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Temporary Anchorage Devices usage stability in modern orthodontics: systematic review

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Abstract: *In orthodontic treatment, TADs have mostly been utilized for anchorage when patient compliance is lacking. Various failure rates have been reported in modern orthodontic literature. An accurate assessment of the TADs stability rate and potential risk factors for the mechanically-retained TADs was the aim of our research. Up to December 2017, MEDLINE, Scopus, and the Cochrane Library were used for electronic database searches. Reference lists were examined and further searching for ongoing and unpublished data was done. Hand searches of pertinent journals and grey literature were also conducted. We gathered English-language published prospective cohort studies (PCSs) and randomised controlled trials (RCTs) that detailed the failure rate of miniscrews, which are less than 2 mm in diameter, when used as an orthodontic anchoring. In this study, data extraction, risk of bias evaluation, and blind and duplicate study selection were done. Using the random-effects model, failure rates and pertinent risk variables for miniscrews were determined, along with the accompanying 95 percent confidence intervals (CIs). The I^2 and Chi^2 tests were used to evaluate the heterogeneity among the studies. The Newcastle-Ottawa Scale and the Cochrane Risk of Bias were used to determine the risk of bias. The robustness of the meta-analysis results was tested by using subgroup and sensitivity analyses. This study comprised 30 prospective clinical trials as well as 16 randomized clinical trials. Because there was insuficient statistical data to calculate the impact sizes, five studies were excluded from the meta-analysis. In a random-effect model, 3250 miniscrews approximately amongst 41 trials were combined. Miniscrews showed an overall failure rate of 13.5% (95% CI 11.5%–15.9%). Analysis of division groups revealed that smoking and the kind of gingivae had statistically significant effects on the rate of miniscrew failure, while the diameter, length, and design of the miniscrews, patient age, and place of insertion had non-significant effects. Conclusion: TADs have an acceptably low failure rate. Because of the high degree of heterogeneity and imbalanced groups in the included research, care should be taken when interpreting the results. To validate the results of this review, significant sample sizes from high-quality randomized clinical trials are needed.*

Keywords: Orthodontic Anchorage Procedures, Orthodontic Tooth Movement, Malocclusion, Orthodontic Appliances, Orthodontic Preventive, Orthodontic, Interseptive.

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Introduction

Orthodontists utilize orthodontic skeletal anchoring devices for a variety of therapeutic purposes. These consist of anchoring reinforcement, incisor and molar intrusion, molar protraction, molar distalization, and cross bite correction [1–7]. The modern form of orthodontic skeleton anchoring devices gained popularity with Konami's 1997 publication [8]. In general, orthodontic skeletal anchorage devices fall into two categories: osteo-integrated implants such as mid-palatal implants [9] and onplants [10], as well as mechanically maintained devices including: titanium mini-plates [11,12], zygomatic wires, and mini-screws [13, 14]. Because miniscrews are biocompatible, easy to assemble and remove, affordable, and able to withstand orthodontic stresses, their usage in orthodontic therapy has expanded [15, 16]. A significant amount of research has been done on mechanically held miniscrews; from a small number of publications in the 1980s to over 5000 papers by the end of 2017, there was a great deal of interest in skeletal anchorage. Regretfully, very few published clinical trials make up the great majority of these publications, which are biomedical science trials and clinical case studies. In order to be successful, orthodontic force should ideally keep miniscrews immobile. Because the stability of the miniscrews rely on the Threads are manually linked into the bone tissues rather than osseointegration, they may be able to withstand orthodontic loads, which has become a concern. Miniscrews' success is influenced by a number of factors, some of which are linked to the patient, some of which are related to the design, and clinical elements. Because of the difference in buccal plate thickness, adolescents have a higher failure rate than adults, which is correlated with age [17]. Other patient-related factors that lower the survival probability of mini-screws include smoking and poor dental hygiene [18–20]. Additional patient-related characteristics include the mucosa type (keratinized versus non-keratinized) and the place of insertion. Miniscrews have generally been shown to have a fair success rate when put through keratinized gingivae and in the maxillary area [17, 19, 21]. When it comes to miniscrew design parameters, it has already been established that miniscrews with a diameter of 1.1 to 1.6 mm provide the highest success rate [22]. Additionally, miniscrews longer than 5 to 8 mm are more stable than shorter ones [19, 22]. Asepsis and sterilization, loading process [23], implantation torque [24, 25], insertion angle [26], and the clinician's experience have all been linked factors connected to clinicians that could have a major impact on miniscrew survival rate. The usefulness of various skeletal anchorage devices for anchorage provision in comparison to traditional techniques has been examined in recent reviews [7, 27, 28]. Nevertheless, the results of these assessments did not address mechanically held miniscrews, the most often utilized skeletal anchorage device. The aim of this study was to perform a systematic review and meta-analysis of controlled and non-controlled prospective clinical trials in order to update our understanding of miniscrews in orthodontic clinical practice, particularly with regard to their stability and associated risk factors. This is because of specific clinical parameters determination that impact clinical success has become increasingly important in nowadays practice.

Methods

No specific grant from a public, private, or nonprofit organization was given for this review. The Cochrane Guidelines for Systematic Reviews [30] and the preferred reporting items for systematic review and meta-analysis [29] were followed in the planning and reporting of this systematic review.

Inclusion criteria

The PICO format was used to define the primary research question (Table 1). English-language publications of prospective cohort studies (PCSs) and randomized clinical trials (RCTs) involving humans until December 2017 were included in this systematic review. Regarding the commencement date, there was no constraint in the search method. Comparators were not required because the objective of this research was to compile failure rates of the miniscrews. This study excludes case reports, case series, reviews, investigations on miniscrews in vitro, animal studies, and miniscrews having

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Table 1. PICO format.

Population	Participants receiving orthodontic treatment who need miniscrews (less than 2 mm) being inserted and are not limited in terms of the patients' presenting age, gender, or type of orthodontic appliance.
Intervention and comparators Any kind of orthodontic procedure that required miniscrew insertion	
Outcome	The primary result was the early loss of the miniscrews within the specified study time, as evidenced by movement, infection, inflammation, or other reasons.Confounders and risk factors linked to miniscrew failure were secondary outcomes.

a diameter larger than 2 mm. Two inquiries for more information were made to the author in cases where the study design was not obvious. The study was disregarded if the author did not respond.

Search strategy

Free text terms and a regulated lexicon were applied to the distribution of completed, ongoing, and unfinished research. If necessary, the original search was followed to update the vocabulary and identify all the research that would be taken into consideration for this evaluation. Up until December 1st, 2017, those databases were searched: the Cochrane Library of Systematic Reviews, PubMed, and Access MEDLINE. Until December 2017, additional bibliographic databases, such as Google Scholar, were also looked for unreported and continuing data. These databases included the clinical trial registration, PhD theses, doctoral theses and the ISRCTN register, and grey literature in Europe. Up to December 2017, a manual search of pertinent orthodontic journals was also conducted. In order to find any more pertinent literature and, if available, to add restricted vocabulary and open access text terms, references of the included papers and any pertinent systematic reviews related to the subject were examined. The two review authors' agreement was evaluated using the Cohen kappa statistic.

Data collection and selection of studies

Software for handling endnote citations was used for remowing duplicate researches. After reviewing the names and abstracts of the papers, the most pertinent ones were found. Two reviewers evaluated the potential papers' full texts (K.K. and P.B.) to determine their eligibility. Only products that came with an open access text in English were decided to be included due to the possible challenges associated with translating several articles into the English language. To prevent bias in the search methodology, this exclusion criterion was, however, used after the initial search and a third reviewer (Z.Z.) resolved any potential conflicts between the two reviewers (K.K., P.B.) as they used a modified data extraction form that Papadopoulos and his associates developed [7] to capture research characteristics and results blindly and independently. For every study, the following details were provided: the study's year of publication, its setting, its design, the number and varieties of miniscrews utilized, the success criteria, the failure rate, and the methods employed to deal with failures.

Assessment of risk bias

A method created by the Cochrane group was used to assess the bias risk of RCTs [30]. The following criteria were used to assess each included study for bias: creating randomised sequences; hiding allocations; masking outcome analysts; providing insufficient outcome data; selectively reporting; and other possible causes of bias. Every randomized controlled trial (RCT) was allocated a total risk of bias, which can be categorized as low, high, or unclear depending on whether more than one critical domain exhibited high, low, or unclear risk. The Newcastle–Ottawa Scale (NOS) was used to evaluate PCSs for bias risk [31]. The research in the following three areas is evaluated by the NOS: 1. choice; 2. equivalent; 3. result. If there was a conflict between both writers, a mutually agreed upon decision was reached through conversation. Once more, the potential disputes resolved by a third reviewer were evaluated using the Cohen kappa statistic to gauge the level of agreement between the two review writers. The pooled estimate,

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subgroup, and divided studies were planned in advance and predetermined (a priori), as were the length, diameter, age group, jaw, study type (cohort or RCT), and size of the sample (100 TADs and more) were used to investigate miniscrews impact. Additionally, we intended to investigate the impact on the pooled estimate of self-drilling miniscrews, non-self-drilling miniscrews, and miniscrew designs that need a pilot hole to be pre-drilled before insertion. It was intended to employ subgroup analysis in at least five different studies.

Assessment of publication bias

The asymmetry of the funnel plot was visually examined in order to evaluate publication bias. Additionally, two statistical techniques—Egger's method [35] and Begg/Mazumdar's method [34]—were applied to generate significance tests in order to identify publication bias.

Results

Study characteristics: combining electronic and manual searches yielded 8636 hits. Following the exclusion of duplicate research, 7915 papers were found to have not met the inclusion criteria based on the abstract and title (Figure 1). After the whole texts of the high-quality studies were obtained, rest of them were disqualified. This was due to the fact that they were not pertinent to the review issue or were laboratory studies, retrospective studies, or systematic reviews.

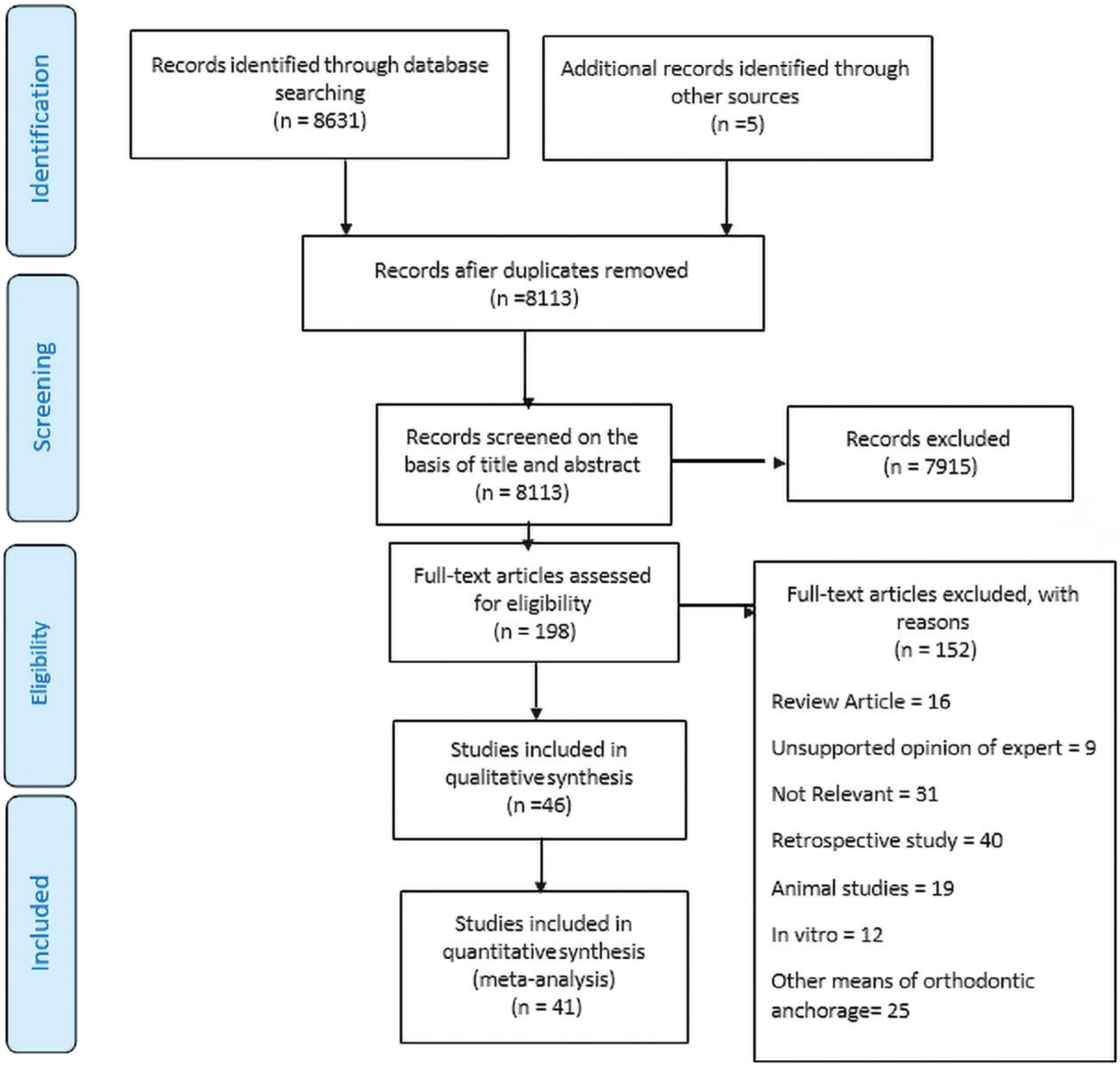

Figure 1. Flow diagram of data collection

46 studies that satisfied the primary inclusion criteria were included in the final sample. There were 30 PCSs [24, 32–45] and 16 RCTs [36–39] among the included studies. There was one split mouth trial conducted with PCSs.

The lack of statistical data required to calculate the effect sizes five studies were almost excluded from the meta-analysis: three PCSs and two RCTs [27, 36, 37, 38, 41]. They were, nevertheless, taken into account when evaluating the studies' quality. When further information was required, the authors were approached twice via email; if no response was obtained, the work was withdrawn. Table 2 lists key features of the 46 featured research projects, which together comprised 3466 miniscrews. Regarding the study environment, 36 (78%) of the research were solely based in academic environments, whilst the remaining 10 studies were conducted in private, hospital, mixed, or unidentified environments. The average number of miniscrews used per research was about 77, and the number of miniscrews used per subject typically ranged from 1 to 4. The locations of miniscrews that were inserted varied significantly, as did the miniscrew manufacturers employed in the included investigations. The miniscrews that were inserted had a diameter of 1.2 to 2 mm and a length of 5 to 15 mm. As shown, the recorded miniscrew failure rate varied from 0 to 40,8%.

Risk of bias of included studies

Nine of the included RCTs' trials were deemed to have an adequate random sequence generation domain, whereas the other trials were deemed to have a high possibillity of bias or an uncertain risk (Table 3). Only five trials were rated as having a low possibility of bias in the allocation concealment domain; the remaining studies were rated as having a high risk of bias or an unknown risk of bias. Because orthodontic treatment is a medical procedure, it was not possible to blind participants or staff in the trials that were included. Though blinding of assessors was feasible and done so in six trials, blinding was either not done or the reporting was insufficient in the ten other investigations. In the trials that were included, there were no dropouts. As a result, the low risk of bias assessment was applied to all included trials. In three experiments, the selective bias domain was found to have a minimal risk of bias. The residual research was deemed to possess an ambiguous risk of bias due to the absence of information provided to facilitate assessment. Only four trials (out of 39) had a summary rating of minimal risk of bias. After evaluating each of the six domains, it was determined that the remaining trials had an overall high risk of bias [40–51].

According to the NOS [14, 22–36], the great majority of prospective cohort studies were medium quality in terms of quality evaluation (Table 4). One study [80] was deemed to have low quality, whereas three studies [17–29] were deemed to have high quality.

Overall miniscrews failure rate (primary outcomes)

The main finding of this review, the miniscrew failure rate, was recorded in 41 out of 46 trials. A random-effect model was constructed by pooling the retrieved data from 3250 miniscrews. According to Figure 2, the combined failure rate was 13.5% (95% CI 11.5–15.9, P = 0.001, I^2 = 57.1%).Thirty investigations yielded data on 1391 miniscrews, of which less than 100 miniscrews were included in each study and combined in a random-effect model. The miniscrew failure rate of 12.5% (95% CI 9.7–16.1, P < 0.001, I^2 = 60.23%) was comparable to the effect size summary point estimates from all the investigations. Data from the 11 experiments where each research comprised more than 100 miniscrews were then evaluated in a random-effect model, the total number of miniscrews inserted was 1893. Miniscrew failure rates were 14.3% (95% CI 11.5–17.7, P = 0.027, I^2 = 71.5%). In studies including over 100 miniscrew placements, the rate also did not substantially differ from the main analysis's estimations of the effect size.

Assessment of the miniscrew failure risk factors (secondary outcomes)

Studies have documented the diameter and length of miniscrews more than any other characteristic, with the exception of placement (maxilla or mandible). We looked into the soft tissue type, diameter, length, age, place of insertion, and smoking status. Planned subgroup analysis was utilized to evaluate factors associated

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Table 2. Features of the included articles

Author	Design	Setting	No. of patients	No. of miniscrews		Type of miniscrews	Dimensions		Success criteria	Failure rate (%)	Handling of failure
				Total	Patient (per jaw)		Diameter (mm)	Length (mm)			
Aboul-Ela *et al.* (40)	RCT	University	13	26	2 (2)	AbsoAnchor (Dentos, Daegu, Korea)	1.3	8	Stability	7.7	Repositioned
Al-Sibaie and Hajeer (38)	RCT	University	30	56	2 (2)	Dewimed®, Tuttlingen, Germany	1.6	7	Stability	5%	Replaced
Alves *et al.* (52)	PCS	University	15	41	2–3 (2–3)	(INP, São Paulo, Brazil)	1.4/2	6/8	Not recorded	14.6	Replaced
Apel *et al.* (53)	PCS	University	25	76	2–4 (2)	Tomas-pin (Dentaurum, Ispringen, Germany)	1.6	8	Stability/Infection	10.5	Excluded
Basha *et al.* (41)	RCT	University	14	14	2 (2)	Stainless steel	1.3	8	Stability	28.6	Replaced
Bayat and Bauss (54)	PCS	Private	88	110	1–4 (1–2)	LOMAS (Mondeal Medical Systems, Tuttlingen,Germany)	2	7/ 9 /11	Stability/Infection	18.2	Not recorded
Bechtold *et al.* (42)	RCT	University	30	76	1–2 (1–2)	Orlus 18107, Ortholution	1.8	7	Not recorded	13.4%	Replaced
Berens *et al.* (61)	PCS	Private	85	239	1–3 (1–2)	AbsoAnchor (Dentos, Daegu, Korea)/ Dual-Top (Jeil Medical, Seoul, Korea)	1.4/1.8/2	Notrecorded	Stability	15.1	Rescrewed/ excluded
Blaya *et al.* (66)	PCS	University/ private	30	30	1 (1)	Sin Implant System (São Paulo, Brazil)	1.2	10	Stability	0	Not recorded
Chaddad *et al.* (43)	RCT	Not recorded	10	32	2–4 (2)	C-Implant (Implantium,Seou, Korea)/Dual-Top (Jeil Medical, Seoul, Korea)	1.4-2	6-10	Stability/infection/treatment completion	12.5	Not recorded
Cheng *et al.* (65)	PCS	University	44	92	Notrecorded	Leibinger (Freiburg, Germany)/Mondeal (Tuttlingen, Germany)	2	5-15	Stability/infection/treatment completion	8.7	Not recorded
Davoody *et al.* (77)	PCS	University	25	26	2 (2)	NR	1.8-2	8-9	Not recorded	16%	Replaced
El-Beialy *et al.* (64)	PCS	University	12	40	Not recorded	AbsoAnchor (Dentos, Daegu, Korea)	1.2	8	Stability	17.5	Excluded
Falkensammer *et al.* (37)	RCT	University	26	Not recorded	Not recorded	Dual Top G2 8x6mm, JeilMedical Corporation, Seoul, Korea)	1.6	8	Not recorded	NR	Not recorded
Garfinkle *et al.* (44)	PCS	University	13	82	4–8 (4)	Osteomed (Addison, Tex)	1.6	6	Stability/treatment completion	19.5	Not recorded
Gelgör *et al.* (63)	PCS	University	25	25	1 (1)	IMF Stryker (Leibinger, Germany)	1.8	14	Stability	0	Not recorded
Gupta *et al.* (55)	PCS	University	20	40	2(2)	Custome made (Denticon, Mumbai)	1.4	8	Stability	22.5	Not recorded
Hedayati *et al.* (62)	PCS	University	10	27	3 (1–2)	Orthognathic screws	2	9/11	Stability	18.5	Repositioned
Herman *et al.* (71)	PCS	Not recorded	16	49	1-2 (1–2)	Ortho Implant (IMTEC, Ardmore, Okla), Sendax MDI	1.8	6/8/10	Stability	40.8	New/ Excluded
Iwai *et al.* (70)	PCS	University	80	142	2 (2)	Orthodontic anchor screws (ISA, BIODENT, Tokyo, Japan)	1.6	8	Stability/mobility/ contacted root	8.5%-5.6%	Not recorded
Khanna *et al.* (56)	PCS	University	25	100	Not recorded	S.K. Surgical Pvt. Ltd.	1.3	9	Not recorded	Not recorded	Not recorded
Kim *et al.* (57)	PCS	University	25	50	2 (2)	C-Implant (Implantium, Seoul, Korea)	1.8	8.5	Stability	4	Replaced
Lehnen *et al.* (45)	RCT	Not recorded	25	60	2 (2)	Tomas-pin (Dentaurum, Ispringen, Germany)	1.6	8	Not recorded	11.7	Excluded
Liu *et al.* (46)	RCT	Not recorded	34	68	2 (2)	(Cibei, Ningbo, China)	1.2	8	Stability	11.8	Replaced
Luzi *et al.* (69)	PCS	University	98	140	Not recorded	Aarhus Mini-Implants (Medicon, Germany)	1.5/2	9.6/11.6	Stability/treatment completion	15.7	Excluded
Ma *et al.* (47)	RCT	University		60	4 (2)	AbsoAnchor (Dentos, Daegu, Korea)/Dual-Top (Jeil Medical, Seoul, Korea)	1.8	5/ 6	Not recorded	Not recorded	Not recorded
Miyazawa *et al.* (68)	PCS	University	18	44	Not recorded	(Jeil Medical, Seoul, Korea)	1.6	8	Treatment completion	9.1	Not recorded
Motoyoshi *et al.* (24)	PCS	University	41	124	1–4 (1–2)	ISA orthodontic implants (BIODENT, Tokyo, Japan)	1.6	8	Stability	14.5	Not recorded
Motoyoshi *et al.* (76)	PCS	University	57	169	1–4 (1–2)	(BIODENT, Tokyo, Japan)	1.6	8	Stability/treatment completion	14.8	Not recorded
Motoyoshi *et al.* (74)	PCS	University	32	87	Not recorded	ISA orthodontic implants (BIODENT, Tokyo, Japan)	1.6	8	Stability/treatment completion	12.6	Not recorded
Motoyoshi *et al.* (67)	PCS	University	52	148	Not recorded	ISA orthodontic implants (BIODENT, Tokyo, Japan)	1.6	8	Stability	9.5	Excluded
Motoyoshi *et al.* (75)	PCS	University	65	209	1–4 (1–2)	ISA orthodontic implants (BIODENT, Tokyo, Japan)	1.6	8	Stability/treatment completion	11.5	Not recorded
Polat-Ozsoy *et al.* (80)	PCS	University	11	22	2 (2)	AbsoAnchor (Dentos, Daegu, Korea)	1.2	6	Stability/Infection	13.6	Replaced
Sandler *et al.* (36)	RCT	Hospital	71	44	2(2)	American Orthodontics	1.6	8	Not recorded	2.8%	Not recorded
Sar *et al.* (58)	PCS	University	28	28	2(2)	Stryker, Leibinger, Germany	2	8	Not recorded	Not recorded	Not recorded
Sarul *et al.* (73)	Split mouth PCS	University	27	54	2 (2)	OrthoEasy Pin (Forestadent, Phorzheim, Germany)	Not recorded	6/ 8	Mobility/stability	26%	Not recorded
Sharma *et al.* (39)	RCT	University	46	30	2(2)	Denticon	1.2	8	Stability	3%	Replaced
Son *et al.* (78)	PCS	University	70	140	2 (2)	(ISA self-drill type anchor screw; Biodent, Tokyo, Japan)	1.6	8	Mobility/stability	4%	Not recorded
Thiruvenkatachari *et al.* (72)	PCS	University	10	18	1–2 (1–2)	Titanium microimplant	1.3	8	Stability	0	Not recorded
Türköz *et al.* (48)	RCT	University	62	112	1–2 (1–2)	AbsoAnchor (Dentos, Daegu, Korea)	1.4	7	Stability	22.3	Not recorded
Yoo *et al.* (60)	PCS	University	132	227	Not recorded	Biomaterial Korea	1.5	7	Stability/problems in loading	19.5	Not recorded
Upadhyay *et al.* (49)	RCT	University	33	72	4 (2)	Modified Ti fixation screws	1.3	8	Stability	6.9	Replaced
Upadhyay *et al.* (51)	PCS	University	30	30	2 (2)	Modified Ti fixation screws	1.3	8	Stability	10	Replaced
Upadhyay *et al.* (59)	PCS	University	40	46	2 (2)	Ti mini-implants	1.3	8	Not recorded	4.3	Replaced
Upadhyay *et al.* (79)	PCS	University	34	28	2 (2)	Ti mini-implants	1.3	8	Not recorded	Not recorded	Not recorded
Wiechmann *et al.* (50)	RCT	Not recorded	49	133		AbsoAnchor (Dentos, Daegu, Korea)/dual-Top (Jeil Medical, Seoul, Korea)	1.2/1.6	5/10	Stability/treatment completion/ infection	23.3	Not recorded

with miniscrew failure whenever feasible. The impact of the study design on the estimation of the mini-screw failure rate was evaluated.

For the sensitivity analysis, 14 RCTs totaling 876 miniscrews were combined into a single random-effect model and 13.1 percent (95%

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Table 3. Risk of bias assessment of the included RCTs.

Author	Study type	Random sequence generation	Allocation concealment	Blinding of outcome assessors	Incomplete outcome data	Selective reporting	Other bias	Overall risk of bias
Aboul-Ela et al. (40)	RCT	Yes	Unclear	No	Yes	Unclear	No	High risk
Al-Sibaie and Hajeer (38)	RCT	Yes	Yes	Yes	Yes	Yes	Yes	Low risk
Basha et al. (41)	CCT	No	No	No	Yes	Unclear	Yes	High risk
Bechtold et al. (42)	RCT	Yes	Unclear	No	Yes	Unclear	No	High risk
Chaddad et al. (43)	CCT	No	No	No	Yes	Unclear	No	High risk
Falkensammer et al. (37)	RCT	Yes	Yes	Yes	Yes	Unclear	Yes	Low risk
Garfinkle et al. (44)	RCT	Unclear	Unclear	No	Yes	Unclear	No	High risk
Lehnen et al. (45)	RCT	Unclear	Unclear	Yes	Yes	Unclear	Yes	High risk
Liu et al. (46)	RCT	Yes	Unclear	No	Yes	Unclear	No	High risk
Ma et al. (47)	RCT	Yes	Unclear	Yes	Yes	Unclear	No	High risk
Sandler et al. (36)	RCT	Yes	Yes	Yes	Yes	Yes	No	Low risk
Sharma et al. (39)	RCT	Yes	Yes	Yes	Yes	Yes	Yes	Low risk
Türköz et al. (48)	RCT	Unclear	Unclear	No	Yes	Unclear	No	High risk
Upadhyay et al. (51)	CCT	No	No	No	Yes	Unclear	Yes	High risk
Upadhyay et al. (49)	RCT	Yes	Yes	Unclear	Yes	Unclear	Yes	Unclear
Wiechmann et al. (50)	RCT	Unclear	Unclear	No	Yes	Unclear	Yes	High risk

confidence interval 9.7–18, Q = 31.5, $P < 0.001$, $I^2 = 55.6\%$) of them failed. Remarkably, this closely resembled the pooled failure rate of 27 PCSs, including 2374 miniscrews, which was 13.5% (95% CI 11.1-16.4, Q = 76.54, $P < 0.001$, $I^2 = 67.34\%$). The impact of miniscrew length and design on miniscrew failure rate estimation was also evaluated. To evaluate the impact of miniscrew length on failure rate, a cut-off 8 mm in length was employed. For miniscrews measuring 8 mm or more, the failure rate was 12.2% (95% CI 6.7–21.4, Q = 15.2, DF = 5, $P < 0.001$, $I^2 = 67.2\%$) for long miniscrews and 12.7% (95% CI 10.5–15.4, Q = 47.26, $P < 0.001$, DF = 26, $I^2 = 44.9\%$) for short miniscrews. In the non-self-drill miniscrews group, the miniscrew failure rate was 14.9% (95% CI 10.4–20.8, Q = 20.7, DF = 8, $P < 0.001$, I2 = 88.9%). This was not significantly different from the estimated effect in the self-drill miniscrews group (14.2%, 95% CI 5.6–31.8, Q = 51.57, $P < 0.001$, $I^2 = 71.41\%$). There was one article [44], which comprised 110 miniscrews, that examined the relationship between smoking and miniscrew failure rates. A total of 73 miniscrews were assigned to nonsmokers, 18 to light smokers (≤10 cigarettes per day), while the remaining screws were assigned to heavy smokers (≥10 cigarettes per day). The corresponding failure rates were 9.5, 11%, and 57.8%. Additionally, a study [43] examined the impact of gingiva type at the place of implantation. There were thirty-two miniscrews in the trial; 11 of them were were put in tissue that was keratinized. and did not fail;

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Table 4. Risk of bias assessment of articles according to Newcastle–Ottawa Scale (NOS).

Study	Selection				Comparability	Outcome			NOS score	Overall assessment
	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at the start of the study	Comparability of the cohorts	Assessment of outcome	Was follow-up long enough?	Adequacy of follow-up		
Alves *et al.* (52)	1	0	1	1	0	1	1	1	6	Medium
Apel *et al.* (53)	1	0	1	1	0	1	1	1	6	Medium
Bayat and Bauss (54)	0	1	1	1	1	0	0	1	5	Medium
Berens *et al.* (61)	1	0	1	1	0	1	1	1	6	Medium
Blaya *et al.* (66)	1	0	1	1	0	1	1	1	6	Medium
Cheng *et al.* (65)	1	0	1	1	0	0	1	1	5	Medium
Davoody *et al.* (77)	1	1	1	1	1	0	1	1	7	High
El-Beialy *et al.* (64)	0	0	1	1	0	1	1	1	5	Medium
Gelgör *et al.* (63)	1	0	1	1	0	1	1	1	6	Medium
Gupta *et al.* (55)	1	1	1	1	0	0	1	1	6	Medium
Hedayati *et al.* (62)	1	0	1	1	0	1	1	1	6	Medium
Herman *et al.* (71)	1	0	1	1	0	1	1	1	6	Medium
Iwai *et al.* (70)	1	1	1	1	0	0	1	1	6	Medium
Khanna *et al.* (56)	1	0	1	1	0	0	1	0	4	Medium
Kim *et al.* (57)	1	0	1	1	0	1	1	1	6	Medium
Luzi *et al.* (69)	1	0	1	1	0	1	1	1	6	Medium
Miyazawa *et al.* (68)	1	0	1	1	0	1	1	1	6	Medium
Motoyoshi *et al.* (67)	1	0	1	1	0	0	1	1	5	Medium
Motoyoshi *et al.* (76)	1	0	1	1	0	0	1	1	5	Medium
Motoyoshi *et al.* (74)	1	0	1	1	0	0	1	1	5	Medium
Motoyoshi *et al.* (75)	1	0	1	1	0	1	1	1	6	Medium
Motoyoshi *et al.* (24)	1	0	1	1	0	0	1	1	5	Medium
Polat-Ozsoy *et al.* (80)	1	0	1	0	0	0	0	1	3	Low
Sar *et al.* (58)	1	0	1	1	0	0	1	1	6	Medium
Sarul *et al.* (73)	1	1	1	1	0	0	1	1	6	Medium
Son *et al.* (78)	1	0	1	1	1	1	1	1	7	High
Thiruvenkatachari *et al.* (72)	1	0	1	1	0	1	1	1	6	Medium
Yoo *et al.* (60)	0	0	1	1	1	1	1	1	6	Medium
Upadhyay *et al.* (59)	1	0	1	1	0	1	1	1	6	Medium
Upadhyay *et al.* (79)	1	0	1	1	1	1	1	1	7	High

the remaining 11 miniscrews, 4 out of 21 miniscrews (19%), were placed in that was not keratinized and failed.

Discussion

Thirty prospective cohort studies and sixteen randomised clinical trials using miniscrews to enhance orthodontic anchoring were included in this systematic review. Most of the included trials were deemed to have a high potential for bias. Randomization and allocation concealment procedures were either documented insufficiently or not at all in the majority of these trials. Most prospective cohort studies had a medium level of quality. This is explained by the fact that the majority of the cohort studies that were included lacked a comparison group, which resulted in a lower NOS score. The meta-analysis determined that the miniscrew failure rate was 13.5% (95% CI 11.5–15.9). Sensitivity analysis revealed a nearly identical 14.3% combined failure rate of mini-screws to the total estimated effect after removing small studies, suggesting sufficient robustness of the findings. This result was rather different from the failure rate that Papageorgiou et al. [7] had previously reported, which was 13.5% (95% CI 11.5–15.8). One possible explanation for the slight variation between the two estimates is that we included a few more studies in our meta-analysis [18, 22, 24, 25, 29, 37, 38, 44]. Second, we eliminated studies that had been included in the earlier meta-analysis [10], studies having an ambiguous design, and studies written in a language other than English. Subgroup analyses were used to evaluate factors associated with miniscrew failure. The results of this meta-analysis suggested that, in comparison to miniscrews with diameters of 1.4–1.6 mm (13.6%, 95% CI 10.3–17.1) and 1.7–2 mm (14.4%, 95% CI 8.8–23.5), those with a diameter of less than 1.3 mm had a lower failure rate (10.7%, 95% CI 7.6–15). Nonetheless, there were 450 small-diameter included miniscrews, 1586 medium-diameter included miniscrews, and 391 large-diameter included miniscrews. The findings' degree of conclusiveness might have been impacted by the variability and differences in sample sizes among the miniscrews that were included. Papageorgiou et al. [7] discovered that miniscrews with small and large diameters had similar failure rates: 10.9 percent (95% CI 7.7–15.3) and 14.3 percent (95% CI 7.4–25.8), respectively. Nonetheless, they discovered that the failure rate of medium-diameter mini-screws was 12.7% (95% CI

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Event rate	Study name	Lower limit	Upper limit	p-Value
0.077	(Aboul-Ela et al., 2011)	0.019	0.261	0.001
0.018	(Al-Sibaie and Hajeer, 2014)	0.003	0.116	0.000
0.146	(Alves et al., 2011)	0.067	0.290	0.000
0.105	(Apel et al., 2009)	0.054	0.197	0.000
0.286	(Basha et al., 2010)	0.111	0.561	0.121
0.182	(Bayat and Bauss, 2010)	0.120	0.265	0.000
0.132	(Bechold et al., 2013)	0.072	0.228	0.000
0.151	(Berens et al., 2006)	0.111	0.202	0.000
0.016	(Blaya et al., 2010)	0.001	0.211	0.004
0.125	(Chaddad et al., 2008)	0.048	0.289	0.000
0.087	(Cheng et al., 2004)	0.044	0.164	0.000
0.192	(Davoody et al., 2013)	0.082	0.387	0.004
0.175	(El-Beialy et al., 2009)	0.086	0.324	0.000
0.195	(Garfinkle et al., 2008)	0.123	0.295	0.000
0.019	(Gelgör et al., 2004)	0.001	0.244	0.006
0.225	(Gupta et al., 2012)	0.121	0.379	0.001
0.185	(Hedayati et al., 2007)	0.079	0.375	0.003
0.408	(Herman et al., 2006)	0.281	0.549	0.201
0.071	(Iwai et al., 2015)	0.039	0.127	0.000
0.040	(Kim et al., 2010)	0.010	0.146	0.000
0.117	(Lehnen et al., 2011)	0.057	0.225	0.000
0.118	(Liu et al., 2009b)	0.060	0.218	0.000
0.157	(Luzi et al., 2007)	0.106	0.227	0.000
0.091	(Myazawa et al., 2010)	0.035	0.218	0.000
0.145	(Motoyoshi et al., 2006)	0.093	0.219	0.000
0.148	(Motoyoshi et al., 2007a)	0.102	0.210	0.000
0.126	(Motoyoshi et al., 2007b)	0.071	0.214	0.000
0.095	(Motoyoshi et al., 2009)	0.057	0.153	0.000
0.115	(Motoyoshi et al., 2010)	0.078	0.166	0.000
0.136	(Polat-Ozsoy et al., 2009)	0.045	0.348	0.003
0.011	(Sandler et al., 2014)	0.001	0.154	0.002
0.259	(Sarul et al., 2015)	0.160	0.391	0.001
0.033	(Sharma et al., 2012)	0.005	0.202	0.001
0.043	(Son et al., 2014)	0.019	0.092	0.000
0.026	(Thiruvenkatachari et al., 2006)	0.002	0.310	0.012
0.223	(Türköz et al., 2011)	0.156	0.310	0.000
0.069	(Upadhyay et al., 2008a)	0.029	0.156	0.000
0.100	(Upadhyay et al., 2008b)	0.033	0.268	0.000
0.043	(Upadhyay et al., 2009)	0.011	0.158	0.000
0.233	(Wiechmann et al., 2007)	0.169	0.312	0.000
0.194	(Yoo et al., 2014)	0.147	0.250	0.000
0.135		0.115	0.159	0.000

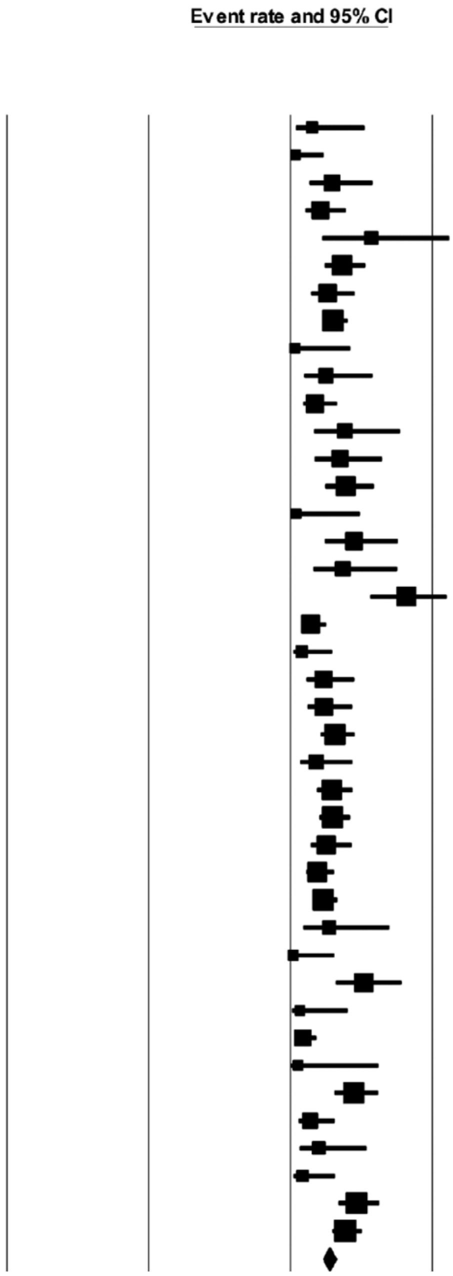

Figure 2. Forest plot of overall miniscrews failure rate (random-effect model)

8.1–19.3). After doing two retrospective tests, Lim and his colleagues discovered that the miniscrew diameter had no discernible impact on the miniscrew's success [41, 45]. Moreover, there was very little roughly 0.8% difference between the large and medium size diameters. This was demonstrated in previous studies that diameter greater than 1.6 mm seems to give no substantial benefit as wide mini-screws are associated with increased risk of root contact than narrow miniscrews [22]. The miniscrews in this meta-analysis were subdivided into short (≤8 mm) and long (>8 mm) group. Most of the studies used short miniscrews. Previous research has shown that a diameter of more than 1.6 mm appears to offer no discernible advantage since wide miniscrews are linked to a higher risk of root contact than narrow miniscrews [22]. In this meta-analysis, the miniscrews were separated into two groups: short (≤8 mm) and long (>8 mm). Short miniscrews were used in the majority of the investigations. The short miniscrew failure rate was 12.7 percent (95% CI 10.5–15.4), which is marginally higher than the

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long miniscrew failure rate of 8.3 percent (95% CI 3.1–20.2). Theoretically, longer miniscrews should have a lower failure rate since they provide better mechanical retention in the bone than shorter miniscrews, albeit the physician will decide whether or not this difference is clinically relevant. According to Lim et al. [32], miniscrews that were 6 mm or shorter had a greater failure rate (25%) than miniscrews that were longer than 6 mm (<12%). This results is not definitive and should be regarded cautiously because it may be the result of the significant heterogeneities in the subgroup analysis. Furthermore, in this review an arbitrary cut-off point of 8 mm was adopted to assess the effect of length of miniscrew on the failure rate; hence, the possibilities of the overlap of the findings on either side of the cut-off point is high, i.e. those miniscrews with 7.9 mm or less will be included in the short group.

Our analysis of a limited number of included trials revealed that the design of the miniscrews had no bearing on the failure rate. Self-drilling miniscrews had a failure rate of 14.2% (95% CI 5.6-31.8) while non-self-drilling miniscrews had a failure rate of 14.9% (95% CI 10.4–20.8). Papageorgiou et al. [7] found a similar result for the self-drilling group (7.7%, 95% CI 4.8–12.0) but a much lower percentage (17.7%, 95% CI 5.1–44.9) for the non-self-drilling miniscrews. The reason for this disagreement could be that we extracted miniscrew design data from nine trials as opposed to the three studies in Papageorgiou and team review [7]. This could have affected the failure rate estimation. Furthermore, this might be the result of the substantial heterogeneities in the subgroup analysis; as such, this results is inconclusive and needs to be read cautiously. In an interesting finding, Chen et al. [17] in their retrospective investigation discovered that, although not statistically significant, the failure rate of self-drilling miniscrews was greater (33%) than that of non-self-drilling (10%) [13]. Due to the probable difference in buccal plate thickness, adolescents have a higher failure rate than adults when it comes to age, which is a patient-related factor [17]. The majority of the studies included in this evaluation included both adult patients (over 18) and younger patients (≤18). Compared to the failure rate published by Papageorgiou et al. [7], who observed that the failure rate in patients younger than 20 years was 12.6 (95% CI 6.4–23.3), the miniscrew failure rate for young patients was 8.6% (95% CI 4.7–15.1). The discrepancy between both estimations was not significant and could be the result of the change in the included studies between those two meta-analyses. In a similar vein, our analysis showed that the failure rate of miniscrews inserted into adults was 11.2% (95% CI 6.6-28.7), but Papageorgiou and colleagues review reported a failure rate of 15.5% (95% CI 11.2-21.0) [7]. On the other hand, retrospective research [12, 34] revealed that older patients had a greater failure rate, most likely as a result of poor periodontal health and smoking. Moreover, since more miniscrews were implanted in younger participants than in adults, these results might just be the result of a smaller sample size.

According to our research, miniscrews inserted into the maxilla had a failure rate of 11.0 percent (95% CI 8.8–13.7), but miniscrews inserted into the mandible had a failure rate of 16.5 percent (95% CI 11.6–22.7). The mandible has a higher failure rate than the maxilla, which could be attributed to factors such as its narrower vestibule, less cortical bone surrounding the mini-screws, and higher bone density [34]. When interpreting the data, it is crucial to take into account the considerable level of heterogeneities in the subgroup analysis. In our analysis, we only found data from one study [24] about the impact of smoking on the failure rate of mini-screws. It seems that smoking negatively affects the stabillity of miniscrews even though the evidence for this claim is extremely scant. Only one study [43] looked into the kind of mucosa insertion and how it related to the miniscrews failure rate. Eleven miniscrews inserted into the keratinized tissue did not fail, according to Chadad et al.

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Conflict of Interest

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Consent to publication

The Author gives her permission for publication

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Стабільність використання тимчасових анкоражних пристроїв у сучасній ортодонтії: систематичний огляд

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Анотація: *ортодонтичному лікуванні TADs в основному використовуються для фіксації, коли пацієнт не дотримується рекомендацій лікаря. У сучасній ортодонтичній літературі наводяться різні показники невдач. Метою нашого дослідження була точна оцінка стабільності TADs та потенційних факторів ризику для механічно фіксованих TADs. До грудня 2017 року для пошуку в електронних базах даних використовувалися MEDLINE, Scopus та Cochrane Library. Було перевірено списки літератури та проведено додатковий пошук поточних і неопублікованих даних. Також було проведено ручний пошук у відповідних журналах та сірій літературі. Ми зібрали опубліковані англійською мовою проспективні когортні дослідження (ПКД) та рандомізовані контрольовані дослідження (РКД), в яких детально описано частоту невдач мінігвинтів діаметром менше 2 мм при використанні їх як ортодонтичних анкерів. У цьому дослідженні було проведено вилучення даних, оцінку ризику упередженості та сліпий і дублюючий відбір досліджень. За допомогою моделі випадкових ефектів було визначено частоту відмов і відповідні змінні ризику для міні-гвинтів, а також супутні 95-відсоткові довірчі інтервали (ДІ). Для оцінки гетерогенності досліджень було використано тести* I^2 *і* Chi^2*. Для визначення ризику упередженості було використано шкалу Ньюкасла-Оттави та шкалу Кокрана. Надійність результатів метааналізу була перевірена за допомогою аналізу підгруп та аналізу чутливості. Це дослідження охоплювало 30 проспективних клінічних випробувань, а також 16 рандомізованих клінічних випробувань. Оскільки статистичних даних для розрахунку розміру впливу було недостатньо, п'ять досліджень було виключено з метааналізу. У моделі випадкових ефектів було об'єднано приблизно 3250 міні-гвинтів з 41 випробування. Міні-гвинти показали загальний рівень відмови 13,5% (95% ДІ 11,5%–15,9%). Аналіз груп поділу показав, що куріння та тип ясен мали статистично значущий вплив на рівень відмови міні-гвинтів, тоді як діаметр, довжина та конструкція міні-гвинтів, вік пацієнтів та місце введення не мали значущого впливу. Висновок: ТАД мають прийнятно низький рівень відмови. Через високий ступінь гетерогенності та незбалансованість груп у включених дослідженнях, слід бути обережними при інтерпретації результатів. Для підтвердження результатів цього огляду необхідні значні розміри вибірки з високоякісних рандомізованих клінічних досліджень.*

Ключові слова: Ортодонтичні Анкоражні Процедури; Ортодонтичне переміщення зубів; Патологічний прикус; Ортодонтія, корекційна; Ортодонтичні апарати, Ортодонтія, профілактична; Ортодонтія, попереджуюча.