Original Research

Effect of micro osteo-perforations (MOP) on the rate of tooth movement and levels of interleukin-1β – a split mouth study

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Abstract

Introduction. Various procedures are available today to enhance tooth movement, with relative success rates, one among them being micro osteo-perforation (MOP). Our aim is to assess the rate of tooth movement and interleukin-1β levels in gingival crevicular fluid levels (GCF) after MOPs.

Methods. A group of 22 patients were selected, who required first premolars extraction and were designated for the split mouth study with equal allocation. MOP was performed on the right side, three vertical MOPs were given using 1.2 X 8 mm mini implants with the gap of 2 mm between them and surgical depth of the implant insertion was 5 mm. The left side was used as control. The individual canine retraction was initiated with placement of 150 grams on 19*25 SS wire. The case was evaluated at different timelines for canine retraction and interleukin-1β levels.

Results. There was a significant difference in the rate of canine movement at 45 days (1.42 mm) and end of canine retraction on experimental side (2.61 mm). The GCF levels were raised at T1 and T2 intervals on the side of MOP and were statically significant (p=0.00).

Conclusion. MOP is a minimally invasive procedure which accelerates the tooth movement by 20%. The increase in IL-1β levels indicates a higher rate of chemical interaction on the surgically assisted side. For enhanced efficiency MOPs should be repeated every 6-8 weeks.

Keywords: micro osteo-perforations, MOP, tooth movement, rapid tooth movement, interleukin-1β

Introduction

The treatment duration is a deterrent for patients who need orthodontic treatment. Numerous attempts have been made to reduce the duration of orthodontic treatment and complications associated with prolonged treatment. With optimal orthodontic forces, the biological rate of tooth movement is 1 mm per month [1]; considering this rate, canine distalization usually takes 6 to 9 months in cases of maximum anchorage, leading to a gross extension of treatment time.

On the grounds of slow metabolism and diminished expression of inflammatory markers in adults, tooth movement is slower compared to younger individuals [2]. Interleukin-1β (IL-1β) is a potent biomarker which stimulates bone resorption and induces osteoclast proliferation. Multiple studies have reported a spike in the levels of IL-1β in GCF during orthodontic tooth movement [3,4]. Hence, it is mandatory to establish the link between the accelerated tooth movement and IL-1β levels.

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Various techniques such as periodontally accelerated osteogenic orthodontics (PAOO) [5], rapid canine distraction [6,7], piezocision [8], micro osteo-perforations (MOPs) [9,10], interseptal bone reduction [11] etc. have been proposed by various authors to intensify the naturally coupled bone remodeling pathways that are activated by orthodontic forces. The principle behind this is that when bone is agitated surgically, a regional acceleratory phenomenon (RAP) [12] is initiated.

Micro osteo-perforation is a safe, minimally invasive, and cost-effective technique which holds advantage over the traditional invasive techniques. Alikhani et al. [9,10] in their study affirmed that MOPs significantly increased the rate of tooth movement by 2.3 folds without any significant pain or discomfort during or after the procedure. To decrease the inventory and to make the procedure cost effective mini implants were utilized for the surgical procedure rather than PROPEL™ as advocated. The current study was focused to evaluate the long term effect of micro osteo-perforations and its effect on gingival crevicular fluid levels of interleukin1β.

Alkebsi et al. demonstrated that MOPs were not effective for accelerating OTM. Hence, the effect of MOP on orthodontic tooth movement still remains indistinct. Therefore, the primary aim of the current study was to evaluate the effect of MOPs on the rate of OTM in a canine retraction model. The secondary outcomes were the effect of the MOPs on levels of interleukin1β in gingival crevicular fluid. The Null hypothesis (H0) of this research was that MOPs do not have any influence on the rate of tooth movement.

Methods

The study was approved by Ethical Committee of AME's Dental college and Hospital (AME/DC/10/11/2017). Twenty two female patients were randomly selected from the Department of Orthodontics, AME Dental College. Patients were enrolled according to the inclusion and exclusion criteria listed in table I. Only female patients were included into the study to avoid gender bias. The study was a split mouth design; the experimental side was allocated by randomization. All patients received appropriate oral hygiene instructions.

Table I. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Age 18-25 years	Chronic medical conditions/ medication
Female patients	Poor oral hygiene
Good oral hygiene	Smoking
No. evident bone loss	Bone loss in radiographs
1st premolar extraction	

Sample size was calculated taking power of 80% (1-β), level of significance at 5% (α error, p≤0.05) and confidence interval 95%. Sample was 20. To cover attrition in study extra 10% sample was added, final sample was 22.

Interventions

All subjects were bonded with M.B.T prescription 0.022″ slot bracket system (Ortho Organisers). After initial alignment with working wire 0.019 x0.025" S.S wire, self-drilling temporary anchorage devices (TADs) (Unitek™ TAD, 1.8 × 8 mm) were placed buccally between upper 2nd premolar and first molar bilaterally. After 1 month on working wire just before retraction MOPs were performed on experimental side. Right side of the patients were designated as experimental side.

After disinfecting the area with betadine, the MOPs were performed under local anesthesia using a TAD (Unitek™ TAD, 1.8 × 8 mm). The TAD was screwed slowly into the alveolar bone, perpendicular to the surface, till slight blanching of the surrounding soft tissue was obtained to ensure full-length penetration of the TAD, then the TAD was unscrewed and removed (Figure 1). All the surgical procedures were done by one operator.

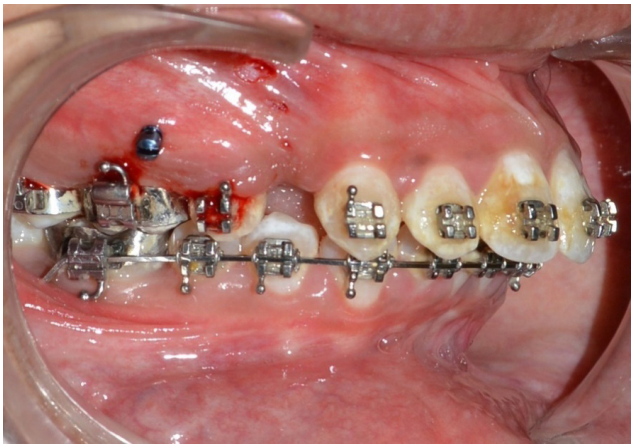

Figure 1. Three MOPs placed distal to canine on the experimental side with 2 mm gap between them. 1.2 × 8 mm implants placed between 2nd premolar and 1st molar.

Canine retraction was then commenced using NiTi closing coil springs applying 150 g extended between the TAD and canine hooks. Force was standardized with Dontrix gauge (Figure 2). To measure canine retraction

Alginate impressions were taken as follows:

1. Immediately before retraction,
2. 45 days of retraction,
3. After complete retraction experimental side.

Impressions were immediately poured up with Orthokal dental stone and casts were labelled with patient's number, date and stored.

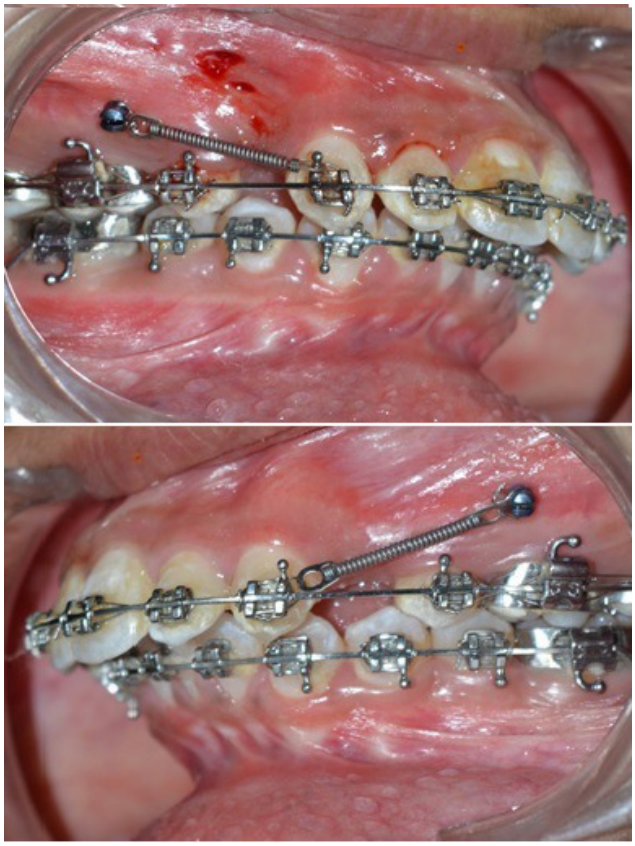

Figure 2. Canine retraction done with NiTi Closed coil spring by applying 150 gms of force.

Cast measurements

Alginate impressions were taken at the beginning of the study, immediately before canine retraction, and subsequent intervals at 45 days and end of canine retraction. The impressions were immediately poured up with Orthokal dental stone and casts were labelled with the patient's number, date and stored.

Vertical lines were drawn on the long axis of canine and lateral incisors to measure the distance between them at the incisal point to assess the tooth movement before and after canine retraction. All cast measurements were made using a digital Vernier calliperby one operator who was blinded about the study.

GCF collection and preparation

GCF samples were collected from each subject to evaluate the levels of IL-1β levels. Samples were collected after micro osteo-perforations, 1. To – immediately before the start of canine retraction; 2. T1 – 3rd day of retraction; 3. T2 – 7th day, T3 – 30 days of retraction.

The patients were asked to gargle vigorously with sterile water to cleanse the oral cavity. The cheek retractor was placed, and sites were isolated and dried using cotton rolls. The micropipette was placed extra crevicularly and 1 µL of GCF was collected from distal side of canine on both sides (Figure 3). Quantitative analysis of IL-1β in the GCF samples was assessed using a commercially available ELISA test (Raybiotech® Human IL-1β and Human PGE2).

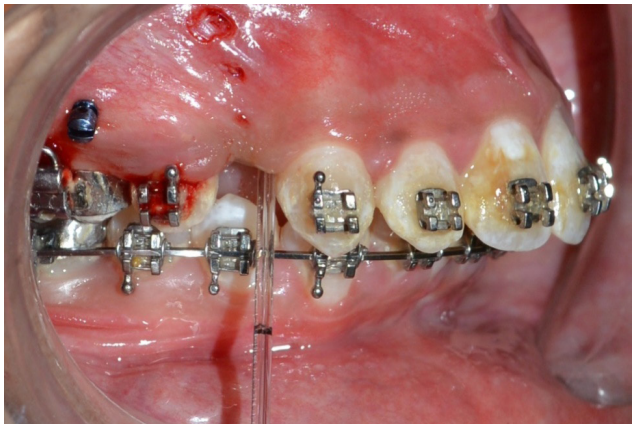

Figure 3. GCF collected from distal side of canine on both experimental and control side. 1 µl of GCF was collected with the help of micro pipette.

Statistical analysis

The statistical analysis was performed using SPSS® 22.0 (SPSS Inc. Chicago, III). Results of continuous measurements are presented as mean±SD (Min-Max). t tests were used to compare the two groups.

Results

The mean distance between the long axis of canine and lateral incisors at the incisal point initially was 7.78±0.45 mm on both the sides. The first observation was made at 45 days after force application. The mean distance on the experimental side was more (10.31±0.55 mm) when compared with the contralateral side (8.89±0.48 mm). Complete canine retraction on the experimental side was accomplished in 114.5±9.5 days. The mean distance between the long axis of canine and lateral incisors after the canine contacted the second premolar was 12.92±0.30 mm while at the same time on the control side the canine was still in the middle of the extraction space (10.31±0.46 mm) (Figure 4 A-C, Table II).

Inter group comparison of the mean levels of IL-1β from GCF at the beginning of the retraction (0.170±0.06 pg/µl), 3 days (0.750±0.09 pg/µl), 7 days (0.510±0.07 pg/µl) and after 2 months of retraction (0.150±0.05 pg/µl) was found to be higher on the experiment side when compared with the contralateral side. On that account, a statistically significant mean difference in the level of IL-1β from GCF after 3 days and 7 days of retraction between experiment and control side was seen (Table III).

Table II. Evaluation of distance between the long axis of canine and lateral Incisor.

	[Mean ±SD] (mm)		Mean Difference (mm)	p
	Experimental Side	Control Side		
Starting	7.780±45.17	7.680±25.17	0.10	-
45 days	10.310±0.55	8.890±0.48	1.4200	0.00*
After complete retraction	12.920±0.30	10.310±0.46	2.6100	0.00*

*Statistically significant, p<0.05

Table III. Comparison of the mean level of Interleukin-1β from GCF.

	[Mean ± SD] (pg/µl)		Mean Difference (pg/µl)	p
	Experimental Side	Control Side		
Beginning of retraction	0.170±0.06	0.150±0.05	0.02	0.47
After 3 days of retraction	0.750±0.09	0.280±0.07	0.47	0.00*
After 7 days retraction	0.510±0.07	0.150±0.05	0.36	0.00*
After 1 month of retraction	0.150±0.05	0.140±0.05	0.01	0.67

*Statistically significant, p<0.05

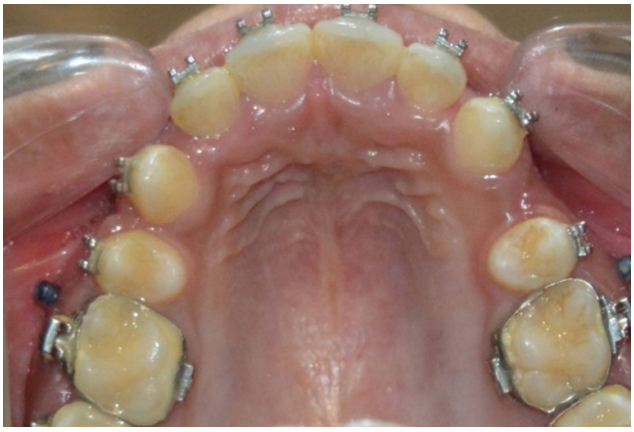

Figure 4A. Occlusal view before canine retraction.

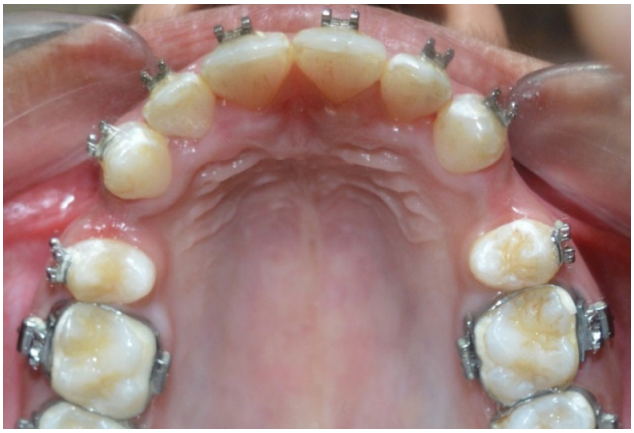

Figure 4B. Occlusal view at 45 days after canine retraction.

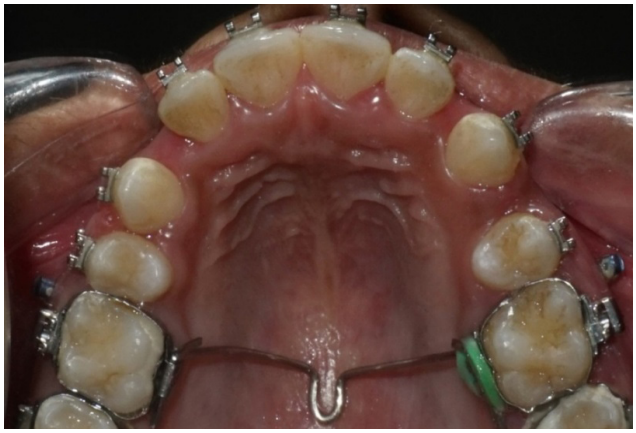

Figure 4C. Occlusal view after complete canine retraction on the experimental side.

Discussion

The recent focus of the orthodontist is to shorten the overall treatment time, with fewer complications and more compliance and satisfaction from the patient. Different approaches have demonstrated enhanced rate of orthodontic tooth movement. While the search for more viable approaches continued, Alikhani et al. [9,10] in 2013 proposed a new effective, comfortable, safe and minimally invasive technique called MOPs. They affirmed that MOPs significantly increased the rate of tooth movement by 2.3-fold without any significant pain or discomfort during or after the procedure.

The current study was carried out on twenty maxillary canines of 10 patients with split mouth design. It is factual that age plays a major role in the rate of tooth movement; hence to rule out the impact of age factor, subjects with the age range of 18-30 years were included in the study [14]. Instructions regarding oral hygiene maintenance were given prior to the start of the study [15]. A detailed medical history of the subjects was done before including them in the study, because many systemic diseases and drugs are known to decelerate the tooth movement [16,17].

Regional acceleratory phenomenon (RAP) [12] associated with extractions was ruled because the extractions were done one week in advance of the initiation of the treatment. The arches were aligned and levelled followed by individual canine retraction with MOPs performed on the experimental side. A mean difference of 1.42 mm was registered after 45 days of force application and 2.61 mm at the time of completion of canine retraction on the experimental side. Statistical analysis validated that the accumulated extent of canine retraction was significantly higher on the experimental side than that of the control side throughout the experimental period. The difference in the rate of canine tooth movement is attributed to the duration and magnitude of RAP [12] which is known to increase the bone turnover rate. The results of the present study were in accordance with the study published by Alikhani et al. [9,10], where they assessed the effect of MOPs on the rate of tooth movement. The difference in the aggregate of canine movement was clinically appreciable.

Nicozisis J [18] outlined the benefits of using the PROPEL™ System in MOPs as reduced treatment time, greater patient satisfaction, and increased efficiency; however the present study subjected MOPs using an implant driver which is more accessible, handy and inexpensive, nonetheless, providing results which are congruent with that of PROPEL™.

Cheung et al. [19] demonstrated an increase of 1.86-fold in the rate of tooth movement in rats, when used an automated mini-implant driver to perform MOPs and concluded that Mini-implant–facilitated MOPs will shorten orthodontic treatment time with improved patient acceptance.

A credible explanation for the increased rate of canine movement following intervention with MOPs is because it escalates body's natural inflammatory response which in turn increases the expression of inflammatory markers leading to increased rate of bone remodeling. The increased level of IL-1β is an indicator of histological and biochemical changes which represent the bone turnover. Thus monitoring the activity of IL-1β in the GCF could be suggestive of the tissue changes occurring during orthodontic tooth movement [20].

The levels of IL-1β elevated after MOP on experimental side which were statistically significant. Elevated levels IL-1β of resulted in the increased bone remodeling on the experimental side that in turn accelerated the rate of tooth movement. While in the control side the levels remained at the baseline throughout the study period further suggesting the direct relationship between the MOPs and the levels of IL-1β.

The results of our study were in agreement with the study conducted by Alikhani et al. [9,10] in 2013 and 2015, where they found significant increase in the expression of cytokines and chemokines such as CCL-2 (MCP1), CCL-3, CCL-5 (RANTES), IL-8 (CXCL8), IL-1ă, IL-1β, IL-6, and TNF-ă following MOPs. They reported a significant increase in the levels of IL-1β after 24 hours in both the control (2.4 folds) and experimental (8.0 folds) groups, when compared with their levels before retraction.

Similarly Teixeira et al. [21] in 2010 in their animal model hypothesized that small perforations of cortical bone stimulates the expression of inflammatory cytokines, which increases the rate of bone remodeling and tooth movement. His investigation demonstrated increase in the expression of various cytokines, chemokines, and inflammatory receptors including interleukins in the experimental group. The results of this study were consistent with the present study.

Uematsu et al. [3] in 1996 studied twelve patients who required retraction of individual canine. Concentrations of IL-1β were significantly higher in the experimental group than in the controls at 24 hours after the experiment was initiated. He concluded that the increased cytokines levels were directly associated with bone remodeling.

The duration of the RAP may vary with different surgical techniques depending on the extent of invasiveness. Since the MOPs are minimally invasive and it is has been established that RAP phenomenon decreases over time, sequential MOPs were done in the present study to prolong the effect.

The results from the present study demonstrated long term benefits of mini implant assisted MOPs. This technique was as effective as PROPEL™ device in delivering the anticipated treatment results. There was no documented post-operative discomfort or pain during the course of the study.

Regardless of the accelerated pace of canine movement, other factors such as, root resorption, pulpal vitality, and stability over the conventional technique and periodontal defects were not investigated in the study. Further studies should include a larger sample which will allow the analysis of aforementioned factors.

Hence the Null hypothesis is rejected as MOPs were able to induce biological reaction which enhances rate of tooth movement.

Conclusion

Micro osteo perforation is a simple, effective and minimally invasive technique, which is capable of increasing tooth movement which is clinically and statistically significant. Time duration for canine retraction is reduced to 3-4 months

The increased GCF levels of IL-1β on the experimental side indicates that micro osteo perforation induces a biological reaction which lasts for more than 4 weeks. The biological reaction was actually complementing the increase in tooth movement after MOP. Hence, for enhanced efficiency the procedure can be repeated every 6-8 weeks.

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