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Accelerating Orthodontic Tooth Movement With Peeso-Reamer Facilitated Micro-Osteoperforations.

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Abstract:
***Background**: Micro-osteoperforations (MOP), among all the techniques of accelerating orthodontic tooth movement, is the least invasive surgical technique that has proven to be a desirable adjunct to orthodontic treatment. This study was done to evaluate the effectiveness of peeso-reamer-facilitated micro-osteoperforations (MOPs).*
***Materials and Methods**: Ten patients aged 17 years and above, requiring fixed orthodontic treatment and extraction of maxillary first premolars were recruited. Each patient's side of the mouth served as a control, receiving no MOPs. Immediately before initiation of en-masse retraction, three MOPs of 5mm depth were randomly performed on either right or left sides, distal to canine, using a peeso-reamer, under copious saline irrigation. The en-masse retraction was done with Ni-Ti coil-spring on either side. Data was collected from the monthly study models over 3 months of the observation period. Parametric tests (t-tests) were used to compare the treatment efficacy.*
***Results**: Over a 3-month observation period, mean en-masse retraction was 0.80mm/month (SD= 0.21mm) on the MOP side and 0.41mm/month (SD= 0.05mm) on the control side which shows that the MOP side exhibited a significantly higher rate of en-masse retraction: 1.97 times more than the contralateral control side. Furthermore, the mean anchor loss on the MOP side was 0.68mm (SD= 0.27mm) and 0.93mm (SD= 0.37mm) on the control side showing that anchorage loss on the MOP side was significantly less than on the contralateral control side.*
***Conclusion:** Peeso-reamer-facilitated micro-osteoperforations effectively accelerated the en-masse retraction rate and reduced anchorage loss.*
***Key Word**: MOPs, RAP, Accelerated orthodontics, En-masse retraction, Peeso-reamer, Adult orthodontics, OTM*

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I. Introduction

For anyone who opts for treatment with braces, whether adolescents or adults, the first question is "How long will they stay on?". A major challenge in orthodontics is decreasing treatment time without compromising its outcome. Long duration of orthodontic treatment brings along potential risks of root resorption, white spot lesions and caries, periodontal problems, and soft tissue trauma, and can also burn out patient's cooperation [1]. All of these consequences can be minimized if we reduce the duration of treatment; however, this is somewhat perplexing because, ultimately, treatment time and rate of orthodontic tooth movement are determined by the patient's biologic response to the orthodontic forces [2, 3], which varies for each individual. The average treatment time is around 2 years [4] and may be extended if space closure is required. Lately, accelerated orthodontics has become a fortified area of research. Several techniques, including surgical, physical/mechanical, and pharmacological methods, have been claimed to reduce orthodontic treatment time with varying degrees of success [5]. According to current research, surgical approaches [5], such as distraction osteogenesis, corticotomy, osteotomy, and piezocision technique, appear to be the most effective adjuncts for accelerating orthodontic tooth movement. However, it is assumed that the surgical approaches have not been widely employed, due to their invasiveness and associated complications [6-8].

Recently, minimally invasive and controlled micro-trauma through micro-osteoperforations (MOP) has shown promising results with a significantly lower risk of surgically related complications [9]. MOP promote tooth movement by increasing inflammatory marker expression, which ultimately increases the migration of inflammatory cells and osteoclast precursors to the inflamed area, where they activate the RANK-RANKL pathway, either directly or indirectly, resulting in osteoclast differentiation and activation [1, 9, 10].

Moreover, MOPs cause no additional pain and can be created using commonly available instruments in the operatory [9, 11-13]. Although MOP have proven to be a desirable adjunct to orthodontic treatment, there are reports on its effectiveness and adverse effects that are paradoxical and knowledge of armamentarium is limited. In the first human trial to evaluate the effectiveness of MOP, Propel device was used and the authors concluded that MOP accelerated tooth movement. Some other studies were done that found that mini-implant assisted MOP increased the rate of tooth movement [11-13], but their results were challenged by others found no significant clinical differences [14, 15]. Two recent systematic reviews on the potency of MOP has conflicting conclusions [16, 17].

Based on the controversial results regarding the impact of MOP on treatment time, the present study evaluated the effect of a novel method that is peso-reamer-facilitated micro-osteoperforations on orthodontic tooth movement, with a motive to introduce a new, simple, and familiar technique to create MOP that reduces chair time and also decreases potential risks. Additionally, the anchor loss on the experiment and control side during 3 months period was investigated.

II. Material And Methods

The study was presented and approved by the scientific review board and institutional ethical committee (Approval Number-RCDSETHICS/20-21/12). The split-mouth design was used to reduce biological variables between the experimental and contra-lateral control sides, with 1:1 allocation.
Study Design: Prospective observational study.

Study Location: This study was done in the Department of Orthodontics and Dentofacial Orthopedics, Rishiraj College of Dental Sciences And Research Centre, Bhopal, Madhya Pradesh.

Study Duration: July 2022 to September 2022.

Sample size: 10 patients.

Sample size calculation: Sample size was calculated based on a type I error frequency of 5%. Power analysis with G*Power software showed that 10 mouth sides each would be needed as experiment and control, giving a total of 20 mouth sides (n=10 patients), for a statistical power of more than 95% to detect a significant difference, with an effect size of 1.34 and 0.05 as the significance level.

Subjects & selection method: The target population consisted of patients of both sexes, ages 16 and above, screened according to the following criteria. A detailed medical history and clinical findings were noted for each patient. Research goals, intervention methods, and probable risks and benefits were explained to the participants priorly. Voluntary participation was emphasized. Written informed consent/ assent was obtained from all the participants (or their parents/guardians) in their native language.

Inclusion criteria:

1. Healthy patients having permanent dentition (with exception of third molars) aged 16 years and above at the start of treatment.
2. Angle's Class I bimaxillary or bilateral Class II div. 1 malocclusion (ANB < 5º) \with mild or no crowding (up to 3mm).
3. Cases requiring extraction of maxillary bilateral 1st premolar.
4. Fully erupted canines with closed apex.
5. No radiographic evidence of bone loss.
6. No history of/current active periodontal disease.
7. No smoking.
8. No endodontic lesions.

Exclusion criteria:

1. Extreme skeletal Class II relationship (ANB>5̊).
2. Extreme vertical skeletal discrepancy (SN- GoGn>38̊).
3. Dental crossbite and deviation in closure due to occlusal interference.
4. Prominent canine roots (in labial cortical bone).

5. Systemic disease or medication that affects bone biology.
6. Presence of Parafunctional habits/habitual effects.
7. Congenital defects like cleft lip and palate.
8. Syndromic patients.
9. Gingival probing depth >4 mm in any tooth.

Randomization: MOP intervention was randomly done on either the right or left mouth side using the numeric randomization method. Random numbers were allocated to the participants by a person who is not involved in the study. All random numbers were kept in separate opaque envelopes until the commencement of en-masse retraction. On the day of the micro-osteoperforation procedure, the participants were allowed to choose one of the envelopes to detect the mouth side that will receive MOP intervention.

Blinding: Blinding was implemented at the measurement level as blinding of either patients or orthodontist was not possible clinically. All the study models were labelled and stored. Measurements were performed by another investigator to prevent any observer bias.

Procedure methodology

(A) Orthodontic protocol

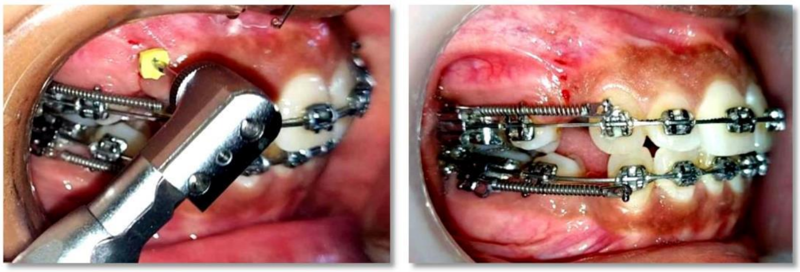
Atraumatic extractions of maxillary first bicuspids were performed at least 4 months before initiation of maxillary en-masse retraction. Furthermore, the extractions were performed by the same surgeon to eliminate the intra-operator variability. All participants were bonded with 0.022x0.028-in MBT prescription appliance (AO). Leveling and alignment were initiated with Ni-Ti archwires and continued until the final working wire was reached ie 0.019 x 0.025 in SS wire. Second molars were included in the setup to reinforce anchorage. Canine-to-canine consolidation was performed, followed by en-masse retraction using NiTi closed coil springs.

Figure no 1: Shows en-masse retraction using NiTi closed coil spring on right (A) and left (B) mouth sides

(B) MOP intervention

The experimental side received MOP intervention on the same day as the initiation of en-masse retraction. Local anesthesia was infiltrated distal to canines. After anesthesia was achieved, the gingiva was dried and the target region was marked. Under profuse saline irrigation, a Peeso-reamer (file #4, diameter=1.3 mm) driven in a micromotor contra-angled handpiece was used to perform MOPs of 5 mm depth. The target region was disinfected with betadine and three micro-osteoperforations were created directly through the alveolar mucosa in the middle of the distance between the canine and second bicuspid at the extraction site, in a vertical direction. Participants were instructed to avoid the use of NSAIDs (only acetaminophen, if needed). Every four weeks, a follow-up was scheduled. The force produced by the Ni-Ti closed coil spring was adjusted at every visit. The appliances were monitored for any deformation or change in position due to chewing.

Figure no 2: Shows peeso-reamer-facilitated MOP intervention (A) during MOP intervention (B) after MOP intervention



Data Collection

An upper alginate impression was made before initiating the retraction phase(T0) and 12 weeks thereafter(T1). The study models were prepared with type-III dental stones and labeled with the patient's name and date and stored. After the study, the models were retrieved and examined by a person not involved in the study.

(A) Determination of the rate of en-masse retraction:

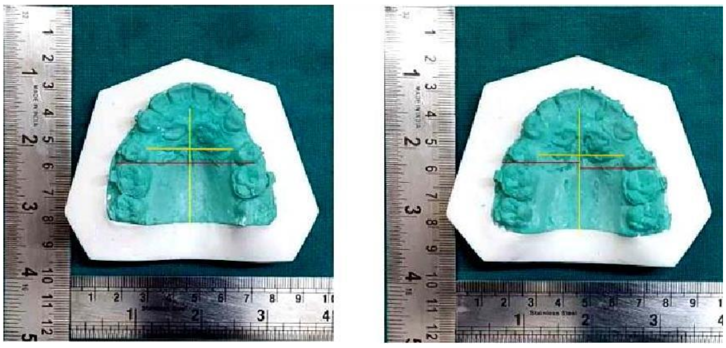
The en-masse retraction rate was measured directly on study models using a digital vernier caliper. The distance
from the most prominent portion of the distal surface of the canine to the mesial surface of the second bicuspid bilaterally at T0 and T1 was measured as suggested by Alkebsi et al [14].

Figure no 3: Shows the measurement of en-masse retraction using vernier caliper.

(B) Determination of Anchorage loss:

Anchor loss was determined to ascertain that the rate of tooth movement calculated was not affected by the loss of true distance travelled by the canine on the experiment and control side. Study models were measured according to the method described by Ziegler and Ingervall [18]. The study models were photographed ere caliberated in reference to a metallic scale. The midpalatal raphe was used to construct a median reference line. A perpendicular line was drawn from the median reference line to the mesial contact point of the first permanent molar on both sides and the distance from the medial aspect posterior-most rugae and mesial contact point of the first molar was calculated in reference to the median reference line on both sides. The anchor loss was calculated by comparing pre-treatment and post-treatment values to their respective sides

Figure no 4: Shows the measurement of anchorage loss (A) Before initiation of en-masse retraction (B) After 3 months of en-masse retraction



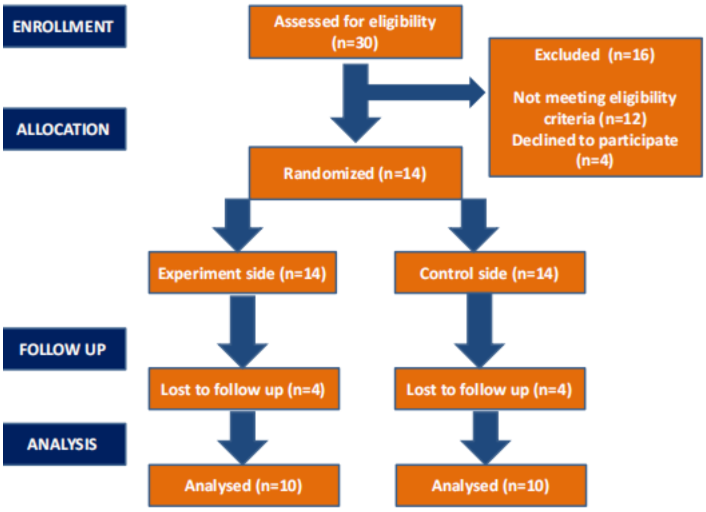
Statistical analysis

The data was entered into an Excel spreadsheet and analyzed with SPSS 21.0. Analysis for probability distribution was done using the Kolmogorov-Smirnov test, p value >.05 indicated that the data was normally distributed. Inter-group comparison of paired data was done using Paired't' test. P value <.05 was considered statistically significant.

III. Result

Fourteen participants were included in the study from September 2021 to March 2022 with data collection completed by September 2022. Four dropouts, were there, thus, 10 out of 14 participants were ultimately part of the study. Participant's ages ranged from 17 to 30 years (20.26±2.13). No deformation of the appliance was observed during the retraction phase, and neither any negative after-effect was reported by any participant during the study.

Figure no 5: Shows consort diagram

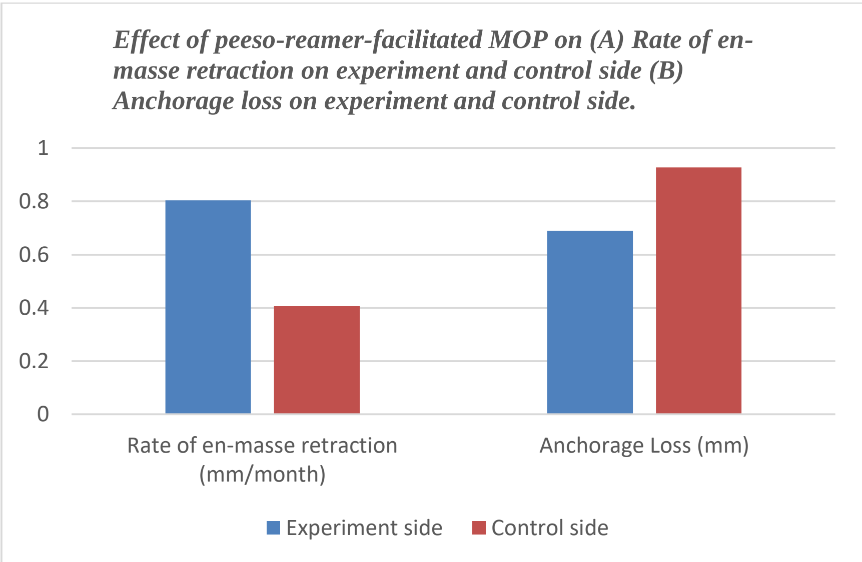


Over a 3-month observation period, mean en-masse retraction was 0.80mm/month (SD= 0.21mm) on the side that received MOP intervention and 0.41mm/month (SD= 0.05mm) on the control side was calculated by the following formula: Rate= Amount of en-masse retraction/ Time(in months) The MOP side thus, exhibited a 1.97 times higher rate of en-masse retraction than the contralateral control side.

Furthermore, the mean anchor loss was 0.68mm (SD= 0.27mm) and 0.93mm (SD= 0.37mm) on the MOP side and the control side respectively. The results distinctly show that anchorage loss on the MOP side was significantly less than on the control side.

Table no 1: Shows Comparison of rate of en-masse retraction and anchor loss on the experimental & control side. Paired 't' test. *p value<0.05 was considered statistically significant

	Side of intervention	**Mean (mm)**	**Standard deviation (mm)**	**T value**	**P value**
Rate of en-masse retraction	Experiment Side	0.8030	0.21823	5.899	0.001*
	Control Side	0.4060	0.04719		
Anchorage loss	Experiment Side	0.6890	0.26714	-3.836	0.004*
	Control Side	0.9270	0.36999		



IV. Discussion

Micro-osteoperforation is a flapless surgical procedure that is the least invasive and produces the same amount of RAP as other invasive surgical modalities to accelerate OTM. Various iatrogenic factors can affect the rate of tooth movement. Nimeri et al [1] reported that the RANKL: OPG ratio affects the rate of bone remodeling and tooth movement and is proportional to age. Keeping that in mind, only adult subjects were included in this study. Occlusal forces have a significant impact on OTM, according to Usumi-Fujita et al [19]. To equalize the effect of occlusion in the study, the participants having malocclusion with similar characteristics and treatment plans were selected.

The consequences of MOP were studied over 3 months in the current study because the RAP that usually follows the MOP procedure lasts 3-4 months. MOP intervention was randomly done on either the left or right side of the maxilla to avoid errors due to unequal occlusion forces that may occur as a result of habitual chewing unilaterally. Between premolar extraction and the start of en-masse retraction, a minimum of three months was allowed to allow for the return of normal bone architecture in the extraction site [20], because regional acceleratory phenomenon can also occur as a sequel to surgical trauma from extraction.

Another important factor influencing the rate of orthodontic tooth movement is the type of movement itself [21]. In this study, an attempt was made to achieve bodily movement, by sliding the canine on 0.019* 0.025" SS wire ligated to 0.022*0.028 MBT appliance.

Immediate retraction could cause bias by the binding of wire in the bracket slot. So, this final working wire (0.019 x 0.025-in SS) was then kept in the bracket slot for 4 weeks, to allow passive contact before the initiation of en-masse retraction.

According to Yang C et al [22], a controlled incision could reduce the bone resistance on the cementoenamel junction at the distolabial side which receives maximum stress during canine retraction. Based on their concept, 3 equidistant MOP were created in this study, only distal to canine along the root length, to reduce the alveolar crestal bone resistance that limits orthodontic tooth movement.

Fattori et al [23] investigated the effect of Propel-assisted MOP and found a similar same average rate as a previous study that used mini-screws to create MOP. They stated that if the depth and MOP design were performed similarly, bone and biological processes would not respond differently to different devices. We used peeso-reamer to create MOP, primarily because it had flutes in its design which are long and sharp that could perforate the alveolar bone cortex. Second, because it is driven in a micromotor-contrangled handpiece, it delivers optimal torque for MOP creation. Because average gingival thickness is 2 to 3 mm, and average cortical bone thickness is 1.5 to 2.0 mm, the perforation depth of peeso-reamer was kept minimum 5 mm and was secured with a rubber stop, After MOP, a NiTi closed coil springs producing force of 150 g was used for en masse retraction [24].

In the present study, the mean rate of en-masse retraction over 3 months, increased on the experiment side that received peeso-reamer facilitated MOP by 1.97 times. This was indistinguishable from the results of previous studies that used other modalities to create MOPs done by Alikhani et al [3], Cheung et al [11], and Feizbakhsh et al [12] that revealed a higher rate of canine retraction following MOP intervention by approximately 2 folds, although they only reported on individual maxillary canine retraction. This result unfortunately was challenged by the results of studies done by Alkebsi et al [14] and Aboalnaga et al [15] who advocated that micro-osteoperforations were not able to accelerate the amount of canine retraction; however, it seemed to facilitate root movement. Probable reasons for the differences observed might be different anchorage planning, treatment mechanics, method of measurement, measurement reference points and also different method of creating osteoperforations.

Furthermore, Alikhani [2] hypothesized that without MOP, there is no decrease in the bone density around the canine; therefore, the time needed to distalize the canine is more which in turn results in a greater reactionary force on anchor units. Consequently, when conventional mechanics with MOP is employed, the canines move faster through the bone because MOP decrease the bone density only in the surrounding area; while the bone density around anchor teeth remains unchanged, which is why the reduced bone density renders the bone weak and resistance to movement. The results of the current study also witnessed the above reported fact and found that the mean anchor loss was significantly lower on the MOP side compared to the contralateral control side.

Limitations

1. Inflammatory biomarkers were not assessed.
2. Measurements were done manually on study models.
3. Measurements were made before the completion of en-masse retraction.
4. Adverse effects of MOP intervention, like root resorption and crestal bone resorption, were not evaluated.

V. Conclusion

Within the limitations of this study, it can be concluded that peeso-reamer- facilitated micro-osteoperforations could be an effective method for accelerating orthodontic tooth movement just as any other modality that has been used to create micro-osteoperforations. Besides that, it reduces the taxing of anchorage units, causes no additional pain, and possesses high patient acceptance.

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