Systematic Review

Comparison of the success rate between self-drilling and self-tapping miniscrews: a systematic review and meta-analysis

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Summary

Background: Both the self-drilling and self-tapping miniscrews have been commonly used as anchorage reinforcement devices in orthodontic treatment.

Objective: The aim of this study was to compare the success rates of self-drilling and self-tapping miniscrews in orthodontic practice.

Search methods: Literature searches were performed by electronic search in database including PubMed, Embase, Cochrane Central Register of Controlled Trials, China National Knowledge Infrastructure and SIGLE, and manual search of relevant journals and reference lists of included studies.

Eligibility criteria: Randomized controlled trials, clinical controlled trials and cohort studies comparing the success rates of self-drilling and self-tapping miniscrews as orthodontic anchorage.

Data collection and analysis: The data of success rates and root contact rates were extracted by two investigators independently. After evaluating the risk of bias, the odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Subgroup analysis was performed on the basis of study design, follow-ups, participant ages and immediate/delayed loading. Sensitivity analysis was performed to test the stability of the results in meta-analysis.

Results: Six studies assessed as high quality were included in the meta-analysis. The meta-analysis results showed no difference between the two types of screws in the success rates. The root contact rates of the two screws were similar, while self-drilling miniscrews displayed higher risk of failure when contacting with a tooth root.

Conclusions: Currently available clinical evidence suggests that the success rates of self-tapping and self-drilling miniscrews are similar. Determination of the position and direction of placement should be more precise when self-drilling miniscrews are used in sites with narrow root proximity.

Registration: None.

Conflict of interest: None.

Introduction

Orthodontic tooth movement is a clinical consequence of appropriate force applied to teeth, while the reactive force could result in reciprocal tooth movement. The anchorage loss is likely to compromise the treatment outcomes (1, 2). Though considered as effective, traditional anchorage reinforcement devices such as headgear require significant cooperation from patients and often fail owing to weak compliance (3).
In past decades, temporary anchorage devices (TADs) have been incorporated into orthodontic treatment as anchorage reinforcement auxiliaries, among which the most widely used is the so-called miniscrew (4). Due to the feasibility of miniscrew placement at various intraoral sites, it is widely utilized in orthodontic practice including vertical control, sagittal tooth movement, maxillary suture expansion, midline correction, etc. (5). Miniscrews have also been described with the merit in providing strong anchorage, more comfort, and less need of compliance from patients, compared to traditional anchorage devices (6, 7).

The stability of miniscrew relies on partial osseointegration and mechanical retention in bone tissue (8). This feature not only allows the effective anchorage and the facility of insertion and removal of miniscrews but also brings about a comparatively lower success rate comparing to the osseointegrated implants (9, 10). Previous studies investigated the factors associating with the stability of miniscrews as orthodontic anchorage and suggested that the success rate was overdetermined (9, 11-13).

In present orthodontic clinics, two types of miniscrews are mainly used, i.e. self-tapping and self-drilling miniscrew. Self-tapping miniscrew requires a pre-drilled hole with a diameter similar to the screw per se, while the self-drilling miniscrew could be inserted without preparation of the pilot hole due to the pointed screw tip and cutting threads (14-16).

Self-drilling miniscrews have been described to shorten operative time, reduce bone damage and patient discomfort comparing to self-tapping miniscrews (17). However, the stability of miniscrews should always be the first concern in orthodontic treatment. Several independent clinical trials compared the success rates of the two types of miniscrews (17-22). Considering the diversity of methodology and results, a critical systematic review would be beneficial. Thus, we conducted a systematic review to comprehensively evaluate, in an evidence-based way, the success rate of self-drilling and self-tapping miniscrew in orthodontic treatment.

Materials and methods
These systematic review and meta-analysis were planned, conducted, and reported following the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) checklist (23). Two calibrated reviewers (J.Y. and M.G.) independently conducted the search, study inclusion, data extraction, and risk of bias evaluation. The kappa score regarding the agreement level was 0.91, indicating that the interobserver bias was low (24). Any disagreement between the two reviewers was resolved by discussing with a third reviewer (M.L.).

Criteria for included studies
The inclusion criteria were the following: 1. Study design: randomized controlled trial (RCT), clinical controlled trial (CCT), and cohort study; 2. Participants: healthy patients who require orthodontic treatment; 3. Intervention: the success/failure rate of self-drilling and self-tapping miniscrews as orthodontic anchoring was compared; and 4. Outcome variables: the rate of success/failure of miniscrew and root contact of miniscrew anchorage.

The exclusion criteria were as follows: 1. Review articles, case reports, descriptive studies, conference abstracts, and letters; 2. Animal Studies, and 3. Subjects with systemic diseases which affect bone metabolism

Search strategy
The electronic searches were conducted in databases including PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), Embase, China National Knowledge Infrastructure (CNKI), and SIGLE. The relevant Chinese journals were hand searched by reviewing the titles and abstracts. The search was from 1 January 1990 to 15 Dec 2015. The reference lists of included articles for the meta-analysis were also manually reviewed. The specific search strategies were summarized in Table 1. There was no language limitation in the electronic searches.

Data extraction and analysis
We developed a standardized data extraction form. The general information of recruited studies regarding study identification, study design, demographic data, site for miniscrew insertion, time for success/failure evaluation, criteria for success/failure evaluation were summarized.

Primary outcomes included the success rate of self-drilling miniscrews and self-tapping miniscrews. Secondary outcomes included the rates of contact root using the two types of miniscrews.

Methodological quality assessment
The modified Newcastle-Ottawa scale (NOS) for cohort study (25) was used to evaluate the methodological quality of included studies (cohort studies and CCTs). The NOS system assesses the methodological quality on the basis of three broad perspectives: selection (4 items), comparability (1 item), and outcome (3 items). Studies would be awarded one star for each item in selection and outcome, and two stars at most for the item in comparability. The methodological quality would be assessed as low if the sum of stars was less than five and otherwise assessed as high (Supplementary Table 1).

Statistical analysis
Quantitative data were statistically pooled for meta-analysis using Review Manager 5 (version 5.3; Nordic Cochrane Centre, Cochrane Collaboration, Copenhagen, Denmark). For dichotomous data, the risk ratio was pooled for analysis. The heterogeneity among recruited studies was estimated by I² statistic. The results would be analyzed using random-effects model when heterogeneity is assessed as moderate (25% < I² ≤ 50%) or high (I² > 50%), and using fixed-effects model when I² ≤25%. The statistical significance for the hypothesis

Table 1. Search strategies for each database.

<table>
<thead>
<tr>
<th>Step</th>
<th>PubMed</th>
<th>Embase, CENTRAL, CNKI, and SIGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>orthodontics [Mesh] OR orthodontic*</td>
<td>orthodontics OR orthodontic*</td>
</tr>
<tr>
<td>2</td>
<td>miniscrew* OR microscrew* OR Mini implant* OR microimplant* OR screw* OR implant* OR temporary anchorage*</td>
<td>miniscrew* OR microscrew* OR Mini implant* OR microimplant* OR screw* OR implant* OR temporary anchorage*</td>
</tr>
<tr>
<td>3</td>
<td>(self-drilling* OR drill free*) AND (self-tapping* OR predrill* OR drill* OR nondrill*)</td>
<td>(self-drilling* OR drill free*) AND (self-tapping* OR predrill* OR drill* OR nondrill*)</td>
</tr>
<tr>
<td>4</td>
<td>1 AND 2 AND 3</td>
<td>1 AND 2 AND 3</td>
</tr>
</tbody>
</table>
test was set at $P < 0.05$ (2-tailed Z-test). Subgroup analysis was performed based on different study designs, different follow-up period, the age of participants, and immediate loading or delayed loading. Sensitivity analysis was conducted to test the stability of some of the debatable results in the meta-analysis. Descriptive analysis was applied when data failed to be statistically pooled. Funnel plots were generated to test the publication bias if the sum of included studies exceeded 10 (26).

Results

Search results

A total of 208 articles were retrieved through electronic and manual searching, among which 194 unrelated citations were excluded after screening titles and abstracts. Subsequently, full text of the reserved studies were retrieved and assessed according to inclusion/exclusion criteria. One potentially qualified study (27) was excluded after discussion with the third reviewer, as attempts for full-text failed, including library search and emails to the authors. Finally, six studies (17–22) were included in the meta-analysis. The procedures of study inclusion are presented in Figure 1.

Characteristics of included studies

All the recruited six studies were published in English, among which, three were categorized as CCTs and the other three were cohort studies. The general information of the included studies and details of miniscrew regimen were shown in Table 2. The modified standardized data extraction form of included studies was shown in Supplementary Figure 1.

Methodological and quality assessment

The detailed results of quality assessment using the NOS were summarized (Supplementary Table 1). The scores of the six studies ranged from 5 to 8, suggesting high quality in methodology of these studies.

Rate of success

Six studies reported the success rates of self-drilling and self-tapping miniscrews as temporary anchorage auxiliaries for orthodontic

Table 2. General information of included studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Age (years)</th>
<th>Design</th>
<th>N (D/T)</th>
<th>Insertion site</th>
<th>Time of success evaluation</th>
<th>Success (S)/failure (F) criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lim et al.</td>
<td>21.9 ± 8.3</td>
<td>Cohort</td>
<td>378 (293/78)</td>
<td>Buccal molar area, midpalatal, palatal slope, maxillary buccal canine</td>
<td>1 week after miniscrew installation</td>
<td>S: miniscrew did not loosen</td>
</tr>
<tr>
<td>(2009)</td>
<td></td>
<td>study</td>
<td></td>
<td>Between the upper 2nd premolar and 1st molar at buccal side</td>
<td>2 weeks and 6 weeks after implantation</td>
<td>F: miniscrew loosened</td>
</tr>
<tr>
<td>Türköz et al.</td>
<td>15.7 ± 4.2</td>
<td>Cohort</td>
<td>112 (34/78)</td>
<td>Between maxillary 2nd premolar and 1st molar bilaterally at the junction of attached gingiva and moveable mucosa</td>
<td>Each follow-up visit for a 6-month period after miniscrew placement</td>
<td>F: significant mobility that could not sustain orthodontic force.</td>
</tr>
<tr>
<td>(2011)</td>
<td></td>
<td>study</td>
<td></td>
<td></td>
<td></td>
<td>F: miniscrew became loose</td>
</tr>
<tr>
<td>Gupta et al.</td>
<td>13–21</td>
<td>CCT</td>
<td>40 (20/20)</td>
<td></td>
<td></td>
<td>S: absence of any mobility</td>
</tr>
<tr>
<td>(2012)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Son et al.</td>
<td>D: 22.3 ± 7.4</td>
<td>CCT</td>
<td>140 (70/70)</td>
<td>Buccal alveolar bone in an area of keratinized gingiva between 2nd premolar and 1st molar of the maxilla</td>
<td>6 months after miniscrew placement</td>
<td>S: miniscrew endured an orthodontic force applied for 6 months without clinical mobility</td>
</tr>
<tr>
<td>(2014)</td>
<td>T: 23.2 ± 7.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yao</td>
<td>29.3</td>
<td>Cohort</td>
<td>496 (161/335)</td>
<td></td>
<td>Not specified</td>
<td>F: miniscrew was significant loosening or with mobility that could not withstand orthodontic loading</td>
</tr>
<tr>
<td>(2015)</td>
<td></td>
<td>study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iwai et al.</td>
<td>23.2 ± 8.0</td>
<td>CCT</td>
<td>142 (71/71)</td>
<td>The screw was fixed at the height of 6 mm on the gingival side from a bracket slot just under the contact point of upper 2nd premolar and 1st molar</td>
<td>6 months after orthodontic force application</td>
<td>F: lost naturally or removed owing to mobility</td>
</tr>
<tr>
<td>(2015)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S: screws used for more than 6 months</td>
</tr>
</tbody>
</table>

CCT, clinical controlled trial; N (D/T), Number of miniscrews (self-drilling/self-tapping).
treatment. The feasible data were pooled to investigate the overall success rates of two miniscrew system. The meta-analysis showed that the success rates did not differ between the two types of miniscrews \(\text{OR} = 0.90, 95\% \text{CI} 0.52–1.53; \text{Figure 2}\).

Out of the six included studies, three were CCTs, while the other three were cohort studies. The CCTs shared the same follow-up durations, 6 months, which were defined as long-term studies. The three cohort studies had varied and comparatively short follow-up periods (defined as short-term studies; Table 2). To decrease the potential heterogeneity accompanying with the different study designs and follow-ups, subgroup analysis was performed, showing no difference in either the studies classified as CCT (long-term study) OR 0.76, 95\% CI 0.33–1.77; Supplementary Figure 2) or those cohort studies (short-term study) (OR 1.12, 95\% CI 0.44–2.80; Supplementary Figure 2). Moreover, consistent results were observed in subgroups classified by different ages (Supplementary Figure 3) and by immediate loading or delayed loading (Supplementary Figure 4).

**Rate of root contact**

Two studies investigated the root contact of self-drilling and self-tapping miniscrews. The meta-analysis found no difference in the rate of root contact between the 2 types of anchorage system (OR 0.96, 95\% CI 0.53–1.71; Figure 3).

Son et al. (19) compared the mobility of miniscrews contacting tooth roots and observed that self-drilling miniscrews displayed significantly higher mobility than self-tapping miniscrews. Iwai et al. (20) observed higher failure rate of self-drilling screws compared to self-tapping miniscrews in the circumstance of root contact. Moreover, Iwai et al. (20) found self-drilling screws tended to contact with distal roots with significance, especially at right maxilla.

**Sensitivity analysis**

The miniscrews were reimplemented at same sites in Yao et al. (21) when failure occurred, thus we only extracted the data of the first implantation to avoid the impact from different bone microenvironments around the reimplanted screws. Different from the other five studies, Iwai et al. (20) compared self-drilling and self-tapping methods deliberately using miniscrews of the same parameters. Subgroups containing Türköz et al. (22) displayed high heterogeneity in all subgroup analysis. Therefore, the three studies (20–22) were omitted individually to carry out the sensitivity analysis. The exclusion of studies reported by Iwai et al. (20), Yao et al. (21), and Türköz et al. (22) resulted in no significant changes in the pooled results (OR 0.97, 95\% CI 0.52–1.84; OR 1.07, 95\% CI 0.49–2.37; OR 0.71, 95\% CI 0.50–1.00; Figure 4).

**Discussion**

This systematic review was conducted to provide data regarding the comparison on the success rates of self-drilling and self-tapping miniscrews. The electronic and manual searches were performed following a precise protocol to minimize possible selection bias. Six studies including three CCTs and three cohort studies were adopted in the meta-analysis. This might be indicative of the deficiency of original high-quality studies, especially RCTs, in the currently existing literature.

The meta-analysis results suggest that there is no difference (OR 0.90, 95\% CI 0.52–1.53; Figure 2) between self-drilling miniscrews and self-tapping miniscrews in the success rate. Subgroup analyses were performed to reduce the heterogeneity from different study designs, follow-ups, participant ages, application of immediate loading or delayed loading, and no significant change of the pooled data was observed (Supplementary Figures 2–4). Moreover, sensitivity analysis displayed similar results (Figure 4). The consistent outcomes could indicate the robustness of the results in the meta-analysis.

Self-drilling miniscrews are commonly featured with deep thread around the reimplanted screws. Different from the other five studies, Iwai et al. (20) compared self-drilling and self-tapping methods deliberately using miniscrews of the same parameters. Subgroups containing Türköz et al. (22) displayed high heterogeneity in all subgroup analysis. Therefore, the three studies (20–22) were omitted individually to carry out the sensitivity analysis. The exclusion of studies reported by Iwai et al. (20), Yao et al. (21), and Türköz et al. (22) resulted in no significant changes in the pooled results (OR 0.97, 95\% CI 0.52–1.84; OR 1.07, 95\% CI 0.49–2.37; OR 0.71, 95\% CI 0.50–1.00; Figure 4).

![Figure 2. Meta-analysis of success rates comparing self-drilling with self-tapping miniscrews. Forest plot for the odds ratio of success rates between self-drilling and self-tapping miniscrews.](https://example.com/fig2)

![Figure 3. Meta-analysis of root contact rates comparing self-drilling with self-tapping miniscrews. Forest plot for the odds ratio of root contact rates comparing self-drilling with self-tapping miniscrews.](https://example.com/fig3)
two types of screws. It should be noted that the higher cutting capacity of self-drilling miniscrews would also result in more microdamage to alveolar bone (32–34). The accumulation of microdamage around screws could lead to local ischemia, bone necrosis, hampered bone remodelling, and thus might induce the premature loss of miniscrews (33).

Contact with tooth root has been described as a potential risk factor for clinical failure of screw anchorage (35). Two recruited studies in the present systematic review explored the potential difference in root contact of the two screw systems (19, 20). The meta-analysis suggested that the root contact rate was similar between the two types of screw anchorage (OR 0.96, 95% CI 0.53–1.71; Figure 3). Nevertheless, under the circumstance of root contact, self-drilling miniscrews displayed a significantly lower stability and higher failure rate than self-tapping miniscrews (19, 20), which could be caused by the higher risks of damage to root and adjacent alveolar bone, and the following inflammation surrounding the implants owing to the higher cutting capacity of self-drilling miniscrews (33). This suggested more attention should be paid to the determination of the placement location when self-drilling miniscrews are used at the sites with narrow root proximity. Interestingly, distal root contact rate was higher than mesial roots for self-drilling screws, especially at the right maxillary alveolar bone (20, 36). This might be due to the fact that most clinicians are right-handed and the observation positions at chairside are different for each quadrant.

Since the proximity to root is critical for success of miniscrews and self-drilling miniscrews displayed lower success rate when contacting with tooth root, the variation in proficiency of clinicians could make an inevitable bias and compromise the quality of systematic review outcomes. Moreover, though previous study reported that the buttress reverse thread could provide better pullout strength than other thread shapes, indicating the potential role of thread shape on the stability of miniscrews (37), limited information regarding the thread shape could be found in present evidences. Therefore, we suggest the future studies exclude confounding effects from root contact and thread shape, which may provide more reliable results.

Lim et al. (18) reported a tendency of lower success rate in mandible compared to maxilla. This could be caused by the higher bone density in mandible, which might lead to higher torque during placement and subsequent bone necrosis, and the narrow attached gingiva of the mandible causing higher susceptibility to infection and higher risk of inserting into the mucosal area (12, 32, 33). Moreover, penetrating the cortical bone of mandible, such as buccal flange area, might abrade the cutting threads and tip of self-drilling miniscrews, thus may reduce the screw stability and bring about higher risk of failure. However, this opinion should be further verified. In the present systematic review, the site for screw placement was between maxillary second premolar and first molar at buccal alveolar bone in four of the six included studies (17, 19, 20, 22). Therefore, the results should be interpreted with caution when inserting miniscrews at other sites.

Inneglectable heterogeneity ($I^2 = 41\%$) was detected when pooling data from all recruited studies. Among the six included studies, the three CCTs shared the same and longer follow-up duration...
(6 months) and were defined as long-term studies, while the three cohort studies had varied and comparatively shorter follow-ups (Table 2). In the study reported by Yao et al. (21), the miniscrews were reimplanted at the same sites up to four times when failure occurred. Since the effects of screw placement to the surrounding bone could be a great confounding factor for the following reimplantations, we only extracted the data of the first implantation. Therefore, we defined Yao et al. (21) and the other two cohort studies as short-term studies (Table 2). Subgroup analysis was performed to eliminate the influence of heterogeneity from different study designs, follow-ups, participant ages, and application of immediate loading on the overall results (Supplementary Figures 2–4). In all subgroup analysis, the subgroup containing Türköz et al. (22) showed high heterogeneity. Therefore, a sensitivity analysis was conducted by omitting Türköz et al. (22). It was observed that five studies displayed weak heterogeneity ($I^2 = 0\%$, Figure 4), indicating the study by Türköz et al. (22) which directly combined the data of two different types of self-tapping miniscrews together could be the main source of heterogeneity.

To the best of our knowledge, this study is the first systematic review and meta-analysis regarding the success rate of self-drilling and self-tapping miniscrews as orthodontic anchorage. The present study suggests that success rates of the two types of screw anchorage were similar, at least in the maxillary molar area. The results should be interpreted with caution at other sites. Moreover, compared to self-tapping system, self-drilling miniscrews seem more susceptible to high mobility and failure when contacting to roots, thus we recommend the utilization of more accurate placement guide for self-drillling miniscrews at position with narrow root proximity. The investigations regarding the success rates and root contact rates of self-drilling and self-tapping miniscrews at more placement sites by well-designed RCTs would be very useful to obtain more reliable results.

**Limitations**

Although this systematic review was carried out carefully following normalized process, some limitations still persisted which deserved further discussion. First, small number of original studies was recruited and the study designs included CCTs and cohort studies; high-quality original studies, especially RCTs, are needed to obtain a more reliable conclusion. Second, the heterogeneity in methodology and missing information caused the extent of statistical data pooling to be unsatisfactory. Third, funnel plots have not been performed, since only six studies were included, thus the publication bias could hardly be avoided.

**Conclusion**

1. The success rates of self-drilling and self-tapping miniscrews are similar in short term and long term, at least at the maxillary buccal area.
2. Determining the position and direction of placement should be more precise when self-drilling miniscrews are inserted into sites with narrow root proximity.

**Supplementary material**

Supplementary material is available at European Journal of Orthodontics online.

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**References**


