International Journal Dental and Medical Sciences Research
Volume 5, Issue 3, May - June 2023 pp 390-396 www.ijdmsrjournal.com ISSN: 2582-6018

Evaluation of two approaches of micro-osteoperforations during orthodontic canine retraction: A prospective clinical study

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Date of Submission: 01-06-2023 Date of Acceptance: 10-06-2023

ABSTRACT:
Objective: The purpose of this split-mouth study was to evaluate the effect of two approaches of micro-osteoperforations (MOPs) on the rate of orthodontic tooth movement.
Material and Methods: 18 patients (10 females, 8 males with a mean age of 16.78 ± 2.22 years in group I and 17.56 ± 2.65 years) in group II who needed fixed orthodontic treatment and extractions of their maxillary first premolars were allocated equally into two groups randomly as follows: Group I, who had MOPs done on one side once only, while Group II who had MOPs done on one side and repeated monthly. Eligibility criteria included: Age range of 15 to 22 years, cases of malocclusion requiring extraction of the maxillary first premolars, good general and oral health, no systemic disease, and no previous orthodontic treatment. The canines were retracted using miniscrews and closed-coil nickel-titanium springs with a 150gm force.
Results: Clinical assessments found no significant difference ($P>0.05$) between the two groups. Although there was an increase in the rate of space closure on the experimental side in both groups during the 1st month ($P\leq0.05$).
Conclusions: Both approaches of MOPs, either single or repeated, revealed an initial accelerating effect regarding the rate of extraction space closure. However, both methods showed comparable rates.
KEYWORDS: Micro-osteoperforation, different approaches, Canine retraction, Orthodontic tooth movement.

I. INTRODUCTION:

Orthodontic patients are very concerned about the length of their treatment[1]. For fixed orthodontic appliances, the typical treatment time is 20 to 30 months. Longer treatment periods have been associated with an increased frequency of dental and periodontal issues such as external apical root resorption, high levels of dental caries, and subsequent gingivitis and periodontitis[2]. Therefore, one of the main goals for all orthodontists is to shorten the length of orthodontic treatment[3].

Orthodontic canine retraction is the step that takes the longest time in premolar extraction cases. Using conventional techniques, the range of canine retraction is from 0.5 to 1 mm/ month, and full canine retraction takes around 5 to 6 months[4].

Currently, Orthodontic tooth movement (OTM) can be accelerated using a variety of techniques to decrease treatment times. These methods are generally designated to surgical and non-surgical approaches. Corticision, piezocision, and MOPs are examples of surgical methods[5].

Micro-osteoperforations were introduced to accelerate OTM that stimulates alveolar bone remodeling without causing surgical injury[6]. This approach was developed after former animal studies revealed that shallow and small perforations in alveolar bone improved tooth movement without the necessity for flap elevation, bone grafting, or suturing[7].Perforations in the alveolar bone stimulated the cytokine pathway, which enhancedosteoclast activity and allowed for improved bone remodeling after orthodontic treatment[7].

Alkebsi et al. demonstrated that MOPs are ineffective in accelerating OTM[8]; hence, the effect of MOPs on OTM remains unclear. On the other hand, systematic reviews of the efficiency of minimally invasive surgical procedures of acceleration, have highlighted the lack of data supporting these operations and the need for more clinical trials[9]. According to the present knowledge, limited clinical data are available concerning the effectiveness of single versus repeated application of MOPs for the acceleration of different OTM, especially canine retraction. Accordingly, it appeared valuable to investigate such an issue.

Specific objectives:

The primary outcome was the rate of extraction space closure measured clinically from the baseline to the first, second, third, and fourth months.

II. PATIENTS AND METHODS:

Study design, sample, and eligibility criteria:

The current split-mouth randomized clinical study was done on a total sample of 18 patients. They were selected from the outpatient clinic of the Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt. Institutional Review Board and Ethical Committee of Al-Azhar University reviewed and approved the study protocol (Approval number 535/1147) and registered on ClinicalTrials.gov (ID: NCT04868721).

According to a previous clinical study[10], a sample size calculation was commenced with G power version 3.1 statistical software based on the following pre-established parameters: 80% power, the sample size for unpaired t-test, significance level (alpha) = 0.05 (two-tailed) taking into consideration differences in tooth movement that are clinically applicable. The anticipated minimal sample needed to have sufficient power to detect a clinical variation would be 18 patients 9 for each group.

Randomization and group allocation:

All patients were randomly divided and allocated into two groups as follows: group I: included 9 patients where MOPs were performed for one time only on one side before retraction. group II: included 9 patients where MOPs were performed on a repeated basis on one side. Each protocol of MOPs was allocated randomly to either the left or right side (split-mouth design). The process of randomization and group allocation was undertaken with coin tosses to prevent selection bias.

Blinding:

Blinding the operator or patient was not possible. However, the investigator was kept blinded to the locations of the MOPs during the analysis step.

Orthodontic appliance:

All patients received fixed orthodontic appliances. Direct bonded pre-adjusted metal brackets utilizing 0.022-in slot (Ormco Corporation, Orange, CA.) from right to left 2nd maxillary premolars, except the maxillary 1st premolars, using light-cured orthodontic adhesive (Grengloo Two-Way Color Change Adhesive, Ormco Corp, Glendora, USA). In addition, the maxillary 1st molars were also directly bonded using single buccal molar tubes with a 0.022-in slot (American Orthodontics, USA) (Fig.1B).

Before the cementation of the orthodontic appliance, each patient was referred to make minimal traumatic extraction of the upper first premolars. Since extraction is regarded as a surgical insult that might increase the inflammatory markers[11,12)]. Leveling and alignment were done in both arches using a sequence of round NiTi wires (Ortho Organizer Super Elastic NitanitumArchwires, USA.), till reaching a final working rectangular 0.016x0.022-in St.St. archwire (Ortho Organizer Stainless Steel Archwires, USA.) for three weeks before retraction of maxillary canine to ensure that the archwire was passive by sliding the archwire through the bracket slots[12,13].

Anchorage preparation:

Miniscrews (AbsoAnchorMicroimplant-Korea 1.6 X 8mm) were inserted between the upper 2nd premolar and 1st molar to be used as direct and indirect anchorage[8,13,14].

Canine retraction phase:

The upper four incisors were ligated using 0.009-in wire in the form of a figure of eight before the canine retraction phase[13,15,16]. The maxillary 2nd premolars were colligated to the maxillary 1st molars with a 0.009-in steel ligature wire on each side[12,17]. Canine retraction was achieved with NiTi closed coil spring (American Orthodontics, Washington Avenue, USA) attached between the head of the miniscrew and the hook of the maxillary canine bracket[13,18]. The canine bracket was ligated by 0.009-in ligature wire to the archwire. The force of the NiTi closed coil spring was measured with a tension gauge (Correx tension gauge, Dentaurum) to produce a force of 150 gm. It was measured at the beginning of the canine retraction and repeated every month to standardize the force of retraction as possible.[13,15,19,20]

Clinical MOPs procedure:[8,12,21,22]

The MOPs were performed immediately before canine retraction. The patients were asked to rinse their mouths with chlorhexidine for 60

International Journal Dental and Medical Sciences Research
Volume 5, Issue 3, May - June 2023 pp 390-396 www.ijdmsrjournal.com ISSN: 2582-6018

seconds. Following that, local anesthesia of 2% lidocaine and 1:100,000 epinephrine was administered. One researcher (B.A.) performed MOPs according to the randomization on either the maxillary right or left side, with the following procedures:

Miniscrews of 1.6 mm diameter and 8 mm length were used at three sites distal to the canine to create three MOPs with a width of 1.6 mm and a depth of 4 mm into the bone. The first insertionsite was 6 mm from the free gingival border, the second point was 5 mm from the first one, and the third position was 5 mm from the second one, at a distance of equal distance between the canine and the 2nd premolar (Fig.1,2). The miniscrew was inserted 4 mm deep into the bone and then removed. The depth of perforation was standardized using a rubber stopper of endodontic files (Fig.1).

Fig 1: An orthodontic miniscrew was used to perform MOPs.In Group I, MOPs were performed once on one side immediatelybefore starting canine retraction, while in Group II, MOPs were repeated every month.

Fig 2: Three MOPs holes were made at an equal distance between the canine and the second premolar.

Clinical measurements:

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. Before starting canine retraction and monthly for 4 months, measurements were taken using a digital electronic caliper (Digimatic Caliper, Mitutoyo, China) to the nearest 0.01 mm (Fig.3)[12,13,18]. All measurements were carried out three times by the same investigator (B.A.), and the mean value was documented.

Fig 3: Direct intraoral measurement of space closure.

Statistical analysis

All measurements were collected and statistically analyzed by Statistical Package for Social Science software for Windows (SPSS, version 25, Inc., IBM Company, Chicago, III, USA). The mean and standard deviation used to define quantitative variables were determined for all variables in both groups, and descriptive statistics such as mean differences, standard deviations, standard errors, and percentage changes in all measures were also calculated. The outcome shows that the data were normally distributed using Shapiro-Wilk (S-W).

III. RESULTS:

All 18 patientshad successfully completed the study's full duration (4 months of canine retraction). The results showed that the rate of extraction space closure was not significantly affected by either method of MOPs. However, during the first month of the orthodontic canine retraction, both approaches of the MOPs technique showed a significant accelerating effect on the rate of extraction space closure.

Analysis of clinical measurements:

Table (1): Descriptive statistics between the differences in the amount (mm) of changes between the intervals every month of space closure in group I (Single MOPs) using Paired t-test.

Table (2): Descriptive statistics between the differences in the amount (mm) of change every month of space closure in group II (Repeated MOPs) using Paired t-test.

Table (3): Descriptive statistics between the differences in the amount (mm) of change every month of space closure between experimental sides in both groups using an independent sample t-test.

Table (1): Group (I): Single MOPs, P=probability level, P-value > 0.05: Non significant, P-value ≤ 0.05: Significant, N=number, SD=Standard deviation, SE= Standard errors, T0-T1= amount of changes of T1, T1-T2= amount of changes of T2, T2-T3= amount of changes of T3, T3-T4= amount of changes of T4, Sig= Significance, NS= Nonsignificant.

Group I	Control side			Experimental side			Difference		95% CI		T-test	P-value	Sig.
	Mean	SD	SE	Mean	SD	SE	Mean	SE	Lower	Upper			
T0-T1	1.244	0.517	0.172	1.678	0.287	0.096	0.433	0.197	0.015	0.006	2.793	0.023	S
T1-T2	1.354	0.354	0.118	1.162	0.416	0.139	-0.192	0.182	-0.578	-0.579	-1.661	0.135	NS
T2-T3	1.008	0.310	0.103	1.103	0.352	0.117	0.096	0.156	-0.236	-0.236	1.029	0.334	NS
T3-T4	0.944	0.535	0.178	1.268	0.584	0.195	0.323	0.264	-0.236	-0.237	1.665	0.135	NS

Table (2): Group (II): Repeated MOPs,P=probability level, P-value > 0.05: Non significant, P-value ≤ 0.05: Significant, N=number, SD=Standard deviation, SE= Standard errors, T0-T1= amount of changes of T1, T1-T2= amount of changes of T2, T2-T3= amount of changes of T3, T3-T4= amount of changes of T4, Sig= Significance, NS= Nonsignificant.

Group II	Control sides (N=9)			Experimental sides (N=9)			Difference		95% CI		T-test	P-value	Sig.
	Mean	SD	SE	Mean	SD	SE	Mean	SE	Lower	Upper			
T0-T1	1.076	0.416	0.139	1.407	0.499	0.166	0.331	0.217	-0.128	0.790	2.663	0.029	S
T1-T2	1.180	0.531	0.177	1.256	0.481	0.160	0.076	0.239	-0.431	0.582	0.296	0.775	NS
T2-T3	1.294	0.449	0.150	1.283	0.358	0.119	-0.011	0.191	-0.417	0.395	0.078	0.939	NS
T3-T4	0.963	0.233	0.078	1.174	0.539	0.180	0.211	0.196	-0.204	0.626	1.374	0.207	NS

Experimental side	Group I			Group II			Difference		95% CI		T-test	P-value	Sig.
	Mean	SD	SE	Mean	SD	SE	Mean	SE	Lower	Upper			
T0-T1	1.678	0.287	0.096	1.407	0.499	0.166	0.271	0.192	-0.136	0.678	1.413	0.177	NS
T1-T2	1.162	0.416	0.139	1.256	0.481	0.160	-0.093	0.212	-0.543	0.356	-0.440	0.666	NS
T2-T3	1.103	0.352	0.117	1.283	0.358	0.119	-0.180	0.167	-0.535	0.175	-1.076	0.298	NS
T3-T4	1.268	0.584	0.195	1.174	0.539	0.180	0.093	0.265	-0.468	0.655	0.352	0.729	NS

Table (3):Group (I): Single MOPs, Group (II):Repeated MOPs,P=probability level, P-value > 0.05: Non significant, P-value ≤ 0.05: Significant, N=number, SD=Standard deviation, SE= Standard errors, T0-T1= amount of changes of T1, T1-T2= amount of changes of T2, T2-T3= amount of changes of T3, T3-T4= amount of changes of T4, Sig= Significance, NS= Nonsignificant.

IV. DISCUSSION

One of the primary issues with orthodontic treatment is its prolonged duration, which leads patients to choose other treatment modalities with unsatisfactory results and negative side effects. The present in-vivo split-mouth study was performed to evaluate two approaches of MOPs during orthodontic canine retraction. The repeated MOPs were based on the rationale that increasing surgical insult will enhance osteoclastic activity, which could reinduce the RAP and the acceleration[23].

Regarding the effect of MOPs, the highest significant rate of space closure was observed during 1st month on the experimental side as compared to the control side in both groups, although there are no significant differences between the two experimental sides in both groups (P>0.05).

There was no significant difference between the experimental and control sides in either group in the second, third, or fourth month of the current study (P>0.05). These results concur with those of Alkabsi et al. and other studies[8,12,14,22,24–27], which found no significant accelerated clinical effect of MOPs on the rate of extraction space closure.

The lack of a significant increase in the rate of OTM in these studies and in the current study could be explained by the negligible surgical insult of MOPs, which may not be sufficient to cause a major inflammatory reaction. It can also be considered that the inflammatory reaction caused by MOPs on one side can cross over to the contralateral side in a split-mouth design [8,22,24,25,27].

Alikhani et al. disagreed with the findings of our study, which showed that MOPs significantly accelerated the distal canine movement by 2.3 times. The randomization by Alikhani et al. was unclear, with a shorter period of only 28 days of study as against ours, which continued for 4 months of canine retraction. Also, the use of the lateral incisors as reference points was also critical due to the risk of lateral incisor movement during canine retraction[6].

Agrawal et al., also against our results, reported a significant increase in the rate of tooth movements. Both buccal bone corticotomy and flapless MOPs assisted orthodontic treatment techniques to cause an increase in canine retraction in a short period of time. MOPs being a flapless procedure, allow clinicians to deliver efficient orthodontic care[28].

Feizbakhsh et al.[10], Shaheed et al.[29], and Attri et al.[30], reported similar results to Alikhani et al.[6], after measuring the rate of canine retraction. Results showed that MOPs increased the rate of canine retraction by more than 2-fold. Moreover, Abdelhameed et al., reported a 1.6 times acceleration in the rate of canine retraction than the control group[18].

In accordance with the current findings of the repeated MOPs, Haliloglu-Ozkan et al[31]. showed non-significant findings in the repeated MOPs group may be because of the reduced depth of perforation.

The controversy observed between the results of previous studies can be attributed to the intensity of the trauma caused by the perforation which may be a significant factor in the findings' variability. Higher OTM acceleration results from increased osteoclast activity and pro-inflammatory markers expression following more severe trauma[32].Other causes for this debate might be the differences in surgical approaches, tooth movement mechanics, OTM measuring methods, and measurement reference points.

Jaiswal et al.[33] contradicted the findings of the current study. They reportedan increase in the rate of tooth movements in the two-time intervention of MOPs by 25% than the one-time. Those results may be attributed to the increased depth of perforation.

V. CONCLUSION:

Both approaches of MOPs, either single or repeated, revealed an initial accelerating effect regarding the rate of extraction space closure. However, both methods showed comparable rates.

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