



## EFFECT OF MICRO-OSTEOPERFORATION ON RATE OF CANINE RETRACTION IN PATIENTS UNDERGOING ORTHODONTIC TREATMENT

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### ABSTRACT

**Introduction** - The concept of accelerated tooth movement has been receiving constant attention. (1) Micro-osteoperforation (MOP) is one of the least invasive and effective surgical techniques described for use in conjunction with orthodontic treatment.

**Aim** - To evaluate the effect of micro-osteoperforation on rate of canine retraction in patients undergoing orthodontic treatment. All published full text RCTs since 10 years on PubMed database was used.

**Results** - Total 8 RCTs were screened which involved micro-osteoperforation before canine retraction. Among 8 RCTs, 5 conclude that MOP increases the rate of canine retraction and 3 concluded that there was minimal or no difference on rate of canine retraction.

**Conclusion** - Micro-osteoperforation is a minimally invasive technique with little patient discomfort also it eliminates the disadvantages of other surgical procedures. Thus, Micro-osteoperforation using Regional Acceleratory Phenomenon (RAP) shortens the duration of adult orthodontic treatment providing efficient outcome.

**Keywords:** Micro-osteoperforation; MOP; Accelerated orthodontics, Corticotomy

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## Introduction

Comprehensive orthodontic treatment takes nearly 2 years to complete but patients expect a shorter duration of treatment time. This expectation of a shorter duration is more in adults. Thus, the concept of accelerated tooth movement has been receiving constant attention. (1) Nowadays several surgical techniques to improve or facilitate the rate of orthodontic tooth movement (ROTM) and to reduce iatrogenic damage caused by the long-term wear of fixed appliances. Many authors have reported a shortened time for orthodontic treatment by using those techniques.(2)Surgical interventions have also been used to increase the rate of tooth movement followed by a decrease in the treatment duration. Surgical methods, such as osteotomies, corticotomies with or without bone grafts, and less invasive techniques, including piezosisions, piezopuncture, and micro-osteoperforations (MOP) have been used to stimulate the natural mechanisms of the bone which in turn increase the rate of tooth movement.(3) However, irrespective of the method, the rate of the tooth movement is dictated by the biologic response to the applied orthodontic forces.(4) Micro-osteoperforation (MOP) is one of the least invasive and effective surgical techniques described for use in conjunction with orthodontic treatment. It involves production of multiple transmucosal perforations within alveolar bone, sited near the region of desired tooth movement and in specific configurations, depending on the tooth movement required.(5)

Micro-osteoperforation is based on the principle of Regional acceleratory phenomenon. The regional acceleratory phenomenon (RAP) is a tissue reaction to different noxious stimuli that was first described as a general entity by Harold Frost. The RAP is characterized by an acceleration of normal ongoing tissue processes and involves both soft and hard tissue. It is a ubiquitous and general post injury phenomenon that does not solely occur in the skeleton, but also in the abdominal viscera, in the intracranial and thoracic cavities, and in the soft tissue of the nasopharyngeal and oral cavities.(6)

The primary objective of this systematic review is to evaluate the effect of micro-osteoperforation on rate of canine retraction in patients undergoing orthodontic treatment.

## METHODS

PubMed search engine was used. English language articles assessed carefully and in detail relating to micro-osteoperforation. According to the formal search strategy, eligible articles were sorted out and required information obtained from eligible articles extracted. Search terms were ((microosteoperforation) OR (MOP)) AND (orthodontic tooth movement).

### Web address –

On PubMed database following link was used.

[https://pubmed.ncbi.nlm.nih.gov/?term=\(\(microosteoperforation\)%20OR%20\(MOP\)\)%20AND%20\(orthodontic%20tooth%20movement\)&filter=pubt.randomizedcontrolledtrial&filter=datesearch.y\\_10&page=2](https://pubmed.ncbi.nlm.nih.gov/?term=((microosteoperforation)%20OR%20(MOP))%20AND%20(orthodontic%20tooth%20movement)&filter=pubt.randomizedcontrolledtrial&filter=datesearch.y_10&page=2)

Inclusion criteria was –Micro-osteoperforation related were considered.Randomized controlled trail study articles were collected which were published from year 2012 to 2021.All articles that were in English language were included.

Exclusion criteria was – Articles, in which micro-osteoperforation was not mentioned.

Pico for this systematic review: (P) Participants – In this systematic review participants are all articles on micro-osteoperforation for canine retraction.(I)Intervention(s), exposure(s) –In this systematic review, intervention is micro-osteoperforation. (C) Comparator(s)/control – Patients undergoing canine retraction without micro-osteoperforation.(O) Outcome –There is accelerated tooth movement with micro-osteoperforation.

## Result –

Words selected are “micro-osteoperforation” OR “MOP” AND “Orthodontic tooth movement”. PubMed database was used and on searching word “micro-osteoperforation”, 14,827 articles were shown and on search of “Orthodontic tooth movement” 4,022 articles were shown. Then filter of randomized controlled trial was applied which gave result of 8 articles. Then the filter of RCT in last 10 years was applied which gave result of 11 articles. . All articles were properly searched for required information. . These 26 articles fulfilled the required criteria for the systematic review. (table no 1)

Risk of Bias - Cochrane risk of Bias assessment was done. Risk of bias was evaluated for each question. For each question-based entry the judgment was: “Yes, for low risk of bias” and a point were allocated (\*), and “No, for high risk of bias” and a point was not allocated by Newcastle Ottawa scale. The evaluation was done on answering the questions, answers were yes towards the low risk bias. Evaluations were done and after estimation were found to be low risk articles.

## Discussion

Prolonged orthodontic treatment could be very disappointing for our patients, particularly for older age categories. (7) This clinical trial, similar to our animal studies, demonstrates that the application of MOPs can increase the rate of canine retraction by more than 2-fold. But many factors could affect the rate of tooth movement and need further study. Another major factor affecting the rate of tooth movement is the type of movement. In this study, an attempt was made to achieve bodily movement. Although our results suggest that retraction of the canines was not completely bodily. (8)

Several animal studies have also been performed to investigate the effects of MOPs on the rate of tooth movement. (9) Cheung et al. conducted a study on rats for 21 days to show the effects of MOPs on tooth movement. They found that MOPs increased the rate of mesial tooth movements of the maxillary first molars by 1.86 fold. (10) Sugimori et al. found greater mesial tooth movements of maxillary first molars in the MOP group than in the control group in a rat study that lasted 14 days (11). Both studies evaluated the distances between first and second molars on microcomputed tomography images to measure the rate of tooth movement. Teixeira et al. showed in their rat study which lasted 28 days that MOPs with flaps increased the rate of tooth movement. (12)

Alkebsi et al. showed a divergent result of no statistically significant difference in the rates of tooth movement between the MOP and the control side at all time points (1, 2, and 3 months). They used micro-implant anchorage for canine retraction similar to our study but had three MOPs distal to canine against six MOPs (three mesial and three distal) performed in our study. The increased surgical trauma with RAP on the mesial and distal aspects might have been associated with a significant increase in the rate of tooth movement in our study of similar duration. The effect of repeated MOPs on the rate of tooth movement has been reported by various authors with different results. The clinical trial by Attri et al. evaluated the effect of repeated MOP (distal to canine) every 28 days on en masse retraction that showed a significant increase in tooth movement, although the effect of RAP on incisors is debatable. In contradiction to this study, Haliloglu-Ozkan et al. showed that repeating the procedure monthly does not appear to show a major advance in tooth movement. A similar clinical trial by Sivaraajan et al. concluded that increased canine retraction achieved using MOP over 16 weeks is unlikely to be clinically significant. (1) Yang et al. have shown that the maximum stress encountered during canine retraction was focused on its cervix at the distolabial side and added that distal corticotomy had similar biomechanical effects as a continuous circumscribing cut around the canine root. Based on their assumptions, the MOPs were only

performed distal to the canine and vertically distributed along the cervical two thirds of the canine root length.(13)

According to study done by Neda et al. there was a significant increase in the rate of canine retraction in the MOP2 group compared to the MOP1 group at all time intervals. This finding may be attributed to the greater surgical trauma that stimulated a higher expression of inflammatory markers and osteoclast activity, which in turn increased the rate of tooth movement. Interestingly, there was no significant difference between the experimental side and contralateral control group at T3 time interval in the MOP1 group. This could be explained by the transient nature of RAP which weakened over time. Alikhani et al.(8) and Feizbakhsh et al. found the greatest increase in RTM with MOPs but used different numbers of holes, force applied, and duration for their studies. Sivarajan et al. affirmed that although the increase in canine retraction rate was statistically significant, it was clinically meaningless; thus, to suggest that a shorter treatment time would be highly speculative.(2) according to Jaiswal et al based on the observations of our study, it can be concluded that the use of two-time MOP accelerates the tooth movement by 25% compared to one-time MOP. Two-time MOP also led to a significant increase in levels of IL-1b that ascertains the observed increased osteoclastic activity after 2nd insult (2nd MOP). However, evaluating specific biomarkers in a time-dependent manner can help assess the later stages of tooth movement, focusing on future studies.(14)

Sivarajan et al in 2018, conducted a study to investigate, using a split-mouth randomized clinical design, the effect of microosteoperforation (MOP) on mini-implant supported canine retraction using fixed appliances. Thirty subjects (seven males and 23 females) with a mean age of 22.2 (3.72) years were randomized into three canine retraction groups: Group 1 (MOP 4-weekly maxilla/ 8-weekly mandible; n ¼ 10); Group 2 (MOP 8-weekly maxilla/12-weekly mandible; n ¼ 10) and Group 3 (MOP 12-weekly maxilla/4-weekly mandible; n¼10) measured at 4-week intervals over 16 weeks. Subjects also completed pain (5-point Likert scale) and pain impact (Visual Analogue Scale) questionnaires. Mean overall canine retraction was 4.16 (1.62) mm with MOP and 3.06 (1.64) mm without. Conclusion of this study was MOP can increase overall mini-implant supported canine retraction over a 16-week period of observation, but this difference is unlikely to be clinically significant.(5) Babanuori et al in 2020, conducted a split mouth study. The study aimed to evaluate the effect of MOP over a 3-month period and to determine the influence of the number of perforations on the rate of canine retraction. Twenty-eight patients (range from 16.3 to 35.2 years) who need fixed orthodontic treatment were recruited and randomly assigned to MOP1 and MOP2 groups. Patients in MOP1 group received 3 MOPs on the buccal surface of alveolar bone in the experimental side to accelerate canine retraction whereas patients in MOP2 group received 3 buccal MOPs and 3 palatal MOPs in the experimental side. There was a significant difference in the rate of canine retraction between the MOP groups and the contralateral control sides, as well as between the MOP1 and MOP2 groups. The study concluded that MOP procedure was effective in accelerating orthodontic tooth movement, although the amount of acceleration was not clinically significant in the case of canine retraction. An increase in the number of MOPs resulted in a significant acceleration of the canine retraction.(4)

Attri et al in 2018, conducted a study to investigate the influence of MOP on rate of Orthodontic tooth movement. 105 patients were screened, out of which 60 met the inclusion criteria and consented to participate; consisting of 33 females and 27 males requiring en-masse retraction following first premolar extractions. The experimental group consisted of patients bonded with a fixed appliance (Gemini 3M) who received MOP distal to canines throughout the period of retraction every 28 days. A statistically significant increase in rate of tooth movement in the MOP group. conclusion of this study was MOP appears to enhance the

rate of tooth movement with no differences in pain perception.(15). Fattori et al in 2020, conducted a study that aimed to investigate the effect of micro-osteoperforation (MOP) on the rate of tooth movement (RTM) and space closure duration. Twenty-four participants with indications for premolar extractions were randomly allocated to treatment with conventional sliding mechanics (control group; CG) or with to treatment in which three MOPs were performed every activation (experimental group; EG). Dental impressions were taken monthly until space closure was completed and dental casts were converted to three-dimensional models. For full space closure RTM, no significant difference was found between groups (0.614 mm/month for the CG; 0.672 mm/month for the EG). The RTM for different time points, groups, time frames and their interaction were statistically different. The study concluded that use of MOPs did not change the full space closure RTM.(2).

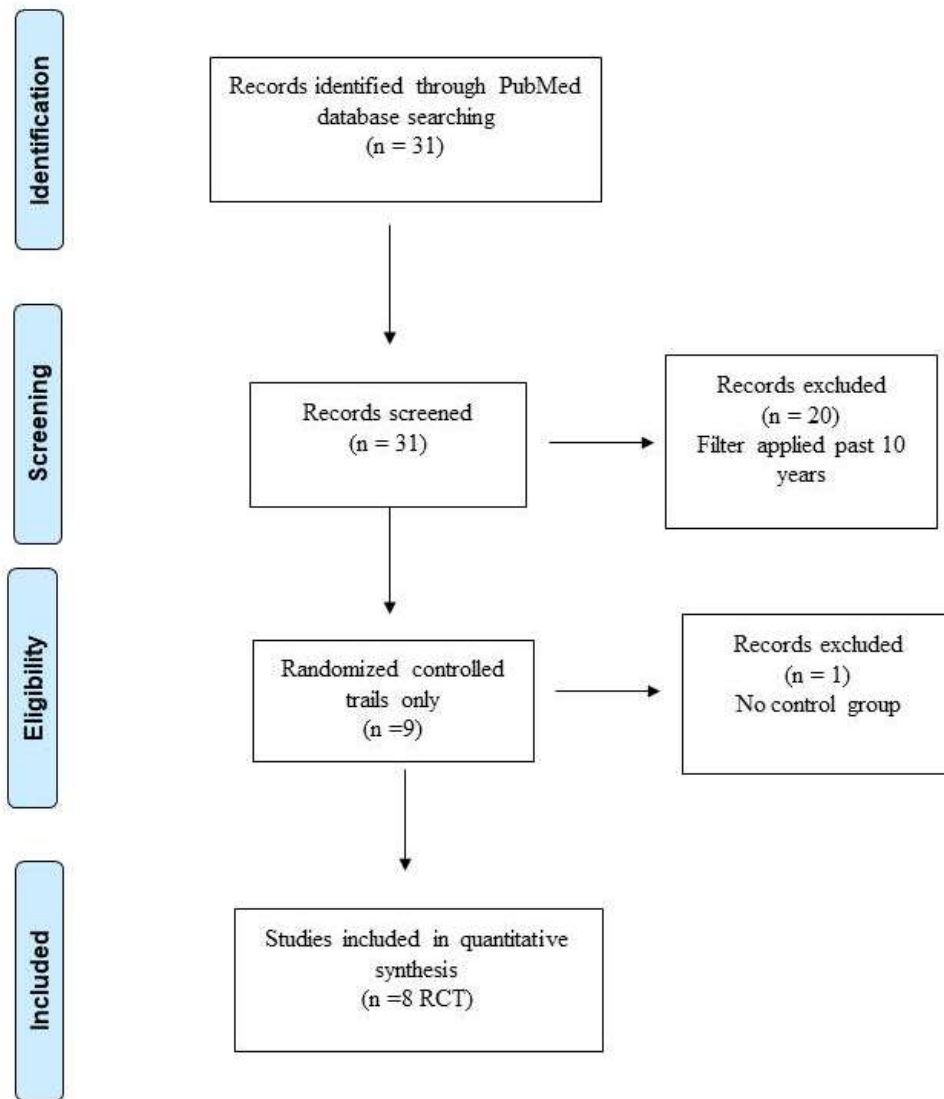
**Conclusion** - Among various techniques that were used for accelerating orthodontic tooth movement, Micro-osteoperforation remains a minimally invasive technique with little patient discomfort. Micro-osteoperforation eliminates the disadvantages of other surgical procedures. Catabolic and anabolic effects can be achieved by performing MOPs according to the patient's treatment plan. Thus, Micro- osteoperforation using Regional Acceleratory Phenomenon (RAP) shortens the duration of adult orthodontic treatment providing efficient outcome. Further studies must be done by increasing the frequency and varying site, e.g by involving mesial side of canine.

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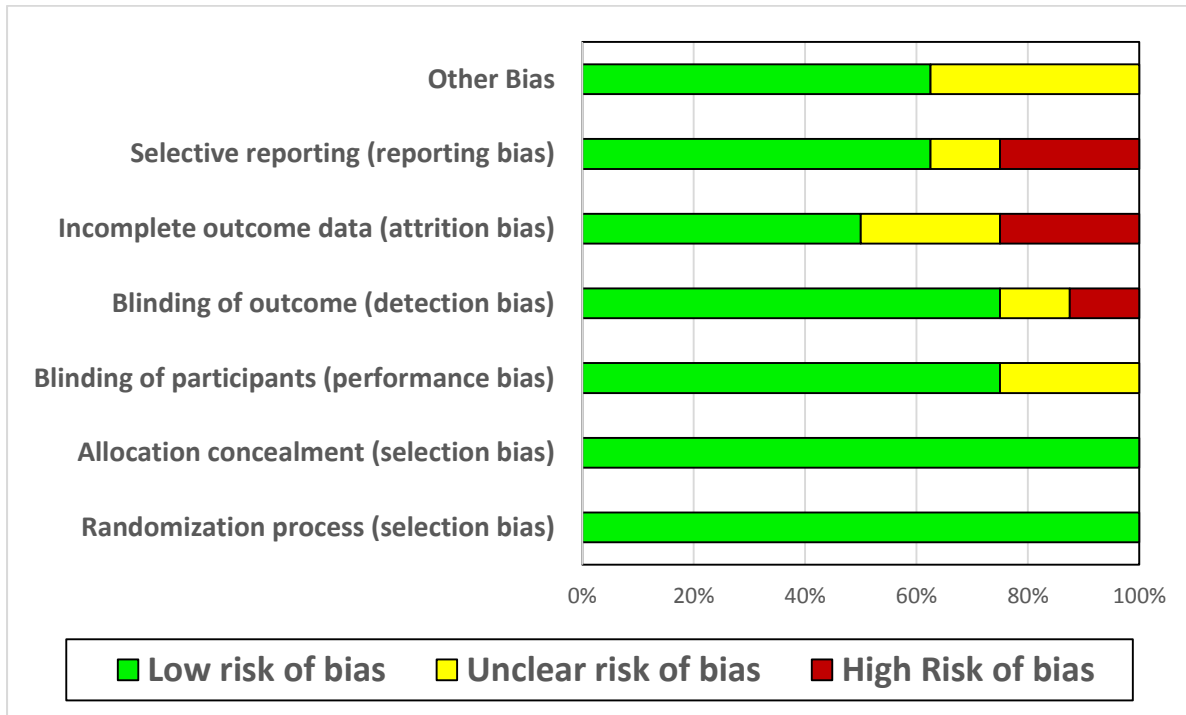
**FIG -1** Flow diagram of systematic review

Cochrane Risk of Bias Assessment (RoB 2) Table 1

+/green color: low risk of bias;  
 ?/yellow color: some concerns;-/red color: high risk of bias

Studies (year)	Randomization process	Allocation concealment	Blinding of participants & personnel	Blinding of outcome	Incomplete outcome data	Selective reporting	Other Bias
Mani Alikhani et al 2013	+	+	+	+	?	+	?
SonalAtri et al 2018	+	+	+	+	+	-	+
Amal Alkebsi et al 2018	+	+	?	+	-	+	+
Amira Aboalnaga et al 2019	+	+	+	-	?	+	?
Saritha Sivarajan et al 2019	+	+	+	+	+	?	+
Liana Fattori et al 2019	+	+	+	?	+	+	?
Neda Babnouri et al 2020	+	+	+	+	+	-	+
Stephy Thomas et al 2021	+	+	?	+	-	+	+





Graph 1

ARTICLES WITH CONCLUSION: Table 2

SR NO	Author name	Conclusion
1	<i>Alikhani et al 2013</i>	Micro-osteoperforation is an effective, comfortable, and safe procedure to accelerate tooth movement and significantly reduce the duration of orthodontic treatment
2	<i>Alkebsiet al 2017</i>	Three MOPs were not effective in accelerating tooth movement at any time point. Other secondary parameters evaluated were not different between the MOP and control sides
3	<i>Attriet al. 2018</i>	MOP appears to enhance the rate of tooth movement with no differences in pain perception.
4	<i>Sivarajan et al. 2019</i>	MOP can increase overall mini-implant supported canine retraction over a 16-week period of observation, but this difference is unlikely to be clinically significant.
5	<i>Amira et al 2019</i>	Micro-osteoperforations were not able to accelerate the rate of canine retraction; however, it seemed to facilitate root movement.
6	<i>Babanouri et al 2020</i>	The MOP procedure was effective in accelerating orthodontic tooth movement, although the amount of acceleration was not clinically significant in the case of canine retraction.
7	<i>Fattori et al 2020</i>	Use of MOPs did not change the full space closure RTM
8	<i>Thomas et al 2021</i>	An increase in the rate of tooth movement can be achieved without any periodontal adverse effects in the first 45 days of the MOP procedure

Author , year	Study design	Sample size (patients)	Gender	Age	Malocclusion	Study duration	Intervention	Mechanics	Mean   moven	
									MOP	CTRL
<a href="#">Alshewari et al. 2013</a>	RCT – Split mouth	40 (20) MOP 10(10); CTRL- 30(20)	M: 8 F: 12	19.5-33.1	Class II Div. 1	4 Weeks	Only upper premolars were extracted, 0.022 ROTH prescription used. 3 MOPs made using PROPEL device	Canine retraction with Miniscrew and 100g NITI Spring. Distance between Canine and lateral was measured at 3 points on cast	1.14mm /month	0.49mm /month
<a href="#">Alkobeisi et al. 2017</a>	RCT –split mouth	64 (32)–MOP:32 (32);CTRL: 32 (32)	M: 8; F: 24	19.26 ± 2.48	Class II Div. 1	12 weeks	Only upper molars were extracted, 0.22 in. MBT (3 M Ujjainiek) bracket were used, 3 MOPs were made using Miniscrews (3 mm distal to canine and 6 mm from gingival margin, 5 mm from each other.)	Canine retraction (absolute anch. With mini screw, coil spring 9 mm, 150 g); 3D models and position of distal of canine and distance between canine and second premolar bracket intracranially.	1.23 mm/month	1.17 mm/month
<a href="#">Agori et al. 2018</a>	RCT –split mouth	120 (60)– MOP:60 (30); CTRL:60 (30)	M: 27; F: 33	17.5 ± 2.52 MOP; 18.16 ± 1.48 CTRL	NR	4 weeks	All four premolars could be extracted, 0.22 in. MBT (3 M Ujjainiek) brackets were used, 3 MOPs made using PROPEL device in both arches (equal distance from canine and premolars. 1.5 mm wide and 2–3 mm deep)	Canine retraction (second molar banding with TPA, 150 g tie back elastic); 3D models and distance between distal of canine and mesial of premolar superimposed on gingiobuccal line was measured	0.89 mm/month	0.58 mm/month
<a href="#">Sivasubramanian et al. 2019</a>	RCT –split mouth	120 (30)–MOP:60 (30);CTRL: 60 (30)	M: 7; F: 23	22.2 ± 3.1	Class I, Class II or Class III (4 PM ex)	16 weeks	All four premolars were extracted, 0.22 in. MBT (3 M Ujjainiek) brackets were used, 3 MOPs made using Mini-Screws (distal to the canine and 5 and 8 mm gingival to the skeletal crest. 1.6 mm wide and 3 mm deep)	Canine retraction (from canine to mini-screw without power-arm, 140–200 g elastomeric chain) intracanal and every 4 weeks from centre of canine bracket to mini-screw, between canine tip to mesio-buccal cusp of molars were measured	1.04 mm/month	0.76 mm/month
<a href="#">Amira et al. 2019</a>	RCT –split mouth	36(18)- MOP, 18(9); CTRL- 18(9)	M:0; F:18	20.5± 2.85	NR	16 weeks	Only upper premolars were extracted, 0.022 ROTH prescription used. 3 MOPs Made using mini-screws distal to canine	Canine retraction with NITI closed coil spring 150g between canine and molar hooks	0.99mm/month	0.83 mm/month
<a href="#">Babunovska et al. 2020</a>	RCT- split mouth	28(14), MOP:14 (7), CTRL: 14 (7)	M:7 F:11	16.3–35.2	NR	7 weeks	Only upper premolars were extracted, 0.022 MBT prescription used, MOP1 Received 3 MOP buccally and MOP2 Received 3 MOP buccally and # MOP Palatally.	Canine retraction with NITI closed coil spring 150g between canine and molar hooks	0.94mm/month	0.64mm/month
<a href="#">Fotouhi et al. 2020</a>	RCT- split mouth	18, MOP:9 CTRL:9	M:7 F:11		NR		Only upper premolars were extracted, 0.022 MBT prescription used. 3 MOPs Made using mini-screws distal to canine	Canine retraction with NITI closed coil spring 200g between canine and molar hooks	0.67mm/month	0.61mm/month
<a href="#">Thomas et al. 2021</a>	RCT-split mouth	33 MOP, 33 CTRL	M: 9 F:24	19-25	Class I Bimaxillary Class II Div.2	12 weeks	Only upper premolars were extracted, 0.018 MBT prescription used. 3 MOPs Made using mini-screws distal to canine	Canine retraction with NITI closed coil spring 150g between canine and mini implants	1.32mm/month	0.86mm/month

TABLE NO 3: EFFECT OF MICRO-OSTEOPERFORATION ON RATE OF TOOTH MOVEMENT