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Evaluation of Canine retraction rate in adult orthodontic patients using miniscrew-facilitated micro-osteoperforation: A split-mouth randomized clinical study

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ABSTRACT

Introduction

Canine Retraction Rate (CRR) using NiTi closed coil springs may be enhanced by miniscrew-facilitated osteoperforation (MOP).

Aims and Objectives

To determine whether MOP significantly accelerates CRR in adults undergoing bilateral first premolar extraction and to evaluate short-term pain levels post-procedure.

Study Design

A split-mouth randomised controlled trial with 17 participants (Mean age: 24.9 ± 4.6 years; 64.7% females). Randomisation was performed per arch with concealed allocation.

Methods

On the experimental side, three vertical perforations were created on the buccal cortical plate using a 6 mm × 1.5 mm miniscrew. A 9 mm NiTi closed coil spring delivering 150 g of force facilitated canine retraction. CRR was measured at weeks 1, 8, and 12, and pain levels were assessed at 24 hours, 3-, and 7-days post-MOP using the Wong-Baker FACES Pain Scale.

Results

The MOP group showed higher mean CRRs (3.6 ± 1.8 mm at week 8, 6.2 ± 1.8 mm at week 12) compared to the control group (2.5 ± 1.5 mm at week 8, 4.7 ± 1.6 mm at week 12). Pain levels at days 3 and 7 post-MOP were significantly higher in the MOP group ($p = 0.027$ and $p = 0.042$).

Conclusion

MOP significantly accelerates canine retraction but increases short-term pain levels.

Keywords

Canine Retraction Rate, Miniscrew-facilitated Micro-osteoperforation, Split-mouth Study, Orthodontic Tooth Movement, Accelerated Orthodontics.

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INTRODUCTION

With the growing demand for orthodontic treatment among adult patients,[1] long treatment duration remains a fundamental issue that has become the most important adverse factor affecting the treatment process.[1,2] Orthodontic tooth movement (OTM) has been estimated to be 1 mm in 4 weeks, putting the average time needed for maxillary canine retraction under maximum anchorage at 7 months and putting total treatment time at about 2 years.[3] The long process that is associated with orthodontic treatment has prompted many adult patients to accept a less esthetic treatment option, like the use of prostheses, than orthodontic treatment, which is an average of 2 years in duration. [4]

Reducing this long duration associated with orthodontic treatment remains a concern for both orthodontists and patients, as prolonged treatment time has been associated with not just loss of time but also oral diseases like dental caries, root resorption,[5] gingival inflammation and recession, and enamel decalcification.[6] Most important too is the patients' psychosocial affectation, and loss of patients' cooperation as a result of burnout , which can further prolong treatment time.[4]

There is still no consensus on the ability of MOP as a procedure to accelerate orthodontic tooth movement, thereby shortening treatment time; hence, several researchers have called for the need for more work to be done on MOP to be able to ascertain its effectiveness or non-effectiveness in accelerating tooth movement[7–9] the extended duration of this treatment often leads to its replacement with alternative methods that offer shorter treatment times. Micro-osteoperforation (MOP. Thus, a need for this study.

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AIMS AND OBJECTIVES

To compare the canine retraction rate using NiTi close coil spring alone in canine retraction with that from the use of NiTi close coil spring with adjunctive miniscrew-facilitated MOP in adult patients aged 18 years and above undergoing fixed orthodontic treatment.

To compare the rate of canine retraction using NiTi closed coil springs with a one-time application of adjunctive miniscrew-facilitated micro-osteoperforation (MOP) at the start of retraction versus repeated applications at the start and 8 weeks after initiation of retraction in adult patients (≥18 years) undergoing fixed orthodontic treatment.

To compare levels of pain and discomfort among adult patients aged 18 years and above undergoing fixed orthodontic treatment in the canine retraction stage using a NiTi close coil spring with the pain and discomfort levels using a NiTi closed coil spring with miniscrew-facilitated MOPs.

METHODOLOGY

This is a multistage randomised clinical trial. The first stage of randomisation was to allocate intervention, i.e., experiment group (EG), either to the right or left with the control, i.e., control group (CG), being the opposite side with a 1:1 allocation. The EG was further randomised into one-off MOP (EG_1) or twice MOP (EG_2) with a 1:1 allocation ratio. The randomisation was accomplished by using the permuted random block size of 2 with the random generation function in Excel (Microsoft, Redmond, Wash).

Subsequently, the random sequences to either the right or left were concealed in opaque envelopes and shuffled before the intervention to increase the unpredictability of the random allocation sequence. Each patient was asked to pick a sealed envelope to assign the surgical intervention to either the right or left side and pick another to assign the intervention side to group EG_1 or EG_2. Allocation concealment was done to prevent selection bias and protect the assignment sequence until allocation.

Participants' Eligibility Criteria

Ethical approval was obtained from the University of Benin Teaching Hospital, Benin City, Edo State, Nigeria, with approval number 148260. This trial was also registered at Pactr.org with identifier number PACTR202201662414178. Participants were recruited from new adult patients attending the orthodontic clinic of the University of Benin Teaching Hospital.

Inclusion Criteria

Patients aged 18 years; patients who underwent bilateral extraction of the first premolars in either one or both arches; no previous history of fixed orthodontic treatment; no history of systemic disease, bone pathology, or active periodontal disease. Patients who do not use tobacco.

Exclusion Criteria

Patients on prolonged use of antibiotics, anti-inflammatory drugs, systemic corticosteroids, and calcium channel blockers, poor oral hygiene even after attempts at motivation, patients who had transalveolar extraction of their first premolars, and patients with evidence of active dental caries.

Sample Size

The formula for comparing means between two groups was used to estimate the sample size for the split-mouth design. [10]

Blinding

This was ensured only during data collection, as blinding of participants and clinicians was not feasible.

Intervention

Before the commencement of this procedure, informed consent was obtained from all study participants.

Accessibility of the area of interest for MOPs was performed as prescribed by Sangsuwon *et al*.[11]

Patients who met inclusion criteria with the following diagnosis:

a. Class I malocclusion cases with moderate to severe crowding
b. Class II malocclusion
c. Class III malocclusion
d. Bimaxillary prognathism

And required 2-unit extractions in one or both arches as part of their treatment were recruited.

Extractions were carried out 2 weeks before the commencement of fixed orthodontic treatment

0.022x0.030 Roth prescription; Dentaurum® brackets were used for all study participants. All teeth were leveled and aligned using various sizes of NiTi wires. The canine retraction was done on a wire sequence of 0.019x0.025 stainless steel wire placed 4 weeks before commencing canine retraction.

A digital periapical radiograph was used to evaluate the bone between the canine and second premolar and to evaluate the root of the canine.

Anchorage for canine retraction was done using a 1.8x8mm miniscrew by GDT® inserted buccally between the roots of the first permanent molar and the second premolar bilaterally one week prior to the commencement of canine retraction.

Impression of the arch(s) to be used for MOP and control was made using Elvydent® colour changing, normal set, peppermint flavoured, and dust-free alginate material. Casts were produced using type IV Dental stone and then converted to digital models using a three-dimensional (3D) scanner. This was performed using the White Light Scanner (COMET5, 100-200-400, Steinbichler Optotechnik Germany) with 3D reverse modeling software.

The distance between the centre of the canine and second premolar brackets was measured as used in a previous study.[12] These landmarks were chosen due to ease of identification. Values obtained are marked as T0. This is the baseline distance before the commencement of canine retraction. All measurements in this study were done on digital models obtained from casts using the 3D reverse scanner with modeling software to remove errors due to parallax. The accuracy of the scanner software was verified and confirmed by scanning and measuring 20 randomly

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selected casts which were rescanned and remeasured one week later.

Following the method described by Sangsuwon *et al.* using orthodontic miniscrews as follows.

- Patient was asked to rinse with 15 ml of chlorhexidine for 30 seconds
- The area intended for MOPs following balloting was identified and anaesthetised first with a topical anaesthetic agent and then two minutes later infiltrated using a local anesthetic agent (0.5 ml Zey∞® lidocaine) placed 3 mm distally away from the intended MOP site. The tip of a dental explorer was used to prick the attached gingiva around the area anesthetised to establish that the anesthesia was sufficient.
- A sterile GDT® orthodontic miniscrew (6 mm × 1.5 mm), attached to a driver, was used to create three equally spaced vertical perforations approximately 2 mm apart. The first perforation was placed apical to the attached gingiva on the buccal cortical plate. The perforations were made along a straight line drawn 3 mm parallel to the distal surface of the canine to be retracted. Each perforation was created using gentle rotational movements of the miniscrew driver until a depth of 6 mm was reached. N/B: One miniscrew per patient per visit was used to reduce the chances of infection from the procedure.
- Where bleeding was observed after MOP, gentle pressure using a gauze pack was used to arrest the bleeding.
- No analgesics were routinely prescribed after the procedure or during the study period. However, participants who experienced severe pain were permitted to take rescue analgesia (1 g paracetamol). Three participants required this within the first 24 hours following MOP. These participants were instructed to record analgesic intake, and while this was considered during data interpretation, it was not adjusted for in the analysis and was therefore regarded as a potential source of bias, particularly in the 24-hour pain and discomfort scores.

A 9mm NiTi closed coil spring (Sentalloy, 3M Unitek, USA) was used in canine retraction on both the experiment and control sides, anchored to the head of the miniscrew posteriorly and to the canine hooks on the canine bracket anteriorly.

A force of 150g,[14] which was produced by 6mm stretching of the springs and was calibrated using a Correx gauge®, where the canine–miniscrew distance was more than the activated coil spring length, ligature wire was used to account for the length disparity by attaching it to the coil spring and securing it to the miniscrew to ensure uniform force delivery on coil springs on the right and left quadrants on the same arch.

A repeat impression of the arch(es) with MOP was made at weeks 8 and 12 for all patients, and casts were converted to digital models.

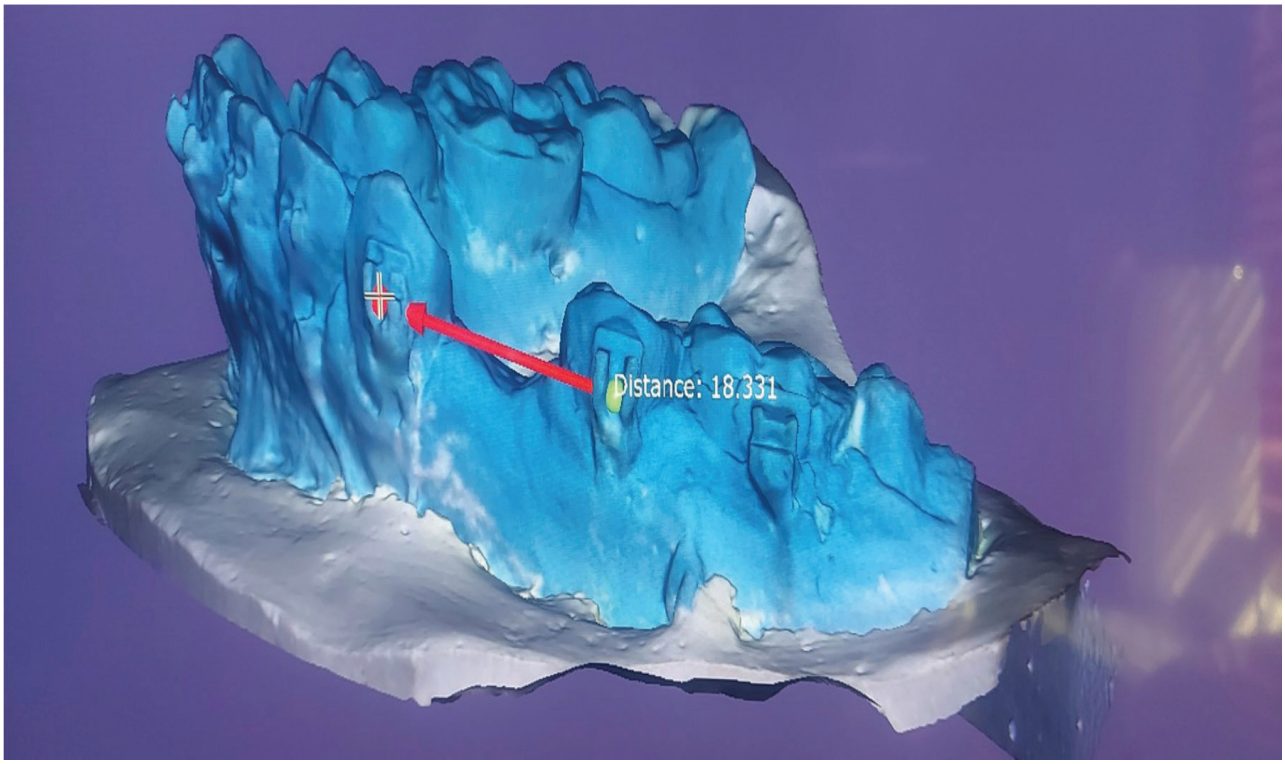
The new distance between the centre of canine and second premolar brackets was measured in T_{week8} and T_{week12}. The difference in this new distance, T_{week8} from the baseline (T_O) and T_{week12} from T0 is the canine retraction rate in 8 weeks and 12 weeks and is marked as T_1 and T_2 respectively. Repeat MOPs were done only for EG_2 patients at 8 weeks from the commencement of retraction to evaluate the effect of repeat MOP application. This is to attempt to sustain the maximum Regional Acceleratory Phenomenon (RAP), which is believed to start to wane after 2 months.[15]

The secondary outcome of this study, which was pain and discomfort, was measured using the Wong-Baker FACES Pain Rating Scale at 24-hour, 3- and 7-day post-MOP procedures at T0 for all participants. Study participants were advised not to take any form of pain medication during the study and to notify the investigator when they had severe pain. Reminders were sent electronically, and values were sent electronically on the day. All values obtained were entered into the data collection form for analysis. Canine retraction in this study was the total distance moved by the canine in 12 weeks.



Figure I: Clinical picture showing 3 bleeding spots following MOP application

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Ethical Considerations

Before the commencement of this study, approval was obtained from the Health Research Ethics Committee of the University of Benin Teaching Hospital, Benin City, with approval number ADM/E22/A/VOL.VII/148260.

Also, an informed consent form was administered to every patient who met the inclusion criteria after a thorough explanation of the procedure and its possible advantages and complications for signature in the presence of a witness.

Data analysis

Data collected was analysed using SPSS version 23.0 (SPSS Inc., Chicago, Ill). The variables and outcome of the study were described by descriptive statistics using mean, standard deviation (SD), range (minimum-maximum), charts, and tables. The Shapiro-Wilk test of normality was used to determine the appropriate parametric and non-parametric tests. Paired samples were used to compare the change in canine retraction over time within CG and EG, while independent samples were used to compare the canine

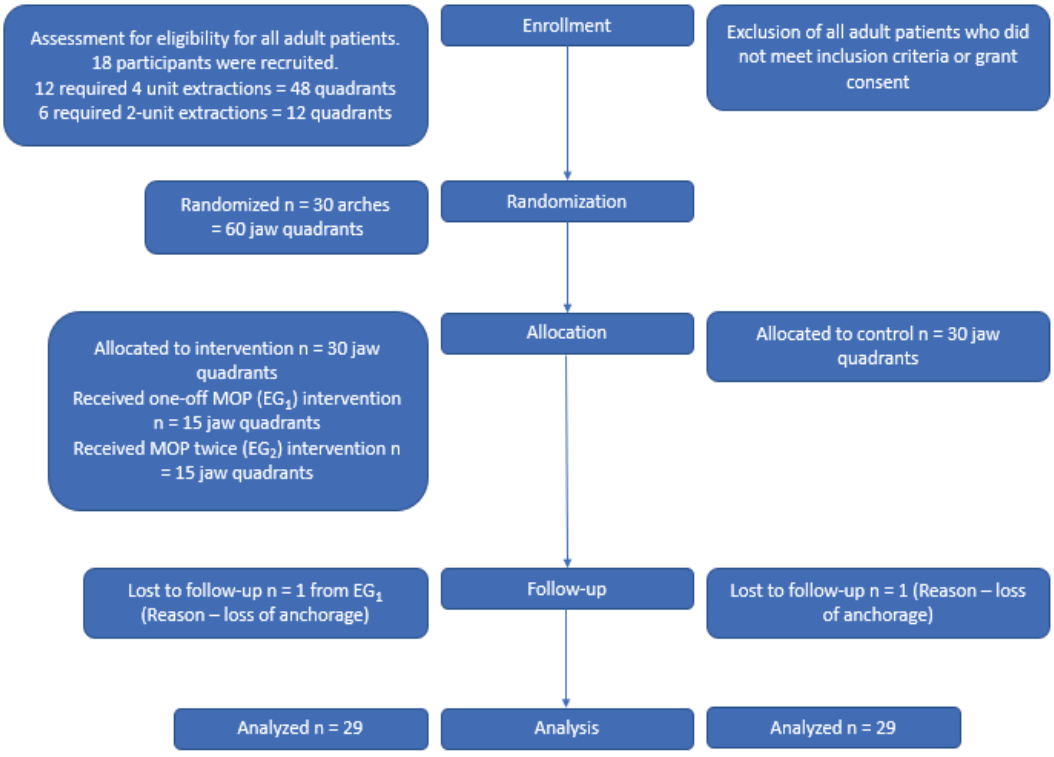


Figure III: Flowchart showing selection, randomization, allocation, follow-up and analysis procedures

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retraction rate between CG and EG. A comparison of the canine retraction rate between genders was done using an independent sample. This was also done to compare the maxilla and mandible. The relationship between age and the canine retraction rate was determined using Pearson's correlation.

The pain levels were described using the median and interquartile range; a comparison between the MOP and control group was done using the Mann-Whitney U statistic. All analysis was evaluated with a $P \leq 0.05$, considered significant in all cases, at 95% confidence intervals (CI).

RESULTS

Participant flow

The subjects' ages ranged from 18 to 33 years (Fig. 1) with a mean age of 24.9 ± 4.6 years and consisted of 11 (64.7%) females and 6 males (35.3%). 29 jaws (14 upper and 15 lower) consisting of 58 quadrants were used in this study. In this study, 18 subjects were recruited into the study. 1 was lost due to loss of anchorage. Out of the 17 subjects who completed the study, 12 had 4-unit extractions constituting 48 quadrants and 5 had 2-unit extractions constituting 10 quadrants. 14 quadrants received one-off MOP with 14 contralateral quadrants as control, and 15 quadrants received MOP twice with 15 contralateral quadrants as control.

Table I: Sociodemographic Characteristics of the Participants

Parameter	N (%)	Mean Age (in years) ± SD
Gender		
Male	6 (35.3%)	21.9 ± 3.1
Female	11 (64.7%)	26.3 ± 4.6
Total	17 (100.0%)	24.9 ± 4.6
SD = Standard deviation		

Average Distance Between Mid-Canine Bracket and Mid-2nd Premolar Bracket

At T_0, the average distance between the mid-canine bracket and mid-second premolar bracket was 15.6 ± 2.5 mm in

Table II: Average distance between mid-canine bracket and mid-2nd premolar bracket

	MOP (T_0 mm)	Control (T_0 mm)	MOP (T_{week8} mm)	Control (T_{week8} mm)	MOP (T_{week12} mm)	Control (T_{week12} mm)
N	29	29	29	29	29	29
Mean	15.6	15.8	12.0	13.4	9.4	11.1
Std. Deviation	2.5	1.9	2.7	2.2	2.2	2.3

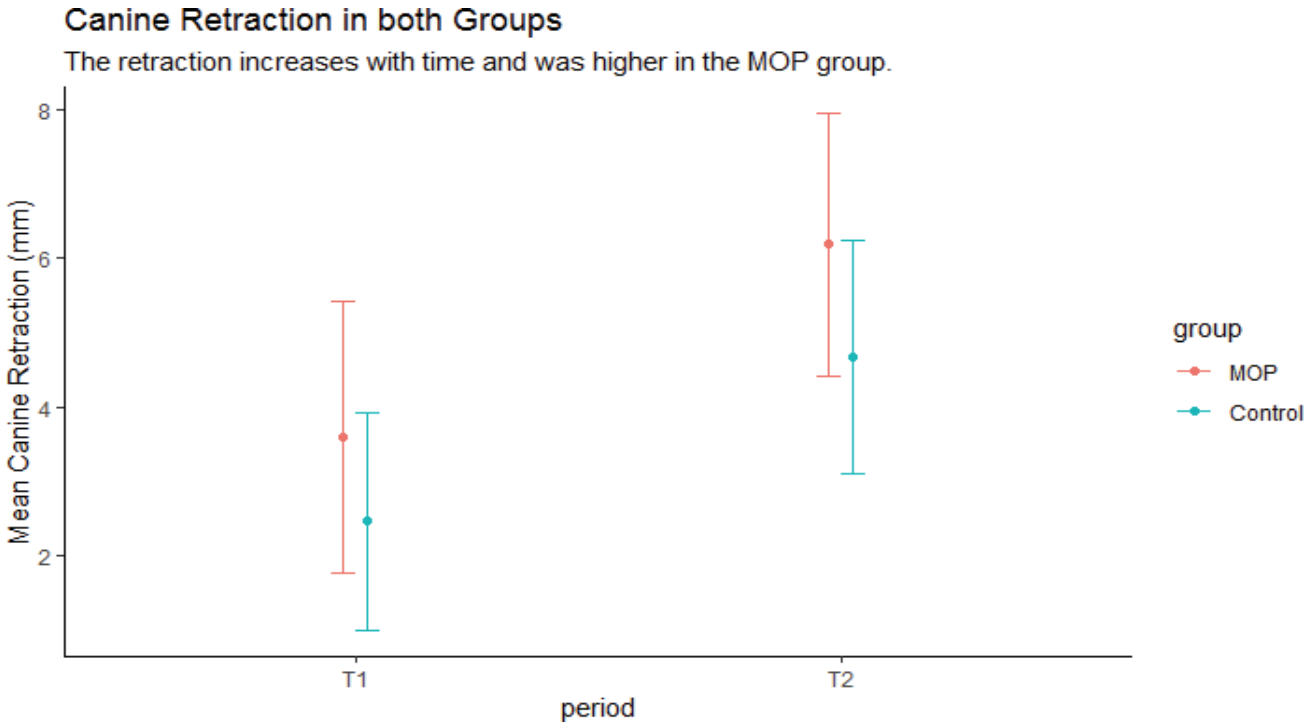


Figure IV: The mean ± 1 standard deviation (error bar) of canine retraction rate across the periods, T1 (week 8) and T2 (week 12) in the MOP and Control.

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the MOP group and 15.8 ± 1.9 mm in the control group. At Tweek8, the average distance was 12.0 ± 2.7 mm and 13.4 ± 2.2 mm in the MOP and control group, respectively. While at Tweek12, the average distance was 9.4 ± 2.2 mm in the MOP group and 11.1 ± 2.3 mm in the control group.

The average canine retraction rate increased over time. At both points in time, the average canine retraction was higher in the MOP group (Figure IV).

Canine Retraction Rate (Mean Difference) within Experiment and Control Groups at 8 Weeks and 12 Weeks

In the MOP group (Table III), the mean canine retraction rate (CRR) was 3.6 ± 1.8 mm at week 8 and 6.2 ± 1.8 mm at week 12, while in the control group, the mean CRR was 2.5 ± 1.5 mm at week 8 and 4.7 ± 1.6 mm at week 12. The retraction rate (Table III) at week 8 and week 12 differed significantly from baseline (week 0) in both the MOP group (p = 0.000) and the control group (p = 0.000).

Comparison between the Canine Retraction Rate (CRR) of MOP and the Control Group

As shown in Table IV, at week 8 the mean CRR of the MOP group was significantly higher (p = 0.011) than that of the control group by a difference of ≈ 1.1 mm (0.3 – 2.0, 95% CI, p = 0.011). This trend was also observed at week 12; the mean CRR of the MOP group was statistically significantly higher (p = 0.001) than that of the control group by a difference of ≈ 1.5 mm (0.6 – 2.4, 95% CI, p = 0.001).

Canine Retraction Rate Based on the Number of MOP Appointments

At weeks 8 and 12, as shown in Table V, the mean canine retraction rate was higher in participants who received two MOP applications compared to those who received a single application. The differences were statistically significant at both time points (p = 0.011 and p = 0.001, respectively).

Gender and Canine Retraction Rate (CRR) in Experiment and Control Groups

In the MOP group, the mean CRR was higher in males across the time periods, although the difference was only statistically significant at week 12 (p = 0.020). In the control group, the mean CRRs of males were slightly higher than that of females but not significant at week 8 (p = 0.353) as well as at week 12 (p = 0.357).

Table III: Canine retraction rate (mean difference) within experiment and control groups at 8 weeks and 12 weeks

Group	Mean Difference (mm) ± SD			
	T_1 (T0 – T_{week8})	p-value	T_2 (T_0-T_{WEEK12})	p-value
N	29		29	
MOP	3.6 ± 1.8	0.000**	6.2 ± 1.8	0.000**
Control	2.5 ± 1.5	0.000**	4.7 ± 1.6	0.000**

T1 = week 8, T2 = week 12, SD = standard deviation
** Significance at the 0.01 level

Table IV: Comparison between the Canine Retraction Rate of MOP and Control Group

Period	MOP	Control			
	Mean (mm) ± SD	Mean (mm) ± SD	Mean Difference (mm)	95% CI	p-value
N	29	29			
T1	3.6 ± 1.8	2.5 ± 1.5	1.1	0.3 – 2.0	0.011*
T2	6.2 ± 1.8	4.7 ± 1.6	1.5	0.6 – 2.4	0.001*

T1 = CRR at week 8, T2 = CRR at week 12, SD = Standard Deviation, CI = Confidence Interval
* Significance at the 0.05 level
** Significance at the 0.01 level

Table V: Canine retraction rate of the MOP group based on the number of MOP appointments

Period	NA = 1	NA = 2			
	Mean (mm) ± SD	Mean (mm) ± SD	Mean Difference (mm)	95% CI	p-value
N	**14**	**15**			
T_1	**3.2 ± 1.3**	**4.0 ± 2.2**	**-0.8**	**-2.1 – 2.0**	**0.011***
T_2	**6.1 ± 1.9**	**6.3 ± 1.6**	**-0.2**	**-1.6 – 2.4**	**0.001***

T_1 = week 8, T_2 = week 12, SD = standard deviation, CI = confidence interval

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Table VI: Canine retraction rate based on gender

	Time	Male Mean ± SD	Female Mean ± SD	MD (mm)	95% CI	p-value
MOP	T_1	4.0 ± 1.5	3.4 ± 2.0	0.6	-0.9 - 2.1	0.390
	T_2	7.3 ± 1.6	5.7 ± 1.7	1.6	0.3 - 2.9	0.020*
Control	T_1	2.8 ± 1.7	2.3 ± 1.4	0.5	-0.6 -1.8	0.353
	T_2	5.1 ± 1.7	4.5 ± 1.5	0.6	-0.7 - 1.9	0.357

T_1 = week 8, T_2 = week 12, SD = standard deviation, MD = mean difference
* Significance at the 0.05 level

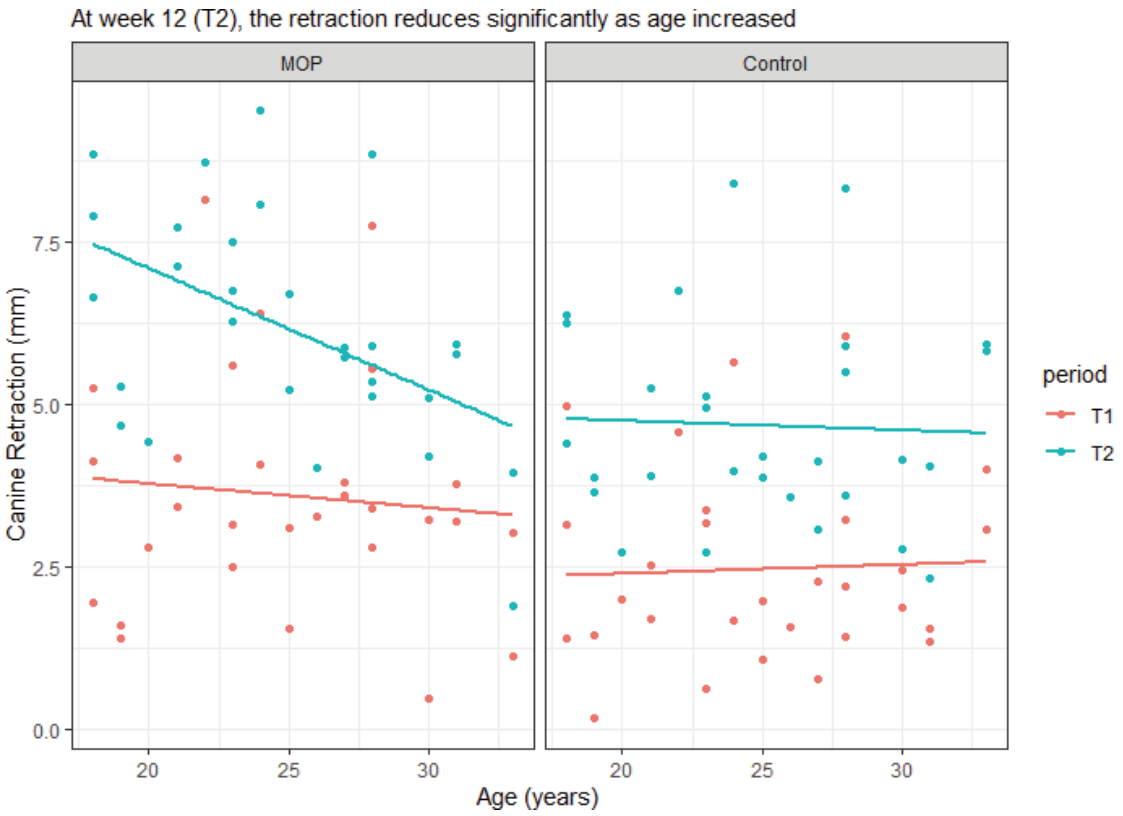


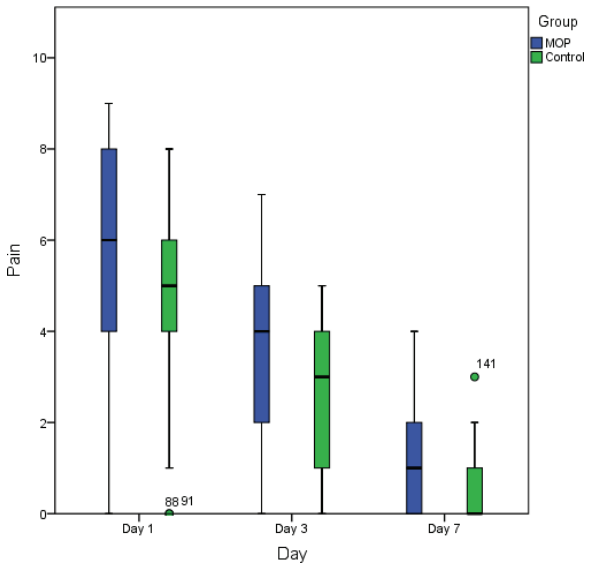
Figure V: Age and Canine Retraction Rate

Age and Canine Retraction Rate

Figure V above shows the correlation between the age of the subjects and the canine retraction rate in both the MOP and control groups. At week 8 (T_1), there was no relationship between age and canine retraction rate in both groups. However, at week 12 (T_2), in the MOP group there was a significant negative relationship (r = -0.49, p = 0.007) between age and canine retraction (retraction decreased as age increased).

Assessment and Comparison of the Level of Pain between the Experiment and Control Groups

The level of pain recorded in the groups is shown in the plot below (Fig. VI). In the MOP group, the median pain level was 6.0 (4.0 – 8.0) on day 1, 4.0 (2.0 – 5.0) on day 3, and 1.0 (0.0 – 2.0) on day 7. In the control group, the median pain level was 5.0 (4.0–6.0) on day 1, 3.0 (1.0–4.0) on day 3, and 0.0 (0.0–1.0) on day 7. In both groups, there was a significant reduction in the level of pain as the days increased (p = 0.000 in both groups).



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Table VII: Comparison between the pain level of MOP and control group

	MOP (N = 29) Median (IQR)	Control (N = 29) Median (IQR)	p-value
Day 1	6.0 (4.0 – 8.0)	5.0 (4.0 – 6.0)	0.094
Day 3	4.0 (2.0 – 5.0)	3.0 (1.0 – 4.0)	0.027*
Day 7	1.0 (0.0 – 2.0)	0.0 (0.0 – 1.0)	0.042*

IQR = Inter-quartile range
* Significance at the 0.05 level

Comparison between the Pain Level of MOP and the Control Group

Between the experiment (MOP) and control groups, as shown in Table VII, the distribution of pain levels was not the same, but the difference was not statistically significant at 24 hours post-procedure (p = 0.094), while at day 3 and day 7, the pain level differences of the MOP group were statistically significant from those of the control (p = 0.027 and p = 0.042, respectively). In the MOP group, there was no significant difference in the distribution of pain from the control group at day 1 (24 hours) (p > 0.05), but there was a significant difference in the distribution of pain at day 3 (p = 0.030) and day 7 (p = 0.040).

DISCUSSION

The daunting task of reducing the treatment duration [16] as well as its accompanying undesirable side effects associated with prolonged treatment time in fixed orthodontic treatment in general and among adult patients in particular has led to the introduction of new treatment modalities such as MOP. [17]

This split-mouth study design helped reduce the biological variability as each subject served as its control. Homogeneous subjects (young adult patients) were, as much as possible, used in this study. This allowed for similar inflammatory responses to MOP based on their close age range. Confounders were eliminated using the inclusion criteria.[18] This study, conducted to determine CRR using a NiTi close coil spring with MOP on the experiment side and a NiTi close coil spring only on the control side, produced a mean retraction rate of 6.2 ± 1.8 mm from the experiment sides and 4.7 ± 1.6 mm from the control sides at the end of 12 weeks of retraction. This finding was significantly higher on the experiment side, which had a NiTi close coil spring with MOPs applied, when compared with that on the control side, which had a NiTi close coil spring only. This result has been attributed to the RAP elicited by the micro-traumatic nature of MOP, which translates into an increase in inflammatory markers and osteoclastic activity, which is the hallmark of OTM.[19] The finding from this study, which showed about 1.34 times faster CRR, is in keeping with reports from other studies like that by Zoya Ahsan *et al.*[20] which had 30 participants and reported a 1.6 times faster retraction rate. Other studies have reported even higher values of a 2.3 times faster retraction rate.[12] Studies that have shown no difference in CRR following MOP application also exist in the literature, with Alkebsi *et al.* reporting no difference whatsoever in retraction rate.[21,22]

One of the popularised distinctive advantages of MOP placement is the repeatability of the procedure as opposed to the other highly invasive surgical-assisted techniques. This repeat application is believed to cause a constant circulation of inflammatory chemokines and cytokines within the localised region where MOP is applied, thus leading to a sustained increase in localised alveolar bone turnover[23,24] and the other side received micro-osteoperforations (MOPs. Wilcko *et al.*[15] reported that RAP takes effect in 1 or 2 days following the surgical intervention and reaches its peak levels in about 1 or 2 months and then starts to wane; repeats of MOP in a subset of the experimental sites in this study were planned for 8 weeks from the time of commencing this study. A statistically significant increase in CRR was observed when MOP was repeated 8 weeks after study commencement in the subset of the experimental group (p = 0.011 at week 8; p = 0.001 at week 12). However the magnitude of the difference between the groups was small, and the confidence intervals included zero, suggesting that the clinical significance of this finding may be limited. This finding contrasts with previous studies that reported no significant increase in OTM following repeated MOP applications over a 3 month-period.[25,26] The discrepancy may be related to methodological differences, including variations in force delivery. In contrast, Attri *et al.*[24] reported a significant increase in retration rate and faster space closure when MOPs were repeatedly applied every 28 days over 3 months. In that study, six MOPs were applied to both the mesial and distal aspects of the alveoalr bone adjacent to the canines, which may have enhanced the RAP, thereby increasing OTM.

Therefore, further studies are needed to evaluate the influence of factors such force reactivation, number and location of perforations, and depth of MOP in determining the effectiveness of repeated applications. Although some studies have reported no increase in OTM following MOP, the variability in findings suggests that the biological response induced by RAP may be modest and influenced by procedural differences.[26]

The average rate of tooth movement by conventional orthodontics is estimated to be around 0.8 to 1.2 mm/month when continuous forces are being applied.[27] It was observed to be less than that derived from this study on both the control and experiment sides with values of 1-2.[6] mm/month. This observation may have been a result of the differences in the form of anchorage used. This study used absolute anchorage in the form of TADs. This is also true when compared to other studies on canine retraction rates published by Dixon *et al.* 28 who observed that the rate of canine retraction with NiTi closed coil springs was 0.81 mm/month, and Cacciafesta *et al.* 29 who reported a 1.1 mm/month canine movement but did not use absolute anchorage.

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Therefore, absolute anchorage should be considered where possible if a faster OTM is desired. This eliminates anchorage loss and invariably reduces OTM associated with other forms of anchorage design.

On the secondary outcome of our study, which was pain and discomfort, the highest values of pain scores were recorded on day one on both the control and experimental sides. This can easily be attributed to the force effect on the periodontium of the canines by the NiTi close coil spring. The pain perception of the study participants from the experiment quadrants when compared to that from the control quadrants was statistically not significant 24 hours post MOP application but was statistically significant at day 3 and day 7 post MOP application. Even though there was a decrease in pain reported from both the experiment and control sides as the number of days post-MOP increased, the pain levels on the experiment sides were higher at day 3 and day 7. This can be a result of the microtrauma associated with MOP, both to the mucosa and the underlying alveolar bone, and/or lack of blinding in the application of MOP to the experiment quadrants in this study. Our study had 11 females and 6 males, with three of the female study participants reporting severe pain before 24 hours post-MOP application, with all three requiring a single dose of 1 g of paracetamol for their pain. Some other studies have not only shown more pain experience on the experiment quadrants but have also reported adverse effects on patients' quality of life.[26]

Other complications associated with MOP administration, which, even though not reported in the results, were observed, were rotation/tipping of the canines. This was observed in both the experiment and control mouth sides despite the use of 0.19 x 0.025 stainless steel wire placed 4 weeks before commencement of retraction and throughout retraction. The direction of force application could have accounted for this finding. Canine root resorption, which is also an associated MOP complication, was equally assessed by comparing digital periapical radiographs taken at the zero week and 12th week of this study, with no form of resorption observed after 12 weeks.

A reduction in time of about 2.9 weeks was observed from this study in the canine retraction phase of fixed orthodontic treatment. This may not still be as significant as the overall reduction in orthodontic treatment time. Therefore, MOP applicability in other stages of orthodontic treatment must be equally evaluated if an appreciable reduction in total treatment time is desired, which will improve its acceptance by both patients and clinicians.

STUDY LIMITATIONS

The use of rescue analgesia by a small number of participants within the first 24 hours may have influenced reported pain and discomfort scores. As this was not adjusted for in the analysis, it represents a potential source of bias, particularly at the 24-hour time point

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CONCLUSION

From this study, the canine retraction rate using a NiTi close coil spring with adjunctive miniscrew facilitated MOP was significantly higher than that from the use of a NiTi close coil spring alone.

Also, the canine retraction rate using a NiTi close coil spring with two applications of an adjunctive miniscrew facilitated MOP at the commencement of retraction and 8 weeks afterward but did not produce a significantly faster retraction rate when compared to once the application of MOP at the commencement of canine retraction.

Pain from the administration of adjunctive MOP to NiTi close coil spring activation in canine retraction, even though it was not statistically significant 24 hours post-administration from pain from NiTi close coil activation alone, was significantly higher than pain from the latter by day 3 and day 7 post-MOP administration.

CONFLICTS OF INTEREST

All authors declare no conflicts of interest related to this study. The research was conducted independently, without financial or personal relationships that could inappropriately influence or bias our findings. All materials and equipment used in this study were obtained through standard procurement channels, and no external funding or sponsorship was received.

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CONSENT TO PUBLISH DECLARATION

Not applicable as study does not contain any identifying information of study participants.

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