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Effect of Local Platelet Rich Fibrin Injection (i-PRF) and Micro Osteo-Perforations (MOPs) on Molar Mesial Movement during Canine Distalization

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ABSTRACT

Background: Adjunctive acceleration techniques such as micro-osteoperforations (MOPs) and injectable platelet-rich fibrin (i-PRF) are increasingly used to enhance orthodontic tooth movement; however, their influence on anchorage loss remains insufficiently defined. **Aim**: This study evaluated and compared maxillary first molar mesial movement during canine distalization on the MOP and i-PRF sides. **Methodology:** A single-blinded randomized split-mouth clinical trial was conducted on 32 participants (mean age 22.22 ± 5.15 years). Each participant contributed both intervention sides: MOPs on one side and i-PRF on the contralateral side. Molar mesial movement was measured on dental casts at 1 month (T1), 2 months (T2), and 3 months (T3). Paired t-tests were applied for inter-side comparisons, with stratification by gender and age group. Statistical significance was set at $p < 0.05$. **Results:** At T1, molar mesial movement was 0.21 ± 0.04 mm on the MOP side and 0.19 ± 0.02 mm on the i-PRF side ($p = 0.120$). At T2, mesial movement was significantly higher with MOP (0.40 ± 0.04 mm) than i-PRF (0.38 ± 0.03 mm; $p = 0.025$). At T3, MOP remained significantly higher (0.70 ± 0.09 mm vs 0.63 ± 0.04 mm; $p = 0.002$). In males, T3 movement was greater with MOP (0.71 ± 0.08 mm) than i-PRF (0.63 ± 0.04 mm; $p < 0.001$), while differences in females were non-significant. At T3, significant differences persisted in both age groups: 21–30 years (0.68 ± 0.07 vs 0.63 ± 0.04 mm; $p = 0.015$) and 13–20 years (0.72 ± 0.11 vs 0.64 ± 0.05 mm; $p=0.035$). **Conclusion:** MOPs were associated with slightly greater molar mesial movement than i-PRF during canine distalization, with significant differences emerging over time.

INTRODUCTION

Orthodontic therapy remains an effective method for correcting malocclusion and improving dental function and aesthetics; however, the overall duration of treatment continues to be one of the most frequent reasons for patient dissatisfaction and discontinuation. Extended treatment time is not merely an inconvenience, as it may increase the cumulative biological burden on the periodontal tissues and expose patients to avoidable enamel and periodontal complications during fixed appliance wear [1–3]. In addition, prolonged appliance therapy places greater demands on oral hygiene maintenance and long-term follow-up, which can adversely affect cooperation and the predictability of outcomes. For these reasons, contemporary orthodontic practice has increasingly focused on strategies that can safely enhance the rate of tooth movement without compromising anchorage control, periodontal integrity, or treatment stability [4,5].

Orthodontic tooth movement is fundamentally a biologically regulated process driven by alveolar bone remodeling in response to applied forces, and its efficiency depends on coordinated cellular and molecular signaling within the periodontal ligament and adjacent bone. Accelerated orthodontic modalities attempt to enhance this remodeling by amplifying local inflammatory signaling and osteoclastic activity. Conventional bone decortication has been linked to the regional acceleratory phenomenon (RAP), defined as a localized reaction whereby tissues heal and remodel more rapidly after injury; however, its clinical use remains limited because of invasiveness and potential periodontal sequelae such as alveolar and gingival recession [4–6]. Corticotomy, while effective through induction of RAP, is similarly constrained in routine orthodontic practice due to surgical morbidity and patient acceptance concerns [7].

Among minimally invasive approaches, MOPs have gained attention as a flapless technique that produces controlled cortical perforations to stimulate local remodeling, while avoiding extensive surgical manipulation. Clinical evidence suggests that MOPs can increase the rate of tooth movement by approximately two to 2.5-fold compared with conventional mechanics, though the magnitude of benefit may vary with site-specific and patient-related factors [8,9]. In parallel, injectable platelet-rich fibrin (i-PRF), derived from autologous blood, has emerged as a biological adjunct that supports healing through sustained delivery of platelet-derived growth factor, transforming growth factor-beta, and vascular endothelial growth factor, thereby promoting angiogenesis, collagen synthesis, and osseous regeneration. Due to its injectable form and regenerative profile, i-PRF has been increasingly explored in orthodontics for potential enhancement of bone remodeling and improved tissue response during active tooth movement [10,11].

During canine distalization, preservation of posterior anchorage remains a critical requirement, as reciprocal forces may contribute to undesirable molar mesial movement and compromise treatment efficiency. Although both MOPs and i-PRF may enhance remodeling at targeted sites, their combined influence on anchorage behavior, particularly molar mesial movement during canine distalization, remains insufficiently clarified. Therefore, evaluation of the effect of local i-PRF injection and MOPs on molar mesial movement during canine distalization is clinically justified within contemporary accelerated orthodontic protocols.

MATERIAL AND METHOD

A single-blinded, split-mouth randomized controlled trial was conducted in the Orthodontic Department of Islamic International Dental Hospital. The study was completed over a period of 3 months 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 was maintained by assigning coded identifiers and restricting access of study data to the research team.

Non-probability consecutive sampling was used. A total of 32 participants fulfilling the eligibility criteria were recruited. Sample size was calculated using the World Health Organization sample size calculator based on comparison of two interventions, employing the standard formula incorporating variance estimates, type-I error, and study power. Randomization was performed at the side level for each participant, where the left or right maxillary quadrant was allocated to injectable platelet-rich fibrin (i-PRF) and the opposite side was allocated to micro-osteoperforations (MOPs). A computer-generated block randomization sequence (block size = 4) was prepared by an independent coordinator. Allocation concealment was ensured using sequentially numbered opaque sealed envelopes that were opened chairside after confirming eligibility and completing baseline impressions. Operator blinding was not feasible due to the procedural differences; however, the assessor performing model measurements remained blinded. Casts were coded as A and B by the coordinator and decoding was performed only after completion of statistical analysis.

Participants aged 13 to 30 years were included to maintain biological consistency for orthodontic bone response. Only patients with no previous history of orthodontic treatment were selected. Individuals requiring extraction-based retraction mechanics for Class II malocclusion were eligible, and patients with Class I malocclusion having dentoalveolar protrusion or moderate anterior crowding requiring first premolar extractions were also included. Participants were required to be systemically healthy and not using medications known to influence bone metabolism or wound healing. Complete permanent dentition was required excluding third molars, with no congenital tooth agenesis except maxillary third molars. Periodontal health was ensured by selecting patients with satisfactory oral hygiene and periodontal probing depths within normal limits (≤3 mm), and only non-syndromic individuals were enrolled. Patients with systemic illness affecting healing, active periodontal disease, compromised oral hygiene, syndromic conditions, incomplete permanent dentition, prior orthodontic treatment, or any condition expected to interfere with standardized orthodontic mechanics were excluded.

Injectable platelet-rich fibrin (i-PRF) was operationally defined as a fully autologous, injectable blood-derived biomaterial with a fibrin framework in a fluid form suitable for submucosal delivery. Micro-osteoperforations were defined as small, controlled perforations placed in cortical bone to induce localized remodeling. Titanium miniscrews were used for temporary orthodontic anchorage through mechanical monocortical retention, and the self-drilling miniscrew design was defined by the ability to engage bone without a pilot drilling step. Molar mesial movement was defined as the amount of mesial displacement (mm) of the maxillary first molar measured over time relative to stable palatal reference landmarks during the canine distalization phase.

After placement of a 0.019″ × 0.025″ stainless steel working archwire, miniscrews (1.4 × 8 mm) were inserted bilaterally between the maxillary second premolar and first molar roots to provide standardized anchorage. One month later, after confirming miniscrew stability, bilateral maxillary first premolar extractions were performed and canine distalization was initiated using nickel-titanium closed coil springs delivering 150 to 200 g of force, engaged from the maxillary canine to the miniscrew. Force levels were verified using a Correx Force Tension Gauge to ensure consistency throughout the study period.

On the i-PRF side, submucosal i-PRF delivery was performed under local anesthesia for patient comfort at 4-week intervals over 12 weeks (T1, T2, and T3). The injection protocol used 0.7 mL delivered through the attached gingiva into the oral mucosa around the canine region, covering buccal, palatal, and distal aspects. i-PRF preparation was standardized by collecting venous blood in anticoagulant-free sterile tubes followed by immediate centrifugation at 800 rpm for 3 minutes. The separated middle layer was aspirated to obtain injectable PRF, and approximately 2.1 mL was drawn from the platelet-rich fraction using a dental syringe, ensuring immediate clinical use after preparation.

On the MOPs side, six micro-osteoperforations were created in the buccal cortical bone adjacent to the canine root, with three perforations placed mesially and three distally. The perforations were created under local anesthesia, placed 3 mm apart vertically, and extended to a depth of 3 mm. The first perforation was initiated at the cervical margin level and progressed apically. A miniscrew (1.4 mm diameter, 6 mm length) fitted with a rubber stopper adjusted for soft-tissue thickness was used to standardize perforation depth and reduce procedural variability.

For outcome assessment, maxillary plaster models were obtained at baseline (T0) and at monthly intervals (T1, T2, and T3). Molar mesial movement was quantified using stable palatal reference landmarks including the incisive papilla and medial ends of the third palatal rugae. Landmarks were marked with a lead pencil, models were photocopied at a 1:1 scale with a ruler for calibration, and a median palatal plane was constructed. Perpendicular reference lines were dropped from the mesiobuccal cusp tips of the maxillary first molars to the median palatal plane, and linear distances were measured using a digital caliper. Measurements were repeated twice by the same examiner at separate times to minimize intra-examiner error. This plaster model-based approach was used as it provides reliable tracking of orthodontic tooth movement measurements.

Data analysis was performed using R software (version 4.3.3 for Windows). Statistical significance was set at $P<0.05$. The Student's t-test was applied to compare molar mesial movement between i-PRF and MOP sides at corresponding time points. Stratified analyses were also performed for age group and gender to evaluate potential effect modification.

RESULTS

A total of 32 participants were analysed using a split-mouth design, with each participant contributing measurements for both intervention sides. The mean age was 22.22 ± 5.15 years, with 59.4% males and 40.6% females, and a higher proportion of participants in the 21–30 years group (Table 1).

Mesial movement of the maxillary first molar increased over time in both interventions. At 1 month (T1), mean molar mesial movement was slightly higher on the MOP side than on the i-PRF side (0.21 ± 0.04 mm vs 0.19 ± 0.02 mm), although this difference was not statistically significant ($p = 0.12$). At 2 months (T2), molar mesial movement became significantly greater on the MOP side (0.40 ± 0.04 mm) compared with the i-PRF side (0.38 ± 0.03 mm; $p = 0.025$). By 3 months (T3), the MOP side continued to demonstrate significantly higher mesial movement (0.70 ± 0.09 mm vs 0.63 ± 0.04 mm; $p = 0.002$), indicating a modest but statistically significant increase in molar mesial movement associated with MOP during canine distalization (Table 2).

Gender-wise analysis demonstrated no statistically significant differences in females at any time point, although numerically higher molar movement was observed on the MOP side throughout follow-up. In males, differences remained non-significant at T1 and T2; however, at T3, molar mesial movement was significantly higher on the MOP side compared with i-PRF (0.71 ± 0.08 mm vs 0.63 ± 0.04 mm; $p < 0.001$) (Table 3).

Across age categories, both groups showed non-significant differences at early intervals (T1 and T2). At T3, molar mesial movement became significantly greater on the MOP side in participants aged 21–30 years (0.68 ± 0.07 mm vs 0.63 ± 0.04 mm; $p = 0.015$) and also in those aged 13–20 years (0.72 ± 0.11 mm vs 0.64 ± 0.05 mm; $p = 0.035$), supporting a time-dependent separation in favour of higher molar mesial movement with MOP (Table 4).

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 (%)

Table 2

Mesial Molar 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)	0.21 ± 0.04	0.19 ± 0.02	0.120
T2 (2nd month)	0.40 ± 0.04	0.38 ± 0.03	0.025
T3 (3rd month)	0.70 ± 0.09	0.63 ± 0.04	0.002

Paired t-test; values reported in mm

Table 3

Mesial Molar 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	0.22 ± 0.06	0.20 ± 0.02	0.200	0.20 ± 0.03	0.19 ± 0.02	0.300
T2	0.41 ± 0.05	0.37 ± 0.03	0.057	0.40 ± 0.04	0.39 ± 0.03	0.200
T3	0.67 ± 0.11	0.64 ± 0.04	0.300	0.71 ± 0.08	0.63 ± 0.04	<0.001

Paired t-test; values reported in mm

Table 4

Mesial Molar 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	0.20 ± 0.03	0.19 ± 0.02	0.300	0.21 ± 0.06	0.19 ± 0.02	0.200
T2	0.40 ± 0.05	0.38 ± 0.03	0.200	0.41 ± 0.04	0.38 ± 0.04	0.066
T3	0.68 ± 0.07	0.63 ± 0.04	0.015	0.72 ± 0.11	0.64 ± 0.05	0.035

Paired t-test; values reported in mm

DISCUSSION

Mesial movement of the maxillary first molar represents a clinically relevant indicator of anchorage loss during canine distalization, particularly when adjunctive acceleration methods are employed. In the present split-mouth randomized comparison, molar mesial movement increased progressively on both intervention sides, but a time-dependent separation was observed, with significantly greater mesial movement on the micro-osteoperforation (MOP) side from the second month onward. Although the absolute difference was small (0.02 mm at T2 and 0.07 mm at T3), the paired design and relatively low within-side variability contributed to statistical significance, indicating that even conservative acceleration protocols may produce measurable anchorage effects over time.

The observed pattern is biologically plausible. MOPs induce controlled cortical trauma and a localized inflammatory response that amplifies osteoclastic recruitment and bone turnover, facilitating tooth displacement through a regional acceleratory phenomenon-like effect [12]. While this mechanism is primarily exploited to enhance canine distalization, the surrounding alveolar bone may also demonstrate a transient reduction in resistance, potentially allowing modest mesial drift of the posterior segment despite anchorage reinforcement. This interpretation aligns with clinical data showing that anchorage loss is not solely determined by the acceleration technique but also by the force system, archwire engagement, and the anchorage design used during retraction [11].

Notably, several MOP trials have reported that acceleration can occur without a statistically meaningful increase in molar mesial movement when anchorage is tightly controlled. Aboalnaga et al. documented enhanced canine movement with MOPs but found no significant anchorage differences between intervention and control sides, supporting the concept that localized stimulation does not inevitably translate into posterior protraction when biomechanics are optimized [13]. Similarly, when mini-implants were used to support canine retraction, minimal molar mesial displacement was reported, indicating that skeletal anchorage can attenuate reciprocal movement even in the presence of acceleration stimuli [9,14]. The present findings are not contradictory to these reports; instead, they suggest that small anchorage effects may still emerge over longer activation periods, particularly when perforations are repeated and remodeling is sustained.

The delayed onset of significant differences in the current data is consistent with reports describing anchorage loss becoming more detectable after the early phase of retraction. Alqadasi et al. described measurable molar mesial movement developing later during follow-up, supporting the view that cumulative retraction mechanics and ongoing bone remodeling may reveal differences that are not apparent at initial intervals [14]. Dose and repetition may further modulate this effect. Evidence indicates that increasing the frequency or repeating MOPs can enhance movement acceleration, while also raising the likelihood of anchorage-related changes, implying a potential dose response relationship [15–17]. In the present protocol, six perforations were performed per session and repeated at monthly intervals, which may have contributed to the time-dependent divergence observed at T2 and T3.

In contrast, the i-PRF side demonstrated slightly lower molar mesial movement at each time point, suggesting that biologic modulation via growth-factor release may not amplify anchorage loss to the same extent. The i-PRF literature has largely emphasized canine movement, patient-reported outcomes, and local tissue response, while anchorage measurements have been inconsistently quantified, limiting direct comparisons [18]. Zeitounlouian et al. reported acceleration-related findings with i-PRF in split-mouth settings, but molar mesial movement outcomes were not uniformly standardized across studies, and when assessed, values were generally small and influenced by anchorage configuration [19]. When platelet-based adjuncts were examined alongside minimally invasive corticotomy approaches, the overall inference was that acceleration can be achieved, yet anchorage preservation still depends primarily on biomechanical planning rather than the biologic intervention itself [19]. Therefore, the comparatively lower molar mesial movement observed with i-PRF may reflect a less osteoclastic-dominant stimulus than MOPs, although definitive mechanistic conclusions require biomarker-based studies.

Stratified analyses suggested that between-side differences in molar mesial movement reached statistical significance in males at T3 only, whereas females demonstrated non-significant differences throughout. This likely reflected limited sample size within strata, wider variability in female T3 measurements, and reduced statistical power for subgroup comparisons, rather than a robust biological sex-specific effect. Both age categories demonstrated significant differences at T3, supporting that time under activation, rather than age alone, may be the dominant factor for anchorage divergence in this protocol.

Strengths and limitations: The split-mouth randomized design reduced inter-individual biological variability and enhanced internal validity. Serial measurements at standardized time points enabled evaluation of time-dependent anchorage changes. However, the study was conducted over three months only, restricting inference regarding longer space-closure phases and overall anchorage requirements. Subgroup analyses were underpowered due to small strata sizes. Cast-based linear measurements, although widely accepted, remain vulnerable to landmark identification error and do not fully capture three-dimensional molar tipping or rotational components.

CONCLUSION

Micro-osteoperforations and injectable platelet-rich fibrin were both associated with progressive mesial movement of the maxillary first molar during canine distalization. However, micro-osteoperforations demonstrated a modest but consistently higher tendency for molar mesial movement over time, with statistically significant separation emerging after the initial phase of retraction. These findings suggest that procedures designed to accelerate orthodontic tooth movement may influence anchorage behaviour, even when supported mechanics are used. Careful anchorage planning and close monitoring remain essential when micro-osteoperforations are incorporated into canine distalization protocols, particularly when prolonged activation is anticipated.

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