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TO EVALUATE THE EFFECT OF NUMBER AND FREQUENCY OF MICRO OSTEOPERFORATION ON RATE OF CANINE RETRACTION: A SINGLE CENTER, SPLIT MOUTH RANDOMIZED CONTROL TRIAL

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ABSTRACT
One of the main issues with conventional fixed orthodontic treatment is its long duration, leading the patients to choose alternative therapeutic approaches with compromised results and adverse effects. Propel is an appliance which is designed to apply alveocentesis procedure. The primary outcome of this study is to evaluate the effects of frequent MOPs and increased number of MOPs on the rate of canine retraction and the secondary outcome is to record the pain perception in the patients mouth following the MOP procedure. The study was carried out to compare and evaluate the effect of number and frequency of MOPs on rate of canine retraction as well as pain perception after performing MOPs. The patients were equally divided into two experimental groups, namely, the MOP1 and MOP2 group. Computer-generated random numbers were generated using Microsoft Office Excel 2007 sheet by a person who is not a primary investigator for the study. The patient's right side was randomly assigned to either the MOP or control groups. The response from the participants were obtained during the first visit after the MOP procedure. Statistical analysis of the present study was done using Statistical Package for the SocialSciences- SPSS version 22. Our study successfully evaluated the rate of tooth movement using MOP by increasing the number and varying the frequency on every 4th,8th and 12th week and as a result the rate of tooth movement increased significantly. Hence, MOPs can be incorporated into routine orthodontic mechanics and at different stages of treatment, facilitating alignment and root movement, stimulating bone remodeling in areas of deficient alveolar bone, and reducing the stress on anchor units. Hence, MOPs offer a practical, minimally invasive, and safe procedure that can be repeated as needed to maximize the biological response to orthodontic forces.
Key words: Canine, Osteoperforation

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INTRODUCTION

One of the main issues with conventional fixed orthodontic treatment is its long duration, leading the patients to choose alternative therapeutic approaches with compromised results and adverse effects[1].

Many orthodontic patients complain about the physical and social discomfort which is associated with prolonged use of fixed appliances[2]. There are also numerous studies which report that dental and periodontal complications such as apical root

resorption, subsequent gingivitis, periodontitis, enamel demineralization, increased levels of dental caries, and open gingival embrasure spaces may occur during prolonged orthodontic treatment[3].

Thus, a major challenge in orthodontics is to shorten treatment time by avoiding undesirable side effects without compromising treatment outcome. The rate of orthodontic tooth movement is primarily determined by the remodelling of tissues surrounding the roots; this in return is under the control of molecular mechanisms regulating cellular behaviours in the alveolar bone and periodontal ligament[4]. Assuming that the clinician optimized mechanics and cooperation for any patient, themain factor controlling the treatment time and rate will be the patient's biological response to the orthodontic forces[5].

In an attempt to shorten this duration of treatment many surgical and non-surgical procedures have been advocated in recent times[6]. The nonsurgical interventions include self-ligating brackets, custom made brackets and wires, medications, injection of cell mediators, low-level laser and photodynamic therapy, electromagnetic fields, and low-intensity highrate vibrations[7]. Surgical methods, such as osteotomies, corticotomies with or without bone grafts, and less invasive techniques, including piezocisions, piezopuncture, and micro-osteoperforations (MOP) have been used to stimulate the natural mechanisms of the bone remodelling by raising the levels cytokines locally induced by microtrauma within the bone and the PDL which in turn increase the rate of tooth movement[6,8].

Corticotomy-assisted orthodontic treatment increases bone remodelling which accelerates recovery and repair mechanisms and tooth movement rate accordingly by creating a mechanical trauma in cortical bone[9]. Although corticotomy-assisted orthodontic treatment was reported to be an efficient method in accelerating tooth movement, the significance of removing flaps is also stated to cause important postoperative complications[10].

Piezoincision technique, which is a minimally invasive technique that includes piezoelectric incisions without removing flaps, was developed in order to overcome these disadvantages[11].Piezoincision is known to be an effective method for acceleration of tooth movement but it was reported to have high risks of damaging tooth roots[12].Surgery-assisted techniques are invasive with disadvantages such as bone loss, postoperative pain, edema and infection, avascular necrosis besides low acceptance rates by the patients[13].

Based on this, the hypothesis that small osteoperforations on cortical bone without removing flaps will increase bone remodelling and tooth movement rate accordingly bys timulating release of inflammatory cytokines minimizing these disadvantages was developed. Micro-osteoperforation is an up-to-date procedure which is promoted as an auxiliary dentoalveolar procedure which can accelerate tooth movement via minimum surgical intervention[14].

Propel is an appliance which is designed to apply alveocentesis procedure. The foremost part of the device which is like an orthodontic stainless steel screw is patented, allowing perforation of alveolar bone traumatically over keratinized gingiva and moving mucosa. Contrary to other rotatory devices, Propel was reported to have a slight effect on soft issue[15].

While it is not always possible to create homogenous perforations of same size using micro-osteoperforation methods such as round burs, Propel device which is designed in order to form MOPs has not included in routine clinical use yet. Thus, mini-implants are considered more advantageous than other methods as they are included in clinical routine and frequently used by orthodontists for different purposes and easily tolerated by the patients[16].

Aksakalli et al.[17] applied three micro-osteoperforations distal to the canine teeth with miniscrews just before canine distalization period. In their case report, they reported that MOP method with miniscrews accelerated canine distalization in their 14-year-oldmale patient with class II malocclusion by almost 1.5-fold and also without harmful effects on root and periodontal structures.

About number of perforations, a recent study has shown increase in rate of tooth movement by doing 6 MOPs (3 buccal and 3 palatal) as compared to 3 MOPs done on buccal side. In a study on beagle dogs it has been shown that effect of MOPs lasts till around 2-3 weeks18. But there are no human studies that have assessed the effect of frequent and increased number of MOPs on rate of individual tooth movement. Thus, the primary outcome of this study is to evaluate the effects of frequent MOPs and increased number of MOPs on the rate of canine retraction and the secondary outcome is to record the pain perception in the patients mouth following the MOP procedure.

MATERIALS & METHODS

The study was carried out to compare and evaluate the effect of number and frequency of MOPs on rate of canine retraction as well as pain perception after performing MOPs. In accordance with a previous study by Alikhani[5], the sample size was determined based on the mean rate of canine retraction (0.67 ± 0.34). The main assumptions were; a canine retraction rate of 0.6mm per month (50% increase), 5% probability of a type I error, and 80% statistical power. Furthermore, on account of using mini-screw as an anchor unit, the amount of canine movement on one side could be considered completely independent from the contralateral side. Accordingly, a sample size of 10 per group is calculated for the present study. Randomization (random number generation, allocation concealment, implementation). The patients were equally divided into two experimental groups,

namely, the MOP1 and MOP2 group. Computer-generated random numbers were generated using Microsoft Office Excel 2007 sheet by a person who is not a primary investigator for the study. The patient's right side was randomly assigned to either the MOP or control groups. The numbers of the subjects were kept in opaque sealed envelopes until the commencement of canine retraction. On the day of MOP procedure, subjects were allowed to choose one of the envelopes to detect their number in the randomization sequence and thus detect which was the MOP side. As a part of the routine orthodontic diagnosis and treatment planning phase, all potential patients fulfilling inclusion and exclusion criteria were assessed and referred for premolar exaction as a part of fixed orthodontic treatment. To negate mesial molar movement, a micro-implant (Ortholution, Korea,1.8 × 8 mm) was placed buccally between upper 2nd premolar and first molar bilaterally. The leveling and alignment phase of the treatment were initiated with bonding fixed appliances in both arches (MBT prescription with 0.022-in.; Leone, USA) by the same orthodontist. Four weekly sequences of 0.014-in., 0.016 x 0.022 in. nickel-titanium followed by 0.016 × 0.022-in. and 0.019 x 0.025 in. stainless steel (SS) working archwire (Stainless Steel; G & H Orthodontics, USA) were performed. After aligning and leveling and minimum four months after premolar extractions first set of alginate impressions for the study was taken and immediately poured with plaster. The casts were labeled with the patient's code and date. After taking first set of records MOPs were performed according to the scheduled intervals of the 2 different groups. For first group (MOP1) at the experimental site, 6 MOPs (3 buccal and 3 palatal) were made directly at extracted first premolars sites, at equidistance from the canine and second premolar under local anesthesia. The MOPs were 2 mm apart in vertical direction and 3 mm in depth. The first MOP were placed starting at the horizontal level of the cervical margin of the canine tooth and extending apically. The Orlus Extra Thread Mini-Implant (Ortholution, Seoul, Korea), 1.6 mm in width and 6 mm in length with a rubber stopper at a measured length(depth of MOP at 3 mm plus soft tissue thickness measured using probe) was used to perform MOPs. For second group (MOP2) the experimental side received 2 MOPs on buccal cortical bone at same position as for group1 (MOP1). MOP2 group received MOPs 3 times with 4 weekly intervals. For both the groups set of plaster models were made at four points in time (baseline T0, 4 weeks T1, 8 weeks T2 and 12 weeks T3). For the canine retraction, a calibrated 150 g NiTi closed coil spring (American Orthodontics, USA) were used, which were connected from micro-implant placed between 1st molar and 2nd premolar to canine hook. The participants were instructed to avoid the use of anti-inflammatory medication and only take acetaminophen if needed. To study the amount of canine retraction, vertical lines were drawn on the scanned image (using EPSON Dual Lense scanner) of the cast over the palatal surface of the canine and lateral incisor from the middle of the incisal edge to the middle of the cervical line. The measurements were done using Adobe Photoshop CS2 measuring tool. Before and after canine retraction, the distance between the canine and the lateral incisor was assessed at three points (incisal, middle, and cervical thirds of the crowns) at different time intervals (T1, T2, and T3). To assess the amount of pain associated with the MOPs, the patients were asked to mark the level of pain and discomfort on each side of the maxilla, both on the day of canine retraction and 24 hrs. later, using a visual analog scale (VAS). VAS is a 10 cm line scaled from 0 (no pain) to 10 (the worst possible pain). The response from the participants were obtained during the first visit after the MOP procedure. Statistical analysis of the present study was done using Statistical Package for the SocialSciences-SPSS version 22.

RESULTS

It was found that the mean MOP at baseline (T0) was 6.40 in group A and 6.57 in group B. The difference in mean MOP at baseline was statistically not significant as p-value was >0.05, analysed using Students-T test. Similarly, at one month time interval (T1) the mean MOP was 7.61 and 6.98 in experimental group 1 and control group 1respectively and the difference was statistically not significant. The mean MOP at T2 was8.04 and 7.31 in group A and group B respectively and that at T3 was 8.26 and 7.53 in group A and group B respectively. The difference in MOP between group A and group B was statistically not significant at T2 as well as T3. Overall, the results showed that the difference in MOP between groups A and B at the incisal third was not significant at any time interval from baseline to three months. It was seen that the mean MOP at baseline (T0) was 6.06 in group A and 6.00 in group B; whereas, it was at T1 was 7.01 and 6.44 in group A and group B respectively. The difference in mean MOP between groups A and B was statistically not significant at T0 as well as at T1 time intervals as p-value in both cases was >0.05, analysed with Students-T test. However, the mean MOP in the middle third at T2 was 7.58 in group A and it was 6.71 in group B and the mean difference was statistically significant with p-value0.014. Similarly, the mean MOP at T3 was 7.76 and 6.88 in group A and group B respectively and the difference was statistically significant wit p-value 0.016 when analysed applying Students-T test. Therefore, the above results show that the difference in mean MOP between group A and B in the middle third was not significant at baseline and at one month interval; however, the mean MOP was significantly higher in group A as compared to group B at two months and three month time intervals. The mean MOP in cervical third was 5.77 and 5.58 in groups A and B at the

baseline (T0);whereas, it was 6.71 in group A and 5.99 in group B at one month (T1) time interval. However, the difference in mean MOP at cervical third between groups A and B at T0 as well as T1 was statistically not significant. At the two month (T2) time interval the mean MOP was 7.16 in group A and 6.45 in group B, the difference was statistically significant with p-value 0.033. The mean MOP in the cervical third at three month (T3) time interval was 7.34and 6.45 in group A and group B respectively, also the difference in group A and B was statistically significant with p-value 0.028 analysed using Students-T test. The results at cervical third show that the difference in mean MOP was not significant at baseline and one month time interval. However, at two month and three month time intervals the mean MOP was significantly higher in the experimental group 1 (group A) as compared to the control group 1 (group B). It was found that the mean MOP at baseline (T0) was 6.37 in group C and 6.42 in group D. The difference in mean MOP at baseline was statistically not significant as p-value was >0.05, analysed using Students-T test. Similarly, at one month time interval(T1) the mean MOP was 6.99 and 6.55 in experimental group 2 and control group 2respectively and the difference was statistically not significant. The mean MOP at T2 was7.63 and 6.81 in group C and group D respectively and that at T3 was 8.13 and 7.09 in group C and group D respectively. The difference in MOP between group C and group D was statistically not significant at T2 as well as T3. Overall, the results showed that the difference in MOP between groups C and D at the incisal third was not significant at any time interval from baseline to three months. It was seen that the mean MOP at baseline (T0) was 6.04 in group C and 6.16 in group D; whereas, the same at T1 was 6.65 and 6.27 in group C and group D respectively. The difference in mean MOP between groups C and D was statistically not significant at T0 as well as at T1 time intervals as p-value in both cases was >0.05, analysed with Students-T test. Further, the mean MOP in the middle third at T2 was 7.26 in group Cand it was 6.27 in group D and the mean difference was statistically not significant as p-value was >0.05. Similarly, the mean MOP at T3 was 7.75 and 6.83 in group C and group D respectively and the difference was statistically not significant. Therefore, the above results show that the difference in mean MOP between group C and D in the middle third was not significant at any time interval from baseline to three months. It showed that the mean MOP in cervical third was 5.89 and 5.93 in groups C and D respectively at the baseline (T0); whereas, it was 6.46 in group C and 6.12 in group D at one month (T1) time interval. However, the difference in mean MOP at cervical third between groups C and D at T0 as well as T1 was statistically not significant. At the two month (T2)time interval the mean MOP was 7.04 in group C and 6.38 in group D, the difference was statistically not significant. The mean MOP in the cervical third at three month (T3) time interval was 7.54 and 6.67 in group C and group D respectively, also the difference in group C and D was statistically not significant with p-value & gt; 0.05 analysed using Students-T test. The results at cervical third show that the difference in mean MOP between experimental group 2 and control group 2 was not significant at any time interval from baseline to three months. It was found that the mean MOP at baseline (T0) was 6.40 ingroup A and 6.37 in group C. The difference in mean MOP at baseline was statistically not significant as p-value was >0.05, analysed using Students-T test. Similarly, at one month time interval (T1) the mean MOP was 7.61 and 6.99 in experimental group 1 and experimental group 2 respectively and the difference was statistically not significant. The mean MOP at T2was 8.04 and 7.63 in group A and group C respectively and that at T3 was 8.26 and 8.13 ingroup A and group C respectively. The difference in MOP between group A and group C was statistically not significant at T2 as well as T3. Overall, the results showed that the difference in MOP between the two experimental groups (1 and 2) at the incisal third was not significant at any time interval from baseline to three months. It was seen that the mean MOP at baseline (T0) was 6.06 ingroup A and 6.04 in group C; whereas, the same at T1 was 7.01 and 6.65 in group A and group C respectively. The difference in mean MOP between groups A and C was statistically not significant at T0 as well as at T1 time intervals as p-value in both cases was >0.05, analysed with Students-T test. Further, the mean MOP in the middle third at T2 was 7.58 ingroup A and it was 7.26 in group C and the mean difference was statistically not significant as p-value was >0.05. Similarly, the mean MOP at T3 was 7.76 and 7.75 in group A and group C respectively and the difference was statistically not significant. Therefore, the above results show that the difference in mean MOP between the two experimental groups (group A and group C) in the middle third was not significant at any time interval from baseline to three months. It showed that the mean MOP in cervical third was 5.77 and 5.89 in groups A and C respectively at the baseline (T0); whereas, it was 6.71 in group A and 6.46 in group Cat one month (T1) time interval. However, the difference in mean MOP at cervical third between groups A and C at T0 as well as T1 was statistically not significant. At the two month (T2) time interval the mean MOP was 7.16 in group A and 7.04 in group C, the difference was statistically not significant. The mean MOP in the cervical third at three month (T3) time interval was 7.34 and 7.54 in group A and group C respectively, also the difference in group A and C was statistically not significant with p-value & gt; 0.05 analysed using Students-T test. The results at cervical third show that the difference in mean MOP between the two experimental groups was not significant at any time interval from baseline to three

months. It was found that pain score1, 2, 3 and 4 was seen in 20%, 50%, 10% and 20% of study subjects respectively. Whereas, in the MOP2 group the scores 1, 2, 3 and 4 was seen in 10%, 40%, 30% and 20% of study subjects respectively. The difference in pain score between MOP1 and MOP2 study groups was statistically not significant analysed using Chi-square test.

Table 1: Comparison of study groups based on mean Micro-Osteoperforation-1 (MOP-1) in the incisal third area at various time intervals.

Tooth area and time interval	**Group A (Experimental Group 1)**		**Group B (Control Group 1)**		**P-value (Students-T test)**
	Mean	Std deviation	Mean	Std deviation	
Incisal T0	6.40	0.809	6.57	1.322	0.733
Incisal T1	7.61	0.738	6.98	1.220	0.179
Incisal T2	8.04	0.874	7.31	1.183	0.134
Incisal T3	8.26	0.920	7.53	1.152	0.139

Table 2: Comparison of study groups based on mean Micro-Osteoperforation-1 (MOP-1) in the middle third area

Tooth area and time interval	**Group A (Experimental Group 1)**		**Group B (Control Group 1)**		**P-value (Students-T test)**
	Mean	Std deviation	Mean	Std deviation	
Middle T0	6.06	0.422	6.00	1.024	0.866
Middle T1	7.01	0.395	6.44	0.895	0.081
Middle T2	7.58	0.571	6.71	0.867	0.014*
Middle T3	7.76	0.594	6.88	0.884	0.016*

*Statistically Significant Value

Table 3: Comparison of study groups based on mean Micro-Osteoperforation-1 (MOP-1) in the cervical third area.

Tooth area and time interval	**Group A (Experimental Group 1)**		**Group B (Control Group 1)**		**P-value (Students-T test)**
	Mean	Std deviation	Mean	Std deviation	
Cervical T0	5.77	0.724	5.58	1.061	0.646
Cervical T1	6.71	0.653	5.99	1.000	0.071
Cervical T2	7.16	0.629	6.27	0.963	0.033*
Cervical T3	7.34	0.680	6.45	1.028	0.028*

*Statistically Significant Value

Table 4: Comparison of study groups based on mean Micro-Osteoperforation-2 (MOP2) in the incisal third area.

Tooth area and time interval	**Group C (Experimental Group 2)**		**Group D (Control Group 2)**		**P-value (Students-T test)**
	Mean	Std deviation	Mean	Std deviation	
Incisal T0	6.37	0.908	6.42	1.177	0.912
Incisal T1	6.99	1.034	6.55	1.257	0.431
Incisal T2	7.63	1.019	6.81	1.266	0.147
Incisal T3	8.13	1.029	7.09	1.300	0.063

Table 5: Comparison of study groups based on mean Micro-Osteoperforation-2 (MOP2) in the middle third area.

Tooth area and time interval	Group C (Experimental Group 2)		Group D (Control Group 2)		P-value (Students-T test)
	Mean	Std deviation	Mean	Std deviation	
Middle T0	6.04	0.814	6.16	1.130	0.786
Middle T1	6.65	0.892	6.27	1.152	0.413
Middle T2	7.26	0.895	6.54	1.224	0.118
Middle T3	7.75	0.900	6.83	1.274	0.079

*Statistically Significant Value

Table 6: Comparison of study groups based on mean Micro-Osteoperforation-2 (MOP2) in the cervical third area.

Tooth area and time interval	Group C (Experimental Group 2)		Group D (Control Group 2)		P-value (Students-T test)
	Mean	Std deviation	Mean	Std deviation	
Cervical T0	5.89	0.955	5.93	1.071	0.931
Cervical T1	6.46	1.056	6.12	1.135	0.492
Cervical T2	7.04	1.041	6.38	1.139	0.182
Cervical T3	7.54	0.972	6.67	1.158	0.086

*Statistically Significant Value

Table 7: Comparison of experimental study groups (Group A and Group C) based onmean Micro-Osteoperforation (MOP) in the incisal third area.

Tooth area and time interval	Group A (Experimental Group 1)		Group C (Experimental Group 2)		P-value (Students-T test)
	Mean	Std deviation	Mean	Std deviation	
Incisal T0	6.40	0.809	6.37	0.908	0.939
Incisal T1	7.61	0.738	6.99	1.034	0.146
Incisal T2	8.04	0.874	7.63	1.019	0.339
Incisal T3	8.26	0.920	8.13	1.029	0.744

Table 8: Comparison of experimental study groups (Group A and Group C) based on mean Micro-Osteoperforation (MOP) in the middle third area.

Tooth area and time interval	Group A (Experimental Group 1)		Group C (Experimental Group 2)		P-value (Students-T test)
	Mean	Std deviation	Mean	Std deviation	
Middle T0	6.06	0.422	6.04	0.814	0.946
Middle T1	7.01	0.395	6.65	0.892	0.259
Middle T2	7.58	0.571	7.26	0.895	0.346
Middle T3	7.76	0.594	7.75	0.900	0.977

Table 9: Comparison of experimental study groups (Group A and Group C) based on mean Micro-Osteoperforation (MOP) in the cervical third area.

Tooth area and time interval	Group A (Experimental Group 1)		Group C (Experimental Group 2)		P-value (Students-T test)
	Mean	Std deviation	Mean	Std deviation	
Cervical T0	5.77	0.724	5.89	0.955	0.755
Cervical T1	6.71	0.653	6.46	1.056	0.533
Cervical T2	7.16	0.629	7.04	1.041	0.759
Cervical T3	7.34	0.680	7.54	0.972	0.601

Table 10: Comparison of study groups MOP1 and MOP2 based on experience of pain among study subjects.

Pain score	MOP1	MOP2
Score 1	20%	10%
Score 2	50%	40%
Score 3	10%	30%
Score 4	20%	20%
p-value	0.695	

DISCUSSION

Acceleration of orthodontic tooth movement is of interest to clinicians as it has the potential to reduce the orthodontic treatment duration. Although there are several factors which affect this duration, the biologic process of tooth movements is a major factor which has captured attention in the recent past. Transient localized osteopenia has shown to be effective in increasing the bone turnover which can in turn increase the rate of orthodontic tooth movement. Several methods of inducing such osteopenia have been advocated and range from osteotomies to small flapless alveolar perforations. This indicates the underlying desire to identify ways of reducing trauma to the patient during this procedure. MOPhas the advantage of being minimally invasive, easy to perform and relatively comfortable for the patient[18].

The osteopenia induced by perforations leads to a zone of increased remodelling activity, which essentially leads to faster tooth movement than normal (Chackartchi et al., 2017)[19].

The present study aimed at evaluating the rate of canine retraction through MOPs by increasing the number and varying the frequency of MOPs at 4,8 and 12 weeks after force application. The normal activation of orthodontic tooth movement is done every 4,8 and 12 weeks respectively. The results were compared with the control group as well as in the inter group in order to estimate the effect of MOPs in accelerated tooth movement. A split mouth randomized controlled study was selected so as to avoid bias related to biologic variations in subjects. Along with the tooth movement this study also aims to record the pain perception in the mouth following the MOP procedure.

It has been shown that the forces of occlusion can effect the rate of tooth movement significantly by Alikhani et al[16]. To rule out the effect of occlusion in this study, we selected patients with similar severity of malocclusion. Patients with crossbite or deviation during closure caused by occlusal interference were not included in this study. In addition, to eliminate the possibility of uneven occlusal forces from habitual occlusion predominantly on one side, MOPs were randomly assigned to the left or right side of each patient. Furthermore, the canines were selected because they were free from occlusal interference.[20- 22] Alkebsi et al[22] in their randomized controlled clinical trial found that three MOPs advocated by previous researchers were not effective for accelerating orthodontic tooth movement in the first 3 months. In our study, we decided to incorporate six MOPs in MOP group 1, three MOPs in the center of extraction socket buccally and 3 MOPs in the center of extraction socket palatally. The MOPs in the center of socket were placed 2mm apart in vertical direction and 3mm in depth from the alveolar crest.

Similarly in MOP group 2 We decided to repeat the MOPs on 4,8, and 12 weeks to find out any net increase in the rate of tooth movement by repeating the MOPs. In their study, Alkebsi et al[22] calculated the space between the second premolar and canine to estimate space closure. The disadvantage in such case is that the mesial movement of the second premolar might give a false reading. Therefore, in our study, we have measured the space created between canine and lateral incisor that estimated the true retraction of canine and avoided bias reading due to mesial movement of premolar. Individual canine retraction using calibrated 150 gm of NiTi closing coil spring (9 mm) connected from a (TAD, 1.8 mm × 8 mm) placed

between the second premolar and molar on the buccal aspect to the vertical slot of canine brackets made with 0.019 × 0.025 ss arch wire. Poor oral hygiene, periodontal disease, alveolar bone loss, systemic diseases, and consumption of anti-inflammatory medications can affect the rate of tooth movement significantly. To reduce these variables, monitoring of patients was done to maintain excellent oral hygiene and clear exclusion criteria was followed. The patients were expected to comply with the instructions regarding strict attention to oral hygiene measures and keeping the follow-up visits.[20- 22]

In our study, we extracted the first premolars in both the arches before aligning and levelling to rule out the bias that extractions can change the rate of tooth movement by increasing the activity of inflammatory markers as suggested by Hasler et al[23].

It is well known that, in most orthodontic extraction patients, anchorage reinforcement is of prime importance from the study done by Thiruvenkatachari et al[55]. Effective and reliable anchorage will dramatically improve the results of treatment. In this study, mini-screw implants were used as skeletal anchorage during canine retraction because of their simpler placement technique and the possibility of eliminating the reliance on patient compliance.

The miniscrews selected had a diameter of 1.8 mm and a length of 8 mm. The rationale was to optimize the mechanical retention of the screws and eliminate any risks of root proximity or contact that might contribute to failure during treatment. The placement site of the miniscrews, between the maxillary second premolar and the first molar buccally, was selected based on the recommendations of Marissa et al. who advocated this site as bone stock for safe miniscrew placement in the maxillary arch. The miniscrews that were placed without flap surgery have higher success rates with less pain and discomfort than those placed with flap surgery, and these findings are in accordance with the that of Kuroda et al[24].

Shpack et al[25]concluded that retraction of maxillary canine into the first premolar extraction site using nickel-titanium closed coil springs occurred faster. Therefore, nickel-titanium closing coil spring (9 mm) was used for retraction to permit constant force application. Pain and discomfort caused by the MOPs were not different from the control group mentioned in the previous study (Alikhani et al)[16]. This indicates that this procedure can be adopted in the routine clinical practice with no distress for the patient. This discomfort caused by a small injection can be bypassed by using a strong anesthetic.

In our study, alginate impressions were taken at the beginning of the study, then immediately before canine retraction, and also on 4,8 and 12 weeks after canine retraction began. In order to monitor the rate of tooth movement in both the arches, the distance between the canine and the lateral incisor was assessed before and after canine retraction at three points: incisal, middle, and cervical thirds of the crowns. All the cast measurements were made using a digitalvernier caliper. Adults between 18 and 40 years were selected for this study, and the average age in both the groups was similar. The canine retraction with both the groups were measured at four different time intervals- T0 – at the time of perforation T1 – at 4 weeks after perforation T2 - at 8 weeks after perforation T3 - at 12 weeks after perforation. We demonstrated that the amount of tooth movement differed depending on the presence and number of MOPs with OTM. The MOP 1 group A (experimental group) exhibited 0.6 times greater tooth movement compared with the MOP 1 group B (control group) after 4 months. The faster tooth movement with MOP accelerated the tooth movement in the target area. These findings are in agreement with those of other author Dutra et al[27],Sugimori et al[28] who found 1.35–2.13 times faster rate of tooth movement in a (2–4) MOP group compared to a control group.

Taking these findings into consideration, we speculated that increase in the number of MOPs had a major effect on the amount of tooth movement, and 6MOPs could sharply induce rapid tooth movement in the later phase of OTM.

The comparison between mean canine retraction scores (taken as mean of incisal, middle, cervical third) at different time intervals between Group A (experimental group) and Group B (control group) i.e MOP 1 was found statistically significant in the later phase of orthodontic treatment. The study performed by Sudhakar Venkatachalapathy et al[29] found varying frequency of MOPs increased the rate of canine retraction by 2-fold when compared with the control group with p value = 0.000.when compared to this study in Group C (Experimental group) and group D (control group) i.e MOP 2 the mean canine retraction was found to be statistically insignificant. But found clinically significant as the canine retraction was 0.5mm times more in experimental side compared to control side.

However, when comparison was done between Group A (experimental group) and group C (experimental group) on mean rate of canine retraction the result was statistically insignificant which concludes that the effect of 6 MOPs and varying frequency of MOPs has same effect on rate of canine retraction. The pain severity experienced by the patients ranged from mild to moderate pain that rapidly faded away after 1 week. Yet, the mean pain scores obtained in the current study were higher than those reported by Alikhani et al[16].

This was the study to determine the effect of MOPs on the rate of tooth movement by increasing the number and varying the frequency of MOPs on humans. We have shown that MOPs were an effective, comfortable, and safe procedure that accelerate tooth movement significantly and could result in shorter orthodontic treatment time.

CONCLUSION

Our study successfully evaluated the rate of tooth movement using MOP by increasing the number and varying the frequency on every 4th,8th and 12th week and as a result the rate of tooth movement increased significantly. Hence, MOPs can be incorporated into routine orthodontic mechanics and at different stages of treatment, facilitating alignment and root movement, stimulating bone remodeling in areas of deficient alveolar bone, and reducing the stress on anchor units. Hence, MOPs offer a practical, minimally invasive, and safe procedure that can be repeated as needed to maximize the biological response to orthodontic forces. Further studies can be done by increasing the frequency along with increasing the number of MOPs to evaluate the rate of canine tooth movement.

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