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Comparison of the Effect of Local Platelet Rich Fibrin Injection (i-PRF) and Micro Osteo-Perforations (MOPs) on Orthodontic Tooth Movement during Canine Distalization

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ABSTRACT

Background and Aim: Accelerating orthodontic tooth movement is clinically important to reduce prolonged treatment-related complications and improve patient acceptance. This study compared the effect of injectable platelet-rich fibrin (i-PRF) and micro-osteoperforations (MOPs) on the rate of maxillary canine distalization during extraction space closure. **Material and Methods:** A single-blinded, split-mouth randomized controlled trial was conducted in 32 participants. The mean age was 22.22 ± 5.15 years, with 19 (59.4%) males and 13 (40.6%) females; 18 (56.3%) were aged 21–30 years and 14 (43.8%) were aged 13–20 years. Each participant received i-PRF on one side and MOPs on the contralateral side, based on computer-generated randomization. Canine retraction was performed using miniscrew anchorage and nickel-titanium closed coil springs (150–200 g). Distal canine movement was assessed at 1 month (T1), 2 months (T2), and 3 months (T3). **Results:** Distal canine movement was significantly greater on the MOP side compared with the i-PRF side at T1 (0.84 ± 0.08 mm vs 0.75 ± 0.24 mm; $p = 0.038$), T2 (1.90 ± 0.08 mm vs 1.82 ± 0.10 mm; $p = 0.001$), and T3 (2.77 ± 0.24 mm vs 2.07 ± 0.26 mm; $p < 0.001$). Females showed greater distalization with MOP at T1–T3 ($p \leq 0.018$), while males demonstrated significant differences at T2 ($p = 0.020$) and T3 ($p < 0.001$). In the 13–20 years group, MOP superiority was significant at T1 ($p = 0.005$), T2 ($p = 0.008$), and T3 ($p < 0.001$), whereas in the 21–30 years group significance emerged at T2 ($p = 0.048$) and persisted at T3 ($p < 0.001$). **Conclusion:** Micro-osteoperforations produced a higher rate of canine distalization than i-PRF during the study period, with more consistent acceleration across subgroups.

INTRODUCTION

Orthodontic treatment frequently extends over 20 to 30 months, and the lengthy duration, particularly in adults, may reduce acceptance of treatment or increase demand for time-saving approaches [1]. Prolonged active treatment is also linked with higher risk of adverse outcomes, including external root resorption, dental caries, white spot lesions, and reduced compliance across follow-up visits [2]. Consequently, multiple strategies have been proposed to accelerate orthodontic tooth movement, ranging from pharmacological modulation and photo biomodulation to vibration-based methods and surgical adjuncts such as corticotomy, piezocision, and micro-osteoperforations (MOPs) [3].

Accelerated tooth movement is fundamentally dependent on the biological response of the periodontal ligament and adjacent alveolar bone, where orthodontic forces induce a coordinated sequence of inflammatory cell recruitment and subsequent osteoclast and osteoblast activity leading to bone resorption and deposition [4]. Early tissue responses after force application include vascular changes and inflammatory cell migration, followed by a lag phase related to hyalinization and later recovery of movement as necrotic tissue is cleared and remodeling progresses [5]. The post-lag phase is characterized by a gradual or sometimes abrupt increase in movement rate as remodeling becomes established [6]. These biological stages provide the rationale for adjunctive methods that aim to enhance controlled inflammation and bone turnover without compromising periodontal integrity [7].

Surgical decortication methods are effective and are commonly explained through the regional acceleratory phenomenon, a localized increase in tissue remodeling after injury, but the invasiveness and potential periodontal effects limit routine use in many patients. MOPs were introduced as a minimally invasive alternative intended to trigger localized inflammation and remodeling without

flap elevation, with the clinical advantage of reduced morbidity compared with more extensive procedures [8]. In parallel, biologic adjuncts have gained interest. Platelet-rich fibrin (PRF), a second-generation autologous platelet concentrate, avoids anticoagulant use and has been associated with a sustained release of growth factors relevant to angiogenesis and osseous regeneration [9]. Prolonged delivery of platelet-derived growth factor, transforming growth factor-beta, and vascular endothelial growth factor has been described as a key mechanism supporting tissue healing and regeneration in the local microenvironment [10]. PRF has also been reported to reduce post-extraction sequelae that may negatively influence orthodontic outcomes, supporting its potential utility during active tooth movement [6].

Canine distalization following premolar extraction is a common stage where shortening treatment time is clinically valuable, yet the comparative effectiveness of biologic stimulation using injectable PRF (i-PRF) versus localized surgical stimulation using MOPs during canine movement remains insufficiently clarified. Therefore, the present study is designed to compare the effect of local i-PRF injection and MOPs on the rate of orthodontic tooth movement during canine distalization.

MATERIAL AND METHOD

A single-blinded, split-mouth randomized controlled trial was conducted in the Orthodontic Department of Islamic International Dental Hospital. The study duration was three months and commenced after approval of the synopsis (April 2025 to July 2025). Ethical approval was obtained from the institutional ethical review committee (Ref. No: IIDC/IRC/2025/004/001). Written informed consent was obtained from all eligible participants prior to enrolment, and confidentiality of clinical records and study measurements was maintained throughout the trial.

Non-probability consecutive sampling was used to recruit patients presenting to the orthodontic clinic who fulfilled the eligibility criteria. The sample size was calculated using the World Health Organization sample size calculator for comparison of two means, applying the formula: $\mathbf{n = (S_1^2 + S_2^2)\,[Z(1-\alpha/2) + Z(1-\beta)]^2 \,/\, (\bar{x}_1 - \bar{x}_2)^2}$, with a 5% level of significance and 80% power. Based on these assumptions, a total of 32 participants were enrolled.

Participants aged 13 to 30 years were included. Only patients with no prior fixed or removable orthodontic treatment were selected. Eligible malocclusion patterns included Class II cases requiring extraction-based retraction mechanics, and Class I cases with dentoalveolar protrusion or moderate anterior crowding requiring first premolar extractions. Participants were required to be systemically healthy, with no medical illness or medication history that could influence bone metabolism or healing. A complete permanent dentition was required except for third molars, and congenital tooth agenesis was excluded other than missing maxillary third molars. Periodontal health was ensured through good oral hygiene and probing depth within normal limits (≤3 mm). Syndromic patients were excluded to minimize biological variability, and patients not meeting the above criteria were not enrolled.

Injectable platelet-rich fibrin (i-PRF) was operationally defined as a fully autologous, blood-derived biomaterial with a fibrin meshwork retaining a fluid injectable form. Micro-osteoperforations (MOPs) were defined as small, controlled perforations created in the cortical bone to stimulate localized bone remodeling. Titanium miniscrew were used as temporary orthodontic anchorage through mechanical monocortical retention, and self-drilling miniscrews were defined as screws with a fluted tip that did not require a pilot hole. The rate of canine retraction was defined as the amount of distal movement of the maxillary canine measured in millimeters per month.

Randomization was performed at the side level for each participant, assigning the left or right side to receive i-PRF while the contralateral side received MOPs. A computer-generated block randomization sequence (block size 4) was prepared by an independent coordinator to maintain balance of allocation. Concealment was ensured using sequentially numbered, opaque sealed envelopes opened chairside only after confirmation of eligibility and baseline impressions. Blinding of the clinical operator was not feasible due to the nature of the procedures; however, the outcome assessor performing cast-based measurements remained blinded. Casts were coded as A and B by the coordinator and were decoded after completion of statistical analysis.

All participants underwent standardized orthodontic mechanics. At placement of the 0.019 × 0.025-inch stainless steel working archwire, miniscrews measuring 1.4 × 8 mm were inserted bilaterally between the maxillary second premolar and first molar to provide anchorage. After one month, and provided that miniscrews remained stable, bilateral maxillary first premolar extractions were performed and canine retraction was initiated using nickel-titanium closed coil springs delivering 150 to 200 grams of force between the canine and miniscrew. Force magnitude was verified using a Correx Force Tension Gauge. The adjunctive interventions were performed at three time points over 12 weeks, spaced four weeks apart, with the first session performed two weeks after initiation of canine retraction.

On the i-PRF side, submucosal injections were administered under local anesthesia for pain control. The material was delivered around the maxillary canine on the buccal, palatal, and distal aspects at each scheduled visit. A volume of 0.7 mL i-PRF was injected through the attached gingiva into the oral mucosa per session. For preparation of i-PRF, venous blood was drawn using a 10 mL syringe and transferred immediately into a sterile 9 mL PRF tube using Red Cap IntraSpin vacuum anticoagulant-free tubes. Centrifugation was performed at 800 rpm for 3 minutes, producing three layers: red blood cells at the bottom, an i-PRF layer in the middle, and platelet-poor plasma at the top. Approximately 2.1 mL of injectable PRF was aspirated from the middle layer using a 2.5 mL dental syringe and used immediately.

On the MOPs side, six perforations were created in the buccal cortical bone under local anesthesia, with three perforations placed mesial to the canine root and three distal to the canine root. Perforations were made 3 mm apart vertically and standardized to a depth of 3 mm. The most coronal perforation was placed at the level of the canine cervical margin and extended apically in sequence. A mini-implant (1.4 mm diameter and 6 mm length) fitted with a rubber stopper calibrated to the required penetration depth was used to standardize the perforation depth while accounting for soft tissue thickness.

Canine movement was assessed using plaster dental models obtained at baseline (T0) and at four-week intervals (T1, T2, and T3). Reference landmarks for model analysis included the incisive papilla and the medial ends of the right and left third palatal rugae. The midpoint between the medial ends of the third rugae was marked, and a median palatal plane was constructed by joining the incisive papilla and this midpoint. The perpendicular distance from the maxillary canine cusp tip to the median palatal plane was measured at each follow-up model to quantify distal movement. Models were photocopied at a true 1:1 scale with a ruler for metric calibration, and measurements were performed using a digital caliper accurate to 0.01 mm. To reduce intra-examiner error, measurements were repeated twice by the same operator at different time points. Plaster model-based linear measurements were used as a reliable method for tracking orthodontic tooth movement [74].

Data were analyzed using R software (version 4.3.3 for Windows), and statistical significance was set at $P < 0.05$. Descriptive statistics were calculated for baseline characteristics and outcome variables. The student's t-test was applied to compare the amount and rate of canine distal movement between i-PRF and MOPs sides over the study period. Stratification by age group and gender was performed to assess potential effect modification on the rate of canine retraction.

RESULTS

A total of 32 participants were included in the final analysis using a split-mouth randomized design. The mean age was 22.22 ± 5.15 years, with 19 (59.4%) males and 13 (40.6%) females. Most participants belonged to the 21–30 years age category (56.3%), while 43.8% were aged 13–20 years (Table 1).

Table 1

Baseline characteristics of study participants (N = 32)

Characteristic	Value
Age (years), Mean ± SD	22.22 ± 5.15
Gender, n (%)	
Female	13 (40.63)
Male	19 (59.38)
Age group (years), n (%)	
13–20	14 (43.75)
21–30	18 (56.25)

Values are Mean ± SD or n (%).

Distal canine movement increased progressively over the three-month follow-up on both experimental sides. At 1 month (T1), the MOP side showed significantly greater canine distalization compared with the i-PRF side (0.84 ± 0.08 mm vs 0.75 ± 0.24 mm; p = 0.038). This difference remained statistically significant at 2 months (T2), where distal movement was 1.90 ± 0.08 mm on the MOP side versus 1.82 ± 0.10 mm on the i-PRF side (p = 0.001). By 3 months (T3), the separation between interventions became more marked, with the MOP side demonstrating greater distalization (2.77 ± 0.24 mm vs 2.07 ± 0.26 mm; p < 0.001), indicating a consistently higher rate of orthodontic tooth movement with MOP across all time points (Table 2).

Table 2

Distal canine movement (mm) comparison between MOP and i-PRF sides (N = 32)

Time point	MOP (Mean ± SD)	i-PRF (Mean ± SD)	p-value
T1 (1st month)	0.84 ± 0.08	0.75 ± 0.24	0.038
T2 (2nd month)	1.90 ± 0.08	1.82 ± 0.10	0.001
T3 (3rd month)	2.77 ± 0.24	2.07 ± 0.26	<0.001

Paired t-test; values reported in mm.

On gender stratification, females demonstrated significantly higher distal canine movement on the MOP side at all assessments (T1–T3), whereas males showed non-significant differences at T1 but significant differences emerged at T2 and persisted at T3. At T3, canine distalization remained significantly greater with MOP in both females (2.84 ± 0.16 mm vs 2.08 ± 0.31 mm; p < 0.001) and males (2.72 ± 0.28 mm vs 2.06 ± 0.23 mm; p < 0.001) (Table 3).

Table 3

Distal canine movement (mm) comparison stratified by gender

Time point	Female: MOP (n=13)	Female: i-PRF (n=13)	p-value	Male: MOP (n=19)	Male: i-PRF (n=19)	p-value
T1	0.84 ± 0.08	0.70 ± 0.13	0.002	0.84 ± 0.09	0.78 ± 0.29	0.400
T2	1.93 ± 0.09	1.84 ± 0.08	0.018	1.88 ± 0.08	1.80 ± 0.11	0.020
T3	2.84 ± 0.16	2.08 ± 0.31	<0.001	2.72 ± 0.28	2.06 ± 0.23	<0.001

Paired t-test; values reported in mm.

Age-based stratification showed that participants aged 13–20 years had significantly greater distal canine movement on the MOP side at all time points, including T1 (0.84 ± 0.09 mm vs 0.70 ± 0.14 mm; p = 0.005). In the 21–30 years age group, differences were non-significant at T1 but became significant by T2 (p = 0.048) and remained strongly significant at T3 (p < 0.001), supporting a sustained advantage of MOP during canine distalization across both age categories, with earlier separation in the younger group (Table 4).

Table 4

Distal canine movement (mm) comparison stratified by age group

Time point	21–30 years: MOP (n=18)	21–30 years: i-PRF (n=18)	p-value	13–20 years: MOP (n=14)	13–20 years: i-PRF (n=14)	p-value
T1	0.85 ± 0.08	0.79 ± 0.29	0.400	0.84 ± 0.09	0.70 ± 0.14	0.005

T2	1.89 ± 0.09	1.82 ± 0.11	0.048	1.91 ± 0.08	1.82 ± 0.09	0.008
T3	2.72 ± 0.23	2.02 ± 0.26	<0.001	2.83 ± 0.25	2.12 ± 0.25	<0.001

DISCUSSION

Distal canine movement increased progressively across the three-month follow-up on both experimental sides, reflecting the expected pattern of continuous orthodontic tooth movement during standardized retraction mechanics. However, a consistently higher magnitude of canine distalization was observed on the micro-osteoperforation (MOP) side compared with the injectable platelet-rich fibrin (i-PRF) side at all assessment points. The difference was already evident at the first month (0.84 ± 0.08 mm vs 0.75 ± 0.24 mm; p = 0.038), persisted at the second month (1.90 ± 0.08 mm vs 1.82 ± 0.10 mm; p = 0.001), and became more pronounced by the third month (2.77 ± 0.24 mm vs 2.07 ± 0.26 mm; p < 0.001). This pattern supported a sustained advantage of MOPs in accelerating canine distalization during extraction space closure under miniscrew-supported anchorage.

The greater retraction observed with MOPs is biologically plausible as MOPs directly induce localized cortical micro-injury, which may amplify inflammatory mediators and osteoclastic recruitment, producing a regional acceleratory response in alveolar bone remodeling. This aligns with the original clinical work by Alikhani et al., who reported approximately 2.3-fold faster orthodontic movement after MOPs compared with conventional mechanics, supporting the concept of cytokine-driven bone turnover acceleration following micro-trauma [11]. The present findings also agree with reports emphasizing that protocol characteristics influence the magnitude and consistency of acceleration. Hashem et al. and Jaiswal et al. suggested that repeated MOP stimulation produces a stronger and more sustained effect than a single intervention, which is consistent with the time-limited nature of inflammatory upregulation and the need for periodic re-stimulation during prolonged retraction phases [4,12]. Similarly, another study reported that MOPs created at 2–4 mm depth yielded superior acceleration compared with shallower or deeper perforations, highlighting the importance of standardized depth to optimize biologic response [13]. The protocol used in the present study employed standardized perforations at approximately 3 mm depth, which lies within the proposed optimal biologic window and may partly explain the clear and persistent superiority of MOPs over i-PRF.

The current results contrasted with trials reporting modest or inconsistent benefit from MOPs. Aboalnaga et al. observed that acceleration may be small or not statistically meaningful in certain settings, suggesting that the effectiveness of MOPs can be sensitive to the number of perforations, timing of intervention, biomechanics, and baseline variability in bone density and remodeling capacity [14]. Farag et al. also emphasized technique sensitivity, reporting that clinically feasible MOP approaches may not uniformly produce large gains across all individuals [10,15]. In this context, the present study's use of miniscrew anchorage, controlled force delivery (150–200 g), standardized perforation distribution, and repeated assessments may have reduced mechanical confounding and increased the ability to detect between-intervention differences.

In contrast to the consistent advantage seen with MOPs, the i-PRF side also demonstrated progressive canine movement, indicating that biologic adjuncts based on platelet concentrates may facilitate remodeling but potentially with a smaller magnitude than surgically induced stimulation in this clinical setting. A study reported that i-PRF accelerated canine retraction compared with control, with higher monthly movement rates and greater cumulative distalization over three months [16]. Likewise, Gupta et al. found greater overall canine displacement with leukocyte platelet-rich fibrin compared with control, supporting the concept that growth factor-rich autologous concentrates can enhance the biologic response during space closure [17]. Eni et al. also reported improved clinical performance of canine retraction with platelet-rich fibrin adjunct use, with beneficial effects extending to patient-centered outcomes [10]. The comparatively lower distalization observed on the i-PRF side in the present study relative to some PRF-based trials may reflect differences in platelet concentrate formulation (i-PRF vs L-PRF), centrifugation protocols, injection volume and interval, or local tissue diffusion patterns that may limit the osteoclast-dominant response required for rapid movement. Importantly, Bardideh et al. highlighted a potential advantage of i-PRF relating to reduced evidence of root length reduction during orthodontic tooth movement, suggesting that biologic adjuncts may offer a favorable safety balance even if acceleration effects are comparatively modest [13]. Therefore, while MOPs demonstrated superior acceleration in the present trial, the potential hard-tissue safety profile of i-PRF remains clinically relevant when selecting adjuncts for adult patients or those at higher risk of resorptive changes.

Stratified analyses demonstrated that females exhibited significantly greater canine distalization with MOPs at all time points, while males showed delayed emergence of significance, becoming apparent from the second month onward. A similar pattern was observed by age, where participants aged 13–20 years demonstrated earlier separation between interventions compared with those aged 21–30 years, in whom differences became statistically significant after the first month. These findings are consistent with the known influence of age-related remodeling capacity, where younger individuals may demonstrate faster biologic responsiveness and earlier acceleration signals, while adults may require stronger or sustained stimuli to achieve measurable differences over time. The observed sex-based differences may reflect variation in bone turnover and hormonal influences, although these factors were not directly measured and should be interpreted cautiously.

Strengths and limitations

Key strengths included the randomized split-mouth design, allocation concealment, assessor blinding for cast measurements, and standardized mechanics with miniscrew anchorage and calibrated force delivery, which

collectively strengthened internal validity and reduced inter-individual biological variability. Limitations included the single-center setting, relatively small sample size, and short follow-up restricted to 12 weeks, limiting inference on long-term acceleration sustainability and post-retraction stability. Operator blinding was not feasible due to the nature of interventions. Patient-reported pain, periodontal indices, inflammatory biomarkers, and radiographic assessment of root resorption were not evaluated, which limited interpretation of biological safety trade-offs between i-PRF and MOPs. Additionally, variability in autologous blood characteristics may influence i-PRF consistency, and unmeasured factors such as baseline bone density and hormonal variations may have contributed to inter-participant response differences.

CONCLUSION

Micro-osteoperforations demonstrated a consistently greater acceleration of maxillary canine distalization than injectable platelet-rich fibrin during the early phase of extraction space closure. The superiority of micro-osteoperforations was evident throughout the follow-up, indicating a stronger biologic stimulus for localized bone remodeling under standardized retraction mechanics. Subgroup findings suggested that the difference appeared earlier in younger participants and was more uniform in females, whereas delayed separation was noted in older participants and males. Overall, micro-osteoperforations provided a more predictable enhancement of orthodontic tooth movement compared with injectable platelet-rich fibrin within the study timeframe.

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