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Effects of Micro-osteoperforation Using a Lance Drill on the Rate of Tooth Movement During Lower Arch En-Masse Retraction in Class I Malocclusion With Bidental Proclination: A Comparative Study

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Abstract

Background and objective

The extended duration of fixed orthodontic treatment carries well-recognized risks, and micro-osteoperforation (MOP) has been proposed as a minimally invasive approach to accelerating orthodontic tooth movement. This study aimed to compare the rate of lower arch anterior en-masse retraction, assessed using three-dimensional (3D) digital models, between patients who received MOPs performed with a lance drill attached to a physiodispenser unit and those who underwent conventional retraction without MOP. The study also assessed associated pain and discomfort.

Materials and methods

Twenty patients aged 12-18 years with Class I malocclusion and bidental proclination who were undergoing fixed appliance therapy involving extraction of the maxillary and mandibular first premolars and lower arch anterior en-masse retraction were enrolled in this prospective, two-group comparative observational study. Patients who underwent MOP as part of their retraction protocol formed the MOP group, whereas those treated with conventional retraction alone formed the comparison group. Group assignment was not randomized. During mini-implant-assisted en-masse retraction, patients in the MOP group received three MOPs in a linear distribution distal to the canine on each side using a lance drill attached to a physiodispenser unit. The procedure was repeated at each 28-day visit over three months. En-masse retraction was performed using nickel-titanium closed-coil springs delivering 150 g of force. The rate of en-masse retraction was measured using 3D digital models at the three-month follow-up, with the outcome assessor blinded to group allocation. Pain and discomfort were recorded using a 100-mm visual analogue scale (VAS) at 24 hours and 7, 14, and 28 days after each MOP procedure.

Results

Seven participants in the MOP group and nine in the comparison group completed follow-up. The mean rates of en-masse retraction were 1.38 ± 0.35 mm on the right and 1.31 ± 0.30 mm on the left in the comparison group, compared with 2.73 ± 0.91 mm on the right and 2.60 ± 0.64 mm on the left in the MOP group. After three months, the rate of en-masse retraction was significantly higher in the MOP group than in the comparison group (Mann-Whitney U test, $p < 0.05$ for both sides). Pain sensitivity was highest at 24 hours after the procedure and differed significantly across time points (Friedman's ANOVA, $p \leqslant 0.003$). Following Bonferroni correction, pain at 24 hours was significantly higher than at 14 and 28 days during the first month only (Dunn's post hoc test, $p < 0.05$).

Conclusions

Physiodispenser-assisted MOP using a lance drill was associated with a significantly higher rate of lower arch en-masse retraction and transient pain that peaked at 24 hours after the procedure. These findings should be interpreted in light of the nonrandomized study design, single-center setting, small sample size, three-month follow-up period, and loss to follow-up associated with the COVID-19 pandemic, which may limit the generalizability and strength of the conclusions. Further multicenter studies involving larger samples and longer follow-up periods are needed to confirm these findings.

Categories: Dentistry
Keywords: accelerated orthodontics, en-masse retraction, micro-osteoperforation, regional acceleratory

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phenomenon, three-dimensional digital models

Introduction

The extended duration of orthodontic treatment, particularly in adults, constitutes a considerable barrier to care. Comprehensive fixed appliance therapy generally requires approximately two years to complete [1]. Prolonged treatment duration is associated with an increased risk of root resorption [2], gingival inflammation, dental caries, enamel decalcification, and reduced patient compliance [3]. These potential adverse effects highlight the need for effective approaches to reduce treatment time and have prompted research into methods to accelerate orthodontic tooth movement (OTM).

Various surgical and nonsurgical methods have been introduced to accelerate OTM. Nonsurgical methods include self-ligating brackets [4], electrical current stimulation [5], and the injection of pharmacological agents such as platelet-rich plasma [6]. Surgical methods include corticotomy [7], piezocision [8], and micro-osteoperforation (MOP) [9].

Surgical methods such as corticotomy have demonstrated substantial effects on the rate of OTM [10]. However, conventional corticotomy involving a mucoperiosteal flap is invasive, painful, and costly and often requires the involvement of an additional specialist. MOP is a newer, flapless, minimally invasive alternative that can be performed by the orthodontist [11]. Teixeira et al. proposed that limited cortical perforations could trigger the regional acceleratory phenomenon (RAP), thereby accelerating OTM [11]. However, subsequent studies have reported mixed results regarding its effectiveness [12].

Alikhani et al. reported that MOP could accelerate OTM by two- to threefold [9], whereas Alkebsi et al. found that MOP was not effective in accelerating OTM [13]. Systematic reviews have consistently highlighted the limited quantity and quality of the available clinical evidence [10]. Several biological and mechanical factors are known to influence OTM, including age, sex, study site, study design, magnitude of force, occlusal interference, and anchorage [14].

Most previous clinical studies investigating MOP have focused on the maxillary arch [9,13,15,16], despite the greater cortical thickness and density of the mandible, which may influence treatment outcomes. Furthermore, most studies have evaluated the effects of MOP during individual canine retraction or two-step retraction, with limited investigation of its application during en-masse retraction [9,13,15,16]. En-masse retraction has been reported to reduce treatment time and may decrease the risk of canine tipping and rotation [17]. Nevertheless, a considerable research gap remains regarding the efficacy of MOP in the mandibular arch during anterior en-masse retraction. The present study addresses this gap by evaluating a simplified, potentially cost-effective MOP technique using a lance drill attached to a physiodispenser unit during lower arch anterior en-masse retraction in patients with Class I malocclusion and bidental proclination. This approach aims to provide evidence relevant to contemporary orthodontic practice.

Materials And Methods

Study design

This was a prospective, two-group, comparative observational study evaluating the rate of lower arch en-masse retraction in patients treated with and without MOP. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The Institutional Ethics Committee of Pushpagiri College of Dental Sciences approved the study (approval no. PCDS/IEC/M1/08/19) in September 2019. No important changes were made to the study methods after recruitment began.

Participants and eligibility criteria

Participants were selected from patients undergoing fixed appliance therapy who required extraction of the maxillary and mandibular first premolars and lower arch en-masse anterior retraction. The inclusion and exclusion criteria of the study are listed in Table *1*. Participant rights were protected, and informed consent was obtained from parents or guardians, with assent from minors.

Inclusion criteria	Exclusion criteria
Age 12-18 years	Previous orthodontic treatment
Angle Class I malocclusion with bidental proclination	Systemic disease
Fully erupted permanent dentition (excluding third molars)	Current or past periodontal disease
Good oral hygiene	Gingivitis
Ovoid lower arch form	Dental caries
Minimal crowding (≤ 4 mm)	Poor oral hygiene
Mandibular plane angle of 22-32°	Oral habits or abnormal perioral muscle activity
Normal overbite (1-4 mm)	Long-term medication use (especially NSAIDs)
Adequate alveolar bone trough width	Canine root prominence

TABLE 1: Inclusion and exclusion criteria

Group assignment

Participants were assigned to the MOP group or the comparison group according to their consent regarding the additional MOP procedure, on a non-randomized basis. The patients who consented to undergo MOP were included in the MOP group, whereas those who did not consent to the procedure were included in the comparison group. As group allocation was based on patient consent rather than randomization, the potential for selection bias was recognized. To limit confounding, strict and identical eligibility criteria were applied to both groups so that they were comparable for the principal known determinants of orthodontic tooth movement (age, occlusion, occlusal interference, periodontal status and anchorage), and baseline comparability between the groups was verified statistically.

Sample size consideration

The required sample size was estimated a priori using the mean and standard deviation of canine retraction rates with and without MOP reported by Feizbakhsh et al. [15], with a 95% confidence level and 80% power. The estimated requirement was 16 participants (8 per group) and increased to 20 (10 per group) to allow for an anticipated 20% dropout rate.

Blinding of outcome assessment

Blinding of participants and operators was not feasible given the nature of the MOP procedure. Outcome assessment, however, was blinded: numeric codes were assigned to the digital models so that the assessor was unaware of the group to which each participant belonged.

Clinical procedures

Before treatment, participants underwent periodontal screening and received oral hygiene instructions. All participants were banded on the first and second molars in both arches, and a transpalatal arch was used for anchorage reinforcement in the maxilla. Fixed appliances (0.022-inch slot MBT prescription, zero-degree torque canine brackets; Minimaster, American Orthodontics, Sheboygan, WI, USA) were bonded by a single operator. The arches were leveled, aligned, and coordinated using the MBT archwire sequence until a 0.019 × 0.025-inch stainless steel working archwire was reached. This archwire remained passive in the bracket slots for at least one month before retraction. Minor anterior spacing was consolidated using figure-of-eight ligatures. Mini-implants (1.5 mm in diameter and 8 mm in length; AbsoAnchor, Dentos, Daegu, South Korea) were placed between the mandibular first molar and second premolar by an orthodontist to provide absolute anchorage. Baseline alginate impressions were obtained before retraction commenced. Participants in the MOP group rinsed with 0.12% chlorhexidine gluconate solution twice for one minute each. Topical anesthesia was then administered using 2% lidocaine, followed by infiltration anesthesia with lidocaine containing adrenaline at a concentration of 1:80,000. An experienced orthodontist performed three linearly distributed MOPs (Figure *1*) in the cortical bone, 3 mm distal to the mandibular canine on each side, using a 1.5-mm-diameter lance drill (GDT Implants, Tel Aviv, Israel) attached to a physiodispenser unit (W&H Implantmed, Burmoos, Austria). Each perforation was 1.5 mm wide and 6 mm deep, as determined using the drill's depth calibration. Lower arch anterior en-masse retraction was performed using 12-mm nickel-titanium closed-coil springs (Ormco, Orange, CA, USA), with the force standardized to 150 g per side using a Correx gauge. Retraction commenced immediately after each MOP procedure in the MOP group (Figure *1*) and at the corresponding visit in the comparison group (Figure *2*). Participants were reviewed every 28 days

for three months. Alginate impressions were obtained at each visit, and MOPs were repeated at each visit for participants in the MOP group.

FIGURE 1: Micro-osteoperforation (MOP) group

FIGURE 2: Comparison group (without micro-osteoperforation)

Outcomes

The primary outcome was the rate of lower arch en-masse retraction (mm) over three months. Dental stone models were scanned using a 3Shape R2000D 3D scanner (3Shape Dental Systems, Copenhagen, Denmark). The distance from the cusp tip of the mandibular canine to the buccal cusp tip of the mandibular second premolar was measured on the resulting standard tessellation language (STL) files (Figure *3*) to the nearest 0.01 mm on each side using Blender v2.9.2 (Blender Foundation). The reduction in this distance was used as an indirect measure of extraction-space closure during the three-month observation period. To assess intra-operator reliability, 30% of the measurements were repeated after a two-week interval.

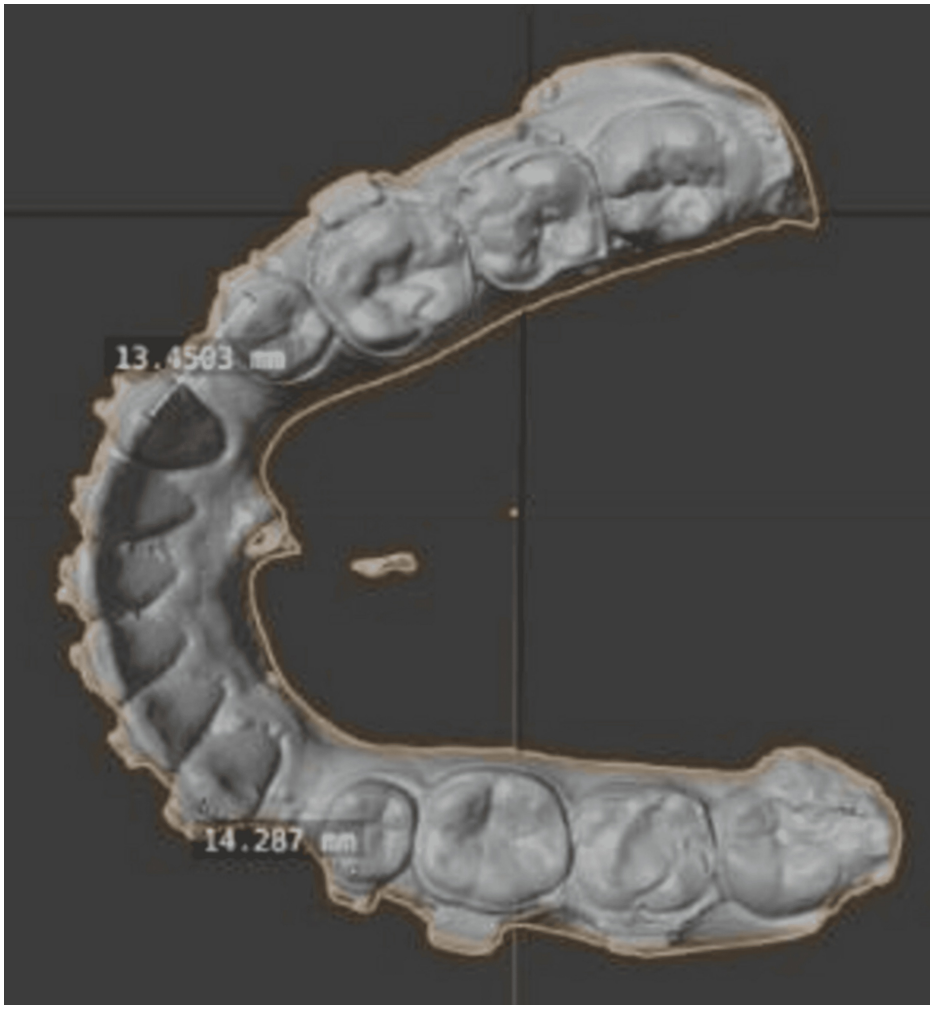

FIGURE 3: Rate of en-masse retraction

The secondary outcome was pain intensity, measured using a 100-mm visual analogue scale (VAS; Figure *4*), where 0 mm indicated no pain and 100 mm indicated the worst imaginable pain. Pain was assessed at 24 hours and 7, 14, and 28 days after each MOP procedure. Following oral instructions, participants marked the scale by hand. The scores were measured using a metric ruler with a precision of 0.5 mm and rounded to the nearest whole millimeter. For statistical analysis, the measurements were converted to a 0-10 scale by dividing the millimeter values by 10.

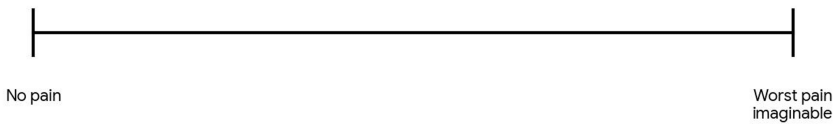

FIGURE 4: Visual analogue scale (VAS)

Statistical methods

Data were entered into Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analyzed using IBM SPSS Statistics for Windows, Version 21.0 (Released 2012; IBM Corp., Armonk, NY, USA). Baseline age and pre-retraction extraction space were compared between groups using independent-samples t-tests, while sex distribution was compared using Pearson's chi-square test to assess baseline comparability. For the chi-square analysis, the test statistic was reported with its degrees of freedom and sample size, and the phi coefficient (ϕ) was used as the effect size. Because some expected cell counts were below five, Fisher's exact

test was also performed. The normality of the tooth-movement data was assessed using the Shapiro-Wilk test. As the data were not normally distributed, the Mann-Whitney U test was used to compare the rate of en-masse retraction between groups, with a 95% confidence interval. The effect size was calculated as $r = |Z|/\sqrt{N}$. Results were summarized as means and standard deviations. Pain-perception data were also non-normally distributed. Differences across time points within the MOP group were assessed using Friedman's test, with the test statistic reported as χ^2 with its degrees of freedom and Kendall's coefficient of concordance (W) used as the effect size. Dunn's post hoc test with Bonferroni adjustment was used for pairwise comparisons. Intra-operator reliability was assessed using the intraclass correlation coefficient (ICC) for the 30% of measurements repeated after a two-week interval. Statistical significance was set at $p < 0.05$.

Results

Participant flow

Sixty-five patients were assessed for eligibility, of whom 45 were excluded: 28 did not meet the inclusion criteria, and 17 declined to participate. Twenty participants were enrolled, with 10 assigned to each group. Subsequently, one participant in the comparison group and three in the MOP group were lost to follow-up because of irregular attendance during the COVID-19 pandemic. No participants discontinued treatment. The final analysis included nine participants in the comparison group and seven in the MOP group.

Baseline data

Participants were aged 12-18 years and comprised 3 males (15%) and 17 females (85%). Baseline comparisons of age, sex distribution, and pre-retraction extraction space revealed no statistically significant differences between the groups (Table 2). Sex distribution did not differ significantly between the MOP group (one male and nine females) and the comparison group (two males and eight females) ($\chi^2(1, N = 20) = 0.39$, $p = 0.531$, $\phi = 0.14$), indicating a small effect. Fisher's exact test yielded a similar result ($p = 1.000$).

Parameters	MOP group	Control group	p-value
Age (years)	15.4 ± 1.90	15.6 ± 1.90	0.816*
Sex (percentage)	Male, 10%	Male, 20%	0.531†
	Female, 90%	Female, 80%	
Pre-retraction extraction space per side (mm)	14.07 ± 3.28	14.10 ± 2.25	0.988*

TABLE 2: Baseline descriptive data

*Independent-samples t-test.

†Pearson's chi-square test: $\chi^2(1, N = 20) = 0.39$, $\varphi = 0.14$ (Fisher's exact test, $p = 1.000$).

MOP: micro-osteoperforation.

Outcome: rate of tooth movement

The amount of en-masse retraction over three months (T3-T0) was assessed separately for the right and left sides (Table 3). The mean values were 1.38 ± 0.35 mm on the right and 1.31 ± 0.30 mm on the left in the comparison group, compared with 2.73 ± 0.91 mm on the right and 2.60 ± 0.64 mm on the left in the MOP group. The between-group mean differences (MOP minus comparison group) were 1.35 mm on the right and 1.29 mm on the left. Approximate 95% confidence intervals calculated using Welch's two-sample t-method ranged from 0.54 to 2.16 mm on the right and from 0.72 to 1.86 mm on the left. Mann-Whitney U tests demonstrated statistically significant between-group differences on both sides (right: $U = 3$, $Z = -3.019$, $p = 0.003$, $r = 0.75$; left: $U = 2$, $Z = -3.125$, $p = 0.002$, $r = 0.78$), indicating substantially greater en-masse retraction in the MOP group than in the comparison group (Table 3). Intra-operator reliability was excellent, with an ICC of 1.00 for both sides and the lower arch overall (Table 3).

Side	Comparison (n = 9), mean ± SD (mm)	MOP (n = 7), mean ± SD (mm)	Mann-Whitney U; Z	p-value	ICC	95% CI lower	95% CI upper
Right	1.38 ± 0.35	2.73 ± 0.91	U = 3; Z = -3.019	0.003*	1.000	0.997	1.000
Left	1.31 ± 0.30	2.60 ± 0.64	U = 2; Z = -3.125	0.002*	1.000	0.995	1.000
Lower arch overall	–	–	–	–	1.00	0.996	1.000

TABLE 3: Rate of lower arch en-masse retraction at three months (T3-T0), by side and group, and intraclass correlation coefficient (ICC) for intra-operator reliability (30% of measurements, repeated at two weeks)

*Statistically significant, p < 0.05.

MOP: micro-osteoperforation.

Secondary outcome: pain sensation

Within the MOP group, pain scores differed significantly across time points during each of the three post-MOP assessment cycles (Friedman's test: month 1, $\chi^2(3) = 18.88$, $p < 0.001$, Kendall's $W = 0.90$; months 2 and 3, $\chi^2(3) = 13.91$, $p = 0.003$, $W = 0.66$; Table *4*). Pain was highest at 24 hours and had resolved by day 14 in each cycle. Dunn's post hoc test with Bonferroni correction (Table *5*) showed that pain at 24 hours during month 1 was significantly higher than at days 14 and 28 ($p = 0.008$ for both comparisons), but did not differ significantly from pain at day 7 ($p = 0.137$). During months 2 and 3, no pairwise comparisons remained statistically significant after correction ($p \geq 0.178$). Mean pain scores at 24 hours were 4.57 ± 2.76 in month 1 and 2.71 ± 2.29 in months 2 and 3.

Time point	Month 1, mean ± SD	Month 2, mean ± SD	Month 3, mean ± SD
24 hours	4.57 ± 2.76	2.71 ± 2.29	2.71 ± 2.29
7 days	0.57 ± 0.79	0.14 ± 0.38	0.14 ± 0.38
14 days	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
28 days	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Friedman's ANOVA, p-value	<0.001*	0.003*	0.003*

TABLE 4: Pain sensation (100 mm VAS) in the MOP group across time points, by treatment month (Friedman's ANOVA)

Friedman's ANOVA (n = 7): month 1, $\chi^2(3) = 18.88$, Kendall's $W = 0.90$; months 2 and 3, $\chi^2(3) = 13.91$, Kendall's $W = 0.66$.

*Statistically significant, p < 0.05.

VAS: visual analogue scale, MOP: micro-osteoperforation, ANOVA: analysis of variance.

Comparison	Month 1	Month 2	Month 3
24 h vs 7 d	z = 2.28, p = 0.137	z = 1.86, p = 0.375	z = 1.86, p = 0.375
24 h vs 14 d	z = 3.21, p = 0.008*	z = 2.17, p = 0.178	z = 2.17, p = 0.178
24 h vs 28 d	z = 3.21, p = 0.008*	z = 2.17, p = 0.178	z = 2.17, p = 0.178
7 d vs 14 d	z = 0.93, p = 1.000	z = 0.31, p = 1.000	z = 0.31, p = 1.000
7 d vs 28 d	z = 0.93, p = 1.000	z = 0.31, p = 1.000	z = 0.31, p = 1.000
14 d vs 28 d	z = 0.00, p = 1.000	z = 0.00, p = 1.000	z = 0.00, p = 1.000

TABLE 5: Dunn's post hoc pairwise comparisons (Bonferroni-adjusted) following Friedman's ANOVA (MOP group, n = 7)

p-values are Bonferroni-adjusted for six comparisons. In month 1, pain at 24 hours was significantly higher than at 14 and 28 days but did not differ significantly from 7 days; in months 2 and 3, no pairwise comparison remained significant after Bonferroni correction. No significant differences were found among the 7-, 14-, and 28-day time points.

*Statistically significant, $p < 0.05$.

ANOVA: analysis of variance, MOP: micro-osteoperforation.

Adverse events

No serious adverse events were reported during the MOP procedure or at subsequent visits. Mild-to-moderate pain was reported in the MOP group 24 hours after the procedure, consistent with the VAS findings reported above.

Discussion

This single-center, two-group comparative observational study investigated the effect of physiodispenser-assisted MOP, delivered with a lance drill, on the rate of lower arch en-masse retraction. Although physiodispenser-assisted MOP has previously been applied to individual canine retraction using a split-mouth design [18], no previous study has evaluated this specific technique for lower arch en-masse retraction, thus contributing to the limited literature on alternative MOP delivery methods. The significant increase in the rate of retraction observed in the MOP group after three months is consistent with prior studies accelerating tooth movement with MOP [9,11,12,15,16,19,20]. In contrast, a few studies have demonstrated insignificant differences between MOP and comparison groups, reflecting ongoing debate regarding the efficacy of MOP in accelerating tooth movement [13,21-24]. The regional acceleratory phenomenon (RAP) [25] is widely recognized as a potential mechanism underlying such acceleration, as supported by both animal and human studies of surgically induced alveolar remodelling. Notably, most previous studies implemented MOP as a single event, whereas the present study applied MOPs every 28 days for three months. This repeated application was based on the hypothesis, supported by RAP literature, that sustained or repeated surgical stimuli may maintain an elevated tissue response, thereby increasing the rate of tooth movement more effectively.

Alikhani et al. found that MOP significantly increased cytokine and chemokine expression, thereby recruiting osteoclast precursors and stimulating osteoclast differentiation [9], which may explain the accelerated OTM after MOP. Differences between studies may be attributable to variations in study design, methodology, methods for assessing tooth movement, and the severity of induced surgical trauma [24]. Alkebsi et al. attributed their negative finding to the comparatively minimal surgical insult of miniscrew-generated perforations, which they judged insufficient to trigger an inflammatory response, RAP, or cytokine expression; they also noted that in a split-mouth design, the inflammatory response initiated on one side may cross over to the contralateral side [13]. Alqadasi et al., also using a split-mouth design, likewise found no significant difference in the rate of OTM between MOP and control sides [21]. Aboalnaga et al., using CBCT imaging, found that MOP did not accelerate canine retraction, although it appeared to facilitate root movement [22]. Alfawal et al. suggested that a decline in tooth movement rate after the first month reflects the transient nature of RAP, or that resistance from bone maturation neutralizes the effect of MOP over time [10].

Pain sensitivity in the present study was significantly greater only in the first 24 hours after MOP. This is consistent with Kundi et al., who reported that MOP-related pain peaked on days 1-2 [20]. It contrasts with Alikhani et al., who reported no significant pain or discomfort with MOP [9], and with Alkebsi et al., who found no effect on daily activities beyond transient swelling [13]. In the split-mouth trial by Sivarajan et al.,

all participants reported some MOP-related pain, classified as moderate in 60% and severe in 15%, mainly affecting chewing and speech [16]. Compared with other surgical acceleration procedures, MOP exhibits better patient compliance and lower pain [10].

A parallel, two-group design was used in this study, whereas most previous MOP studies have used a split-mouth design. Carry-over effects can bias split-mouth designs [9,13,15,16] and require more elaborate statistical handling, as space closure on one side can influence the contralateral side; therefore, split-mouth designs may not be ideal for assessing retraction rate. This study sought to minimize bias by controlling for several known confounders of OTM, including age, occlusion, occlusal interference, and anchorage [14]. Restricting enrolment to participants aged 12-18 years addressed age effects and reflects the age group most commonly presenting for fixed appliance therapy. Inclusion of Class I malocclusion with bidental proclination, requiring only first-premolar extraction, may limit the ability to address occlusion-related effects. A defined mandibular plane angle range (22-32°) and normal overbite (1-4 mm), together with prior levelling and aligning, reduced occlusal interference during retraction. Periodontal screening with reinforced oral hygiene measures addressed confounders such as poor oral hygiene, periodontal disease, and NSAID consumption, which can all affect the rate of tooth movement. Extractions were performed at least six months before space closure to avoid extraction-related RAP effects that could confound the MOP-related response. Although sex hormones have been suggested to influence the rate of tooth movement in animal studies, human studies, including the present study, have not shown a significant sex difference in OTM [14]. Babanouri et al. similarly found no significant sex difference in the effect of MOP [23].

Most previous MOP studies were conducted in the maxillary arch [9,13,22,24]. Deguchi et al. [26] reported that the maxilla and mandible differ markedly in the rate of tooth movement, with thinner cortical bone, higher resorption rates, and greater trabeculation in the maxilla plausibly permitting faster OTM than in the mandible. Relatively few studies have examined MOP in the mandibular arch [15,16,19]; both Feizbakhsh et al. [15] and Attri et al. [19] reported significantly faster mandibular tooth movement with MOP, broadly consistent with the present findings. However, the rate of tooth movement in the maxilla in previous studies has generally been somewhat higher than in the mandible.

This study followed en-masse retraction over three months, compared with one month in several earlier studies [9,15,19]. Earlier work has more often assessed individual canine retraction or two-step retraction [9,13,15,16]; en-masse retraction is now generally preferred clinically, since two-step mechanics prolong treatment [17] and individually retracted canines tend to tip and rotate more [17]. Absolute anchorage was provided by mini-implants, with retraction delivered through 0.019 × 0.025-inch stainless steel archwires and NiTi closed-coil springs at a standardized 150 g force per side, consistent with force magnitudes commonly used in sliding-mechanics space closure.

Earlier studies by Alikhani et al. [9] and Attri et al. [19] used a first-generation Propel device to create MOPs, while several others used miniscrews [13,15,16,22]. Propel is costly, and miniscrew-generated MOPs require longer chairside time; the present study instead used a lance drill mounted on a physiodispenser unit, which provides adjustable drill speed and torque and an integrated coolant system. The lance drill's depth calibrations (6, 8, 10, 11.5, 13, and 16 mm) and tapered tip allow accurate, reproducible cortical perforation. Given reported mandibular cortical bone thicknesses of approximately 1.98 mm (molar), 1.20 mm (premolar), and 0.99 mm (anterior region) [27], a 6 mm perforation depth was selected to reliably reach medullary bone through an estimated 3 mm of soft tissue in the premolar region. No complications or adverse effects were observed at this depth.

Linear measurements on digital models are reported to be accurate and reproducible [28], and most recent MOP studies have used digital models with various software packages to assess retraction rate [13,15,19-23,29]. This study measured retraction on three-dimensional digital models using Blender v2.9.2, as in Raghav et al. [29], and intra-operator reliability at a two-week retest interval was excellent.

Limitations, generalizability, and further studies

Several limitations should be considered. As a non-randomized, comparative observational study, group assignment was not randomized or concealed, so the findings are subject to potential selection bias and residual confounding despite the application of strict, identical eligibility criteria and the demonstrated baseline comparability of the groups; causation therefore cannot be inferred with the same confidence as in a randomized controlled trial, and the results are best regarded as hypothesis-generating. The three-month follow-up period did not permit complete space closure, indicating the need for future longer-term studies and investigations using frictionless mechanics with larger sample sizes. Anchorage loss during retraction could not be assessed due to the absence of a stable anatomical landmark in the mandible comparable to the third palatal rugae used in maxillary studies. The COVID-19 pandemic contributed to loss to follow-up among three MOP-group participants and one comparison-group participant owing to irregular attendance, thereby reducing the sample size analyzed and potentially affecting the precision of the estimates and robustness of the findings. Generalizability may be limited, as this was a single-center study conducted in a teaching hospital, where patient demographics, clinical protocols, and supervision may differ from those in private practice. Notwithstanding these limitations, the clinically relevant increase in the en-masse retraction rate observed in the MOP group suggests that physiodispenser-assisted MOP may be an effective

means of reducing the duration of orthodontic treatment. Used in routine orthodontic practice, this technique may improve treatment efficiency, provided the transient increase in pain is appropriately managed. To improve external validity, subsequent studies should replicate these outcomes in adequately powered randomized and multicenter studies, including participants from diverse clinical settings and wider demographic groups. Such efforts will clarify whether the observed effects can be consistently achieved in varied orthodontic practices.

Conclusions

Within the limitations of this observational study, physiodispenser-assisted MOP with a lance drill was associated with a significantly higher rate of lower arch en-masse retraction. Pain sensation was significantly greater only in the first 24 hours after the MOP procedure, with no significant difference thereafter, and 3D linear measurement on digital models using Blender v2.9.2 was an accurate and repeatable method of assessing tooth movement. Since group assignment was not randomized, these findings should be regarded as hypothesis-generating and confirmed in adequately powered randomized or multicenter studies.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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