Review Article

Micro-Osteoperforation and the Rate of Orthodontic Tooth Movement: Systematic Review and Meta-Analysis

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Abstract

Background: The development of minimally invasive strategies, together with Micro-Osteoperforations (MOPs), has made improved orthodontics more acceptable. While a few research about the effect of MOPs on RTM showed positive effects, other studies have proven no huge medical variations. These days, systematic evaluations about the effectiveness of MOPs had opposite conclusions. **Aim:** This work aims to determine the efficacy of Micro-Osteoperforation (MOP) on the rate of tooth movement in patients undergoing orthodontic treatment. **Literature Review:** A systematic search was performed over different medical databases to identify dentistry studies, which studied the outcome of the MOP group versus the control group of patients undergoing orthodontic treatment. We conducted a meta-analysis process on the rate of tooth movement as the main primary outcome. Eight studies were identified involving 496 patients, with 238 patients in the MOP group, and 258 patients in the Control group. Our meta- analysis process showed a highly significant increase in mean distance of tooth movement in the MOP group compared to the control group ($p<0.001$). **Conclusion:** To conclude, the rate of orthodontic tooth movement can be accelerated by the MOP technique with frequently repeated MOPs throughout the treatment. The MOP procedure was effective in accelerating orthodontic tooth movement. An increase in the number of MOPs resulted in a significant acceleration of the canine retraction.

Keywords: Micro-osteoperforation; Rate of orthodontic tooth movement; Trabecular bone

Introduction

Orthodontic treatment time is an essential issue for patients to don't forget whilst making treatment alternatives. Routine active remedy takes a median of 24 months; some patients have a longer period because of the issue of treatment, a complicated remedy plan, and personal motives. The prolonged orthodontic remedy could have many adverse effects, such as pain and pain, dental caries, gingival recession, and root resorption. Further, increasingly more adult patients want to stop orthodontic treatment faster due to social or aesthetic motives. Consequently, accelerating teeth movement and shortening the remedy time have emerged as the not unusual goals of orthodontists and patients. [1]

It is a common grievance among sufferers undergoing orthodontic treatment of the exhaustive time undertaken till completion, accomplishing an average of two or more years. Orthodontic treatment isn't always a 1-day or 30-minute remedy like different disciplines of dentistry. In orthodontic remedies, the patient is going *via* craniofacial rehabilitation and it takes months or years. This extended treatment also affects diverse complications for teeth in addition to the related tooth-helping structures. [2]

The development of minimally invasive strategies, together with Micro-Osteoperforations (MOPs), has made improved orthodontics more acceptable. While a few research about the effect of MOPs on RTM showed positive effects, other studies have proven no huge medical variations. These days, systematic evaluations about the effectiveness of MOPs had opposite conclusions. [3] The consequences of MOPs at the rate of orthodontic teeth movement and trabecular bone parameters were mentioned on animal fashions the usage of micro-CT and it is considered to be the gold standard for assessing radiographic trabecular alveolar bone microstructural parameters. However, its application on the human experimental model is not possible due to the limited range of scanning sites. Cone-Beam Computed Tomography (CBCT) in dental practice has numerous blessings over other Computed Tomography (CT) modalities like rapid experiment time, better spatial resolution,

How to Cite this Article: Alferm AB, et al. Micro-Osteoperforation and the Rate of Orthodontic Tooth Movement: Systematic Review and Meta-Analysis. Ann Med Health Sci Res. 2021;11:S6:16-20.

beam limitations, specific area of view, isotropic voxels, and dose reduction. [4] This work aims to determine the efficacy of Micro-Osteoperforation (MOP) on the rate of tooth movement in patients undergoing orthodontic treatment.

Literature Review

Our review came following the (PRISMA) statement guidelines. [5]

Study eligibility

The included studies should be in english, a journal published article, and a human study describing patients undergoing orthodontic treatment. The excluded studies were either animal or non-english studies or articles describing other types of interventions in patients undergoing orthodontic treatment.

Study identification

Basic searching was done over the PubMed, Cochrane library, and Google scholar using the following keywords: micro-osteoperforation, rate of orthodontic tooth movement.

Data extraction

Comparative studies, clinical trials, and Randomized Controlled Trials (RCTs), which studied the outcome of the MOP group versus control group of patients undergoing orthodontic treatment, will be reviewed. Outcome measures included the rate of tooth movement (as the primary main outcome).

Study selection

We found 150 records, 90 excluded because of the title; 60 articles are searched for eligibility by full-text review; 23 articles cannot be accessed; 13 studies were reviews and case reports; 11 were not describing functional outcome; the desired procedure not used in 5 studies. The studies which met all inclusion criteria were 8 studies.

Statistical analysis

Pooled Standard Mean Differences (SMDs), with 95% Confidence Intervals (CI) assessed, using a statistical package (MedCalc, Belgium). The meta-analysis process was established *via* I^2-statistics (either the fixed-effects model or the random-effects model), according to the Q test for heterogeneity.

The included studies were published between 2013 and 2021. Regarding patients' characteristics, the total number of patients in all the included studies was 496 patients, with 238 patients in the MOP group, and 258 patients in the control group, while their average study period was (8 weeks). The mean age of all patients was (23 years) [**Table 1**]. Our meta-analysis included 8 studies comparing 2 different groups of patients; with a total number of patients (N=258) [**Table 2**]. [6-13]

Each outcome was measured by

Standard Mean Difference (SMD)

- **For the rate of tooth movement.**

Concerning the primary efficacy outcome measure, we found 8 studies reported the rate of tooth movement. I^2 (inconsistency) was 95.6%, Q test for heterogeneity ($p<0.0001$), so random-effects model was carried out; with overall SMD=-2.416 (95% CI=1.338 to 3.495). The random-effects model of the meta-

Table 1: Patients and study characteristics.

N	Author	Number of MOPs	Number of patients			Age	Study duration
			Total	MOP group	Control group	(average years)	(weeks)
1	Alikhani et al. [6]	Three MOPs	40	10	30	25	4
2	Alkebsi et al. [7]	Three MOPs	64	32	32	19.2	12
3	Attri et al. [8]	Three MOPs	120	60	60	18	4
4	Feizbakhsh et al. [9]	Three MOPs	40	20	20	28	4
5	Kundi et al. [10]	Three MOPs	60	30	30	27.9	4
6	Sivarajan et al. [11]	Three MOPs	120	60	60	22.2	16
7	Babanouri et al. [12]	Three MOPs	28	14	14	25.5	12
8	Ozkan et al. [13]	Three MOPs	24	12	12	17.5	4

Table 2: Summary of outcome measures in all studies.

N	Author	Primary main outcome			
		The rate of tooth movement (mm)			
		MOP group	SD	Control group	SD
1	Alikhani et al.	1.14	0.13	0.49	0.12
2	Alkebsi et al.	0.65	0.26	0.67	0.34
3	Attri et al.	0.89	0.19	0.58	0.14
4	Feizbakhsh et al.	1.36	0.49	0.74	0.4
5	Kundi et al.	1.34	0.12	0.47	0.08
6	Sivarajan et al.	1.04	0.4	0.76	0.41
7	Babanouri et al.	1	0.15	0.73	0.12
8	Ozkan et al.	1.29	0.31	0.88	0.19

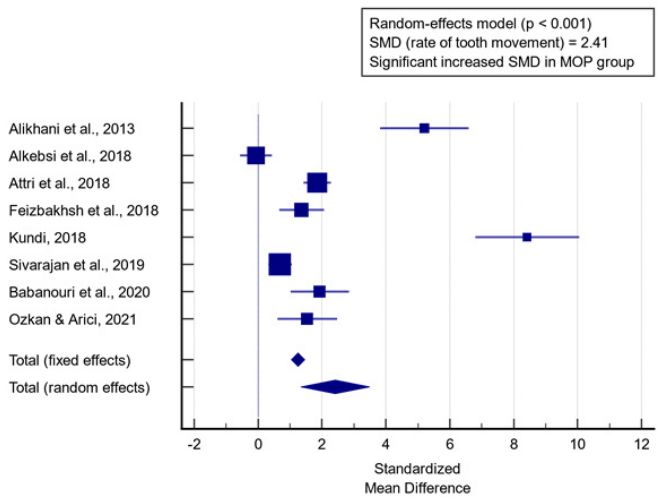

Figure 1: Forest plot (the rate of tooth movement - mm).

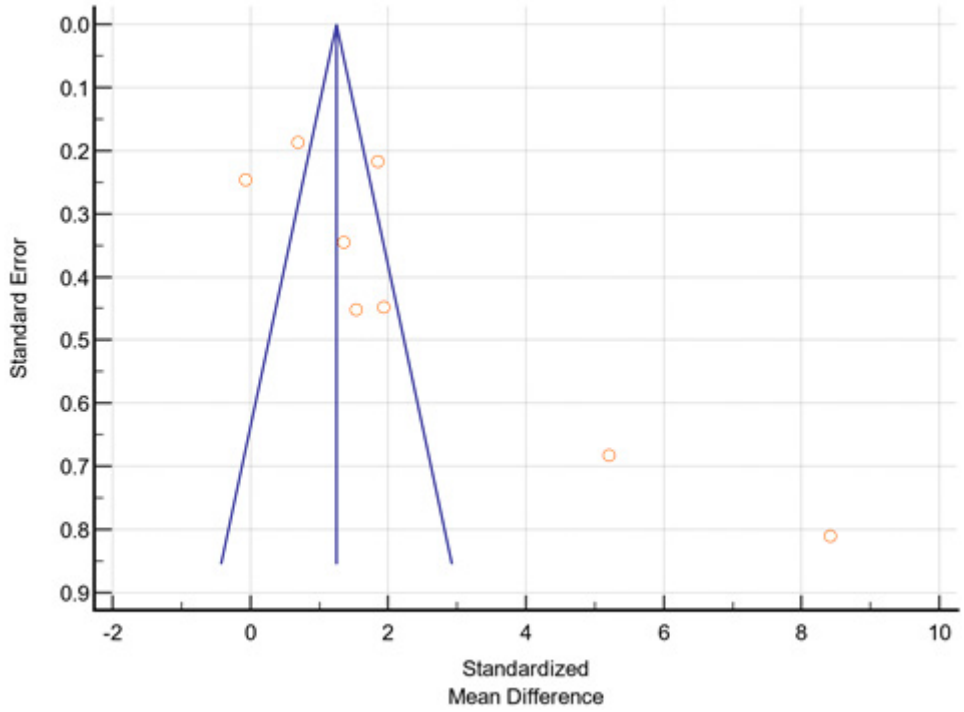

Figure 2: Funnel plot (the rate of tooth movement–publication bias was significant).

analysis process revealed a highly significant increase in mean distance of tooth movement in the MOP group compared to the control group ($p<0.001$) [**Figure 1**]. The funnel plot showed significant publication bias, Egger's test ($p=0.029$) [**Figure 2**].

Discussion

This work aims to determine the efficacy of Micro-Osteoperforation (MOP) on the rate of tooth movement in patients undergoing orthodontic treatment. The included studies were published between 2013 and 2021. Regarding patients' characteristics, the total number of patients in all the included studies was 496 patients, with 238 patients in the MOP group, and 258 patients in the control group, while their average study period was (8 weeks).

The mean age of all patients was (23 years). Our meta-analysis included 8 studies comparing 2 different groups of patients; with a total number of patients (N=258). Concerning the primary efficacy outcome measure, we found 8 studies reported the rate of tooth movement. The random-effects model of the meta-analysis process revealed a highly significant increase in mean distance of tooth movement in the MOP group compared to the control group ($p<0.001$) which came in agreement with Babanouri et al.; Kundi et al.; Al-Khalifa et al.; Fu et al.; Shahabee et al.; Tsai et al.; Asif et al.; Feizbakhsh et al. [1,2,4,14-18]

Babanouri et al. reported that the result of the intra-examiner reliability of the usage of ICC was 0.97 ($p<0.001$), indicating excellent repeatability and reliability of the measurements. The baseline characteristics between the groups were similar ($p>0.05$). There was a considerable difference in the charge of canine retraction between the MOP groups and the contralateral manage sides, as well as between the MOP1 and MOP2 groups ($p<0.05$). [14] Kundi et al. reported that significant canine retraction in sufferers with FCP (imply retraction of 6.68 ± 0.60 (measured at crown tip level) and 5.97 ± 0.71 mm (measured at a mid-cervical level)) was revealed, even as sufferers with traditional mechanics had mean retraction of 2.54 ± 0.49 and 2.33 ± 0.46 mm. Mesial movement of molar additionally confirmed good sized distinction (FCP=0.48 ± 0.11 mm and traditional=0.65 ± 0.19 mm). Ache belief in the control group was appreciably decreased on days 1 and 2. [15]

Al-Khalifa et al. reported that MOPs were proven time and again, in animal and human studies alike, to boom the charge of orthodontic teeth movement. The application of perforations to cortical bone present inside the pathway of the tooth that is specifically to be moved creates transient osteopenia. This reduces the density of the cortical bone, therefore speeding up the rate of orthodontic tooth motion. Good-sized difference determined in intergroup teeth movement. Tooth movement became visible to be improved *via* 46.5% in IC organization, 44.2% in TC institution, and 32% in MP organization. Indentation corticotomy organization (2.52 mm) and TC institution (2.48 mm) showed the largest amounts of teeth movement. The micro-osteoperforation group showed 2.27 mm enamel movement and lastly the control institution had 72 mm teeth movement. [2]

Fu et al. reported that nineteen articles (538 participants) were blanketed inside the evaluation: 9 research assessed the price of upper canine motion; five considered the remedy time; 1 evaluated the en masse retraction time, and 4 studied destructive effects. They finished a meta-evaluation for the fee of dog movement and treatment time and described the results for the destructive results in a systematic comparison. The effects of the subgroup evaluation in step with micro-osteoperforation and piezocision have been covered within the examination. No prolonged enamel movement was determined in the micro-osteoperforation group. After flapless corticotomy strategies,

increased enamel motion fees had been identified *via* weighted mean differences of 0.63 (p=0.003) and 0.64 (p=0.16) for 1 and a couple of months, respectively. The suggested remedy time changed to 68.42 (p=0.003) much less that than for minimally invasive surgery. [1]

Shahabee et al. reported that a meta-analysis was performed for the differences in the rate of canine retraction after 1 month. An inverse-variance random-effects meta-analysis was performed due to the differences in terms of methodologies (intervention and measurement) and the obvious heterogeneity of the data. The intervention group had a significantly higher rate of tooth movement than that of the control group (p=0.002, Mean Difference (MD)=0.45). Also, based on the study by Wang and Lee (28) the 95% prediction interval for this outcome was calculated as -0.70 to 1.60. This outcome results from analysing 384 participants in six studies and shows that the rate of tooth movement per month is 0.45 mm faster by performing MOP. [16]

Tsai et al. reported that forty-five 8-week-old male Sprague-Dawley rats have been divided into the following corporations: Micro-Osteoperforation and Orthodontic Force (MOP+F), Corticision and Orthodontic Force (C+F), and orthodontic pressure handiest (F, control). The left maxillary first molars were pulled ahead with a pressure of 50 g. Flapless surgical interventions were conducted inside the MOP+F and C+F organizations. The entire duration of the experiment turned into 6 weeks. Alveolar bone density and the number of osteoclasts had been evaluated the usage of micro computed tomography and histologic examination, respectively. The enamel movement distance turned significantly better in each experimental company than in the manage group. Bone density and bone mineral density decreased in the MOP+F and C+F agencies. The range of osteoclasts in the MOP+F and C+F corporations turned significantly better than inside the managed institution F. [17]

Asif et al. reported that a significant difference was determined inside the rate of canine movement between manipulating and MOP. Paired take a look at evaluation confirmed a large difference (p<0.001) within the suggested ratio between control and MOP aspects in all of the frequency periods corporations. However, the difference was tremendous simplest in institution 1 (p=0.014). A strong negative correlation (r=0.86) changed into discovered among the rate of canine tooth motion and the BV/television ratio on the MOP aspect for group 1 and all frequency periods collectively (r=0.42). [4]

Feizbakhsh et al. reported that micro-osteoperforations significantly increased the rate of tooth movement by more than 2-fold (p=0.000). However, comparing the differences in the rate of tooth movement when maxillary and mandibular canine retraction, in both interventional and control sides yielded insignificant results (p>0.05). [18]

Conclusion

To conclude, the rate of orthodontic tooth movement can be accelerated by the MOP technique with frequently repeated MOPs throughout the treatment. The MOP procedure was effective in accelerating orthodontic tooth movement. An increase in the number of MOPs resulted in a significant acceleration of the canine retraction.

Acknowledgment

All the listed authors contributed significantly to the conception and design of study, acquisition, analysis, and interpretation of data and drafting of the manuscript, to justify authorship.

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