Effect of Two Different Penetration Depths of Micro-osteoperforation on the Rate of Orthodontic Tooth Movement: A Prospective Clinical Study

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Abstract

Objective: The objective is to evaluate the effectiveness of two different penetration depths of micro-osteoperforations (MOPs) on the rate of orthodontic tooth movement over 60 days. In addition, the amount of pain and discomfort caused by the MOP was evaluated. **Materials and Methods:** A total of 22 patients (18–30 years) who need fixed orthodontic treatment were recruited and randomly assigned into two groups. Randomization for determination of the experimental side and depth of perforations was done using sealed envelopes. On each patient, the other side of the mouth worked as control side with no MOPs. Patients in group 1 (MOP-5) received 3MOPs on the buccal surface of the alveolar bone each at 5 mm depth, whereas patients in group 2 (MOP-7) received 3MOPs on the buccal surface of the alveolar bone each at 7 mm depth. The amount of canine retraction was measured every 30 days at two intervals on both sides of the mouth. Pain perception was measured after 1 h, 24 h, 72 h, 7 days, and 28 days of procedure. MOP-related pain was measured using a visual analog scale. The level of statistical significance was $P \leq 0.05$. **Results:** The result of the intra-examiner reliability using intraclass correlation coefficient more than 0.97 ($P < 0.001$), indicating excellent repeatability and reliability of the measurements. The baseline characteristics between groups were similar ($P > 0.05$). Both the groups demonstrated a significantly higher canine movement than the control group. No significant difference was seen between the MOP-5 and MOP-7 groups ($P > 0.05$) in terms of canine retraction. Mild-to-moderate pain was experienced only in the first 24 h of the procedure. **Conclusion:** Three MOPs with a depth of 5 mm can be performed as an effective method to increase the rate of tooth movement. However, increasing the depth of perforation beyond 5 mm does not additionally enhance tooth movement.

Keywords: *Micro-osteoperforation, orthodontic tooth movement, regional acceleratory phenomenon, visual analog scale*

Introduction

In the field of dentistry, orthodontics deals with both function and aesthetics. The transforming change after the treatment and the retention of those changes has led to its popularity amongst the young generation. With the increase in popularity, the concern for treatment time is seen as a major shortcoming. Orthodontic treatment time varies from several months to 3 years depending on the type of malocclusion and the treatment modality. Although many patients comply with the treatment modality, others go for less optimal options such as veneers or implants.[1] Invasive methods such as corticotomy[2] and peizocision[3] and less invasive methods like micro-osteoperforation have been employed to reduce the treatment time. Nonsurgical methods like low-level laser technique,[4] medications,[5] or self-ligating brackets are used to reduce treatment time. Surgical methods have been used for a long to accelerate tooth movement. These methods were based on the principle that when the bone is irritated surgically, an inflammation cascade is initiated, which causes increased osteoclastogenesis, hence causing faster tooth movement (Regional Acceleratory Phenomenon or Periodontally Accelerated Osteogenic Orthodontics).[6]

Studies by Alikhani *et al*.[1] and Feizbakhsh *et al*.[7] stated that the rate of tooth movement associated with MOP increased by 2–3 folds with no side effects. Although exploring a biological bone response seems exciting from a scientific perspective, there is a lack of evidence supporting such a new idea.[7] Most of the previous studies used three MOPs.[8,9] The only study that

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used two MOPs was by Feizbakhsh *et al*.[7] which showed a much higher rate of tooth movement compared to some other studies using three MOPs.[10] The heterogeneity and relativity of the parameters (especially the number, frequency, and depth of MOPs) tested in previous studies make it impossible to establish clear guidelines for the use of MOPs. Hence, the main objective of this study was to check the effectiveness of a minimally invasive MOP protocol using three MOPs with different penetration depths on the rate of Orthodontic tooth movement.

Objectives and hypotheses

The primary objective of this study was to assess the impact of MOPs with different penetration depths on canine retraction over 60 days. The null hypothesis was that an increase in the depth of perforations does not accelerate the rate of canine retraction compared to the control side and the group receiving fewer perforations. A secondary objective was to assess the level of pain and discomfort using the visual analog scale (VAS).

Materials and Methods

Trial design

This was a single-center, split-mouth, parallel-arm, double-blind, randomized, prospective clinical study performed with a 1:1 allocation ratio in the Department of Orthodontics and Dentofacial Orthopedics, Hazaribag College of Dental Sciences and Hospital, Jharkhand.

Participants and eligibility criteria

The sample consisted of 20 patients who were recruited from the orthodontic waiting list. This study was approved by the Institute Ethics Committee of Hazaribag College of Dental Sciences and Hospital (HCDSHIEC/2021/011). A detailed informed written consent was obtained from all subjects and/or guardians, who were willing to participate in the study and his or her treatment.

Inclusion criteria

- Patients with Angle's Class II Division 1 malocclusion (indicated for bilateral maxillary first premolar extraction) or Class I bimaxillary protrusion (indicated for all first premolar extraction)
- Aged 18–30 years
- Good periodontal condition (probing depth 1–3 mm/pocket depth <3 mm/no bleeding while probing)
- Good oral hygiene and general health.

Exclusion criteria

- Medical history that would affect the development or structure of the teeth and jaws and any subsequent tooth movement
- Medical conditions and medications affecting bone turnover and orthodontic tooth movement
- History of trauma, bruxism, or parafunction
- Past and present signs and symptoms of periodontal disease
- Smoking
- Previous orthodontic treatment.

Informed consent was obtained from all subjects or guardians and pretreatment records including alginate impressions, orthopantomograms, and extra- and intraoral photographs were collected.

Randomization

MOPs were performed on a total of 20 patients divided into two groups: MOP-5 (n = 10) and MOP-7 (n = 10). The participants for each group and the experimental side for each participant were selected randomly using sealed envelopes. At the start of the study, each participant was asked to pick a sealed envelope that determined the depth of MOPs to be done (5 or 7 mm) followed by another sealed envelope determining the experimental side (right or left) for that particular participant.

Blinding

Blinding was not possible during the clinical procedure as both the patients and the clinician applying the MOPs were aware of the experimental side. Therefore, blinding was implemented at the measurement level. All the study models were coded. Measurements and data analyses were performed by a different investigator who was blinded to all the procedures performed.

Sample size calculation

Statistical power analysis was used to determine the number of samples at $\alpha = 0.05$, at 80% power, and with a standard deviation of 0.34. The sample size was calculated using the method described in a previous study.[9] A 50% difference in the rate of canine retraction, which was adopted to be clinically meaningful, was detected to calculate the sample size. Furthermore, on account of using a mini-screw as an anchor unit, the amount of canine movement on one side could be considered completely independent from the contralateral side. Based on the calculation, 10 patients were found to be adequate for each arm. To compensate for follow-up loss, 11 patients were included in each group. Accordingly, 32 patients referred to the orthodontic department were examined. Of these, 6 patients did not meet the inclusion criteria and 4 declined to participate. Therefore, 22 patients were finally included in the study.

Orthodontic appliance

Extractions of first premolars were performed 4 months before initiation of canine retraction or at the beginning of treatment to avoid a confounding factor because surgical trauma from extraction can also initiate the RAP phenomenon. All the subjects were bonded with pre-adjusted Edgewise Mechanotherapy (MBT prescription; 0.022 slot). Segmental retraction of 13 and 23 was done on 0.019″ × 0.025″ stainless steel wire, which was left *in situ* for 4 weeks before the commencement of retraction. This period enabled full archwire passivity before the retraction. A power arm was made using 0.019 × 0.025-in. SS wire, based on the estimated center of rotation, bonded just mesial to the canine bracket on the buccal surface.

Micro-osteoperforation technique and canine retraction procedure

Modified MOPs were performed under local anesthesia (2% lidocaine with 1:100,000 epinephrine) and with standard asepsis. A rubber stopper was used to standardize the depth of penetration of the mini-screw implant [Figure 1]. Each perforation was 1.5 mm wide and depth was determined as per randomization.

Three MOPs were created on the buccal surface of the alveolar process on the experimental side of both groups. In the MOP-5 group, three MOPs of 5 mm depth were done on the buccal surface, and in the MOP-7 group, three MOPs of 7 mm depth were created on the buccal surface. MOPs were created directly through the alveolar mucosa in the middle of the distance between the distal surface of the canine and the mesial surface of the second premolar at the extraction site, in the vertical direction and 2 mm apart [Figure 2]. The first MOP was located 5 mm away from the free gingival margin. Concurrently, local anesthesia was applied on the control sides and extremely shallow insertions were made corresponding to those of the experimental sides, but only in the gingival tissue.

Bilateral canine retraction was achieved using pre-calibrated 150 g NiTi closed coil springs connected from a temporary anchorage device (1.5 mm × 8 mm) placed between the maxillary second premolar and the first molar and loaded immediately [Figure 3]. The participants were instructed to avoid the use of anti-inflammatory medication.

Measurement of rate tooth movement

All the measurements were performed on the dental casts. Alginate impressions were taken at the beginning of the study, immediately before canine retraction (T0), 30th day (T1), and 60th day (T3) after the commencement of canine retraction, and were poured immediately to monitor the rate of tooth movement. The casts were labeled with the patient's code and stored [Figure 4]. All cast measurements were made using a digital vernier caliper with an accuracy of 0.01 mm.[1] All measurements were done by a single observer. The amount of extraction space closure in millimeters was measured as the distance between the cusp tip of the maxillary canine to the mesiobuccal cusp tip of the maxillary 1st permanent molar at the same side using digital vernier calipers.

Assessment of pain and discomfort levels

Each patient was instructed to complete a VAS pain assessment form to assess the pain experienced from the MOP procedure. The participants were asked to assess their level of discomfort on the day of canine retraction,

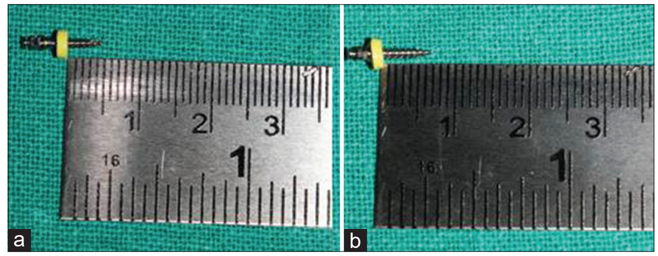

Figure 1: Mini-implant with stopper set at 5 mm depth (a), Mini-implant with stopper set at 7 mm depth (b)

Figure 2: MOP procedure on the experimental side using mini-implant

Figure 3: 150 g of force applied by the Closed NI-Ti coil spring from the power arm to the mini-implant for canine retraction

and subsequently at 1 h, 24 h, 72 h, 7 days, and 28 days after canine retraction with a VAS. Patients filled out the questionnaires at home and brought them to their follow-up appointment. This method is fairly sensitive for assessing pain in response to treatment.[11]

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) for Windows Version 22.0 Released 2013. Armonk, NY,

Figure 4: Canine retraction was measured as the distance between the cusp tip of the maxillary canine to the mesiobuccal cusp tip of the maxillary 1st permanent molar at T0, T1 and T3 (blue dots)

USA: IBM Corp., will be used to perform statistical analyses.

Descriptive statistics

Descriptive analysis of the rate of tooth movement was expressed in terms of mean and standard deviation for each group.

Inferential statistics

Independent Student's *t*-test was used to compare the mean rate of tooth movement between MOP-5 and MOP-7 between experimental and control sides at different time intervals and also between the experimental and control side in the MOP-5 and MOP-7 groups. Mann–Whitney test was used to compare the mean difference in the rate of tooth movement between MOP-5 and MOP-7 between experimental and control side at different time intervals and also between the experimental and control sides in the MOP-5 and MOP-7 groups. The VAS scores were compared between the MOP-5 and MOP-7 groups. The difference in the VAS scores between the groups was evaluated using the independent *t*-test. The level of significance was set at $P < 0.05$.

Results

The error in the method

All measurements on the study models were done by a single examiner. To evaluate the intra-examiner reliability, ten study models were randomly chosen and measured twice within a 2-week interval. The intra-examiner reliability was assessed using the intraclass correlation coefficient (ICC). The result of the intra-examiner reliability using ICC was 0.97 ($P < 0.001$), indicating excellent repeatability and reliability of the measurements.

Primary outcome

The mean rate of tooth movement (in mm) in the MOP-5 and MOP-7 groups on the experimental and control sides at different time intervals (T0, T1, and T2). However, there were no statistically significant differences ($P > 0.05$) between the experimental and control sides in the MOP-5 and MOP-7 groups [Table 1]. The average amount of canine retraction (T0–T1) over 30 days was 1.213 ± 0.374 mm on the experimental side and 0.645 ± 0.227 on the control side in the MOP-5 group and 1.208 ± 0.472 mm on the experimental side and 0.615 ± 0.305 in control side in the MOP-7 group. On the 60th day (T0-T2), the average amount of canine retraction was 2.165 ± 0.357 mm on the experimental side and 1.279 ± 0.408 on the control side in the MOP-5 group and 2.070 ± 0.663 mm in experimental side and 1.209 ± 0.587 in control side in the MOP-7 group. It was observed that there was a 2.0-fold increase in the first 30 days and a 1.8-fold increase in 60 days in the rate of tooth movement on the experimental side as compared to the control side in the MOP-5 and MOP-7 groups. In the MOP-5 and MOP-7 groups, the mean difference in the rate of canine retraction on the experimental side was significantly higher than on the control side ($P < 0.05$). However, there were no statistically significant differences between the experimental and control sides during the T1-T2 time interval in the MOP 7 group [Table 2]. A comparison of the effectiveness of the two penetration depths on canine retraction showed no clinically or statistically significant differences ($P > 0.05$) [Table 3].

Secondary outcome

Mean VAS scores for pain were slightly higher on the experimental side compared to the control side. Most participants rated the pain on the experimental side slightly higher on day 0. After 24 h of force application, the pain scores on the control side became similar to the experimental side [Table 4]. Data analysis [Table 5] indicated that till 24 h after the beginning of canine retraction both the control and experimental sides reported higher levels of pain compared with the levels before retraction, this was statistically significant ($P \leq 0.05$). From day 7 onward, the patients reported little to no pain or discomfort.

Discussion

We chose the split-mouth design for our study to reduce biological variables, thus facilitating a lower sample size.[12] Randomization and blinding were done to remove the risk

Table 1: Comparison of mean rate of canine retraction (mm) of experimental and control Side in micro-osteoperforation 5 and micro-osteoperforation 7 group at different time intervals using independent Student's *t*-test

Groups	Time interval	Experimental, mean±SD	Control, mean±SD	Mean difference	*P*
MOP 5	Day 1 (T0)	21.237±2.015	20.278±2.637	0.959	0.37
	Day 30 (T1)	20.024±2.206	19.633±2.613	0.391	0.72
	Day 60 (T2)	19.072±2.068	18.999±2.597	0.073	0.95
MOP 7	Day 1 (T0)	21.382±1.560	21.234±1.667	0.148	0.84
	Day 30 (T1)	20.174±1.479	20.619±1.563	−0.445	0.52
	Day 60 (T2)	19.312±1.605	20.025±1.582	−0.713	0.33

MOP: Micro-osteoperforation; SD: Standard deviation

Table 2: Comparison of mean difference in rate of canine retraction (mm) on experimental and control side in micro-osteoperforation 5 and micro-osteoperforation 7 group at different time intervals using Mann–Whitney test

Groups	Time interval	Experimental, mean±SD	Control, mean±SD	Mean difference	*P*
MOP 5	T0–T1	1.213±0.374	0.645±0.227	0.568	<0.001*
	T1–T2	0.952±0.310	0.634±0.268	0.318	0.02*
	T0–T2	2.165±0.357	1.279±0.408	0.886	<0.001*
MOP 7	T0–T1	1.208±0.472	0.615±0.305	0.593	0.003*
	T1–T2	0.862±0.401	0.594±0.295	0.268	0.23
	T0–T2	2.070±0.663	1.209±0.587	0.861	0.006*

*Statistically significant. MOP: Micro-osteoperforation; SD: Standard deviation

Table 3: Comparison of mean difference in rate of canine retraction (mm) on experimental and control side between micro-osteoperforation 5 and micro-osteoperforation 7 at different time intervals using Mann–Whitney test

Side	Time interval	MOP 5, mean±SD	MOP 7, mean±SD	Mean difference	*P*
Experimental	T0–T1	1.213±0.374	1.208±0.472	0.005	0.88
	T1–T2	0.952±0.310	0.862±0.401	0.090	0.26
	T0–T2	2.165±0.357	2.070±0.663	0.095	0.31
Control	T0–T1	0.645±0.227	0.615±0.305	0.030	0.60
	T1–T2	0.634±0.268	0.594±0.295	0.040	0.94
	T0–T2	1.279±0.408	1.209±0.587	0.070	0.60

MOP: Micro-osteoperforation; SD: Standard deviation

Table 4: Descriptive statistics of mean Visual Analogue Scale scores for pain between experimental and control sides at different time intervals micro-osteoperforation - 5 and micro-osteoperforation - 7 group

Groups	Time	Experimental, mean±SD	Control, mean±SD
MOP-5	1 h	3.10±1.60	2.00±1.94
	24 h	1.10±0.88	0.80±0.92
	72 h	0.00±0.00	0.10±0.32
	7 days	0.00±0.00	0.00±0.00
	28 days	0.00±0.00	0.00±0.00
MOP-7	1 h	3.40±1.84	3.30±1.49
	24 h	1.60±1.17	0.80±0.92
	72 h	0.00±0.00	0.00±0.00
	7 days	0.00±0.00	0.00±0.00
	28 days	0.00±0.00	0.00±0.00

MOP: Micro-osteoperforation; SD: Standard deviation

of information bias and conflict of interest throughout the study.

Several factors which could affect the rate of tooth movement were considered during the study. The forces of occlusion are one such confounding factor.[13] To rule out its effect, we selected patients with similar severities of malocclusion. Primary leveling and alignment were done to reduce occlusal interferences. Patients with cross-bite or deviation during closure caused by occlusal interference were excluded. MOPs were randomly done to eliminate the possibility of uneven occlusal forces that may occur as a result of the unilateral chewing habit. Occlusal interferences during canine retraction were checked, but none was found that required occlusal adjustment.

Another major factor influencing the rate of tooth movement is the type of movement.[14] Therefore; we attempted to move the canine bodily by sliding the tooth on the 0.019″ × 0.025″ stainless steel archwire on the 0.022″ × 0.028″ slot. The force applied to the bracket hook was closer to the center of rotation of the tooth giving a more parallel movement.

The age of patients was shown to influence the rate of tooth movement in relation to bone density and bone

Table 5: Comparison of mean Visual Analogue Scale scores for pain at different time intervals in experimental and control sides using paired *t*-test in Micro-osteoperforation - 5 and Micro-osteoperforation - 7 group

Groups	Side	Time (h)	Paired differences					*P*
			Mean	SD	SEM	95% CI of the difference		
						Lower	Upper	
MOP-5	Experimental	1–24	2.00	0.94	0.29	1.33	2.67	0.000
	Control	1–24	1.20	1.81	0.57	−0.97	2.49	0.066
MOP-7	Experimental	1–24	1.80	1.48	0.47	0.74	2.86	0.004
	Control	1–24	−2.50	1.65	0.52	−3.68	−1.32	0.001

SD: Standard deviation; SEM: Standard error of mean; CI: Confidence interval; MOP: Micro-osteoperforation

metabolism.[15,16] To rule this out, adult patients between 18 and 30 years were considered in the study.

Poor periodontal health, systemic diseases, and the use of certain medications can affect the rate of tooth movement significantly. Proper oral hygiene and exclusion criteria were taken into consideration to reduce the effect of these variables.

Malocclusion requiring bilateral extraction of upper first premolars with maximum anchorage was selected to allow investigation of the long-term effect of RAP following the MOP procedure, which usually lasts for 2–3 months on average.

To avoid the RAP induced by tooth extractions a 3-month time interval between premolar extraction and canine retraction commencement was scheduled.[17]

The magnitude of trauma is directly proportional to the magnitude of the inflammatory response induced. MOPs can be used to accomplish this in two ways: (1) by increasing their number and (2) by increasing their depth of perforation. In our study, the number of MOPs was kept constant to investigate another variable; the depth of MOPs.

Alikhani *et al*.[18] tested the effect of 1, 3, and 4 MOPs on the rate of tooth movement and stated that 1 MOP was not effective in increasing the rate of tooth movement, while 3 and 4 MOPs could be used to achieve an accelerated movement. Feizbakhsh *et al*.[7] also reported that accelerated tooth movement could be achieved by performing only 2 MOPs.

In the current study, our objective was primarily to investigate the effects of MOP depths; thus, we preferred to use 3 MOPs, which was the number used in the majority of previous studies.[1,19,20] Considering the limited distance between the dental roots, a higher number of MOPs may not be suitable for every case. Therefore, it is more logical to increase the depth of MOPs. MOPs reportedly have both anabolic and catabolic effects. To achieve a catabolic effect (an effect that is mandatory while moving a tooth), penetration depths of 3–7 mm into the bone are recommended. For this purpose, we tested 7 mm as our upper limit of perforation.

The use of TADs with stoppers to perform the MOPs allowed standardization of the width and depth of the perforation. The mini-implant used was attached with a stopper to calibrate a depth of 5–7 mm. According to the histological observations of the sequential events in periosteal repair by Wilderman *et al*.,[21] it takes 3 months for the mature periosteum to be evident in the operated surgical areas. The average gingival and cortical bone thickness is 1.29–1.35 mm and 1.12–1.22 mm,[22] respectively. This perforation of 6 mm would go 2–4 mm in the medullary bone.

Unlike shorter duration studies of 30 days, this study was conducted for 60 days to evaluate the effect of MOP. Achieving the highest rate of tooth movement with minimal iatrogenic side effects is the common goal of orthodontists with a good understanding of "optimal" force magnitude. Boester and Johnston[23] found that a retraction force of 150 g resulted in the highest canine retraction rate. Therefore, a force of 150 g was employed in the present study.

Yang *et al*.[24] showed that the maximum stress encountered during canine retraction was focused on its cervix at the distolabial side and added that distal corticotomy had similar biomechanical effects as a continuous circumscribing cut around the canine root. Based on their assumptions, the MOPs were only performed distal to the canine and vertically distributed along the cervical two-thirds of the canine root length.

The monthly rate of orthodontic tooth movement in patients treated using traditional methods involving continuous force application is 0.8–1.2 mm/month.[25] In a recently published meta-analysis, MOPs have been stated to increase the amount of canine retraction at the rate of 0.45 mm/month, and this change was found to be statistically significant.[26] In the current study, the difference in the mean rate of canine retraction between the experimental and control sides in both groups was 0.58 mm, indicating similarity with previous published literature.

In the present study, the mean difference in the rate of canine retraction on the experimental side was significantly higher than the control side for both the penetration depth. This result is similar to other studies that showed a clinically significant increase in the amount of tooth movement after using MOPs with different depths of penetration.[27]

In our study, the rate of canine movement was 1.8-fold more on the experimental side than the control side after 60 days (T0–T2). The results of the present study, as well as other studies[28,29] indicate that MOPs accelerate the orthodontic tooth movement until 4–6 weeks after induction of trauma.

There was no significant difference ($P > 0.05$) in the rate of canine retraction between the two groups during the entire study period. The result of the present study is in accordance with the study done Ozkan and Arici[27] who also found no significant difference between the MOP-4 and MOP-7 groups in terms of the canine retraction rate.

One of the unanswered questions about MOP is the frequency of application. The effect of repeated MOPs on the rate of tooth movement has been reported by various authors with different results. The clinical trial by Attri *et al*.[19] evaluated the effect of repeated MOP (distal to canine) every 28 days on en masse retraction that showed a significant increase in tooth movement, although the effect of RAP on incisors is debatable. In contradiction to this study, Ozkan and Arici[27] showed that repeating the procedure monthly does not appear to show a major advance in tooth movement. A similar clinical trial by Sivarajan *et al*.[20] concluded that increased canine retraction achieved using MOP over 16 weeks is unlikely to be clinically significant based on the above finding.

Based on the results of the present study, it is wise to use it after every 60 days. The reason behind the accelerating effect of MOPs might be that microtrauma induces alveolar bone inflammation, which leads to an increase in cellular activity, thereby increasing the bone turnover rate, and causing a decrease in bone density, thus increasing orthodontic tooth movement. Thereafter, as the healing process progresses, bone remodeling returns to its initial pace, and there is a regaining of the bone density to the pre-MOPs level.

Pain perception

The examination of the VAS scores in the two MOP groups indicated that deeper (MOP-7) MOPs led to more pain than did the MOPs with a depth of 5 mm. The VAS pain questionnaire indicated that the discomfort associated with MOPs is tolerable and was higher on the MOP side for the first 24 h after the intervention which gradually faded away and was not statistically significant. This is similar to other studies that showed no significant differences between experimental and controls, although pain experienced with MOP is slightly higher.[1,9,19,29]

Others using increased number or frequency of perforations reported significant pain and discomfort following MOPs. A study by Aboalnaga *et al*. showed results that patients experienced mild to moderate transient pain following MOPs that almost disappeared 1 week later.[30] Sivarajan *et al*. compared pain perception of three different MOP intervals and showed that moderate pain was associated with 4-weekly intervals while only mild pain for 8- and 12-week intervals.[20]

Since the retraction force was applied immediately after the MOP procedure, the possibility of the patient not being able to differentiate between orthodontic pain and the pain caused by MOP should be considered. In addition, gingival insertions on the contralateral side were given for blinding purposes and the results for VAS pain scores between the two sides are questionable.

MOPs are a comfortable, safe, and effective procedure for accelerating tooth movement and could result in shorter orthodontic treatments.

Limitation

The current study did not evaluate the effect of different sites and repetition of MOP on the rate, type of tooth movement effect on overall treatment duration, periodontal status, and root resorption. Furthermore, the assessment of inflammatory markers, the degree of rotation of teeth, and its effect on orthodontic tooth movement were not accessed in the current study. Our trial was not registered, however, no changes were made to the protocol after commencement and no harms were observed.

Conclusion

- Three MOPs with a depth of 5–7 mm significantly accelerated canine retraction
- Micro-osteoperforation increases the rate of canine retraction by two-fold at the end of 60 days and could be effective in our daily orthodontic practice for decreasing treatment time
- As no difference was found between the MOP-5 and MOP-7 groups, the null hypothesis of this study was rejected. Therefore, only three MOPs of 5 mm depth would be enough for efficient results
- The patient reported only mild pain and discomfort locally at the site of MOPs. Little to no pain was experienced after 72 h
- Micro-osteoperforation is a simple, comfortable, minimally invasive, and effective procedure to accelerate tooth movement and reduce the treatment period.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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