00), and with a narrow prediction range (Figure 4).

Figure 4 – Comparison of periodontal probing depth between tractioned teeth and their contralateral counterparts, showing the risk of bias for each included study.



The evaluation of keratinized tissue width also showed no significant difference when comparing the two groups [MD = 0.23; CI 95% = -0.21 – 0.66; I^2 = 70%], with no difference between impacted teeth and their contralateral counterparts (Figure 5). To explore heterogeneity, subgroup analysis was performed; however, the type of teeth was not a predictive factor that explained the heterogeneity between the observed effects.

Figure 5 – Comparison of keratinized tissue width between tractioned teeth and their contralateral counterparts, showing the risk of bias for each included study.



Risk of bias legends:

Randomized Clinical Trials
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

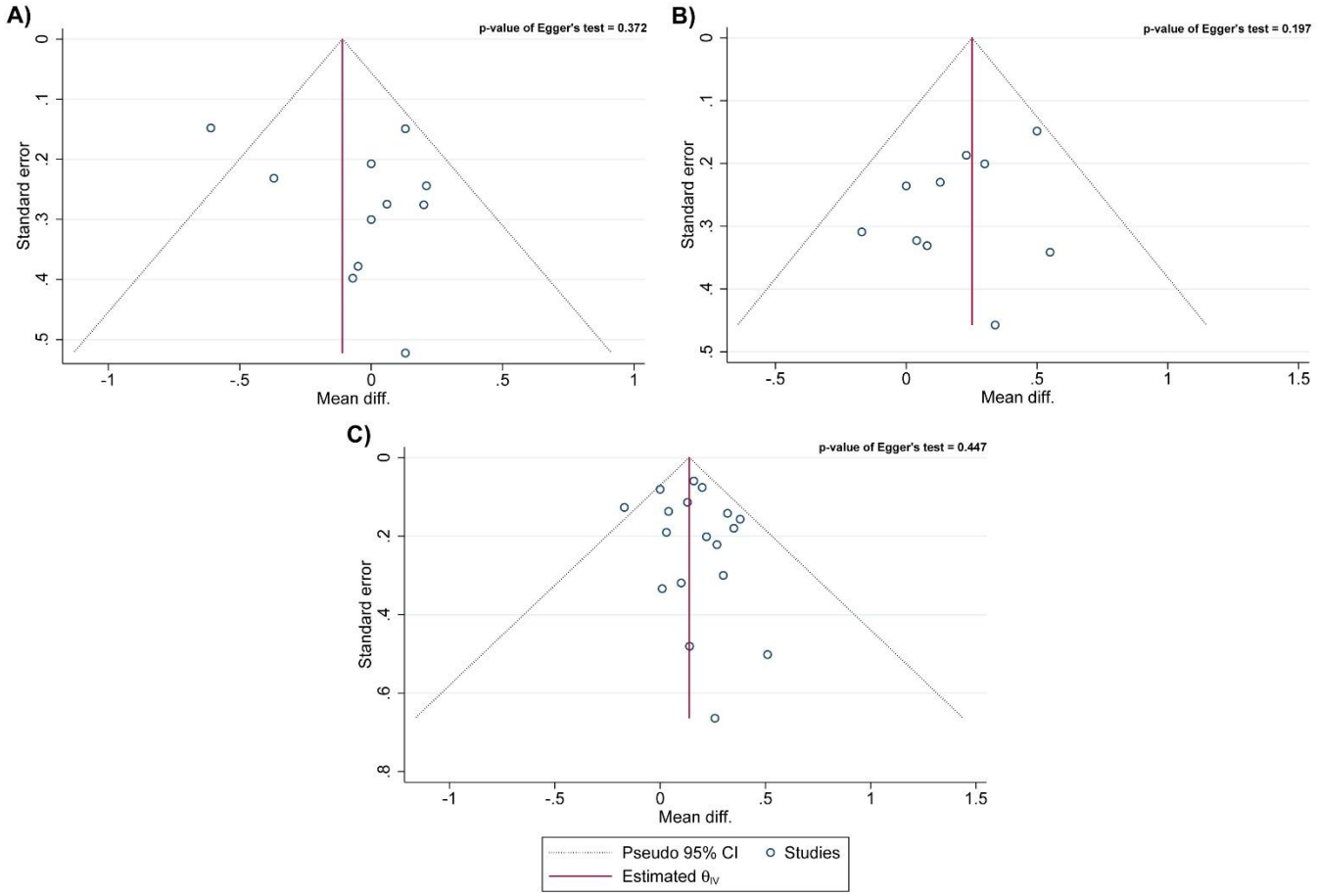
Cross-sectional studies
(H) Was the study based on a random or pseudorandom sample?
(I) Were the criteria for inclusion in the sample clearly defined?
(J) Were confounding factors identified and strategies to deal with them stated?
(K) Were outcomes assessed using objective criteria?
(L) If comparisons are being made, was there sufficient description of the groups?
(M) Was the follow up carried out over a sufficient time period?
(N) Were the outcomes of people who withdrew described and included in the analysis?
(O) Were the outcomes measured in a reliable way?
(P) Was an appropriate statistical analysis used?

Cohort study
(Q) Was the sample representative of patients in the population as a whole?
(R) Were the patients at a similar point in the course of their condition/illness?
(S) Had bias been minimized in relation to selection of cases and of controls?
(T) Were confounding factors identified and strategies to deal with them stated?
(U) Were the outcomes assessed using objective criteria?
(V) Was follow-up carried out over a sufficient time period?
(W) Were the outcomes of people who withdrew described and included in the analysis?
(X) Were outcomes measured in a reliable way?
(Y) Was appropriate statistical analysis used?

Reporting biases

Funnel asymmetry, evaluated by the Egger test, showed no statistical significance ($p > 0.05$), thus indicating the absence of publication bias (Fig. 6).

Figura 6 - Funnel plot to assess the existence of publication bias for the following outcomes: a) plaque index; b) gingival index; c) periodontal probing depth.



Certainty of evidence

As most of the included studies were cross-sectional, the certainty of evidence was reduced for the outcomes: plaque index, gingival index, and probing depth. Furthermore, the heterogeneity for the assessment of keratinized tissue width persisted even after subgroup analysis, thus decreasing the certainty of evidence to a very low level (appendix 4).

Discussion

The present study analyzed the available evidence on the periodontal aspects of orthodontically tractioned teeth in relation to their nontractioned contralateral counterparts. The current available literature and the eligibility criteria established for this systematic review enabled a quantitative analysis of data on the following periodontal parameters: plaque index, gingival index, keratinized mucosa width, and probing depth. The results indicate an association between orthodontic traction and worsening of periodontal parameters, measured through the significant increase in gingival index and periodontal probing depth, with no differences in relation to plaque index and keratinized mucosa width. Furthermore, the heterogeneity between the study effect sizes was very low for the analyses that demonstrated statistical significance, regardless of the group of teeth included in the analysis.

Dental plaque is considered a primary cause of periodontal disease, requiring mechanical cleaning of all sides of the tooth to maintain good oral health [44]. Bolero et al. [18] found no difference between impacted canines and their contralateral counterparts, regardless of the arch in which they were positioned. On the other hand, Evren et al. [38] observed an increase in plaque index and gingival index scores in lower canines under traction in relation to their contralateral counterparts; notwithstanding, the authors could not elucidate the reasons for this worsening in periodontal health. In the present systematic review, the mean of plaque index scores showed no statistical difference ($p > 0.05$), with only one study [38] not touching the null line. However, the study showed no influence on the analysis to the point of changing the significance for this outcome.

Patients undergoing orthodontic treatment need periodontal evaluations at each visit due to possible periodontal implications during orthodontic therapy[45]. Based on data available in the current literature on this topic, tractioned teeth had higher gingival index scores and greater probing depth ($p < 0.05$). Lee et al. [29] report that periodontal tissues may differ between canines impacted after orthodontic traction and canines with normal eruption. Factors involving the surgical procedure performed, such as the need for more extensive bone removal in closed flaps, may correlate with the increase in pocket depth and gingival level after

treatment [38]. In this review, both outcomes showed low heterogeneity between the effect sizes of the articles included in the analysis. This denotes that the type of tooth did not interfere with the observed effect, with a similar effect with worsening in these parameters, regardless of the type of impacted tooth. Despite demonstrating statistical significance, data regarding probing depth should be considered in relation to the clinical significance of these findings, as the difference between groups had a small effect size.

In clinical practice, factors such as the dimensions of soft and hard oral tissues are essential parameters that can influence periodontal diagnosis and treatment [46]. The results presented show divergent data on whether keratinized tissue width differs between impacted teeth and teeth with normal eruption after orthodontic-surgical traction. Lee et al. [29] found a significant decrease in keratinized tissue width in canines in relation to their nontractioned contralateral counterparts. In that study, the minimum width considered for the maintenance of periodontal health was 2 mm, and the authors found values less than 2 mm for this parameter in treated teeth, which predisposes to recurrent inflammation and loss of periodontal support. Smailiene et al. [40] did not observe statistically different values between treated teeth and their nontractioned contralateral counterparts. On the other hand, Bollero et al. [18] observed a greater amount of keratinized tissue in tractioned canines in relation to contralateral teeth. The meta-analysis performed did not demonstrate statistical significance for this outcome ($p > 0.05$); however, there was heterogeneity between the observed effects that persisted even after subgroup analysis. As the source causing the heterogeneity could not be identified, the certainty of evidence for this outcome is reduced.

The results of this systematic review and meta-analysis reveal important data on periodontal aspects in impacted teeth subjected to orthodontic treatment, revealing clinical parameters that can undergo significant changes after a tooth is exposed to this treatment. By demonstrating the current stage of knowledge on the subject, these findings help the orthodontist and/or the surgeon to stipulate the risks, know about the predictability of the techniques, and easily communicate with the patient. Some limitations should be pointed out, such as the study design. Most of

the included studies are cross-sectional observational studies, subject to different confounding factors due to the impossibility of randomization.

Conclusions

Tractioned teeth showed worsening in the periodontal parameters gingival index and probing depth. Notwithstanding, probing depth should be weighed as to its clinical significance due to the small effect size observed. Regardless of the group of teeth analyzed, the observed effect size remained similar.

Other informations

Registration and protocol

The protocol for this study was registered on the PROSPERO website (International Prospective Register of Systematic Reviews - Center for Reviews and Dissemination, University of York) under number CRD42020205104.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding No external funding was provided in regard with this study. The authors received no other institutional funding beyond their employment.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

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1 Appendices

2 Appendix 1- Search strategy used in electronic databases.

COCHRANE	("impacted tooth" OR "impacted teeth" OR "impacted" OR "unerupted tooth" OR "unerupted teeth" OR "ectopic Tooth eruption" OR "ectopic") AND (“traction” OR “tractioned” OR “orthodontic traction”)
LILACS	("impacted tooth" OR "dente impactado" OR "diente impactado" OR "impacted teeth" OR "dentes impactados" OR "dientes impactados" OR "impacted" OR "impactado" OR "unerupted tooth" OR "dente não eruptado" OR "diente sin erupción" OR "unerupted teeth" OR "dentes não eruptados" OR "dientes sin erupción" OR "ectopic Tooth eruption" OR "erupção dentária ectópica" OR "erupción dental ectópica" OR "ectopic" OR "ectópica") AND ("traction" OR "tração" OR "tracción" OR "tractioned" OR "traccionado" OR "tracionado" OR "orthodontic traction" OR "tracionamento ortodôntico" OR "tracción ortodoncia")
PUBMED	"Tooth, Impacted"[mesh terms] OR "impacted"[All Fields] OR "tooth, unerupted"[MeSH Terms] OR "unerupted "[All Fields] OR "Tooth eruption, ectopic"[MeSH Terms] OR "ectopic tooth eruption"[All Fields] OR “ectopic”[All Fields] “traction”[All Fields] OR “tractioned”[All Fields] OR “orthodontic traction”[All Fields] #1 AND #2
EMBASE	('impacted tooth':ti,ab OR 'impacted teeth':ti,ab OR 'impacted':ti,ab OR 'unerupted tooth':ti,ab OR 'unerupted teeth':ti,ab OR 'ectopic tooth eruption':ti,ab OR 'ectopic':ti,ab) AND ('traction':ti,ab OR 'tractioned':ti,ab OR 'orthodontic traction':ti,ab)
SCOPUS	("impacted tooth" OR "impacted teeth" OR "impacted" OR "unerupted tooth" OR "unerupted teeth" OR "ectopic Tooth eruption" OR "ectopic") AND (“traction” OR “tractioned” OR “orthodontic traction”)
WEB OF SCIENCE	1. TS=("impacted tooth" OR "impacted teeth" OR "impacted" OR "unerupted tooth" OR "unerupted teeth" OR "ectopic Tooth eruption" OR "ectopic") 2. TS=(“traction” OR “tractioned” OR “orthodontic traction”) 3. #1 AND #2
GOOGLE SCHOLAR	“impacted teeth” AND “traction”
OPENGREY	“impacted teeth”

PROQUEST	“impacted teeth” AND “traction”

1

2

Appendix 2 - Excluded articles and reasons for exclusion (n=30)

Author, Year	Reason for exclusion
Albiol and Garcia. 2007[1]	4
Azeem et al. 2018[2]	3
Bado-Silveira and Recoing. 2005[3]	4
Bariani et al. 2017[4]	4
Bassigni and Knoche. 1975[5]	4
Birn and Andersen. 1971[6]	4
Carnero. 1976[7]	4
Carnero 1977[8]	4
Consolaro 2010.[9]	4
Cozzani et al. 2003[10]	4
Dagg. 1973[11]	4
Dijakiewicz et al. 2004[12]	4
Diliberti. 2000[13]	4
Ericson and Kurol. 1988[14]	4
Fingeroth et al. 1979[15]	4
Giancotti et al. 2009[16]	4
Helmore. 1967[17]	4
Hunt. 1977[18]	4
Kurol. 2002[19]	4
Mydlová et al. 2015[20]	4
Migliorati et al. 2012[21]	3
Sagnani and King. 2015[22]	3
Schmidt and Kokich, 2007[23]	3
Shino et al. 2012[24]	4
Soroka-Letkiewicz et al. 2012[25]	3
Spencer et al. 2010[26]	3
Vaid et al, 2014[27]	4
Vieira et al. 2013[28]	4
Wang et al. 2008[29]	3
Wang et al. 2012[30]	4

1) Studies in animals; 2) Studies including participants with craniofacial deformity or syndromic subjects; 3) Studies in which none of the variables of interest have been evaluated; and 4) Reviews, letters, conference abstracts, personal opinions, case reports and case series.

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Appendix 3 - Risk of bias of studies included in the qualitative and quantitative analyses assessed by: a) Cochrane Collaboration's tool for assessing risk of bias; b) Meta-Analysis of Statistics Assessment and Review Instrument (MASTARI).

3a – Cochrane's tool to assessed risk of bias in randomized controlled trials (Higgins et al 2011)[1]

Author, year	Questions	Suport for judgement	Risk of Bias
Caminiti, M.F., et al., 1998[2]	Random sequence generation (selection bias)	The sample was not randomized	HIGH RISK
	Allocation concealment (selection bias)	There was no randomization of the sample	HIGH RISK
	Blinding of participants and personnel (performance bias)	Not applicable	UNCLEAR RISK
	Blinding of outcome assessment (detection bias)	Not applicable	UNCLEAR RISK
	Incomplete outcome data (attrition bias)	Qualitative assessment, no statistical analysis was applied, no control group	LOW RISK

	Selective reporting (reporting bias)		LOW RISK
Caprioglio, A., et al., 2013[3]	Random sequence generation (selection bias)	The sample was not randomized	HIGH RISK
	Allocation concealment (selection bias)	There was no randomization of the sample	HIGH RISK
	Blinding of participants and personnel (performance bias)	Not applicable	HIGH RISK
	Blinding of outcome assessment (detection bias)	Not applicable	HIGH RISK
	Incomplete outcome data (attrition bias)	No missing outcome data	LOW RISK
	Selective reporting (reporting bias)	The study include all expected outcomes	LOW RISK

Smailiene, D., et al., 2013[4]	Random sequence generation (selection bias)	Simple randomization	LOW RISK
	Allocation concealment (selection bias)	Randomized allocation, but does not make clear the secrecy	UNCLEAR RISK
	Blinding of participants and personnel (performance bias)	Article does not report on blinding, only that the steps were not performed by the same operator	UNCLEAR RISK
	Blinding of outcome assessment (detection bias)	Article does not report on blinding, only that the evaluator is an expert and has been calibrated	UNCLEAR RISK
	Incomplete outcome data (attrition bias)	No missing outcome data	LOW RISK
	Selective reporting (reporting bias)	The study include all expected outcomes	LOW RISK
Smailiene, D., et al., 2013[5]	Random sequence generation (selection bias)	Simple randomization	LOW RISK
	Allocation concealment (selection bias)	Randomized allocation, but does not make clear the secrecy	UNCLEAR RISK
	Blinding of participants and personnel (performance bias)	Article does not report on blinding, only that the steps were not performed by the same operator	UNCLEAR RISK
	Blinding of outcome assessment (detection bias)	Article does not report on blinding, only that the evaluator is an expert and has been calibrated	UNCLEAR RISK
	Incomplete outcome data (attrition bias)	No missing outcome data	LOW RISK
	Selective reporting (reporting bias)	The study include all expected outcomes	LOW RISK

Parkin et al., 2013[6]	Blinding of participants and personnel (performance bias)	It was not possible to mask those administering the surgical treatment; Therefore, there was an unavoidable risk of treatment bias. For measurement purposes, a masked assessor would probably be able to guess which canine was previously impacted, owing to positional differences, but would not be able to tell which technique was used	LOW RISK
	Allocation concealment (selection bias)	Allocation concealment was done with consecutively numbered, sealed, opaque.	LOW RISK
	Random sequence generation (selection bias)	The randomization was undertaken using computer-generated random numbers to ensure that equal numbers were allocated to each intervention.	LOW RISK
	Blinding of outcome assessment (detection bias)	The examiners were masked as to the patient's group allocation for the clinical examinations. The patient details were removed from all study models and radiographs, which were labeled with only the participant's randomization number	LOW RISK
	Incomplete outcome data (attrition bias)	No missing outcome data.	LOW RISK
	Selective reporting (reporting bias)	All of the study's pre-specified (primary and secondary) outcomes that are of interest in the review have been reported.	LOW RISK

3b - Risk of bias for the studies included in the qualitative and quantitative analysis, assessed by "Meta-Analysis of Statistics Assessment and Review Instrument" (MAStARI) critical appraisal tools. Risk of bias was categorized as High when the study reaches up to 49% score "yes", Moderate when the study reached 50% to 69% score "yes", and Low when the study reached more than 70% score "yes".

3.1 - Studies included in the qualitative analysis

A *– Cross-sectional. Descriptive Studies.*

Question		Answer														
	Becker, A., et al., 2002[7]	Becker, A., et al., 1983[8]	Bollero, P., et al., 2017[9]	Caprioglio et al., 2019[10]	Cercadillo - Ibauguren, I., et al., 2011[11]	Chaushu, S., et al., 2003[12]	Chaushu, S., et al., 2009 [13]	Crescini, A., et al., 2007[14]	Crescini, A., et al., 2007[15]	Evren, A. D., et al., 2014[16]	Kohavi, D., et al., 1984[17]	Landim, F. S., et al.,2010[18]	Lee, J. Y., et al., 2010[19]	Odenrick, L. and T. Modeer, 1978[20]	Quirynen, M., et al., 2000[21]	Zasciurinskiene et al., 2008[22]
1. Was the study based on a random or pseudorandom sample?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2. Were the criteria for inclusion in the sample clearly defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	Y
3. Were confounding factors identified and strategies to deal with them stated?	U	U	U	Y	U	U	U	U	U	U	U	U	U	U	N	N
4. Were outcomes assessed using objective criteria?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	U	Y	Y
5. If comparisons are being made, was there sufficient description of the groups?	Y	Y	Y	Y	Y	Y	Y	NA	NA	Y	Y	N	Y	U	Y	Y
6. Was the follow up carried out over a sufficient time period?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	U	U	Y

7. Were the outcomes of people who withdrew described and included in the analysis?	U	U	Y	U	Y	Y	N	Y	Y	Y	N	Y	N	N	N	U
8. Were the outcomes measured in a reliable way?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	U	Y	Y
9. Was an appropriate statistical analysis used?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	U	Y	Y
% yes/risk	66.6% Moderate	66.6% Moderate	77.7% Low	77.7% Low	77.7% Low	77.7% Low	66.6% Low	75% Low	75% Low	77.7% Low	66.6% Moderate	22.2% High	66.6% Moderate	0% High	55.5% Moderate	66.6% Low

1 Legend - *Y=Yes, N=No, U=Unclear, NA=Not applicable

2

B *- Cohort Study/ case-controlled studies.*

Question	Crescini, A., et al., 1994[23]	Crescini, A., et Al., 2007[24]	Crescini, A., et Al., 2007[25]
1. Was the sample representative of patients in the population as a whole?	Y	Y	N
2. Were the patients at a similar point in the course of their condition/illness?	Y	Y	Y
3.Had bias been minimized in relation to selection of cases and of controls?	Y	Y	Y
4. Were confounding factors identified and strategies to deal with them stated?	N	N	N
5. Were the outcomes assessed using objective criteria?	Y	Y	Y
6. Was follow-up carried out over a sufficient time period?	Y	Y	Y
7. Were the outcomes of people who withdrew described and included in the analysis?	N	Y	Y
8. Were outcomes measured in a reliable way?	Y	Y	Y
9. Was appropriate statistical analysis used?	Y	Y	Y
% yes/risk	77.7% Low	88,8% Low	77.7% Low

Legend - Y=Yes, N=No, U=Unclear, NA=Not applicable.

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Appendix 4 - Evaluation of the certainty of evidence by the GRADE tool, for the different periodontal parameters evaluated.

Outcomes	№ of participants (studies) Follow up	Certainty of the evidence (GRADE)	Anticipated absolute effects
			Periodontal aspects in impacted teeth
Plaque Index	347 (11 observational studies)	⊕⊕◯◯ LOW	MD **0.07 lower** (0.27 lower to 0.14 higher)
Gingival index	295 (10 observational studies)	⊕⊕◯◯ LOW	MD **0.25 higher** (0.1 higher to 0.4 higher)
Probing pocket depth	887 (17 observational studies)	⊕⊕◯◯ LOW	MD **0.14 higher** (0.07 higher to 0.2 higher)
Width of Keratinized tissue (mm)	534 (8 observational studies)	⊕◯◯◯ VERY LOW [a]	MD **0.23 higher** (0.21 lower to 0.66 higher)

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **MD:** Mean difference

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Source of heterogeneity was not detected, persisting even after subgroup analysis

ARTIGO 2 – VERSÃO EM INGLÊS (submetido no periódico Clinical Oral Investigations – Qualis A1/IF 3.573)

Risk factors associated with the stability of mini-implants and mini-plates: systematic review and metanalysis

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Abstract

Objective: The objective of this systematic review is to answer the following question: "What are the risk factors associated with the stability of mini-implants and mini-plates?" *Material and methods:* Search strategies were developed for each electronic database (PubMed/Medline, LILACS, Scopus, Web of Science, Embase, and Cochrane Library) and gray literature (Google Scholar, Proquest, and Open Grey). The risk of bias was assessed using the Cochrane Collaboration tool for assessing the risk of bias and Meta-Analysis of Statistics Assessment and Review Instrument. The certainty of the evidence was assessed using the GRADE tool. Meta-analyses and meta-regressions of random effects were performed for the outcomes of interest. *Results:* A total of 1,517 articles were found, of which seven were selected for quantitative synthesis. When comparing the risk of failure between mini-implants and mini-plates, the risk values approached the threshold of statistical significance ($p = 0.07$) (RR = 1.83; 95% CI = 0.96 - 3.50; $I^2 = 69\%$), showing significance after sensitivity analysis ($p < 0.05$) and a greater risk for mini-implants. Mandible installation presented a higher risk of failure (RR = 1.85; 95% CI = 1.17 - 2.91). *Conclusions:* The evidence found indicates that failure in the stability is related to the type of device and that there is a greater risk by using isolated mini-implants, especially when positioned in the mandible. *Clinical relevance:* These findings, help the orthodontist and/or the surgeon to stipulate risks, learn about the predictability of techniques, and communicate with the patient in an easier way.

Keywords: temporary anchoring devices, mini-implant, mini-plate, stability, systematic review

Introduction

Temporary anchorage devices (TADs) are widely used in orthodontic mechanics to expand the limit of tooth movement through skeletal anchorage [1-4]. TADs are a helpful treatment alternative in complex malocclusions, especially those with vertical discrepancies, such as open bite and dental extrusions due to the loss of the antagonistic tooth [5-10].

The treatment for some severe discrepancies is usually surgical and sometimes invasive. Before orthodontists knew and used TADs, it was common to solve a case of dental extrusion with endodontic treatment and a fixed prosthesis. The use of these anchoring devices has shown a lower risk to the individual, as it is a more conservative treatment with satisfactory results [5-7]. Skeletal anchorage with these devices is versatile and effective in treating all types of malocclusions when not associated with the need for extensive surgical interventions to achieve a harmonious skeletal relation [10, 11].

Studies using mini-plates for skeletal anchorage have decreased undesirable dental effects and significant skeletal effects [12-15]. There has been a substantial decrease in treatment time of patients with Angle Class III malocclusions [15]. The mini-implants may also provide skeletal anchorage for orthodontic movement [11, 12] by presenting an easier insertion or removal, besides a lower cost [12, 16]. However, the stability of TADs depends on the mechanical locking that occurs in bone tissue, unlike dental implants whose main stability is directly related to the osseointegration process. This mechanical stability allows the device to withstand tooth movement without requiring healing periods [1, 17, 18]. Some risk factors can be associated with loss of stability, such as the type of device, screw diameter and presence of inflammation in the soft tissue around the device[19].

There are no systematic reviews on risk factors associated with the stability of mini-implants compared to mini-plates; there are only studies reporting isolated data on these devices [11, 19-25], justifying the conduction of a systematic review on the subject. Thus, the objective of the present study is to answer the following focused question: "What are the risk factors associated with the stability of mini-implants and mini-plates?"

Material and Methods

Eligibility criteria

To consider the eligibility of studies to be included/excluded in this review, the acronym "PICOS" was considered:

- *Population* (P) – Patients undergoing orthodontic treatment with TADs for skeletal anchorage;
- *Intervention* (I) – Mini-implants;
- *Comparation* (C) – Mini-plates;
- *Outcomes* (O) – Risk factors associated with the stability of TADs (type of device, place of installation, type of the soft tissue and width/diameter of the screw used, average age of the sample);
- *Study design* (S) – Randomized, pseudo-randomized, or non-randomized clinical studies, cross-sectional observational studies, cohort, or case control.

Inclusion Criteria

The studies included had necessarily evaluated patients with mini-implants, patients with mini-plates and the factors associated with failure in stability of the TADs in the same study were included, to allow inferences on risk association between both methods. Randomized, pseudo-randomized, non-randomized, prospective, or retrospective observational studies were included in controlled clinical trials. There was no restriction to the type of malocclusion, gender, and age. There was also no restriction to the language of the study and time of publication.

Exclusion criteria

The following exclusion criteria were considered:

- Studies on animals or those including patients with syndromes associated with dentofacial deformities;
- Studies that have not compared patients with mini-implants and patients with mini-plates;

- Studies in which none of the variables of interest have been evaluated;
- Reviews, letters, conference summaries, expert opinions, reports, and case series.

Sources of information and search strategy

Combinations of words and appropriate truncations were selected and adapted for each database search. Search strategies were developed specifically for each of the following electronic databases: PubMed/Medline, LILACS, Scopus, Web of Science, Cochrane Library, and Embase. In addition, the search for gray literature was carried out on Google Scholar, Proquest, and Open Gray (appendix 1). All searches were carried out on November 10, 2019 and updated on May 6, 2021.

Finally, a manual search of references of the studies included was carried out, and an expert on the subject was also consulted to verify any possible publications on the topic. The EndNote® software (EndNote® X7 Thomson Reuters, Philadelphia, PA) was used to manage and remove duplicate references.

Selection process

The selection of articles was carried out in two phases. In phase 1, two reviewers (P.M.M. and I.B.B.) independently reviewed the titles and abstracts of all references. All studies that did not meet the inclusion criteria were excluded. In phase 2, the same reviewers performed a full reading of the selected articles independently. In case of disagreement, which was not resolved through discussion between the first and second reviewers, a third author (C.M.A.) was involved in the final decision.

To protect the reading of references and ensure independence and confidentiality in both phases, the Rayyan website (http://rayyan.qcri.org) was used, where the reviewers were blinded in all evaluations and a member of the team (C.M.A.), who did not participate in the selection, served as moderator.

Data collection process

Two reviewers (P.M.M. and I.B.B.) collected information from the included studies, which was then discussed. The data collected consisted of study

characteristics (authors, year of publication, country, study design), population characteristics (sample size, age), evaluation characteristics (composition of the control and experimental groups, number of evaluators, parameters of interest, method of evaluation of outcomes, index used for assessment), characteristics of results (results presented concerning the effect), and main conclusions.

If any data were missing or incomplete in the article, attempts were made to contact the authors to obtain relevant unpublished information.

Three attempts were made to contact the first author, the corresponding author, and the last author of the article, and the time interval between attempts was one week. In case of non-response, the article was excluded with due justification.

Data items

The frequency of events of device loss was extracted from the studies included considering the type of device, the arch in which it was installed, and the characteristic of the gingival tissue where it was inserted. Possible confounding factors were also extracted concerning the estimation of effects, such as the mean age of participants and the diameter of the screw used in the study.

Study risk of bias assessment

The methodology of the selected observational studies was assessed using the Meta-Analysis of Statistics Assessment and Review Instrument (MASTARI) risk of bias tool for observational studies. The risk of bias was categorized as "high" when the study had a "yes" score lower than 50%; "Moderate" when the study presented between 50% to 69% of score "yes"; and "low" when the study showed more than 70% of score "yes" for questions of risk of bias.

For interventional studies, the "Cochrane Collaboration tool for assessing the risk of bias" was used. This tool covers seven domains: generation of random sequence, concealment of allocation, blinding of participants and professionals, blinding of outcome evaluators, incomplete outcomes, selective outcome reporting, and other sources of bias. The judgment regarding the possible risk of bias in each of these domains was made based on the information extracted from the study and classified as "high risk" or "low risk" of bias. If there were not

enough details reported in the study, the risk of bias was judged as "unclear," and the authors of the original study were contacted for further information. The judgments were made by two independent reviewers (P.M.M and I.B.B). Disagreements were first solved by discussions, and in case of non-consensus, the third reviewer (C.M.A) was consulted for the tiebreaker vote.

Effect measures

As the outcome chosen is binary, the relative risk was calculated to assess the association between the loss of the device related to the variables of interest.

Synthesis methods

A method of meta-analysis of random effects using the RStudio statistical software v. 1.2.1335 (Rstudio Inc, Boston, USA) was carried out. The studies were weighted by the Mantel-Haenszel method. The heterogeneity was calculated by the inconsistency index (I^2) and the variance by Tau^2, estimated by the DerSimonian-Laird method. Possible confounding factors, where there was no direct comparison (pair by pair), were evaluated by meta-regression with random effect models to verify whether the variance in the effect estimates (failure prevalence) observed was explained by these covariables. For this, the failure frequency data were transformed by the Freeman-Tukey arcsine double method to follow an approximately normal distribution, and a bubble plot graph was generated for analysis.

A sensitivity analysis was performed to assess whether studies classified as high risk of bias affected the size of the summary effect. 95% confidence intervals were considered (95% CI), and the level of significance was 5%.

Reporting bias assessment

In case it was impossible to carry out evaluations using the funnel plot (n <10) to avoid publication bias, a broad search was carried out in several databases, including a database in a language other than English (LILACS), and also a search in the gray literature was performed.

Certainty assessment

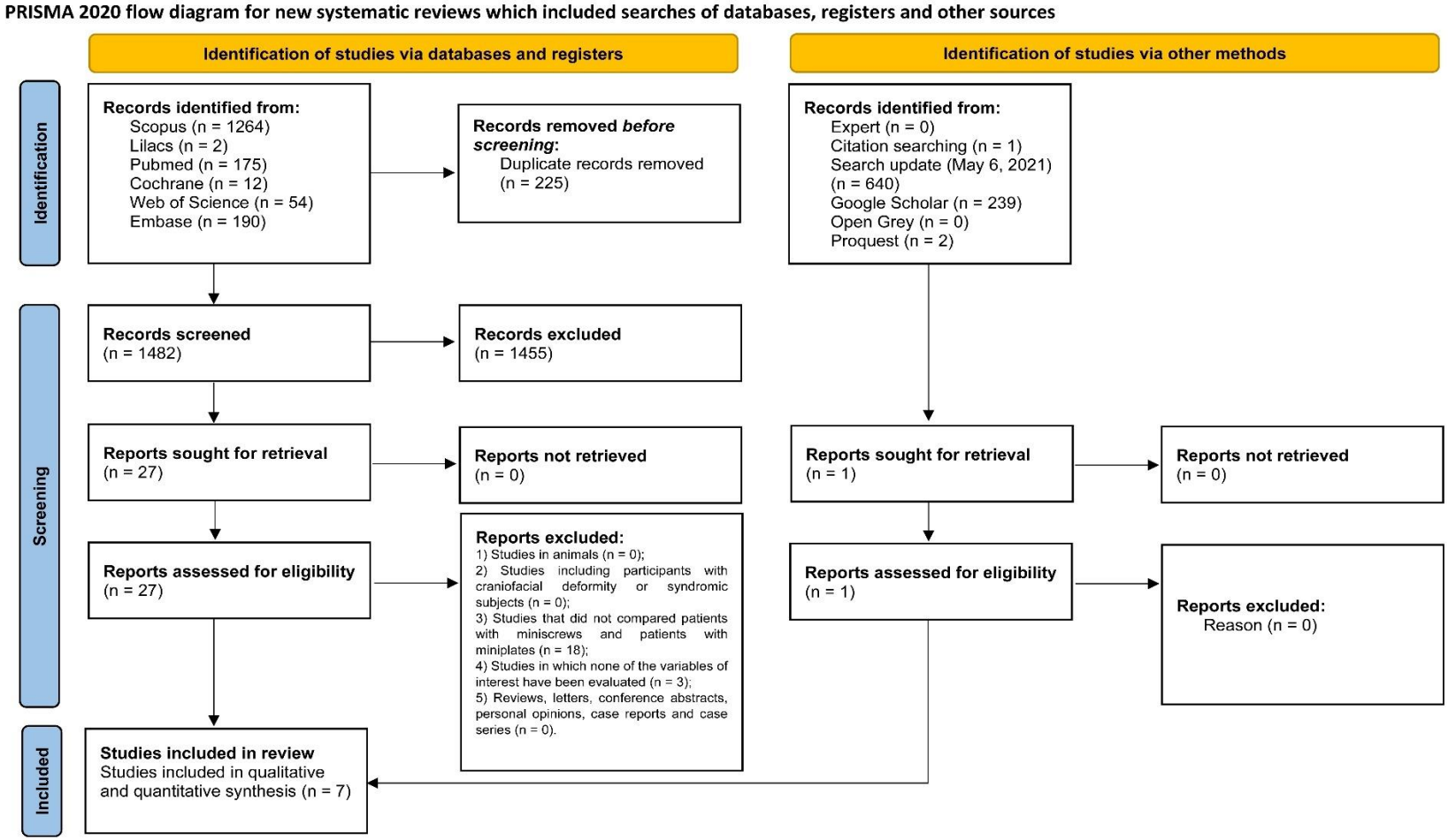
The certainty of evidence was assessed using the GRADE tool [26] in all domains of risk of bias, consistency, accuracy, precision, and publication bias. Quality was judged as high, moderate, low, or very low.

Results

Study selection

The elaborated research strategy resulted in 1,707 articles after searching the databases. Excluding duplicate articles, 1,482 articles proceeded for reading the titles and abstracts (phase 1). Of these articles, 28 were read in full (phase 2), of which 21 were excluded (appendix 2), resulting in seven articles for qualitative synthesis (Fig 1).

Figure 1 - Flowchart of literature search and selection criteria



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

1

Study characteristics

All articles included were published in English in China, Japan, and Taiwan.

The sample sizes varied between 44 and 455 patients, with the average age ranging between 21.8 and 29.3 years. The included studies that reported the gender in samples showed a higher percentage of female patients (78%) than males (22%).

As for the study design, six articles were observational cross-sectional, and one was a randomized clinical trial. Four of the seven articles included directly evaluated the failure rate of the devices compared considering patients who used mini-plates and mini-implants of different sizes as a sample; these plates and implants were of titanium or stainless steel, pre-drilled, self-drilling, or palatal. The other three articles assessed success rates, indirectly assessing the factors that affect failure rates, factors associated with post-operative stability, pain or discomfort. These factors related to the implantation, type of device, and the proposed movement with the installation of devices. Other factors could also be related to the patient, such as age, gender, bone density, and the angle of the mandibular plane. Table 1 shows all characterization data of the studies.

1 **Table 1** - Characteristics of the studies included (n = 7)

Study, Author/Year (Country)	Sample (gender / device types)	Diameter and length of DATs	Age (Median or Mean ± SD)	Risk factors	Results	Conclusions
Chen, Y. J., et al., 2007 (Taiwan)	359 devices / 129 patients (25 M, 104 F / 86 miniplates, 201 mini-implants)	miniplates (2mm diameter screws, length 5-9mm) / mini-implants (2mm diameter, length 5-21mm)	24.5 +-7.1	Gender, age, type of malocclusion, local treatment or total arch, installation site, proposed movement, method of applied force and healing time.	There was no statistical difference in the factors gender, type of malocclusion, local treatment or full arch, buccal or lingual installation, length, load pattern and duration of the healing phase. Statistical difference for age (greater risk of failure in young patients), proposed movement (retraction or protraction), arch (mandible, region anterior to the 2nd premolars) and type of device (mini-implant - 66% - and micro-implants - 32.1%) After adjusting for potential confounding effects, only three factors (type of device, placement in the mandibular arch, and age) were considered statistically significant in predicting failure.	Mini-implants installed in younger patients and in the mandibular arch have a higher risk of failure. The miniplate system has greater stability compared to mini-implants.

Chen, Y. J., et al., 2008 (Taiwan)	194 patients (42 M, 152 F /171 miniplates, 264 pre-drilled mini-implants and 57 self-drilling mini-implants)	miniplates (diameter 2mm pre-drilling screws, length 5-9mm) / pre- and self-drilling mini-implants (diameter 2mm, length 8-14mm)	25.1 +-8.7	Gender, age, type of malocclusion, facial divergence, proposed movement, method of applied force, device type, insertion site, bone density, soft tissue around device, degree of tissue inflammation, healing time, and operator.	There were no significant differences for the factors: sex, type of malocclusion, facial divergence, implantation site, location, method of force application, arch, type of soft tissue, type of examiner who installed and most cephalometric measurements that reflect the dentocraniofacial features. A significant failure rate was observed for the self-drilling mini-implant, used for uprighting teeth, inserted into bone with lower density, associated with local inflammation of the surrounding soft tissue, loaded within 3 weeks after insertion and installed in patients with greater mandibular retrusion.	Soft tissue inflammation around a TAD and early loading within 3 weeks of insertion were the most significant predictors of TAD failure.
Cheng, S. J., et al., 2004 (Taiwan)	44 patients (6 M, 38 F / 48 miniplates, 92 mini-implants)	miniplates (screws diameter 2 or 2.3mm length 5-15mm or 5-7mm / mini-implants diameter 2 or 2.3mm length 5-15mm or 5-7mm	29+-8.9	Device type, mini-implant length, magnitude of orthodontic load, insertion site, and soft tissue around the device.	The cumulative success rate was 89% (125/140). There was no significant difference in the success rate between miniplates and independent mini-implants. The Cox proportional hazards regression model identified the anatomical location and character of the peri-implant soft tissue as 2 independent prognostic indicators. The estimated relative risk of implant failure in the posterior mandible was 1.101 (95% confidence interval, 0.942-1.301; p = 0.046). The risk of failure ratio for implants surrounded by non-keratinized mucosa was 1.117 (95% confidence interval, 0.899 to 1.405; p = 0.026).	The results confirmed the effectiveness of orthodontic mini-implants, but in certain situations the adjustment of the treatment plan or modifications in the implant placement technique can lead to better success rates.

Yao, C. C., et al., 2015 (Taiwan)	220 patients (66 M, 154 F / 159 miniplates, 388 pre-drilled titanium mini-implants and 180 stainless steel self-drilling mini-implants)	ND	median 29.3	Gender, age, type of malocclusion, facial divergence, device type, insertion site, bone density, soft tissue around the device, soft tissue inflammation, and healing time.	The failure rate for miniplates was significantly lower than for mini-implants. The stability of pre-drilled titanium mini-implants and stainless steel self-drilling mini-implants were comparable to the first implantation. In the second implantation, the failure rate of stainless steel mini-implants increased. The following had a significant influence on mini-implant failure rates: age (35 years), type of mini-implant (self-drilling), implantation site (bone crest), late loading (after 30 days) and soft tissue characteristics around the mini-implants.	The stability of orthodontic mini-implants depends on the type of mini-implant, the patient's age, the implantation site and the healing time. Miniplates are a more viable anchorage system when mini-implants repeatedly fail.
Takaki, T., et al., 2010 (China)	455 patients (97 M, 358 F / 225 self-drilling mini-implants and 444 mini-plates)	Self-drilling mini-implants (diameter 1.4mm, length ND)	25.7 +-9.8	Soft tissue inflammation and granulation tissue formation.	Each type of device had a high success rate (about 90%). Failure rates were as follows: mini-screws, 6% and miniplates, 6%. The rate of inflammation in the soft tissue around the TADs was as follows: plaque, 7.6%; mini-screws, 1.3%. The frequencies of inflammation with the rate of granulation in the soft tissues around the TADs were: self-drilling mini-screws, 0%; plate, 0.9%.	Success rates were 94% for miniplates and mini-implants, 93%. The highest failure rate occurred in the palatal region of a young patient, the same with mini-implants in the alveolar region of the mandible. The rate of inflammation of the surrounding soft tissue was highest with the plate-type devices (acute inflammation), followed by mini-implants.

Kuroda, S., et al., 2007 (Japan)	75 patients (12 M 63 F / 37 type A mini-implants, 79 type B mini-implants and 38 mini-plates)	Miniplates (2mm diameter, length 5mm) / type A mini-implants (diameter 2.0 or 2.3 mm, length 7 or 11 mm, screw head 3 mm) / type B mini-implants (diameter 1.3 mm, length 6 , 7, 8, 10 and 12 mm, screw head 3 mm)	21.8+-8.2	Gender, age, mandibular plane angle, periodontitis control, temporomandibular disorder symptoms, applied load and device length.	The success rate for each type of device was over 80%. No statistical difference between device types. The analysis of 79 mini-implants with 1.3 mm in diameter did not show significant relationships between the success rate and the variables: age, sex, mandibular plane angle, anteroposterior mandibular base relationship, periodontitis control, dysfunction symptoms temporomandibular, load and length. Type B mini-implants had a higher success rate for intrusion and a lower success rate in the molar region than in the premolar when installed via the buccal.	Mini-implants installed without flaps have higher success rates than mini-implants installed in flap or mini-plate surgery.
Miyawaki, S., et al., 2003 (Japan)	51 patients (9 M, 42 F / 10 type A mini-implants, 101 type B mini-implants, 23 type C mini-implants and 17 mini-plates)	Miniplates (diameter 2mm, length 5mm) / type A (diameter 1.0 mm, length 6 mm) / type B (diameter 1.5 mm, length 11 mm / type C (diameter 2.3 mm, length 14 mm)	21.8+-7	Gender, age, mandibular plane angle, soft tissue inflammation, device length, surgical technique, time of load application, site of installation, pain and swelling after 1 week, tooth crowding, periodontitis with controlled resorption and symptoms of dysfunction temporomandibular.	The 1-year success rate of smaller diameter mini-implants (type A) was significantly lower than that of type B, type C or miniplates (10% higher success rate than types B and C). An elevated angle of the mandibular plane and inflammation of the peri-implant tissue were risk factors for mobility. There was no significant association between the success rate and the following variables: length, surgical technique, applied load, implantation site, age, sex, dental crowding, anteroposterior relationship of the base of the mandible, controlled periodontitis and symptoms of temporomandibular disorders.	A diameter of 1.0 mm or less, inflammation of the peri-implant tissue, and a high angle of the mandibular plane (thin cortical bone) were associated with mobility due to failure of the mini-implant installed in the posterior alveolar alveolar bone. Mini-implants with a diameter greater than 1.0 mm are desirable in patients with a medium to low mandibular plane angle. Mini-implants with a diameter greater than 2.3 mm, or with miniplates is desirable in patients with a high mandibular plane angle (thin cortical bone).

M, Male; F, Female; SD, Standard Deviation; TAD, Temporary anchorage device; ND, Not described

1

Risk of bias in studies

Among the six observational studies included, five had a low risk of bias, and only one had a high risk of bias. The only randomized clinical trial included presented three of the six domains with a high risk (50%), and the other domains were considered of low risk (appendix 3).

Results of individual studies

Six articles included compared some variables between mini-plates and mini-implants that showed statistical significance ($p < 0.05$).

Comparing the types of TADs, the failure rate of mini-implants was significantly higher than that of mini-plates regardless of length and diameter. Studies comparing more than one type of mini-implant diameter and devices with a smaller diameter showed a higher failure rate [11, 19]. Two studies compared self-drilling mini-implants and those for pre-drilled regions, and there was a statistical significance in relation to self-drilling devices with a high failure rate [27, 28].

The literature is controversial regarding the influence of age as a risk factor. There are results with no differences according to age [11, 19, 27] and results presenting a higher risk for younger patients in relation to device failure [28, 29].

The type of the soft tissue around the device were factors that had a significant influence on failures. Devices associated with inflammation in non-keratinized tissue, compared to regions of keratinized tissue, also showed a higher failure rate [19, 27, 28, 30].

Regarding the location of installation and the function of the TAD, three articles reported the increase in failure rates of devices installed in the mandible [29, 30], specifically in the posterior region [11, 29]. There was a high failure rate in devices installed for the purpose of retraction [27, 29], protraction [29], or buccal teeth [27].

Two articles cited the moment of load application as a reason for the failure rate, presenting data in a controversial way. An article showed the relation of the application of an early loading within three weeks after installation [27]. Another

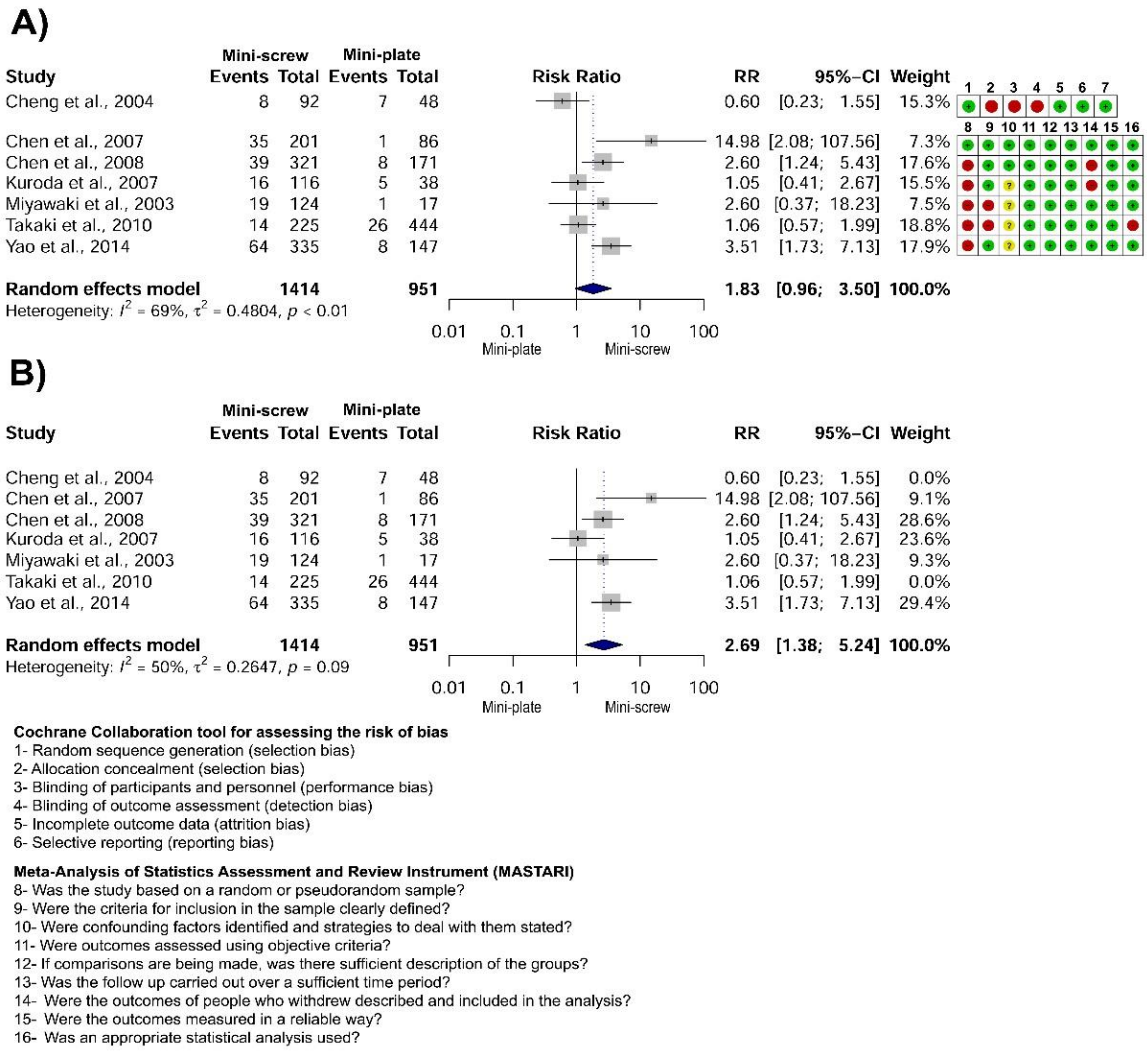
article, after 30 days of installation, reported that the late load affected the failure of the device [28].

Results of syntheses

Seven articles underwent quantitative synthesis and random effect meta-analyses could be performed aiming the following outcomes: type of device, place of installation, and type of the soft tissue. Due to the lack of direct comparisons for the variables mean diameter of screw and mean age of the sample, underwent meta-regression of random effects.

When comparing the risk of failure between mini-implants and mini-plates, the risk values approached the threshold of statistical significance (p = 0.07) (RR = 1.83; 95% CI = 0.96 - 3.50; I^2 = 69%) (Fig 2a). After conducting sensitivity analysis and excluding studies with a high risk of bias, there was a statistically significant difference, with a 2.69 times greater risk of mini-implants when installed individually compared to mini-plates [RR = 2.69; 95% CI = 1.38 - 5.24]. There was a 19% decrease in the heterogeneity observed (I^2 = 50%; Tau^2 = 0.264; *p* = 0.09) (Fig 2b).

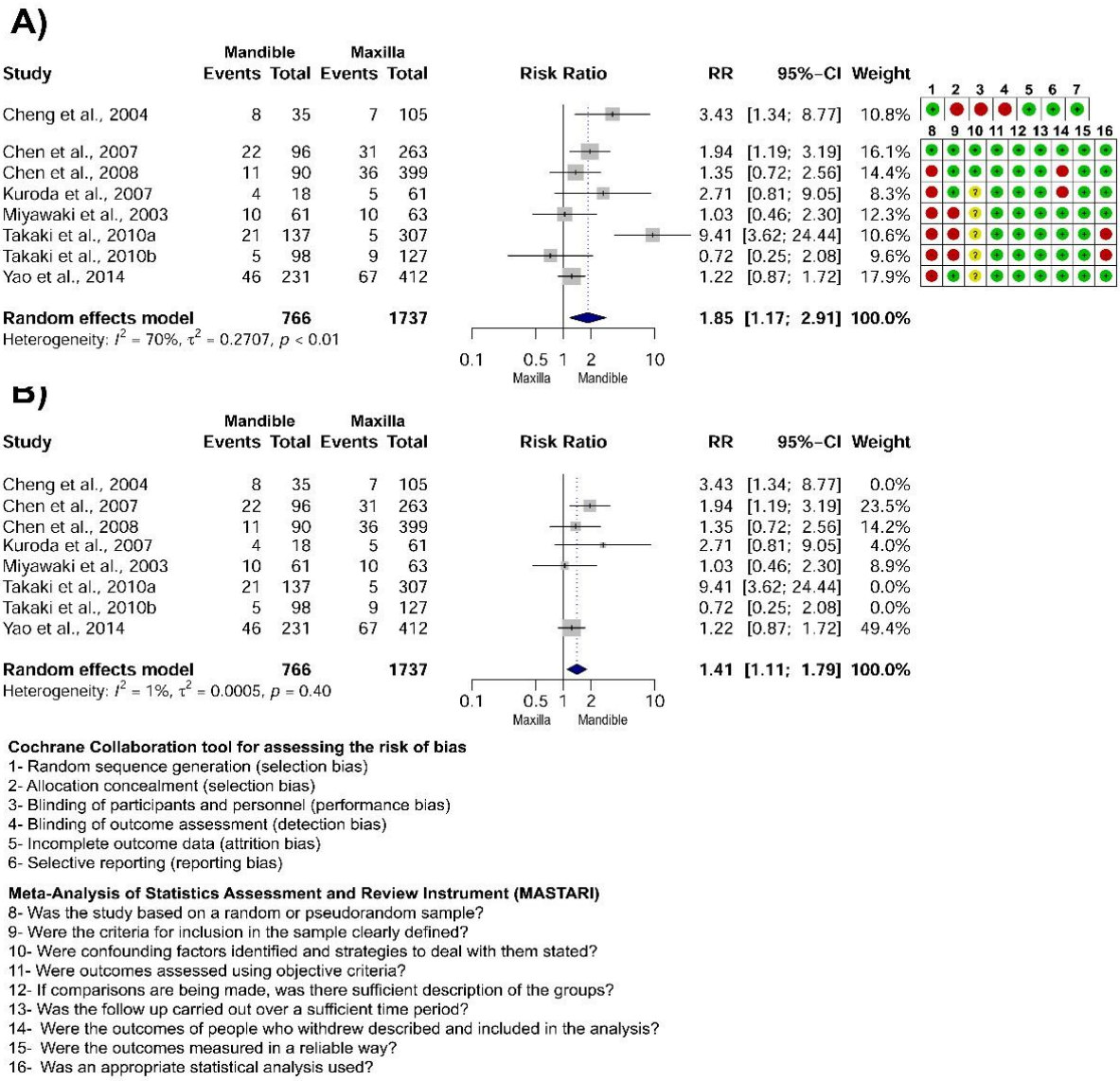
Figure 2 - Forest Plot graph to assess the association between the risk of failure when comparing mini-screws and mini-plates: a) analysis of all included studies, displaying risk of bias judgements for each study; b) sensitivity analysis, excluding studies with a high risk of bias.



When assessing secondary outcomes, there was a greater risk of failure for anchoring devices when devices were installed in the mandibular arch, presenting a 1.85 times greater risk in this situation (RR = 1.85; 95% CI = 1.17 - 2.91; I^2 = 70%) (Fig 3). With the exclusion of studies with a high risk of bias, the value of the relative risk showed a similar decrease as that of heterogeneity

between results [RR = 1.41; 95% CI = 1.11 - 1.79; I^2 = 0%]. However, it still had a statistical significance.

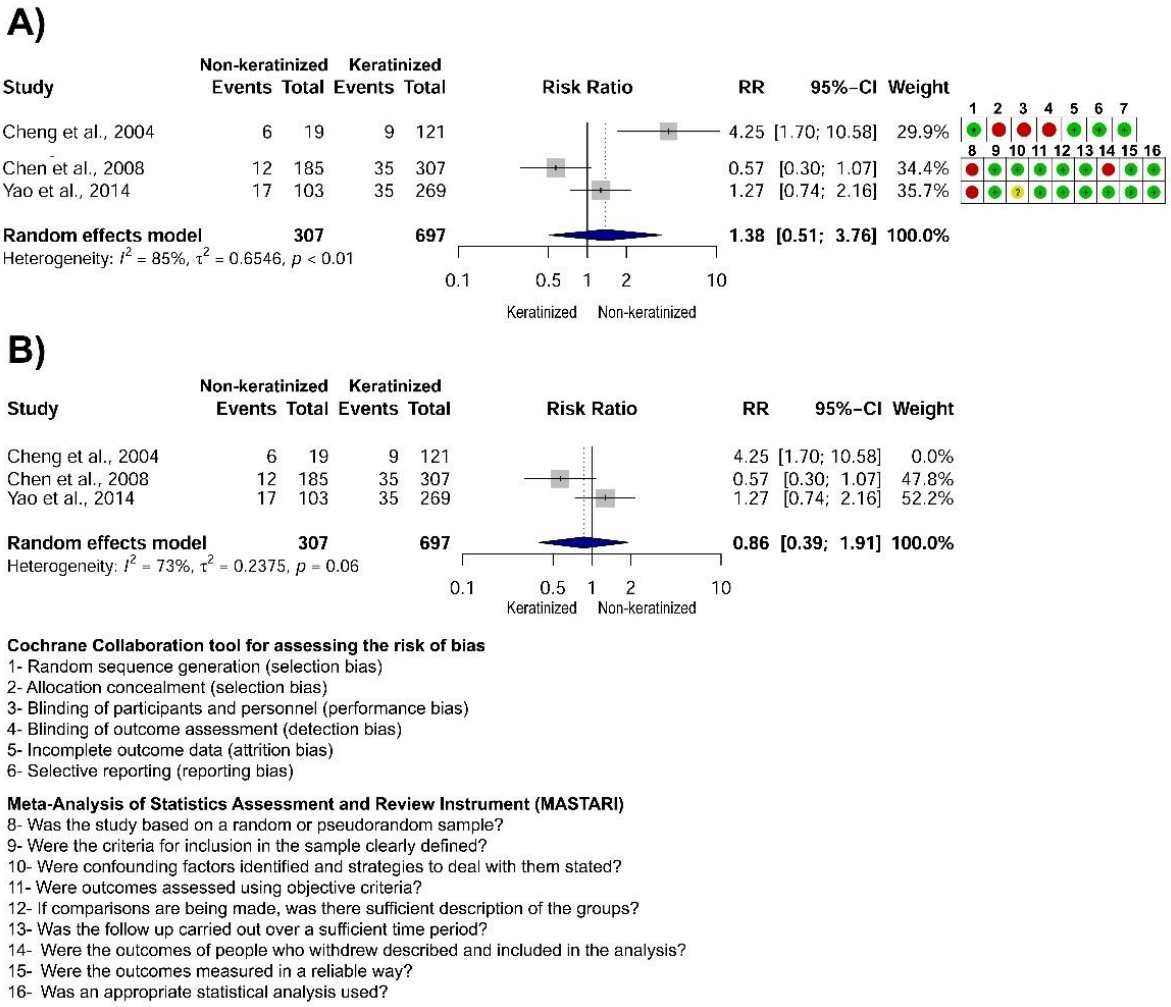
Figure 3 - Forest Plot graph to assess the association between the risk of failure according to the arch in which the anchoring device was installed: a) analysis with all included studies, displaying risk of bias judgements for each study; b) sensitivity analysis excluding studies with a high risk of bias.



There was no statistically significant difference when considering the type of soft tissue in which the device was inserted even after performing the sensitivity analysis (Fig 4). There was a 12% decrease in heterogeneity, with a substantial level of variance between the effects of the studies included (Tau^2 = 0.237; p =

0.06). However, even with different directions of effects, both studies approached the null line, showing no significance.

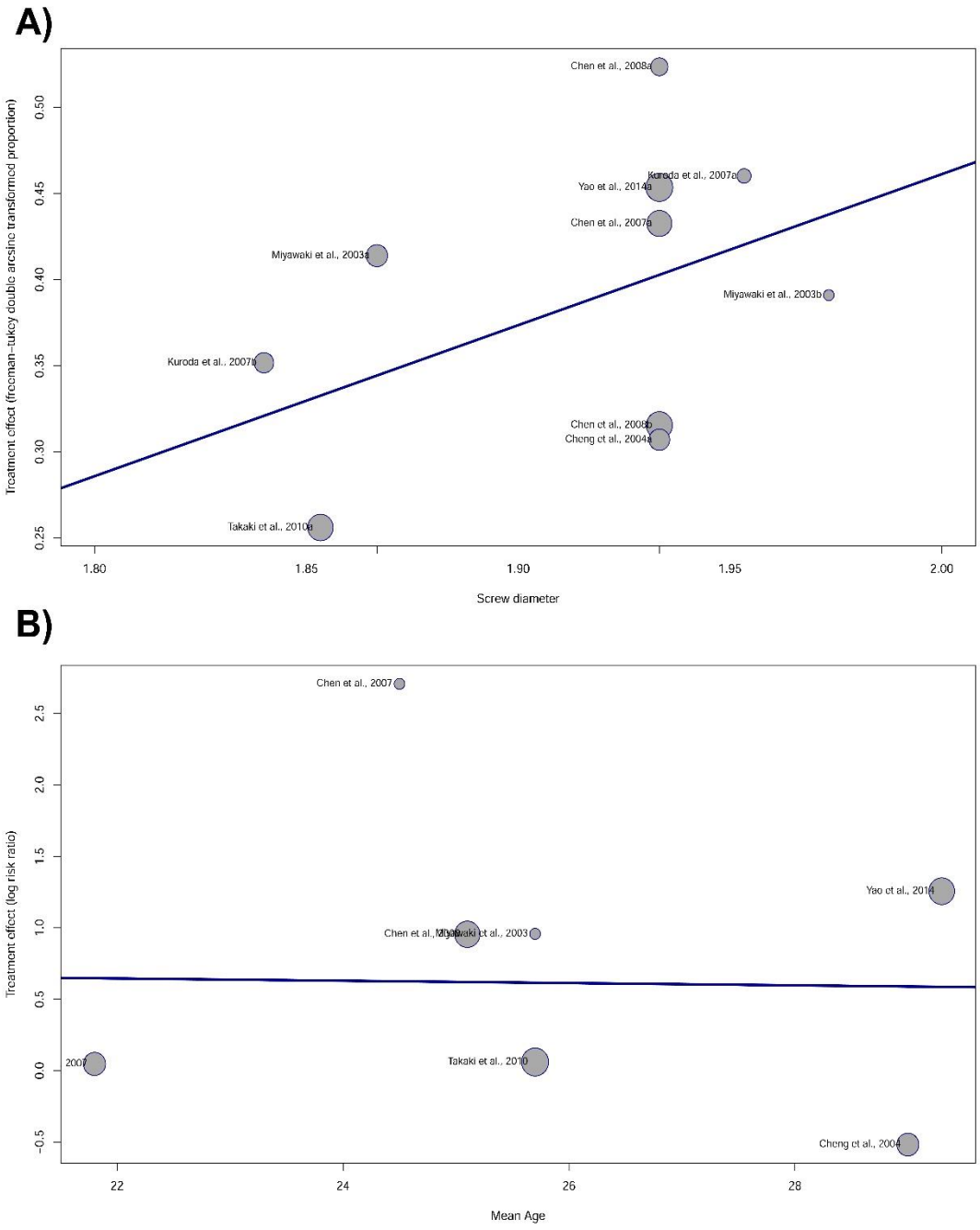
Figure 4 - Forest Plot graph to assess the association between the risk of failure according to the type of the soft tissue where the device was inserted: a) analysis with all included studies, displaying risk of bias judgements for each study; b) sensitivity analysis excluding studies with a high risk of bias.



When considering confounding factors, the mean diameter of the screw used in the study partially explained the regression model (R^2 = 21.24%). However, the p-value was not significant for this model (p = 0.176). In the same sense, the covariable average age did not explain the variation between the sizes

of effects observed in the meta-analysis (p = 0.95; R^2 = 0%); thus, there is no linear relation between these covariables and the observed effect size (Fig 5).

Figure 5 - Bubble-plot graph for meta-regression: a) Prevalence of failures in mini-implants in relation to the diameter; b) Log of the relative risk of comparison of failures between mini-implants and mini-plates, which was regressed in relation to the average age of the sample.



Reporting biases

Due to the number of studies included in the analysis, it was not possible to assess the presence of publication bias using the funnel plot. However, the inclusion of a Latin American database (LILACS) with a language other than English, the broad search strategy, and the search in gray literature, decrease the probability of occurrence of this bias.

Certainty of evidence

The certainty of evidence was very low for all comparisons. The domains related to risk of bias, imprecision, and inconsistency were responsible for the loss of score of the assessed certainty (appendix 4).

Discussion

This systematic review and meta-analysis analyzed the available evidence on risk factors related to the stability of mini-implants and mini-plates, as well as the type of device with a greater or a lesser risk of failure. Based on the current available literature and the eligibility criteria established for this systematic review, it was only possible to quantitatively analyze data regarding the type of device, the arch in which it was installed, and the type of the soft tissue where the device was inserted. In addition, the literature reported that the covariables screw diameter and mean age were possible confounding factors; as they were not directly compared in the studies, they were then meta-regressed. The results indicate that the installation of TADs in the lower arch (mandible) presents a significant risk of failure in relation to stability. There was a greater risk of failure when using isolated mini-screws. The demonstration of the tendency of the screw diameter affected the failure of the device but presenting a statistically non-significant result.

The mandibular bone has a higher density and cortical thickness than the maxilla, which may enable a greater stability of TADs through mechanical retention. According to Chen et al. [29], surgical factors such as overheating of perforation (when there is a harder bone in the jaw) or the amount of gingiva inserted (smaller in the jaw) may contribute to the high failure rate of the devices

installed. Accordingly, Cheng et al. [30] also report that posterior implants in the mandible region are more susceptible to infection because, in addition to the low amount of attached gingiva, there is a greater influence of food and difficulty in cleaning. The authors highlight overheating, especially in the use of self-drilling mini-implants, which contributes to the loss of stability and failure of devices. In the same sense, the data in the present review point to a greater risk of loss of devices when they are inserted in the lower arch, with a risk of failure 1.85 times greater when compared to insertion in the maxilla. However, the data are not statistically significant when considering the type of tissue to be inserted. The meta-analysis shows a difference in the direction of the effects observed between the studies included, requiring further studies to increase the certainty of evidence of this outcome in relation to non-significance.

Regarding the types of devices compared in this article and based on the results of the articles included that showed statistically significant results, the use of mini-implants associated with mini-plate shows a tendency towards a low failure rate, approaching the significance threshold ($p = 0.07$). However, after excluding studies with a high risk of bias, there was a 2.69 times greater risk of failure of mini-implants compared to mini-plates. The use of mini-implants alone has some advantages, such as lower cost, versatility, and simple surgical installation compared to the association with mini-plates, which requires different surgical times for installation and removal [31]. Chen et al. [29] found an association between the type of movement performed with the device and the failure rates, which proved to be higher in regions where the device was installed for dental movements associated with retraction and protraction than for intrusion movements. The authors regarded it as a possible justification for failure rates to be lower in mini-plates because they were used for intrusion to a greater extent. In the same sense, the data in the present review point to a statistical significance as for the type of device installed. However, the type of orthodontic movement may act as a confounding factor not reported by the studies included, reducing the certainty of evidence of this outcome.

The stability of TADs occurs when there is mechanical retention of TADs to the bone tissue through bone-metal contact. Mini-implants are manufactured in different lengths and diameters, and studies such as that of Miyasaki et al. [19]

evaluated whether different lengths and diameters of mini-implants - that is, different areas of the bone-metal contact – affect the failure rates in terms of stability. The authors found a significant difference in stability in relation to the mini-implant diameter. They considered that a length from 5 mm is acceptable, since the highest success rate of the study occurred with the mini-plates (96.4%) and the length of the two screws installed was 5 mm. Regarding the diameter, the failure rate was higher in mini-implants with smaller diameters (100% for 1-mm diameter, 16.1% for 1.5-mm diameter, 15% for 2.3-mm diameter). In addition, they concluded that in regions with the thinnest cortical bone, the mini-implant with a larger diameter - in the study, 2.3 mm - are more suitable, and in regions with anatomical limitation and thicker cortical bone the thinnest mini-implant (1.5 mm) must be used. The study of Kuroda et al. [11] used implants with a diameter of 1.3 mm in the sample and had a failure rate of 11.4%, concluding that mini-implants are as stable as mini-plates or mini-implants with a larger diameter, not substantially proving the diameter influence on stability. These data are in line with the findings of the present study, where there was no statistical significance when the screw diameter was measured in relation to the prevalence of failures. On the other hand, the diameter explained 21.24% of the regression model, thus denoting a trend. As the p-value is a probability that depends on the standard error, a greater number of future studies should be included in the analysis to guarantee a greater reliability in the meta-regression estimate.

Regarding age as a possible risk factor, Chen et al. [29] observed a higher failure rate in younger patients (<30 years), and considered that in older patients the cortical bone has a greater density and thickness, contributing to the mechanical retention and, consequently, to the stability of TADs. Likewise, Yao et al. [28] also observed that density and bone maturation affected the stability of devices. These factors may compromise the stability of anchoring devices, increasing the risk of failure in patients under 35 years old. On the other hand, other studies [11, 20, 31] did not find statistical significances in relation to age as a risk factor in relation to stability, which is consistent with the results of the present study. The meta-regression carried out considered the average age of the sample of the studies included. However, all studies had an average below 35 years old; therefore, to confirm this finding, it is necessary that further studies

with an average age above 35 years old be performed and included in the regression analysis.

The results of this systematic review and meta-analysis reveal important data on risk factors related to the lack of stability and that may affect the loss of mini-implants and mini-plates. These findings, as they show the current stage of knowledge on the subject, help the orthodontist and/or the surgeon to stipulate risks, learn about the predictability of techniques, and communicate with the patient in an easier way. However, some limitations should be pointed out, such as the number of studies included and the study design – six studies included out of seven are observational. Confounding factors, such as the type of orthodontic movement performed, the complexity of cases, and the level of hygiene around the devices, in the absence of a process of randomization and control of these variables, may act by altering the observed effect and reducing the certainty of evidence. The inability to analyze quantitatively directly through the meta-analysis variables that may also influence the failure in relation to the stability of devices (such as screw diameter and average age) is also a limitation of this review. Thus, the present study emphasizes the need for further prospective, multicenter, randomized clinical studies that are well conducted methodologically in order to make the analysis more robust, with a greater control of possible confounding factors.

Conclusion

The evidence found in the literature indicates that failures in the stability of TADs is related to the type of device, with a greater risk for the use of isolated mini-implants, especially when positioned in the mandible. It is not possible to state that age affects the stability of these devices. There is a tendency for screw diameter in explaining the variance observed in the results. However, the number of available studies is not sufficient to confirm this finding. The type of orthodontic movement and hygiene around the devices may act as a confounding factor not reported by the studies included, reducing the certainty of evidence of this outcome.

Other information

Protocol and registration

This systematic review was carried out in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Checklist) [32] and the protocol was registered at the PROSPERO website (International prospective register of systematic review - Center for Reviews and Dissemination University of York) - CRD42020222035.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding No external funding was provided in regard with this study. The authors received no other institutional funding beyond their employment.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

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1 Appendices

2 **Appendix 1 -** Search strategy used in electronic databases

COCHRANE	(“miniplates” OR “miniplate” OR “mini-plate” OR “mini-plates”) AND (“bone screw” OR “bone screws” OR “mini-implant” OR “mini-implants” OR “mini implant” OR “mini implants” OR “miniscrews” OR “miniscrew” OR “mini-screw” OR “mini-screws”) AND (“risk factors” OR “risk factors” OR “stability” OR “risk factor” OR “risk”)
LILACS	("miniplates" OR "miniplacas" OR "miniplate" OR "miniplaca" OR "mini-plate" OR "mini-placa" OR "mini-plates" OR "mini-placas") AND ("bone screw" OR "parafuso ósseo" OR "tornillo de hueso" OR "bone screws" OR "tornillo de huesos" OR "parafusos ósseos" OR "mini-implant" OR "mini-implante" OR "mini-implants" OR "mini-implantes" OR "mini implant" OR "mini implante" OR "mini implants" OR "mini implantes" OR "miniscrews" OR "miniparafusos" OR "miniscrew" OR "miniparafusos" OR "mini-screw" OR "mini-screws") AND ("risk factors" OR "risk factors" OR "stability" OR "risk factor" OR "risk" OR "fatores de risco" OR "factores de riesgo" OR "factor de riesgo" OR "estabilidad" OR "estabilidade" OR "risco" OR "riesgo")
PUBMED	(“miniplates”[All Fields] OR “miniplate”[All Fields] OR “mini-plate”[All Fields] OR “mini-plates”[All Fields]) (“bone screw”[MeSH] OR “bone screws”[All Fields] OR “mini-implant”[All Fields] OR “mini-implants”[All Fields] OR “mini implant”[All Fields] OR “mini implants”[All Fields] OR “miniscrews”[All Fields] OR “miniscrew”[All Fields] OR “mini-screw”[All Fields] OR “mini-screws”[All Fields]) (“Risk factors”[MeSH Terms] OR “risk factors”[All Fields] OR “stability”[All Fields] OR “risk factor”[All Fields] OR “risk”[All Fields]) #1 AND #2 AND #3

SCOPUS	(“miniplates” OR “miniplate” OR “mini-plate” OR “mini-plates”) AND (“bone screw” OR “bone screws” OR “mini-implant” OR “mini-implants” OR “mini implant” OR “mini implants” OR “miniscrews” OR “miniscrew” OR “mini-screw” OR “mini-screws”) AND (“Risk factors” OR “risk factors” OR “stability” OR “risk factor” OR “risk”)
EMBASE	('miniplates' OR 'miniplate'/exp OR 'miniplate' OR 'mini-plate' OR 'mini-plates') AND ('bone screw'/exp OR 'bone screw' OR 'bone screws'/exp OR 'bone screws' OR 'mini-implant' OR 'mini-implants' OR 'mini implant'/exp OR 'mini implant' OR 'mini implants' OR 'miniscrews' OR 'miniscrew'/exp OR 'miniscrew' OR 'mini-screw' OR 'mini-screws') AND ('risk factors'/exp OR 'risk factors' OR 'stability'/exp OR 'stability' OR 'risk factor'/exp OR 'risk factor' OR 'risk'/exp OR 'risk')
WEB OF SCIENCE	TS=(“miniplates” OR “miniplate” OR “mini-plate” OR “mini-plates”) TS=(“bone screw” OR “bone screws” OR “mini-implant” OR “mini-implants” OR “mini implant” OR “mini implants” OR “miniscrews” OR “miniscrew” OR “mini-screw” OR “mini-screws”) TS=(“Risk factors” OR “risk factors” OR “stability” OR “risk factor” OR “risk”) #1 AND #2 AND #3
GOOGLE SCHOLAR	“miniscrew” AND “mini-plate”
OPENGREY	“miniscrew” AND “mini-plate”
PROQUEST	“miniscrew” AND “mini-plate”

Appendix 2 - Excluded articles and reasons for exclusion (n = 21).

Author, Year	Reason for exclusion
Barros et al. 2011[1]	3
Baxmann et al. 2010[2]	3
Chang et al. 2015[3]	3
Choi et al. 2005[4]	3
Dobranszki et al. 2014[5]	3
Findik et al. 2017[6]	3
Hibi et al. 2010[7]	3
Janson et al. 2013[8]	3
Jing et al. 2016[9]	3
Kim et al. 2016[10]	3
Kuroda et al. 2007[11]	3
Lai and Chen. 2014[12]	4
Lam et al. 2018[13]	3
Lee et al. 2008[14]	3
Leung et al. 2008[15]	3
Lin et al. 2015[16]	3
Lu et al. 2011[17]	4
Madalone et al. 2010[18]	4
Rodrigues et al. 2014[19]	3
Topouzelis and Tsaousoglou. 2012[20]	3
Tsai et al. 2016[21]	3

1) Studies in animals; 2) Studies including participants with craniofacial deformity or syndromic subjects; 3) Studies that did not compared patients with miniscrews and patients with miniplates; 4) Studies in which none of the variables of interest have been evaluated; and 5) Reviews, letters, conference abstracts, personal opinions, case reports and case series.

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Appendix 3 – Risk of bias of the studies included in the qualitative and quantitative analysis assessed by: a) "Meta-Analysis of Statistics Assessment and Review Instrument" (MAStARI) critical appraisal tools. Risk of bias was categorized as High when the study reached up to 49% score "yes," Moderate when the study reached 50% to 69% of score "yes," and Low when the study reached more than 70% score "yes."; b) Cochrane's tool to assess risk of bias in randomized controlled trials (Higgins et al 2011)[1]

3.1 - Studies included in the qualitative analysis

A *– Cross-sectional. Descriptive Studies.*

Question	Chen, Y. J., et al., 2007[1]	Chen, Y. J., et al. 2008[2]	Kuroda, S., et al., 2007[3]	Miyawaki, S., et al., 2003[4]	Takaki, T., et al., 2010[5]	Yao, C. C., et al., 2015[6]
1. Was the study based on a random or pseudorandom sample?	Y	N	N	N	N	N
2. Were the criteria for inclusion in the sample clearly defined?	Y	Y	Y	N	N	Y
3. Were confounding factors identified and strategies to deal with them stated?	Y	Y	U	U	U	U
4. Were outcomes assessed using objective criteria?	Y	Y	Y	Y	Y	Y
5. If comparisons are being made, was there sufficient description of the groups?	Y	Y	Y	Y	NA	Y
6. Was the follow up carried out over a sufficient time period?	Y	Y	Y	Y	Y	Y

7. Were the outcomes of people who withdrew described and included in the analysis?	Y	N	N	Y	Y	Y
8. Were the outcomes measured in a reliable way?	Y	Y	Y	Y	Y	Y
9. Was an appropriate statistical analysis used?	Y	Y	Y	Y	N	Y
% yes/risk	100% Low	87.5% Low	85.7% Low	85.7% Low	% High	87.5% Low

Legend - *Y=Yes, N=No, U=Unclear, NA=Not applicable

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1

2 **b –** Cochrane's tool to assessed risk of bias in randomized controlled trials (Higgins et al 2011)[1]

Author, year	**Questions**	**Suport for judgement**	Risk of Bias
Cheng, S. J., et al., 2004[2]	Random sequence generation (selection bias)	Simple randomization	LOW RISK
	Allocation concealment (selection bias)	Randomized allocation, but does not make clear the secrecy	HIGH RISK
	Blinding of participants and personnel (performance bias)	The authors did not report on how the allocation was carried out and whether there was confidentiality	HIGH RISK
	Blinding of outcome assessment (detection bias)	The authors did not report on how the allocation was carried out and whether there was confidentiality	HIGH RISK
	Incomplete outcome data (attrition bias)	No missing outcome data	LOW RISK
	Selective reporting (reporting bias)	The study included all expected outcomes	

			LOW RISK

1. Higgins JP, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928.
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Appendix 4 - Assessment of the Certainty of evidence by the GRADE tool for the different comparisons: a) risk of failure according to the type of device; b) risk of failure according to the arch in which the anchoring device was installed; c) risk of failure according to the type of the soft tissue.

A)

Certainty assessment							Summary of findings				
Participants (studies) Follow up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%) With Mini-plate	Study event rates (%) With Mini-screw	Relative effect (95% CI)	Anticipated absolute effects Risk with Mini-plate	Anticipated absolute effects Risk difference with Mini-screw
Failure											
2365 (7 observational studies)	serious [a]	serious [b]	not serious	not serious	none	⨁◯◯◯ VERY LOW	56/951 (5.9%)	195/1414 (13.8%)	**RR 1.83** (0.96 to 3.50)	59 per 1.000	**49 more per 1.000** (from 2 fewer to 147 more)

B)

Certainty assessment							Summary of findings				
Participants (studies) Follow up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%) With Mandible	Study event rates (%) With Maxilla	Relative effect (95% CI)	Anticipated absolute effects Risk with Mandible	Anticipated absolute effects Risk difference with Maxilla
Failure											
2503 (8 observational studies)	not serious	serious [b]	not serious	not serious	none	⨁◯◯◯ VERY LOW	170/1737 (9.8%)	127/766 (16.6%)	**RR 1.85** (1.17 to 2.91)	98 per 1.000	**83 more per 1.000** (from 17 more to 187 more)

CI: Confidence interval; **RR:** Risk ratio

C)

Certainty assessment							Summary of findings				
							Study event rates (%)			Anticipated absolute effects	
Participants (studies) Follow up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	With non-keratinized	With Keratinized	Relative effect (95% CI)	Risk with non-keratinized	Risk difference with Keratinized
Failure											
1004 (3 observational studies)	not serious	very serious [c]	not serious	very serious [d]	none	⨁◯◯◯ VERY LOW	79/697 (11.3%)	35/307 (11.4%)	**RR 1.38** (0.51 to 3.76)	113 per 1.000	**43 more per 1.000** (from 56 fewer to 313 more)

CI: Confidence interval; **RR:** Risk ratio

Explanations

a. A study with a high risk of bias, altered the final effect estimate, verified by sensitivity analysis
b. Presence of substantial heterogeneity
c. Presence of substantial heterogeneity and different direction of effect
d. Wide confidence interval

CONCLUSÕES GERAIS

As evidências encontradas na atual literatura indicam que dentes tracionados ortodonticamente apresentaram piora nos parâmetros periodontais índice gengival e profundidade de sondagem, contudo, a profundidade de sondagem deve ser ponderada quanto ao seu significado clínico, devido ao pequeno tamanho de efeito observado. A falha na estabilidade dos DATs está relacionada com o tipo de dispositivo e o local da instalação, com maior risco para utilização de mini-implantes isolados e quando posicionados em mandíbula. O tipo de movimento ortodôntico e higiene ao redor dos dispositivos podem agir como fatores de confusão não descritos pelos estudos incluídos, diminuindo a certeza de evidência deste desfecho.

A falha na estabilidade dos DATs está relacionada com os fatores de risco tipo de dispositivo e local da instalação, sendo maior quando utilizados os mini-implantes isolados e posicionados em mandíbula. Não é possível afirmar que a idade pode afetar a estabilidade destes dispositivos. Houve tendência de que o diâmetro do parafuso explique a variância observada nos resultados, porém, o número de estudos disponíveis não é suficiente para afirmar esse achado. O tipo de movimento ortodôntico e higiene ao redor dos dispositivos podem agir como fatores de confusão não relatados pelos estudos incluídos, diminuindo a certeza de evidência deste desfecho.

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