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Evaluation of Modified Micro-Osteoperforation on the Rate of Enmasse Retraction - A Prospective Clinical Study

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Abstract

Aim: To assess the effect of micro-osteoperforations on the rate of tooth movement in enmasse retraction of anteriors.

Materials and Methods: 20 patients were included in the study and retraction was started using sliding mechanics. They were randomly divided into two groups, experimental and control. Micro-osteoperforations were done in the experimental group and 150 grams force was applied immediately using active tie-backs on both sides and enmasse retraction was done. Measurements were taken at 4th, 8th, 12th, 16th, 20th and 24th week intervals.

Results: Results showed that there was statistical significance in the rate of tooth movement in the experimental group compared with the control group.

Conclusion: There was increase in the rate of orthodontic tooth movement in the experimental group compared with the control group. There was minimal anchorage loss in both experimental and control group.

Keywords: Micro-osteoperforations, Mini Implants, Enmasse Retraction.

Introduction

Orthodontic treatment is based on the principle that when force is delivered to a tooth and transmitted to the adjacent investing tissues, certain mechanical, chemical, and cellular events take place within these tissues, which allows structural alterations and contribute to the movement of the tooth. [1] Barlow reported that teeth move 0.8 – 1.2 mm/month when continuous forces are applied. [2] Of the various procedures introduced, Corticotomy assisted orthodontic tooth movement (CAOT) had emerged as a promising technique with 70% reduction in treatment duration.[3] In adults especially, it has many advantages because it helps to overcome many of the current limitations including lengthy duration, potential for growth and the limited envelope of tooth movement. Very recently, Mani Alikhani et al,[4] reported that micro-osteoperforations (MOPs) are an effective, comfortable and safe procedure that accelerates tooth movement significantly and could result in shorter orthodontic treatments.

Micro-osteoperforation is the only micro-invasive option able to accelerate orthodontics. MOP creates predictable orthodontic treatment results, improves finishes with braces, and reduces or eliminates with clear aligner therapy. [5] MOP can be completed in chair side in minutes, and does not require any advanced training. Additionally, the treatment yields very little discomfort to the patient. There is zero recovery time, and the patients are able to immediately return to their normal daily routine. The various devices used for MOP are; Excellerator by PROPEL Orthodontics, Excellerator RT (removable tip) by PROPEL Orthodontics, Excellerator PT (power tip) by PROPEL Orthodontics, TADs, mini-implants, and burs. [5]

Micro-implants routinely being used in orthodontics these days, can be used for this osteoperforation procedure which is a less extensive approach. With these implants, perforations in each inter proximal area can be enough to generate the regional acceleration of bone remodelling, producing a faster tooth movement.[6] As safe, minimally invasive, and cost-effective treatments are being sought to shorten orthodontic treatment time, the possibility of accelerating tooth movement by miniscrew implant perforations has been assessed in the present study. Since very less literature is available about the effect of micro-osteoperforations on rate of tooth movement, a study was undertaken to evaluate the effects of modified micro-osteoperforations on the rate of enmasse retraction in orthodontic treatment.

Materials and Methods

Ethical clearance was obtained from the institution. A randomised controlled trial was conducted in the Department of Orthodontics and Dentofacial Orthopedics at Al-Ameen Dental college And Hospital, Vijayapur. 20 patients were selected and 10 patients were randomly divided into experimental and control groups each.

Inclusion Criteria

- Subjects in the age range of 18 – 30 years and/or who have completed their growth.
- Angle's Class I malocclusion with either bidental protrusion or Angle's Class II, division 1 malocclusion with minimal crowding who require maxillary first premolar extraction and have completed levelling and alignment.
- Average growth pattern.
- No systemic, bone/metabolic disorders.

Exclusion Criteria

- Previous history of orthodontic treatment.
- Class II division I malocclusion with extreme skeletal class II malocclusion, overjet more than 10 mm and indicated for orthognathic surgery.
- Severe vertical growers.

- Long term use of analgesics, phenytoin, cyclosporine, anti-inflammatory drugs, systemic corticosteroids, and calcium channel blockers.
- Patients with thin gingival biotype.
- History of extraction of any permanent teeth anterior to the 3rd molars.
- Poor periodontal status (Radiographic evidence of bone loss)

Methodology

Extractions were done 6 months prior to levelling and alignment completion. In all the subjects, retraction using sliding mechanics was planned. The duration of the study was set up for 6 months or till closing of the extraction space from initial month of retraction.

Group I: This group comprised of 10 subjects who were treated with micro- osteoperforations.

Group II: This group comprised of 10 subjects treated without micro- osteoperforations.

Patient preparation

The patients were informed about the study and consent was obtained from all the patients. Once levelling was achieved, 0.019 × 0.025” SS wire was left for 6 weeks, for the residual tip and torque to be expressed. Before retraction, alginate impressions of maxillary arch were taken, poured immediately and models were made. All the casts were labelled. Prior to retraction, all maxillary anteriors were consolidated with a 0.010” SS ligature wire.

Micro-osteoperforations procedure

The procedure was done only in the experimental group. After the preliminary evaluation, patient was instructed to rinse his/her mouth with 0.2% chlorhexidine or povidone iodine mouth wash and surgical area was prepared. Local infiltrations (2% lidocaine with 1:100000 epinephrine) were given at appropriate sites over the anterior region. The gingival surface of the insertion areas were palpated to demarcate the adjacent roots and actual sites. Before perforations at those sites, indentations were made at the interdental depressions using a probe. The soft tissue thickness was measured using a needle with a stopper before performing MOPs. A rubber stopper was used to standardize the depth of penetration of the miniscrew implant. Each perforation was 1.5 mm wide and 3 mm deep in the bone. Three MOPs were performed gingival to the extraction site distal to the canines at coronal, middle and apical regions. The miniscrew implant was removed after creating MOPs. Non inflammatory analgesic (paracetomol) was prescribed for any discomfort if present later.

Enmasse retraction of anteriors was performed in both the groups with active tie-backs after having a basal 0.019”× 0.025” stainless steel arch wire, providing 150 gms of force with the help of dontrix guage. All patients were recalled for routine activations at an interval of 4 weeks. At each visit, the force produced by active tie-back was checked.

Determination of rate of retraction

Distance between the canine and second premolar was calculated to 0.1mm with the help of sliding caliper. Weekly measurements were then recorded until complete retraction was achieved. The rate of retraction was calculated by distance divided by time.

Determination of the anchor loss

- Lateral cephalograms were taken before the retraction and after the retraction.
- Cephalometric tracings were traced and maxilla was superimposed and mesial movement of the first molar was calculated.

Statistical Analysis

The data was entered and analyzed using the Statistical Package for Social Sciences (SPSS) for Windows 26.0.

(SPSS, Inc. Chicago, Illinois) Confidence intervals were set at 95%, and a p-value $\leq$ of 0.05 was considered as statistically significant. Paired t test was applied to compare pre-operative and post-operative serum C-reactive levels in both the groups. Independent t test was applied to compare serum C-reactive protein levels in both the groups.

Results

Right and left side scores of maxillary arch were taken for each patient at each time interval (0, 4, 8, 12, 16, 20, 24 weeks). Amount of enmasse retraction done was measured as differences between these average scores in consecutive time intervals, T0&T1, T1&T2, T2&T3, T3&T4, T4&T5, T5&T6. In the experimental group (space closure with micro-osteoperforations), it decreased from 1.74 to 1.63 mm by the end of 8^{th} week which is statistically non-significant but decreased to 1.36 mm by the end of 12^{th} week, 1.326 mm by 16 weeks and decreased continuously which is statistically significant. (Table 1) In control group (space closure without micro-osteoperforations), a non-significant decrease is seen with differences D1, D2, D3, D4, D5, D6 shown as 1.08, 1.03, 1.01, 0.99, 0.96, 0.93 mm respectively. (Table 2) There is statistical significant difference in the rate of enmasse retraction at the end of 4^{th} week D1 ($p<0.024$), 8^{th} week D2 ($p<0.029$), 12^{th} week D3 ($p<0.001$) and 16^{th} week D4. ($p<0.001$) There was statistical significance in the rate of tooth movement in the experimental group compared with the control group. (Table 3) There was statistically non significant difference between pre and post anchorage loss ($p>0.05$) between both the groups.

Discussion

Patients who seek orthodontic treatment often desire their treatment to be completed as early as possible. Routinely, however it takes a minimum of 18 to 24 months for orthodontic treatment completion depending on various malocclusions. There are methods said to accelerate OTM, and are associated with many other advantages like reduction in root blunting,[7-8] lesser decalcifications and white lesions formation. However, rapid orthodontics is still at its emerging phase and need further research in the form of clinical trials to evaluate all these treatment modalities. [9]

The rapid tooth movement produced after MOPs is substantially different than periodontal ligament cell-mediated tooth movement. Recent evidence suggests a localized osteoporosis state, as a part of a healing event called Regional Acceleratory Phenomenon (RAP), may be responsible for the rapid tooth movement after MOP. The fact that the teeth can be moved more rapidly, thus resulting in shortened treatment times, is certainly advantageous to the patient's periodontal health because less time in fixed appliances reduces patient "burnout" and substantially reduces the time available for relatively benign commensal bacterial biofilms to assume qualitative changes and convert to a destructive cytotoxic potential often seen when fixed appliances have remained on the teeth for more than 2 to 3 years.[10] The significance of the increase of the rate of tooth movement, however, pales in comparison to the fact that the teeth can be moved two to three times further than would be possible with traditional orthodontics alone, and that the cases can be completed with an increased alveolar bone volume. This increased alveolar volume can provide for a more intact periodontium, a decreased need for extractions, a degree of facial reshaping, and an increase in the bony support for both the teeth and the overlying and soft tissues. [11] Recently, Nicozisis J et al.[10] suggested micro-osteoperforation (MOP) as a micro-invasive option able to accelerate orthodontics. Gadakh SB et al. [6] suggested that Micro-osteoperforation, Piezoincision are the least discomforting among all the surgical procedures and this will make them more commonly used procedures in future. So, adapting these techniques might prove to be beneficial in reducing orthodontic treatment time.

Thus, in the present study, randomized controlled trial was done to investigate the effect of micro-osteoperforations on the rate of tooth movement in enmasse retraction in comparison with the conventional orthodontic technique. The results of the present study showed that, MOPs increased the rate of enmasse retraction by 2.1 fold when compared to the control group. The results are in agreement with results of the study by Alikhani et al[4] reported in 2013. They observed that after 28 days of canine retraction, there was 2.3 fold significant increase in canine retraction in the MOP group when compared with control group and contra lateral side. However, unlike the present study, perforations were not done whole in the anterior segment. Probably, this may have further increased the rate in the present study. Alikhani et al. [4] reported that generally, the rate of tooth movement depends on forces of occlusion, occlusal interferences, age, and prescribed further studies eliminating all these confounding variables. In the present study, patients were selected with similar severities of malocclusion to rule out the effect of occlusion which could cause significant reduction in tooth movement. [12] Occlusal interferences during retraction were regularly checked. But none was found that required occlusal adjustment. Bone density, rate of osteoclast recruitment and activation are dependent on age which can have an effect on the rate of tooth movement. To eliminate the effect of age,[13] only patients of age between 18 and 28 years were selected for this study, and the average ages in both groups were similar. 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, oral hygiene and clear exclusion criteria were maintained as well. According to Alikhani et al.[4] extractions also can change the rate of tooth movement by increasing the activity of inflammatory markers, which could obscure the effect of MOPs. To minimize this possibility in the present study, extraction was done at the start of the treatment, 6 months prior to enmasse retraction.

Aboul-Ela et al. [14] in 2011 using only buccal cortical perforations found that on the side where the corticotomy was performed, individual tooth movement velocity was two to three times faster than on the control side. This result agrees with the findings of Wilcko et al. [15] suggesting that the rapid rate of tooth movement seems to depend mostly on RAP rather than bony block movement. Jahanbakhshi MR et al.[16] concluded that buccal corticotomy alone can increase the rate of tooth movement and also reported that there is a need to know whether this less severe approach can be better or comparable to still less invasive adjuncts like micro-osteoperforations and low level laser corticotomy. So, in this study, it was assumed that one of the micro invasive procedure, micro-osteoperforations be applied only on the buccal side, instead of both buccal and palatal cortical plates, orthodontic forces in conjunction with this microinvasive procedures were given and checked if it still produces substantially greater tooth movement than orthodontic forces alone.

In the present study also, rate of tooth movement increased in the first eight to 12 weeks following the perforation procedure and decreased continuously. So, MOPs may be required at regular intervals like every 6 – 8 weeks for better tooth movement. Minor surgical operations over limited mouth regions rather than the entire mouth can be used in large space closures, molar protraction, molar intrusion, wisdom teeth uprighting or protraction, unilateral arch expansion, and the conditions where there is difficulty in moving the teeth. As RAP created by micro-osteoperforations is of limited duration and varied in various case reports ranging from 2 to 4 weeks depending on perforation site and type of procedure, additional studies must be conducted to identify the effects of flapless and less invasive micro-osteoperforations. Recent studies reported that MOPs are to be given every 6 to 8 weeks for a better tooth movement.

Thus, evidences supporting that surgically creating RAP may reduce root resorption as well as anchor loss. But further studies are still necessary to elucidate the suitability of these invasive micro or macro surgical procedures for orthodontic treatment. Reducing the duration of anterior teeth retraction may decrease the risk of apical root resorption especially in the lateral incisors[17] and anchor loss. In this study, enmasse retraction was preferred avoiding individual canine retraction for the main reason of reducing the treatment time. Along with this, these types of surgical procedures can be of help in further reducing the treatment time. Root resorption would be difficult to study because many variables can contribute to root resorption. The longer the study, the more difficult it would be to control these variables. No patient in this clinical trial showed any evidence of root resorption or alveolar bone loss in the routine panoramic radiographs taken for some patients. However, panoramic or periapical radiographs are not precise for measuring the magnitude of root resorption, and future studies are necessary.

According to Nicozisis J et al[10], the ideal treatment device for micro-osteoperforation should be able to provide clinician an ergonomic control, and remain sharp through multiple perforations, and have a depth limited to ensure penetration to the minimal effective depth. In this study, an implant driver was used and to which a screw was attached, and a rubber stopper was adjusted in such a way that the depth penetration can be known on the device. This is a cost effective instrument compared to propel and is easily available in every dental clinic. However, it has its own limitations that one implant can be used only once for a patient. If we have to do more MOPs in next appointment for the same patient then again we have to use new implant.

This indicates that the procedure can be adopted in routine clinical practice with no distress for the patient. The procedure is indicated for approximately 80% of patients receiving orthodontic treatment and can be used in conjunction with any treatment modality, including but not limited to, TADs, Invisalign (Align Technology), and conventional braces. Much of the literature on micro-osteoperforations in orthodontics is based on the empirical evidence and case reports. Experimental human based histologic studies are still much needed to elucidate the tissue changes with this technique.

Silvia Geron [18] studied the factorial response which is responsible for the anchorage loss. For the measurement of anchorage loss he used two methods one is radiographic method in which he uses lateral cephalograms of pre and post treatment difference of the distal contact point of maxillary first molar to a line perpendicular to occlusal plane through sella.. Then these casts were photocopied at 200% enlargement. He measured the distance between two points. The difference between pre and post treatment length is the anchorage loss. Study suggested that incorporation of second molars in the anchorage strategy, low retraction forces, and frictionless mechanics are superior to the conventional means. They calculated the anchorage loss 0.5mm/year for the females and 0.9mm/year for the males.[19]

Conclusion

There was increase in the rate of orthodontic tooth movement in the experimental group compared with the control group. There was minimal anchorage loss in both experimental and control group.

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Legend Tables

Table 1: Amount of en masse retraction done in consecutive time intervals in experimental group

Side	Time Interval	Mean	Standard Deviation	F-value	p-value
Right	D1	1.7420	0.04492	550.985	0.0001*
	D2	1.6390	0.03381		
	D3	1.3660*	0.01350		
	D4	1.3260*	0.01350		
	D5	0.9820*	0.41507		
	D6	0.2150*	0.31585		
Left	D1	1.7420	0.03795	549.388	0.0001*
	D2	1.6390	0.02846		
	D3	1.3670*	0.01767		
	D4	1.3190*	0.01853		
	D5	0.9810*	0.42120		
	D6	0.2240*	0.33060		

* Significant

Table 2: Amount of enmasse retraction done in consecutive time intervals in right and left (control)

Side	Time Interval	Mean	Standard Deviation	F-value	p-value
Right	D1	1.086	0.088	652.01	0.5
	D2	1.041	0.067		
	D3	1.022	0.059		
	D4	0.997	0.055		
	D5	0.975	0.054		
	D6	0.944	0.058		
Left	D1	1.072	0.095	670.07	0.6
	D2	1.026	0.067		
	D3	1.007	0.057		
	D4	0.983	0.057		
	D5	0.955	0.054		
	D6	0.917	0.053		

Table 3: Comparison between Experimental and Control group

Time Interval	Groups		Mean	Standard Deviation	t-value	p-value
D1	Right	Experimental	1.74	0.04	20.86	0.02 (S)
		Control	1.08	0.08		
	Left	Experimental	1.74	0.03	20.67	0.005 (HS)
		Control	1.07	0.09		
D2	Right	Experimental	1.63	0.03	25.07	0.02 (S)
		Control	1.04	0.06		
	Left	Experimental	1.63	0.02	26.61	0.004 (HS)
		Control	1.02	0.06		
D3	Right	Experimental	1.36	0.01	17.69	0.0001 (H.S)
		Control	1.02	0.05		
	Left	Experimental	1.36	0.01	18.85	0.001 (H.S)
		Control	1.0	0.05		
D4	Right	Experimental	1.32	0.01	18.25	0.001 (HS)
		Control	0.99	0.05		
	Left	Experimental	1.31	0.01	17.57	0.0001 (HS)
		Control	0.98	0.05		
D5	Right	Experimental	0.98	0.41	0.05	0.003 (HS)
		Control	0.97	0.05		
	Left	Experimental	0.98	0.42	0.19	0.002 (HS)
		Control	0.95	0.05		
D6	Right	Experimental	0.21	0.31	-7.17	0.01 (S)
		Control	0.94	0.05		
	Left	Experimental	0.22	0.33	-6.54	0.01 (S)
		Control	0.91	0.05		

HS – Highly Significant, S – Significant.

Table 4: Comparison of Anchor Loss between experimental and control groups

Anchor loss		Mean	Standard deviation	t-value	p-value
Experimental	Pre	20.80	1.54	-0.997	0.487 (NS)
	Post	21.60	2.01		
Control	Pre	20.60	1.50	-1.259	0.432 (NS)
	Post	21.60	2.01		
	Control	1.0	0.94		

NS – Non Significant