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Assessment of Pain Intensity During Leveling and Alignment of Maxillary Anterior Teeth Assisted with Micro-Osteoperforations: A Comparative Clinical Trial

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Abstract

Objectives: This study compared pain levels after using micro-osteoperforations versus no application during leveling and alignment of anterior maxillary crowding.

Methods: A randomized parallel-arm clinical trial was conducted in the outpatient orthodontic clinic in the Faculty of Dental Medicine l Azhar University Cairo – Egypt, on 20 eligible participants, ages 13 to 19, undergoing orthodontic treatment for moderately crowded maxillary anterior teeth. Participants received bonded conventional fixed orthodontic appliances with NiTiarchwires for leveling and alignment and were randomly assigned into two equal groups of 10 each to receive micro-osteoperforations or none. Micro-osteoperforations were applied under local anesthesia with orthodontic mini-screws, 3 mm apart within the attached gingiva and 1 mm apical to mucogingival junction equidistant between the upper right and upper left canine at every interdental labial alveolar bone except at the midline to avoid injury to the labial frenum. Pain intensity was measured using a 10 cm visual analog scale at 24 hours, three days, and one week after insertion of the first leveling and alignment arch wires. Data were analyzed using an independent t-test for intergroup comparison and one-way repeated measure ANOVA for intragroup comparison.

Results: Twenty patients were randomized and analyzed at the end of the study. Pain levels in the micro-osteoperforation group were higher than in the control group but with no statistically significant difference (P-value > 0.05). Pain levels were higher at 24 hours and significantly reduced till one week in each group.

Conclusions: Micro-osteoperforations, a minimally invasive tool for accelerating orthodontic tooth movement, showed promising results with mild to moderate pain levels after aligning crowded maxillary anterior teeth.

Keywords: micro-osteoperforations, pain intensity, leveling and alignment, crowded maxillary teeth.

Introduction

Pain and discomfort, a common and often shared experience during fixed orthodontic appliance treatment in orthodontics, vary individually and are caused by multiple factors [1]. The extended duration of orthodontic treatment is a significant concern due to potential adverse effects such as discomfort, pain, white spot lesions, and reduced patient compliance [2,3]. This extended duration may also contribute to patients' declining orthodontic treatment. Numerous methodologies have been developed to accelerate tooth movement, encompassing surgical and nonsurgical approaches. While surgical interventions such as corticectomies have demonstrated promising outcomes, their invasive nature raises concerns regarding their practicality for routine integration with orthodontic treatment [4,5]. As a result, recent studies have focused on performing the so-called flapless corticotomies, which are minimally invasive and, at the same time, can achieve the same results as conventional corticotomy[6,7].

Micro-Osteoperforations (MOPs) are one of the recent minimally invasive modalities [8,9], which could accelerate tooth movement by transiently reducing mineral density in the bone due to regional accelerated phenomena (RAP). This reduction in mineral density decreases the mechanical resistance of dental-alveolar tissue to orthodontic force, potentially leading to a reduction in treatment duration. [10,11]. Using surgical-assisted techniques to accelerate orthodontic treatment has brought attention to the patient's experience, including pain, discomfort, functional impairments, and satisfaction with the procedure.

A recent systematic review revealed limited evidence indicating that these techniques may cause mild to moderate pain and discomfort on the first day. Still, these symptoms resolve entirely within a week [12]. Some studies were identified using MOPs to accelerate the leveling and alignment of anterior upper/lower teeth, with controversial results [13–15]. Two studies reported higher pain levels after MOPs application compared to no MOPs application [14,15]. Conversely, one study found lower pain levels in the MOPs group compared to those with no MOPs application [13].

This highlights the necessity for additional well-designed randomized clinical trials to compare pain levels when using MOPs to level and align anterior teeth, as recommended by a recent systematic review [12]. Therefore, this study aimed to assess the pain intensity after using MOPs as a non-invasive, surgically-assisted acceleration technique during leveling and alignment of maxillary anterior teeth compared to no application in patients undergoing orthodontic treatment for anterior crowding.

By contributing to the body of knowledge in this area, we can better understand and improve the patient experience during orthodontic treatment.

Materials and methods

Study design and setting

This was a single-center parallel-arm randomized clinical trial with an allocation ratio of 1:1. The study was conducted in the outpatient clinics of the Department of Orthodontics, Faculty of Dental Medicine (Boys), AL-Azhar University, Cairo, Egypt. The faculty research ethics committee approved the study with (Approval number: 660/301) and registered on ClinicalTrials.gov (ID: NCT05605652).

Participants and eligibility criteria

Participants were recruited from the outpatient clinic of the Department of Orthodontics, Faculty of Dental Medicine (Boys), AL-Azhar University, Cairo, Egypt. The participants were selected according to the following criteria:

Inclusion criteria:

- Males and females aged 13 to 19 years old with moderate crowding in the maxillary anterior region as assessed by the Little Irregularity Index (LII), which requires orthodontic treatment with a fixed appliance to relieve the crowding with non-extraction approach.
- Class I skeletal relationship without any facial discrepancies.
- Good oral hygiene, low caries index, and all permanent teeth erupted.

Participants with retained or ankylosed deciduous teeth, missing maxillary teeth in the anterior region, or with any systemic conditions or chronic intake of NSAIDs that could affect orthodontic tooth movement were excluded from the study. Participants with repeated missing appointments or frequently broken appliances were discontinued from the trial.

Enrollment

Based on a previous study [16], using Open Epi version 3 and adjusting the confidence interval to 95%, the power of the test to 80%, the margin of error accepted to 5%, and the ratio between groups to 1:1, the minimum number needed for this study was found to be 20 patients divided into two equal groups, each group having ten patients. The research objectives were discussed with the patients and their parents in detail, and all patients and their parents signed informed consent before initiating treatment.

Randomization and group allocation

After enrollment and informed consent signing, participants were randomly assigned into two groups to receive either MOPs with leveling and alignment of the anterior maxillary teeth (intervention group) or leveling and alignment of the anterior maxillary teeth without MOPs (control group). The allocation sequence was generated by simple randomization using a computer-generated random number sequence generated using online software. Allocation sequence concealment was carried out using sequentially numbered opaque sealed envelopes with the intervention or control written on a folded piece of paper. Blinding to the intervention wasn't possible due to its nature [17].

Appliance design

Before starting orthodontic treatment, all patients underwent detailed clinical and radiographic examination, which included intra-oral and extra-oral photographs, panoramic and lateral cephalometric radiographs, and study casts. All patients received orthodontic treatment with pre-adjusted edgewise fixed orthodontic appliance with direct bondable 0.022×0.028-inch slot Roth pre-adjusted edgewise metallic bracket (Ormco Mini 2000, USA.). The nickel-titanium (NiTi) archwires (Dentaurum Super Elastic Ni-Ti Arch wires, Germany.) were used in a sequence of 0.012, 0.014, 0.016, and 0.018 inches as recommended

by the manufacturer and ligated to the brackets by elastomeric O ties. The NiTiarchwires were replaced every four weeks, starting with the smaller diameter and progressing to the larger only when the wires were passive in the bracket slots.

MOPs application

All participants in the MOPs group were instructed to rinse their mouths using 0.12% chlorhexidine mouthwash before the application. MOPs were applied under local anesthesia using 2% lidocaine with 1:100,000 epinephrine before applying the leveling arch wire.

A calibrated periodontal probe was used to obtain bleeding points for proper standardization of the technique and precise location of screw insertion. Two vertical holes were made at an equal distance of 3mm; the first insertion point was 2mm apical to an alveolar crest, then the second point was marked 3mm from the first one. Two vertical perforations of 1.4 mm width and 3 mm depth inside the bone were made using orthodontic mini-screws (Smart Anchor, GNI Corporation, Korea.) with the help of an orthodontic mini-screws driver and rubber stops. The MOPs are 3 mm apart within the attached gingiva and 1 mm apical to mucogingival junction equidistant between upper right canine to upper left canine at every interdental labial alveolar bone except at the midline alveolar bone to avoid trauma to the soft tissue labial frenum (Fig. 1). Post-operatively, the patients were asked to rinse their mouths with 0.12% chlorhexidine twice daily for one week.

Post-operative pain assessment

The patients were asked to record their pain intensity in a pain assessment chart using 10 cm visual analog scale 24 hours, three days, and one week after starting the leveling and alignment. They were asked to mark their pain levels on the 10 cm line, where 0 means no pain and 10 is the worst pain possible. Patients were instructed to return the pain chart during the next follow-up visit to measure the pain intensity each time. They were instructed not to take any NSAIDs, which could hinder tooth movement during the orthodontic treatment [18].

Statistical methods

The level of statistical significance was set at 5%. Statistical analysis was done using R and R Studio software [19,20]. Data organization, manipulation, and summarization were done using the “tidyverse” R package. Continuous data were summarized into mean and standard deviation. The normality of data distribution was explored using the Shapiro-Wilk test function from the “rstatix” R package. The independent t-test was used to compare the two groups at different time points, and one-way repeated measures ANOVA was used to compare each group's time points. Both tests were done using the “rstatix” R package. In case of a significant one-way repeated measures ANOVA, multiple pairwise paired t-tests will be used to check for significant groups.

Results

The Consort flow diagram in Fig.2 shows the participants' flow. Only 30 patients were diagnosed, of which 20 were eligible and enrolled in the trial. Ten patients in each group received either MOPs or none before the arch wire placement for leveling and alignment. No patients were lost to follow-up.

Patients ranged from 13 to 19 years, with a mean age of 15.5 ±2.3 and 16.1 ±2.1 in the intervention and control groups, respectively. There were fewer male subjects than females, with six males in the intervention group and none in the control group.

Tables 1 and 2 show mean pain intensity values for each group at each time point with intergroup and intragroup comparisons. The MOPs group showed higher pain intensity levels than the control groups but with non-statistically significant differences (p-value > 0.05). Pain intensity decreased over time in both groups with statistically significant differences (p-value < 0.05). Multiple pairwise paired t-tests revealed a statistically significant (p-value < 0.05) higher pain intensity mean value at 24 hours than the two other time points in both groups.

Table 1: mean pain intensity values and standard deviation for both groups (intergroup comparison).

Timepoint/Group	MOPs group		Control group		T value	P value
	Mean	SD	Mean	SD		
24 hours	4.6	0.97	4.3	0.82	-0.74	0.46 NS
72 hours	3.4	0.69	3	0.67	-1.31	0.21 NS
Seven days	1.4	0.52	1.3	0.48	-0.447	0.66 NS

NS: non-significant

Table 2: mean pain intensity values and standard deviation for both groups (intragroup comparison).

Timepoint/Group	MOPs group		Control group		F value		P value	
	Mean	SD	Mean	SD	MOPs	Control	MOPs	Control
24 hours	4.6	0.97	4.3	0.82	36	75.4	0.05*	0.01*
72 hours	3.4	0.69	3	0.67				
Seven days	1.4	0.52	1.3	0.48				

*: significant difference

Fig. 1: position of MOPs done using the mini-screws

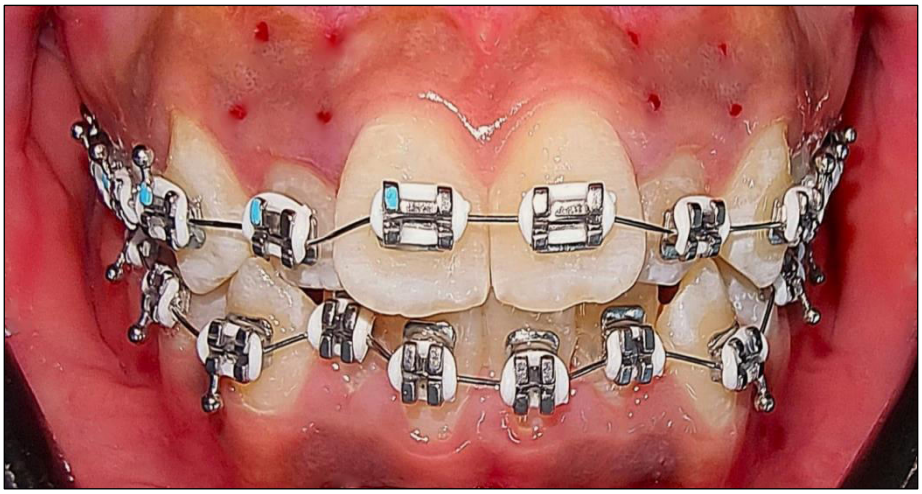
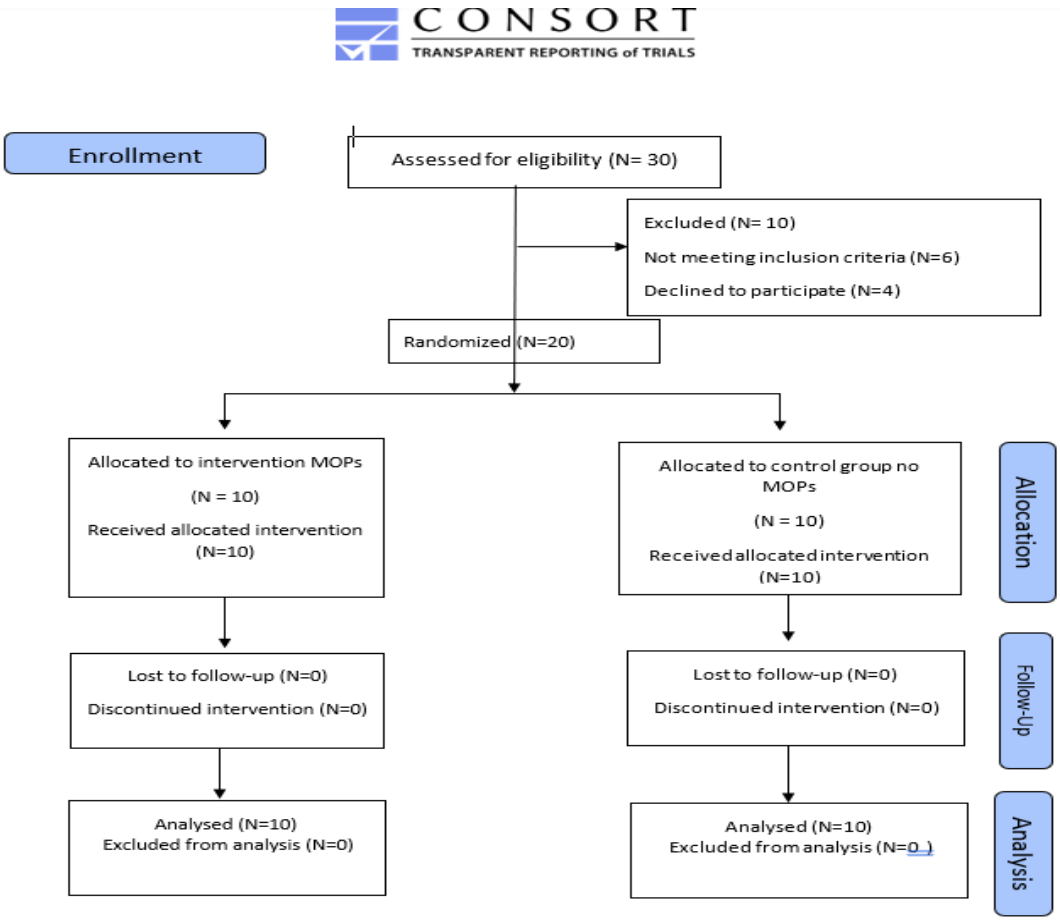


Fig.2: CONSORT flow chart showing the flow of the participants through the trial



Discussion

The first stage of orthodontic therapy involves leveling and alignment, during which highly flexible and round arch wires apply light and continuous forces. These forces may help minimize tissue hyalinization and reduce resorption, but they can also cause pain and discomfort for the patient. [21]. Fixed orthodontic treatment usually takes about 20 months or

more. Patients main concern is shorter treatment times, so the current orthodontic study aimed to find ways to reduce treatment duration. This is particularly important for adult patients who may avoid orthodontic treatment due to the lengthy process [2]. One way to help accelerate orthodontic tooth movement is through surgically assisted acceleration techniques, such as MOPs, which are considered flapless, minimally invasive techniques with minimal tissue trauma [5].
Therefore, this study aimed to evaluate the pain intensity after using MOPs as an adjunctive technique for orthodontic tooth movement acceleration during leveling and alignment of the maxillary crowded anterior teeth.

All patients underwent the same procedures and were fitted with a fixed orthodontic appliance featuring NiTiarchwires of increasing width to level and align their crowded upper anterior teeth. Postoperative pain intensity was measured using a 10 cm VAS scale at 24 hours, three days, and one week, similar to recent studies [12–14].

Regarding intragroup comparisons, pain intensity levels were reduced considerably from one day to one week in each group, which was statistically significant, as shown by the multiple pairwise t-tests. The reduction of pain levels from one day to one week agrees with studies using MOPs for leveling and alignment of crowded anterior teeth as identified by a systematic review [12]. The main findings in this study revealed that pain intensity was higher in the MOPs group than in the control group at all time points as shown in the results of the intergroup comparison. However, this difference was not statistically significant. These results are in disagreement with other recent studies identified in a systematic review that had controversial results [12–15].

In Shahrin et al.'s study [13] contrary to our results and other studies, pain scores were higher in the control group than in the MOPs group at all assessment times. The researchers explained this using the gate control theory, which contradicts pain induction theories associated with the regional acceleratory phenomenon (RAP) due to cytokine release in tooth movement areas [10,22]. These controversial results could be due to the difference in the device used for MOPs. Our study used mini-screws, while the other study used the PROPEL device.

Other studies by Bansal et al. and Faik Sahin et al. [14,15], applied MOPs during leveling and alignment in the mandibular teeth crowding and found significantly higher pain levels in the MOPs group than the control group at 24 hours, which is in partial agreement with our study but with different sites for application. Significantly higher pain levels could be explained by the use of mini-implants in the mandibular anterior segments, which would expectedly cause more pain than using a specifically designed instrument in the maxillary spongy bone [12].

In other studies, [23,24] flapless piezosurgery during the leveling and alignment of crowded mandibular anterior teeth showed no statistically significant differences between the intervention and control groups in one study and a significantly higher pain level in the other. This partially aligns with our study results, although the sites and devices used to accelerate orthodontic tooth movement differed.

A recent systematic review [12] evaluating patient-reported outcomes measures for surgically assisted orthodontic tooth movement acceleration revealed that the certainty of the evidence for studies using MOPs for leveling and aligning crowded anterior teeth was low. This

highlights the need for additional high-quality, well-designed randomized clinical trials focusing on patient-reported outcomes using MOPs.

A recent randomized clinical trial to assess pain intensity levels during orthodontic therapy of Class II malocclusion patients undergoing skeletally anchored maxillary molar distalization assisted with different micro-osteoperforation (MOP) approaches concluded that the repeated application of MOPs on either the buccal side only or on both buccal and palatal sides during maxillary molar distalization did not affect the levels of pain experienced; however, these levels were reported to be higher than that obtained in the control group. Moreover, it is observed that these pain levels tend to gradually reduce to mild levels over the subsequent days. [25]

Conclusion

MOPs, a minimally invasive adjunctive tool for orthodontic tooth movement acceleration, offered promising results with mild to moderate pain levels after their use in leveling and aligning crowded maxillary anterior teeth, which did not differ significantly from the lack of application.

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