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Evaluation the Effect of Micro-osteoperforation on the Tooth Movement Rate and the Level of Pain on Miniscrew-supported Maxillary Molar Distalization: A Systematic Review and Meta-analysis

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ABSTRACT

Background and aim: The recent meta-analysis and systematic review concentrated on the retraction of canine teeth. There was no previous meta-analysis or systematic review to evaluate the effects of micro-osteoperforations on the maxillary molar distalization. The present meta-analysis and systematic review were intended to assess the effect of micro-osteoperforatio on the tooth movement rate and the level of pain on the miniscrew-supported maxillary molar distalization.

Materials and methods: From the electronic databases, PubMed, Cochrane Library, Embase, ISI have been used to perform systematic literature until July 2020. Therefore, a software program (Endnote X8) has been utilized for managing electronic titles. Searches were performed with mesh terms. The Cochrane Collaboration tool was deployed to assess the quality of the randomized clinical trials that were included. We also used SYRCLE's (SYRCLE's RoB tool is an adapted version of the Cochrane RoB tool.) risk of tool bias for animal interventional studies was included. Mean differences between the two groups (MOP and without MOP) with a 95% confidence interval (CI), fixed-effect model, and Inverse-variance method were calculated.

Results: Totally, 65 potentially relevant studies were found in the electronic search according to their titles and abstracts. Lastly, merely three publications were eligible according to the inclusion criteria of the current systematic review. In humans, the mean difference of tooth movement was (MD, 0.00mm 95% CI -0.00, and 0.00. P= 0.58) among one study.

Conclusion: Animal studies showed positive effects and statistically significant of micro-osteoperforation interventions on tooth movement.

1. Introduction

Various non-surgical and surgical techniques have been shown to rate of tooth movement.[1] Although surgical techniques, including corticotomies, are associated with favorable results, this procedure is aggressive. Non-surgical treatments include low-level laser therapy, biological molecules and micro-vibrations, and systemic administration, but few Randomized controlled trial studies have been performed. It is essential to use a minimally invasive method.[2-5] Micro-osteoperforation (MOP), a minimally invasive procedure, has accelerated the tooth movement.[6] Over the past few years, various surgical procedures have been introduced, one of which is the regional acceleratory phenomenon (RAP) used by Wilckodontics to increase tooth movements.[7, 8] For the first time, Frost reported that an increase in inflammatory mediators could increase absorption and bone metabolism, affect the rate of teeth movement, and MOPs may affect the cell as RAP.[9] An essential factor in accelerating tooth movement is the biological response to orthodontic force. Recent studies have shown that using MOP during orthodontic tooth movement increases tooth movement rate, and inflammatory markers such as chemokines and cytokines increase orthodontic forces.[10-12] MOP may cause difficulty eating and mild pain, but these are usually not noticeable. In one study, almost all people reported MOP pain associated with chewing and speech.[13] The recent systematic review and meta-analysis are concentrated on the retraction of canine teeth.[4] There was

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no systematic review and meta-analysis that evaluated the effects of micro-osteoperforations on maxillary molar distalization. The present systematic review and meta-analysis aimed to assess the effectiveness of micro-osteoperforatio to rate of tooth movement and pain level on miniscrew-supported maxillary molar distalization.

2. Materials and methods

Search strategy

From the electronic databases, PubMed, Cochrane Library, Embase, ISI have been used to perform systematic literature between January 2018 and July 2020. Therefore, a software program (Endnote X8) has been utilized for managing electronic titles. Searches were performed with mesh terms:

(((("Minimally Invasive Surgical Procedures/methods"[Mesh]) AND ("Tooth Movement Techniques/adverse effects"[Mesh] OR "Tooth Movement Techniques/methods"[Mesh])) AND "Dental Prosthesis, Implant-Supported"[Mesh]) AND "Pain"[Mesh]) AND ("Molar"[Mesh] OR "Molar, Third"[Mesh]) AND "micro-osteoperforation"[Mesh]). This systematic review has been conducted based on the key consideration of the PRISMA Statement–Preferred Reporting Items for the Systematic Review and Meta-analysis, and PICO or PECO strategy (Table1).

Selection criteria

Inclusion criteria

1. Randomized controlled trial studies, controlled clinical trials, and prospective and retrospective cohort studies.
2. Studies with the control group (treatment without MOP).
3. Skeletal Class I, II, III.
4. Only studies focused on MOPs on maxillary molar distalization.
5. In English.

Exclusion criteria

1. In vitro studies, case studies, case reports, and reviews.
2. Systemic diseases.
3. Studies focused on the retraction of canine teeth.

Table 1. PICO OR PECO strategy.

PICO OR PECO strategy	Description
P	Population/ Patient: Patients that do orthodontic treatment
E	Exposure/ Intervention: MOPs on maxillary molar distalization
C	Comparison: MOP group vs. control group (without MOP)
O	Outcome: the determine rate of tooth movement and pain level

Data Extraction and method of analysis

The data have been extracted from the research included about the study, years, study design, Intervention group, control group, Gender, sample size, mean/range of age; the quality of the RCT studies included were investigated using the Cochrane Collaboration's tool.[14] The scale scores for low risk were one and for High and unclear risk was 0. Scale scores range from 0 to 6. A higher score means higher quality and used SYRCLE's (SYRCLE's RoB tool is an adapted version of the Cochrane RoB tool) risk of bias tool for animal intervention studies included.[15] In this scale, the "yes" judgment suggests the low risk of bias; the "no" judgment suggests a high bias risk; the "unclear" judgment will confer reporting insufficient details to assess the bias risk accurately. For Data extraction, two reviewers blind and independently extracted data from the studies' abstract and full text. Moreover, the mean differences between the two groups (MOP and without MOP) with a 95% confidence interval (CI), fixed-effect model, and Inverse-variance method were calculated. Random effects were used to deal with potential heterogeneity, and I2 showed heterogeneity. The Meta-analysis and forest plots have been evaluated using a software program available in the market (i.e., Comprehensive Meta-Analysis Stata V16).

3. Results

According to the research design, 65 potentially relevant research abstracts and titles have been discovered in our electronic searches. In the first phase of the study selection, 21 research has been about the topics and abstracts. Therefore, we thoroughly assessed the complete full-text papers of the rest 19 studies in the second stage. We excluded 16 publications due to the lack of the defined inclusion criteria. Then, three papers remained in agreement with our inclusion criteria required (Figure 1). Table 2 reports the individual studies in this meta-analysis.

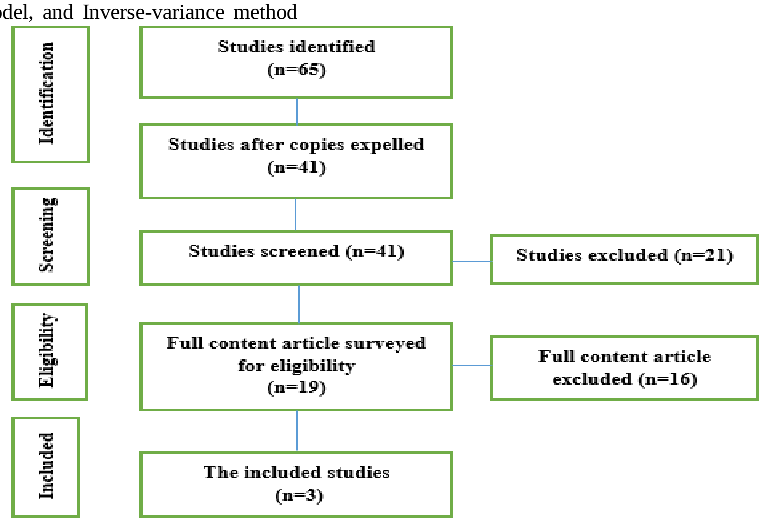

Figure 1. Study Attrition.

Sample size

Therefore, three studies (one randomized controlled trial and two animal studies) have been included. Gulduren et al. 2020 (6) was the first study to evaluate the effects of micro-osteoperforations on maxillary molar distalization in humans. The Number of Patients A total was 9 in the human study[6] 21.8 years(Table 2), and the sample size in animal study was 56 (Rat)(Table 3).

Bias assessment

According to Cochrane Collaboration's tool, one study had a total score of 5/6. This outcome showed a low risk of bias (Table 4). SYRCLE's RoB tool showed a low risk of bias (Table 5).

Table 2. Human studies were selected for systematic review and meta-analysis.

<table>
<tr><th rowspan="3">Study. Year</th><th rowspan="3">Design</th><th colspan="4">Number of Patients</th><th colspan="2">Mean/ Range of age</th><th rowspan="3">Intervention Group (MOP)</th><th rowspan="3">Control Group (without MOP)</th></tr>
<tr><th colspan="2">MOP</th><th colspan="2">Control</th><th rowspan="2">MOP</th><th rowspan="2">Control</th></tr>
<tr><th colspan="2">Male</th><th colspan="2">Female</th></tr>
<tr><td rowspan="3">Gulduren et al. 2020 [6]</td><td rowspan="3">RCT</td><td colspan="4">9</td><td rowspan="3">21.8</td><td rowspan="3">17.7</td><td rowspan="3">MOPs were done on the first day of the distalization treatment and three weeks after the procedure three times.</td><td rowspan="3">MOP was not performed I the contralateral sides of the intervention group.</td></tr>
<tr><td colspan="2">9</td><td colspan="2">9</td></tr>
<tr><td>5</td><td>4</td><td>6</td><td>3</td></tr>
</table>

RCT: randomized clinical trial.

Table 3. Animal studies were selected for systematic review and meta-analysis.

Study. Year	Animal	Sample size	Intervention Group (MOP)	Control Group (without MOP)
Kim et al. 2016 [16]	rats	6	Received mini-implant–facilitated MOPs on only the left maxilla.	The right maxilla was used as the control
Sugimori et al. 2018 [17]	rats	50	The force was applied in addition to three small perforations on the cortical plate (TM + MOPs).	10 g of orthodontic force was applied to the first maxillary molar.

In humans, the mean difference of tooth movement was (MD, 0.00mm 95% CI -0.00, and 0.00. P= 0.58) among one study. This result showed no statistically significant difference between the MOP and the control group (p=0.58). Emphasized Gulduren et al. 2020[6] study is the first RCT that evaluates the effects of micro-osteoperforations on maxillary molar distalization (Figure 2).

Table 4. Risk of bias assessment based on Cochrane Collaboration's tool.

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Total score
Gulduren et al. 2020 [6]	+	?	+	+	+	+	5

Low (+), unclear (?), high (-).

Table 5. Risk of bias assessment according to SYRCLE's RoB tool.

Question	Kim et al.2016 (16)	Sugimori et al. 2018 (17)
Crossover design that was not suitable.	YES	YES
Crossover design with the risk of carry-over effect.	NO	NO
Crossover design with only first period data being available.	NO	NO
Crossover design with many animals not receiving 2nd or following treatment due to a large number of drop-	YES	YES

outs, probably due to longer duration of stud.		
Crossover design in which all animals received the same order of interventions.	YES	YES
Multi-arm study in which the same comparisons of groups are not reported for all outcomes.	YES	YES
Multi-arm study in which results of different arms are combined (all data should be presented per group).	YES	YES
Cluster randomized trial not taking clustering into account during statistical analysis (unit of analysis error).	YES	YES
Crossover design in which paired analysis of the results is not taken into account.	YES	YES

YES= Low risk, NO= high risk.

The mean difference of tooth movement in animals was (MD, 0.20mm 95% CI 0.13, 0.28. P= 0.00) among the two studies. This result showed a statistically significant difference between the MOP and the control group (p=0.00) (Figure 3).

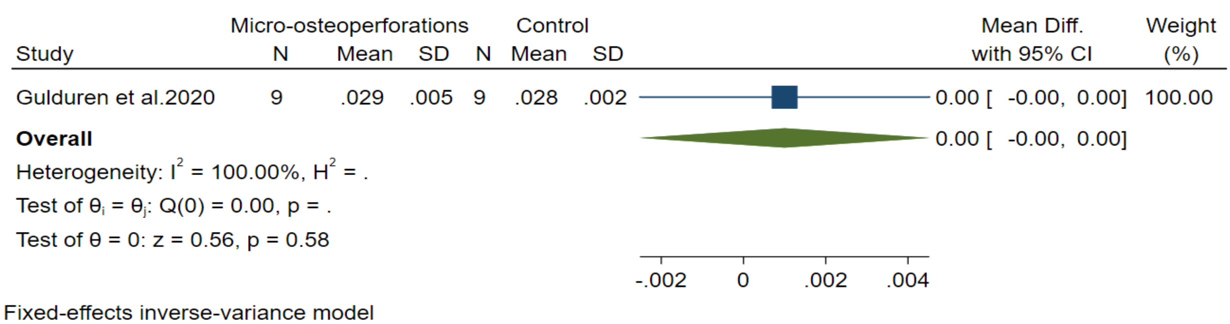

Figure 2. Mean difference of Daily rate of tooth movement with MOP vs. whiteout MOP on miniscrew-supported maxillary molar distalization.

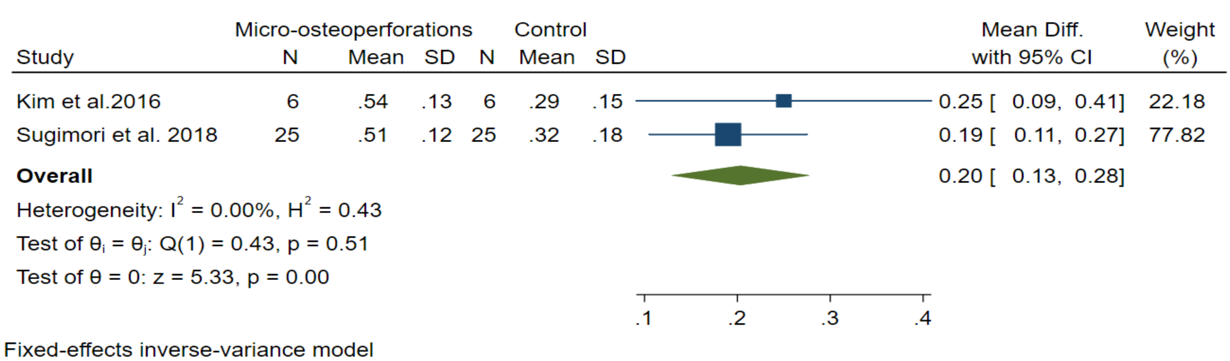

Figure 3. Mean difference of tooth movement with MOP vs. whiteout MOP.

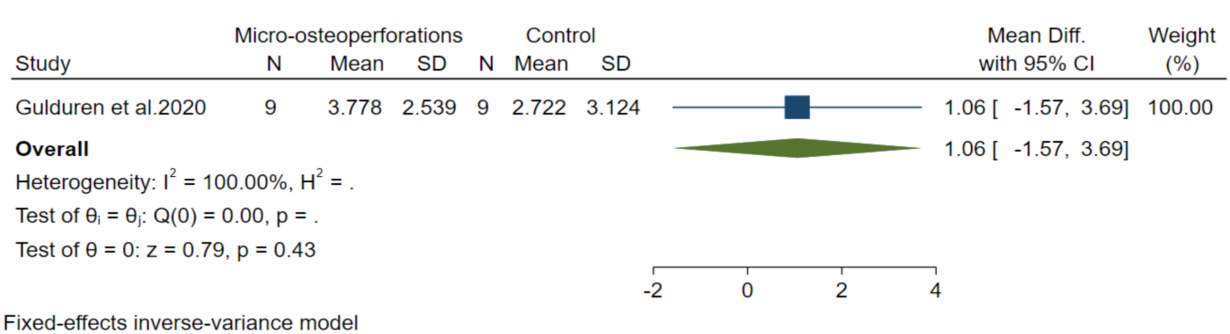

Figure 4. Mean difference of pain level in MOP group vs. control group.

The mean difference of pain level was (MD, 1.06 95% CI -1.57, 3.69. P= 0.43) among one study. This result showed no statistically significant difference in the pain level between the MOP and the control group (p=0.58) (Figure 4).

4. Discussion

The current meta-analysis and systematic review findings show that human study[6] did not show any statistically significant difference regarding the tooth movement rate between the group with MOP and without MOP. Also, there was a statistically significant difference in animal studies regarding the tooth movement rate when comparing the MOP and control groups. The recent meta-analysis and systematic review of the human studies regarding the retraction of canine teeth revealed statistically significant differences regarding tooth movement rate comparing the group with MOP and without MOP.[4] Gulduren et al. 2020[6] study was the first study in human that Evaluate the effective of micro-osteoperforatio to rate of tooth movement and the pain level on the miniscrew-supported maxillary molar distalization. In this study occlusal forces, subjects with similarly severe malocclusion had been considered Since it's possible to virtually tooth movement. Several human studies have stated the effects of MOPs on the rate of tooth movement, including Babanouri et al. 2020[18] Sivarajan et al. 2019[13] Aboalnaga et al. 2019[19] Shah et al. 2019[20] Kundi et al. 2018[24] Feizbakhsh et al. 2018[25] Attri et al. 2018[26] and Alikhani et al.[1] their RCT evaluated the maxillary canines'. The result of that study showed micro-osteoperforations was able to accelerate the orthodontic tooth movement effectively. Babanouri et al. 2020[18] reported MOP interventions to positively affect the rate of tooth movement over three months. The result of Sivarajan et al. 2019[13] showed a minimum difference in tooth movement when intervals of 4, 8, and 12-week MOP were used. Feizbakhsh et al. 2018[21] reported the significantly increased tooth movement rate following MOP interventions.Yet, comparing the tooth movement rate differences in maxillary and mandibular canine retraction, both intervention and control sides presented insignificant changes. As a result, Alkebsi et al., 2018[22] observed the different outcomes and did not report a significant effect of MOP on the tooth movement rate. In present systematic review and meta-analysis used animal studies because found only one RCT find until July 2020; animal studies have similar biologic variability to humans, so should be assessed with caution.[16] Animal studies revealed that MOPs could increase the tooth movement rate.[16-17] The cause of differences in results between human studies and animal studies included in the current meta-analysis and systematic review was Gulduren et al. 2020 study. The first study is the effects of MOPs on the posterior dentoalveolar region is investigated in humans. This is different from all previous human studies, and the effect was possibly less prominent than their expectations, which revealed a significant difference between MOPs and control groups. The present study did not suggest a significant difference regarding the pain level between groups, which was consistent with the other studies.[1, 22] Due to the difference between the present study results and other studies, more RCT studies with a higher sample size and longer treatment duration are essential in achieving more exciting results. The present study's limitations include the differences in how the selected studies data analysis methods perform interventions. However, the present study tried to reduce the studies' inconsistency to reach a more comprehensive result. Given that the risk of bias was low in all studies, the present study's findings can be used for orthodontic treatment.

5. Conclusion

There were no significant differences between the MOP and control groups in a human study, but animal studies showed positive effects and statistically significant micro-osteoperforation interventions on tooth movement.

Conflict of Interest

The authors declared that there is no conflict of interest.

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