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EVALUATION OF MOLAR PROTRACTION WITH DISTRACTOR AND MICRO-OSTEOPERFORATION- A COMPARATIVE STUDY"

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Abstract

Background: Accelerating orthodontic tooth movement is a major clinical goal to reduce treatment duration. Techniques such as micro-osteoperforation (MOP) and distraction osteogenesis (DO) have been proposed as effective adjuncts.

Materials and methods

This in-vivo randomized clinical study was conducted on 30 patients with Class I malocclusion requiring molar protraction. The subjects were randomly allocated into three groups of 10 each: Group A treated with conventional T-loop mechanics, Group B with distractor-assisted osteogenesis, and Group C with micro-osteoperforation (MOP) combined with T-loop mechanics. Standard MBT fixed appliances were used in all patients. Molar protraction was measured intraorally as the distance between the second molar and premolar using a digital vernier caliper at baseline (T0), 45 days (T1), and 90 days (T2). The collected data were subjected to statistical analysis using appropriate parametric and non-parametric tests, with the level of significance set at $p < 0.05$.

Objective: To evaluate and compare the amount and rate of second molar protraction using conventional T-loop mechanics, distractor-assisted osteogenesis, and MOP combined with T-loop mechanics.

Results:
All groups showed significant molar protraction ($p<0.05$). The distractor group demonstrated the highest rate of tooth movement, followed by MOP with T-loop, while conventional T-loop showed the least movement.
Conclusion:
Distractor-assisted osteogenesis provides maximum acceleration but is invasive. MOP offers a minimally invasive alternative with significant acceleration, while T-loop remains a reliable conventional method.
Keywords: Molar protraction, Micro-osteoperforation, Distraction osteogenesis, T-loop, Accelerated orthodontics

INTRODUCTION

Orthodontic tooth movement (OTM) is a biologically regulated process involving the displacement of teeth within the alveolar bone through coordinated remodeling of the periodontal ligament (PDL) and surrounding bone. Mechanical forces applied to teeth induce cellular responses that lead to osteoclastic resorption on the pressure side and osteoblastic deposition on the tension side, facilitating tooth movement. Burstone et al.[1] introduced the principles of segmented arch biomechanics, highlighting the importance of controlled force systems to achieve efficient and predictable tooth movement while minimizing undesirable effects. Further refinement by Burstone and Koenig[2] established optimal moment-to-force ratios necessary for controlled tipping and bodily movement. Loop mechanics, particularly T-loops fabricated from titanium-molybdenum alloy (TMA), are widely used for space closure due to their ability to deliver precise and continuous forces; their biomechanical efficiency has been demonstrated by Viecilli et al.[3]. Biologically, appropriate force magnitude is critical, as excessive forces may result in adverse effects such as root resorption and periodontal damage (Melsen et al., 1999)[4].

The average rate of conventional orthodontic tooth movement ranges from 0.8 to 1.0 mm per month, with canine retraction generally occurring faster (~0.95 mm/month) than molar protraction (~0.8 mm/month) due to differences in root morphology, bone density, and surrounding anatomical conditions (Davis et al., 2018[5]; Syal et al., 2023)[6]. In response to the clinical demand for reduced treatment duration, accelerated orthodontic tooth movement (AOTM) techniques have been developed based on the Regional Acceleratory Phenomenon (RAP), described by Frost (1983)[7], which enhances bone remodeling following surgical or mechanical stimulation.Paul R et al[8] concluded in a case report that Corticotomy-assisted orthodontics (PAOO) effectively accelerates tooth movement by inducing regional acceleratory phenomenon, significantly reducing treatment duration while maintaining favorable clinical outcomes.Among these techniques, micro-osteoperforation (MOP) is a minimally invasive method that induces localized RAP and has been shown to nearly double the rate of tooth movement (~1.8 mm/month) (Alikhani et al., 2013)[9], with supporting evidence from subsequent studies (Tsai et al., 2020[10]; Jain et al., 2021[11]). Corticotomy, introduced by Wilcko et al. (2001)[12], involves surgical decortication and produces a two- to three-fold increase in tooth movement, although it is associated with greater invasiveness and morbidity

(Dibart et al., 2009)[13]. Piezoincision offers a less invasive alternative with comparable acceleration using ultrasonic micro-incisions (Chandorikar and Bhad, 2023)[14]. In contrast, distraction osteogenesis (DO) is the most invasive technique, involving osteotomy and gradual mechanical distraction, and provides the highest rates of tooth movement (2.5–3.5 mm/month), particularly useful in molar protraction for large edentulous spaces (Cope and Sampson, 1999[15]; Sayin and Türkkahraman, 2004[16])

Quantitatively, while conventional orthodontics achieves movement rates of approximately 0.8–1.0 mm/month, MOP can increase this to about 1.4–2.0 mm/month, corticotomy and piezoincision to 1.8–3.0 mm/month, and distraction osteogenesis to 2.5–3.5 mm/month. However, increased acceleration is often accompanied by increased invasiveness, patient morbidity, and cost, necessitating careful clinical decision-making. The T-loop remains a fundamental component in space closure mechanics, offering controlled force systems with optimal moment-to-force ratios, and its modifications—such as adjustments in loop height, gable bends, and positioning—enhance its effectiveness in both canine retraction and molar protraction (Natarajan et al.[17], 2016; Shetty et al., 2022[18]). Despite advancements, all accelerated techniques present limitations, including risks of root resorption, transient bone loss, and variability in patient response. Importantly, there remains a lack of direct comparative studies evaluating micro-osteoperforation and distraction-based approaches specifically for molar protraction, highlighting the need for further research to determine their relative efficacy, stability, and clinical applicability.

AIM OF THE STUDY:

- To evaluate and compare the amount of protraction of the second permanent molars by micro-osteoperforation, distractor and conventional T-loop mechanics.

OBJECTIVE OF THE STUDY:

- To evaluate the amount of protraction of the second permanent molar by T-loop mechanics.
- To evaluate the amount of protraction of the second permanent molars by distractor.
- To evaluate the amount of protraction of the second permanent molars by micro-osteoperforation with T-loop mechanics
- To compare the amount of protraction of the second permanent molars by micro-osteoperforation , distractor and T-loop mechanics.

NULL HYPOTHESIS

There is no significant difference in the amount of protraction among micro-osteoperforation, distractor, and T-loop mechanics in second permanent molars.

MATERIAL AND METHOD

SAMPLE SELECTION:

This in-vivo study included 30 subjects who were clinically diagnosed with Class I canine malocclusion on the basis of inclusion and exclusion criteria in the Department of Orthodontics

and Dentofacial Orthopaedics at Inderprastha Dental College and Hospital, Ghaziabad, Uttar Pradesh ,UP.

Inclusion Criteria:

- Age group ≥ 14 years
- Missing or grossly carious first permanent molars
- No history of systemic disease
- No history of allergy
- Presence of second permanent molars

Exclusion Criteria:

- Knife edge alveolar ridge
- History of allergy
- History of systemic disease
- Absence of second permanent molar

STUDY METHOD/TOOLS:

- Random sampling

Materials used for the study:

- Molar band material (0.005×0.180)
- Premolar band material (0.004×0.150)
- Weldable Molar tubes
- Flux and Antiflux
- Hydrosolder
- Hyrax expander (11mm)
- Bp blade (no 15) and handle
- Periosteal elevator Molt no -9
- Scissors
- Silk suture (3/8 circle)
- Micromotor
- Blow torch
- Vernier caliper
- MBT Appliance System prescription with 0.022" x 0.028" slot.
- Dontrix Gauze

METHOD

In this study, a total of 30 patients were selected reporting to the Department of Orthodontics and Dentofacial Orthopaedics at Inderprastha Dental College and Hospital, Sahibabad, Ghaziabad, India for Orthodontic treatment, they were selected on the basis of inclusion and exclusion criteria and patient consent was taken and were informed about the study. In all patients, leveling and

alignment was completed, followed by protraction of the permanent second molar, and a 0.019" × 0.025" stainless steel stabilizing archwire was placed in the anterior segment

Selected patients were randomly divided into three groups with 10 patients in each group:

Group A: Protraction of permanent second molar by using conventional T- loop mechanics.(control group)

Group B: Protraction of permanent second molars using distractor.

Group C: Protraction of permanent second molars by micro-osteoperforation followed by T- loop mechanics.

The results showed significant differences in molar protraction among all three groups. Group B demonstrated the greatest protraction compared to Group C and Group A .

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- In Group A, protraction of second permanent molar was done by conventional mechanics with the use of T loops.(Fig1)

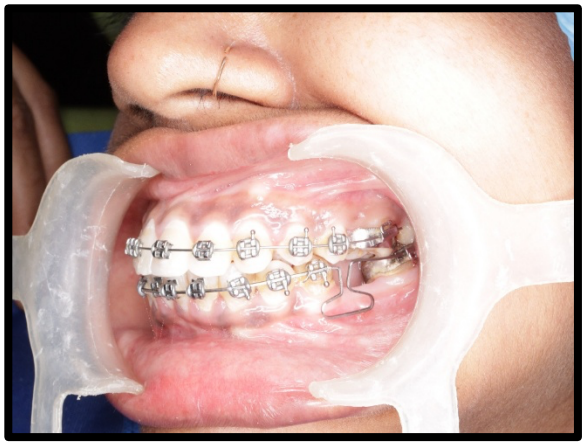


Fig1:Intra-oral T loop

- In Group B, flap was raised and corticotomy was performed on second permanent molar in which buccal and lingual cortex was cut mesial and distal to the second permanent molar with the help of metal bur so that alveolar segment of second permanent molar encounter less resistance for distraction and then flap was closed. Then customised distractor was cemented on second permanent molar and premolar after 1 week of surgery(latency phase) and distraction was done at rate of 0.5mm/day(1/4 turn in morning and ¼ turn in evening) for protraction of second permanent molar for space closure.After closure of space consolidation phase is maintained.(Fig 2)

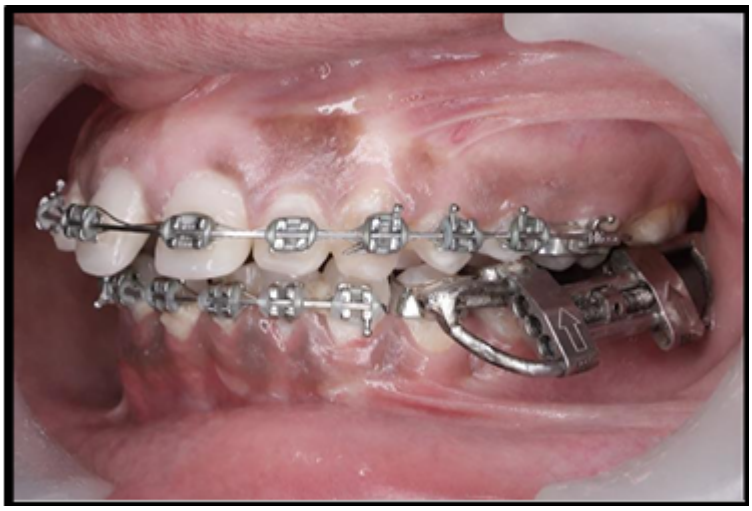
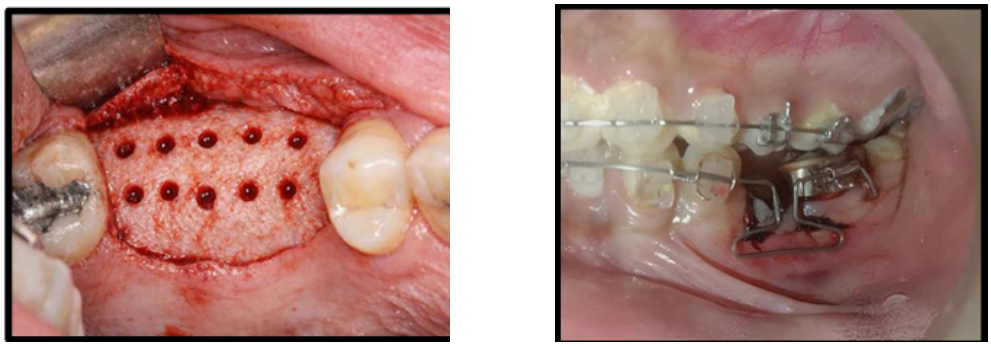


Fig 2: Intra -Oral Customized Distractor

- In Group C, flap was raised and micro-osteoperforation was performed in which 2-4 perforation of 2-7mm in depth were done on the buccal cortex by round bur in the region of attached gingiva along the roots of second permanent molar to accelerate the tooth movement. After micro-osteoperforation of buccal cortex around second permanent molar and on the edentulous site present mesial to second permanent molar and then flap was closed. After procedure of micro-osteoperforation ,protraction of second permanent molar was done by conventional mechanics using T loops.(Fig 3)



A) B)

Fig 3:Intra -Oral linear T-Loop With Micro-Osteoperforation A) Occlusal View B) Buccal View

The distance between the mesial surface of second permanent molar and distal surface of second premolar was measured intra-orally by digital vernier caliper at T0,T1 &T2 in Group A , Group B and Group C(Fig 4).

Data collection was done at three stages:

- T0-at the beginning of protraction of second permanent second molar.
- T1-after 45 days of the beginning of protraction of second permanent molar.
- T2-after 90 days of the beginning of protraction of second permanent molar.

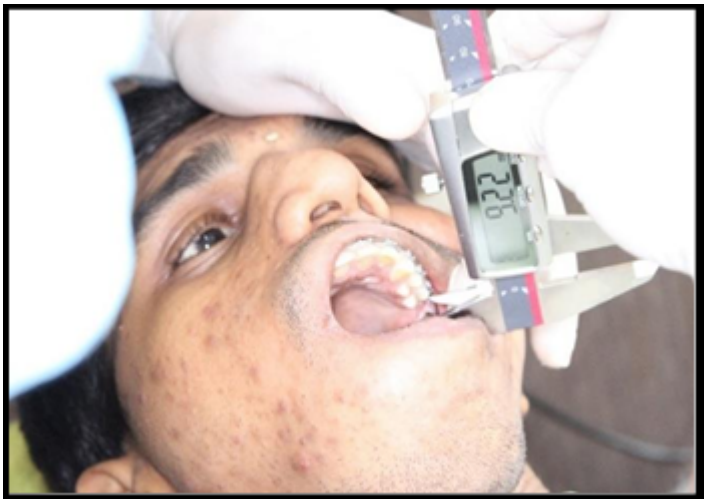


Fig 4: Intra -oral linear measurement

Rate of molar protraction was calculated by following formulae:-

Rate of second molar protraction(T0-T1) = difference in molar protraction in mm(T0-T1)/45 days

Rate of second molar protraction(T1-T2) =difference in molar protraction in mm(T1-T2)/45 days

PLAN FOR DATA ANALYSIS:

The data for the study was entered in the Microsoft Excel 2010 and was analysed using the SPSS statistical software 27.0 Version. The descriptive statistics included mean and standard deviation. Normality of the data was assessed by using Kolmogorov-Smirnov test. For the normal data, the intragroup and intergroup comparison of the quantitative data was done by t-test and One Way ANOVA test respectively and for not normal data, intragroup and intergroup comparison was done by using Wilcoxon signed rank test and Kruskal-Wallis test respectively. The level of the significance for the present study was fixed at 5%.

RESULTS

The study was a prospective, randomized clinical trial and consisted of 30 subjects, conducted in the department of Orthodontics and Dentofacial Orthopedics, Inderprastha Dental College and Hospital, Sahibabad, Ghaziabad. The subjects were randomly divided into three groups. Group A (T-loop control), Group B (distractor) & Group C (micro-osteoperforation).

Table 1: Evaluation of amount of distance between point X and point Y in Group A, B and C

Time Interval	Groups	Mean (mm)	Std. Deviation	Minimum	Maximum

T0	**Group A (Control)**	10.18	0.314	9.51	10.56
	Group B	10.18	0.373	9.71	10.75
	Group C	10.22	0.517	9.55	10.98
T1	**Group A (Control)**	9.40	0.382	8.58	9.95
	Group B	1.19	0.688	.00	1.90
	Group C	8.58	0.490	7.80	9.29
T2	**Group A**	8.61	0.486	7.61	9.25

Time Interval	**Mean (mm)**	**Std. Deviation**	**Z-value**	**p-value,S/NS**
T0-T1	0.78	0.134	-2.810	**0.005,S**
T1-T2	0.78	0.131	-2.805	**0.005,S**
T0-T2	1.57	0.258	-2.803	**0.005,S**

Table-1represents the mean distance between point X and point Y that at baseline (T0), Group A (control) showed distance of 10.18 mm (SD 0.314, range 9.51-10.56 mm), Group B 10.18 mm (SD 0.373, range 9.71-10.75 mm), and Group C 10.22 mm (SD 0.517, range 9.55-10.98 mm), indicating initial group homogeneity. At T1, Group A exhibited mean distance to 9.40 mm (SD 0.382, range 8.58-9.95 mm), Group B to 1.19 mm (SD 0.688, range 0-1.90 mm), and Group C to 8.58 mm (SD 0.490, range 7.80-9.29 mm).At T2, Group A mean distance to 8.61 mm (SD 0.486, range 7.61-9.25 mm), Group B to 0.44 mm (SD 0.307, range 0-0.96 mm), and Group C to 7.03 mm (SD 0.578, range 6.09-7.86 mm)

Table 2: Evaluation of molar protraction at different time intervals in Group A. (Wilcoxon Signed rank test)
$p \leq 0.05$ – Significant, CI = 95 %

Table 2 represent that in Group A (control group), the Wilcoxon Signed Rank test demonstrated statistically significant molar protraction across evaluated time intervals, confirming the efficacy of conventional T-loop mechanics in achieving controlled space closure by 0.78 mm, 0.79 and 1.57 mm during T0-T1, TI-T2 and T0-T2 interval respectively.

Table 3: Evaluation of molar protraction at different time intervals in Group B. (Wilcoxon Signed rank test)

Time Interval	**Mean (MM)**	**Std. Deviation**	**Z-value**	**p-value,S/NS**
T0-T1	8.98	0.581	-2.803	**0.005,S**
T1-T2	0.75	0.469	-2.666	**0.008,S**

T0-T2	9.73	0.395	-2.805	**0.005,S**

p ≤ 0.05 – Significant, CI = 95 %

Table 3 represent that in Group B, the Wilcoxon Signed Rank test demonstrated highly significant molar protraction across evaluated time intervals, confirming the efficacy of customized distractor in achieving controlled space closure by 8.98 mm, 0.75 mm and 9.73 mm during T0-T1, TI-T2 and T0-T2 interval respectively.

Table 4: Evaluation of molar protraction at different time intervals in Group C. (Wilcoxon Signed rank test)

Time Interval	Mean (mm)	Std. Deviation	Z-value	p-value,S/NS
T0-T1	1.64	0.160	-2.807	**0.005,S**
T1-T2	1.65	0.152	-2.803	**0.008,S**
T0-T2	3.29	0.307	-2.807	**0.005,S**

p ≤ 0.05 – Significant, CI = 95 %

Table 4 represent that in Group C, the Wilcoxon Signed Rank test demonstrated statistically significant molar protraction across evaluated time intervals, confirming the efficacy of conventional T-loop with micro--osteoperforation in achieving controlled space closure by 1.64 mm,1.65 mm and 3.29 mm during T0-T1, TI-T2 and T0-T2 interval respectively.

Table 5: Comparison of tooth movement at different time intervals in Group A, B and C

Time Interval	Group	Mean Difference (mm)	Std. Deviation
T0-T1	**Group A (Control)**	0.78	0.134
	Group B	8.98	0.581
	Group C	1.64	0.160
T1-T2	**Group A (Control)**	0.78	0.131
	Group B	0.75	0.469
	Group C	1.65	0.152
T0-T2	**Group A (Control)**	1.57	0.258

	Group B	9.73	0.395
	Group C	3.29	0.307

Table 5 illustrate the comparative molar protraction across Groups A (T-loop control), B, and C where highest amount of tooth movement was shown by Group B, moderate by Group C and followed by group A during T0-T1 interval. During T1-T2 interval highest amount of tooth movement was shown by Group C followed by Group A & Group C whereas during T0-T2 interval highest amount of tooth movement was shown by Group B, moderately by Group C and least by Group A.

Table 6: Intergroup comparison of tooth movement at different time intervals in Group A, B and C. (Kruskal Wallis test)

Time Interval	Group	Group	Chi-square value	p-value, S/NS
T0-T1	**GROUP A**	**GROUP B**	14.329	**<0.001,S**
		GROUP C	25.841	**<0.001,S**
	GROUP B	**GROUP C**	14.307	**<0.001,S**
T1-T2	**GROUP A**	**GROUP B**	0.023	0.880,NS
		GROUP C	19.369	**<0.001,S**
	GROUP B	**GROUP C**	14.286	**<0.001,S**
T0-T2	**GROUP A**	**GROUP B**	14.296	**<0.001,S**
		GROUP C	29.824	**<0.001,S**
	GROUP B	**GROUP C**	14.318	**<0.001,S**

p ≤ 0.05 – Significant, CI = 95 %

Table 6 represent the Kruskal-Wallis test for Intergroup comparison of tooth movement at different time intervals in Group A, B and C.At T0-T1 interval, all pairwise comparisons showed highly significant differences. At T1-T2 Interval, all pairwise comparisons were significant except for group A with Group B was non-significant. At T0-T2 interval showed highly significant intergroup differences among all the groups.

DISCUSION

The present study was conducted among 30 patients reporting to the Department of Orthodontics & Dentofacial Orthopaedics at Inderprastha Dental College & Hospital, Ghaziabad, Uttar Pradesh. Included subjects underwent orthodontic treatment with fixed pre-adjusted edgewise orthodontic appliance following leveling and alignment, with protraction of second permanent molars measured intraorally between the mesial molar surface and distal premolar surface at T0 (baseline), T1, and T2. The aim of the study was to evaluate and compare the amount of protraction of the

second permanent molars by micro-osteoperforation, distractor, and conventional T-loop mechanics. The results demonstrated that all three methods achieved significant molar protraction with marked intergroup differences.

This study established a clear sequence where distractor osteogenesis proved most effective, followed by micro-osteoperforation augmented T-loop mechanics, with conventional T-loop showing minimum movement in the given timeline. The pattern reflects graduated regional acceleratory phenomenon responses from surgical distraction, micro-invasive perforations, and standard biomechanics respectively.

Distraction osteogenesis involves corticotomy/osteotomy separating dentoalveolar segments, followed by latency (3-7 days for hematoma/callus formation), distraction (0.5-1 mm/day traction), consolidation (woven-to-lamellar bone maturation), and remodeling. Traction generates tension-stress (Ilizarov effect), boosting vascular endothelial growth factor (VEGF), hyaluronan, and cytokines (BMPs, TGF-β), forming parallel regenerate bone via intramembranous ossification and fibrous callus stretching—mimicking fracture healing but directed mesially. This hyperactivates RAP, explaining rapid protraction with osteoclast hyperactivity resorbing native bone ahead and osteoblasts filling behind; post-distraction slowdown occurs during consolidation as lamellar bone densifies.

Micro-osteoperforation induce localized trauma without full osteotomy, transiently reducing bone density and upregulating proinflammatory cytokines (IL-1, TNF-α, IL-6, CCL2/3/5) and RANKL for osteoclast recruitment. This extends RAP increasing BMU activity 2-4x via inflammatory cascade, enhancing PDL mechanotransduction under T-loop forces for frontal resorption and tension-mediated apposition.Protraction exceeds conventional T loop mechanics due to stress absorption in perforations (as "escape zones") and Wnt/β-catenin pathway activation for faster remodeling/cementogenesis, with minimal root resorption risk.

The result of present study supports the maximum efficiency of distractor in the tooth movement as advocated by Wilcko et al.[11] who reported substantial treatment time reductions via dentoalveolar distraction. Similarly Kisnisci et al.[19] achieved rapid retraction through dentoalveolar distraction with minimal resorption. Tooth movement achieved with micro-osteoperforation also aligns with the study done by Alikhani et al.[9] via enhanced remodeling. T-loop predictability is affirmed by Burstone (1976)[20] across molars and canines.

Although contrasting views in the literature include Mahajan et al. (2020)[21] who found no MOP acceleration for molars. Alqadasi et al. (2019)[22] also concluded MOP didn't show significant increase in amount of tooth movement.

This discrepancy could be due to distinct accelerated protocols—corticotomy/piezocision ,variations in sample traits (age, bone density, edentulous space), force systems ,anchorage and time interval of the study.

Similar finding are confined to the first phase i.e 45 days of the tooth movement with distractor showing highest amount of the tooth movement followed by mico-osteoperforation and minimum amount of tooth movement was shown by conventional T loop.

During the second phase of the study, micro-osteoperforation achieved the greatest tooth movement, exceeding distractor osteogenesis with its moderate consolidation phase, while conventional T-loop mechanics produced the least displacement. This shift underscores the enduring RAP induced by micro-osteoperforations, which outperformed distractor consolidation and standard T-loop velocities, as validated by Kruskal-Wallis test revealing significant intergroup variations. The observed trend indicates an initial rapid peak from distraction followed by sustained bone remodeling from micro-invasive interventions.

Teixeira et al. (2010)[23] reported prolonged elevation of bone turnover biomarkers extending past the acute MOP period in canine retraction, corroborating the persistent effectiveness of micro-osteoperforations. Frost (1983)[7] described RAP's transient nature (peaking 4-6 weeks then extending with micro-trauma), consistent with MOP dominance in this study's second phase of tooth movement. Jacobsen et al. (2008)[24] documented post-distraction deceleration attributable to lamellar bone consolidation.

CONCLUSION

This study aimed to evaluate and compare the amount of protraction achieved in permanent molars using three different modalities—micro-osteoperforation, distractor-assisted mechanics, and conventional T-loop mechanics.

- Conventional T-loop mechanics ,demonstrated statistically significant molar protraction across all time intervals over the 90-day study period. The mean available space reduced significantly during both active and consolidation phases, confirming T-loop efficacy at physiological rates with consistent low standard deviations.
- Distractor osteogenesis, the revealed highly significant molar protraction, with early-phase closure during active distraction followed by consolidation-phase movement. Near-complete space closure validated customized distractors for rapid extraction site management.
- Micro-osteoperforation with T-loop, confirmed significant acceleration across both phases. Total movement doubled conventional rates through sustained regional acceleratory phenomenon with stable variability.
- All methods induced significant tooth movement via pressure-tension remodeling and regional acceleratory phenomenon (RAP) of varying intensity, with intergroup Kruskal-Wallis tests confirming marked differences tied to procedural invasiveness. Distractor osteogenesis proved most efficacious for rapid space closure, followed by micro-osteoperforation-augmented T-loops outperforming conventional mechanics alone.

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