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Original Research Article

Evaluation of the effectiveness of injectable platelet-rich fibrin on the rate of orthodontic tooth movement: a clinical study

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ABSTRACT

Background: Prolonged orthodontic treatment duration remains a major clinical concern because of its association with root resorption, enamel decalcification, periodontal complications, and reduced patient compliance. Injectable platelet-rich fibrin (I-PRF), a second-generation autologous platelet concentrate rich in growth factors and inflammatory mediators, has recently gained attention as a minimally invasive adjunct for accelerating orthodontic tooth movement (OTM). Aim was to evaluate the effectiveness of I-PRF on the rate of OTM during maxillary canine retraction.

Methods: This prospective split-mouth clinico-experimental study included nine patients requiring bilateral maxillary first premolar extractions for orthodontic treatment. The right maxillary quadrant received intraligamentary I-PRF injections, while the contralateral side served as the control. Canine retraction was performed using nickel-titanium closed-coil springs delivering 150 g force on 0.019″×0.025″ stainless steel archwires. I-PRF was prepared using low-speed centrifugation at 700 rpm for 3 minutes and administered at baseline and eighth week. OTM was evaluated monthly for three months using three-dimensional digital model superimposition. Statistical analysis included paired t-test, repeated measures ANOVA, and Bonferroni post-hoc analysis.

Results: The I-PRF group demonstrated greater OTM compared to the control group at all evaluated intervals. Statistically significant differences were observed during the initial phase of retraction and in cumulative tooth movement from baseline to the third month. Repeated measures ANOVA revealed significant variation in tooth movement across different intervals in both groups.

Conclusions: I-PRF demonstrated a positive effect on accelerating OTM and may serve as an effective, minimally invasive biologic adjunct for enhancing orthodontic treatment efficiency.

Keywords: Injectable platelet-rich fibrin, Orthodontic tooth movement, Canine retraction, Accelerated orthodontics, Platelet concentrates

INTRODUCTION

Orthodontic treatment is fundamentally based on the biologic response of the periodontal ligament and alveolar bone to applied mechanical forces, resulting in controlled tooth movement through coordinated bone resorption and formation. Although orthodontic therapy has become increasingly efficient and esthetic, prolonged treatment duration continues to be a major clinical concern, particularly in adult patients, where treatment may extend beyond two years. Long treatment time is frequently associated with complications such as enamel decalcification, root resorption, gingival recession, periodontal breakdown, and reduced patient compliance.[1] Consequently, accelerating orthodontic tooth movement (OTM) without compromising periodontal health has become an important objective in contemporary orthodontic research.

Recent advances in bone biology have highlighted the pivotal role of osteocytes and inflammatory mediators in regulating alveolar bone remodeling during tooth

movement. Mechanical loading initiates a cascade of cellular events involving osteoclast activation on the pressure side and osteoblastic bone deposition on the tension side through pathways such as RANK-RANKL-OPG signaling. These biologic responses form the basis of the regional acceleratory phenomenon (RAP), first described by Frost, in which localized tissue injury temporarily increases bone turnover and metabolic activity, thereby facilitating faster tooth movement. Various surgical procedures including corticotomy, piezocision, and micro-osteoperforations have been developed to induce RAP and accelerate OTM. However, their invasive nature, postoperative discomfort, and associated risks have limited their routine clinical acceptance.[2-4]

In recent years, biologic adjuncts such as platelet concentrates have emerged as promising minimally invasive alternatives for accelerating tooth movement. Platelet-rich plasma (PRP), the first-generation platelet concentrates, demonstrated regenerative potential because of its high concentration of growth factors, but its clinical application remained limited by complex preparation protocols and the requirement for anticoagulants and exogenous activators. Platelet-rich fibrin (PRF), introduced as a second-generation concentrate, overcame many of these limitations by providing a natural fibrin scaffold capable of sustained release of growth factors such as PDGF, TGF-β1, and VEGF, thereby enhancing angiogenesis, tissue healing, and bone remodeling.[5,6]

Further refinement in centrifugation protocols led to the development of I-PRF, a liquid autologous concentrate rich in platelets, leukocytes, and growth factors. Owing to its injectable nature and prolonged biologic activity, I-PRF has gained increasing attention as a potential adjunct for accelerated orthodontics. Preliminary animal and clinical studies have suggested that I-PRF may enhance the rate of OTM while maintaining periodontal health.[7,8]

However, available evidence remains limited and inconsistent because of variations in study design, injection protocols, and assessment methods. Therefore, further well-designed clinical studies are required to evaluate the effectiveness and clinical applicability of I-PRF in accelerating OTM.

METHODS

The present investigation was designed as an in-vivo, prospective, split-mouth, clinico-experimental study conducted in the Department of Orthodontics and Dentofacial Orthopaedics, D. J. College of Dental Sciences and Research, Modinagar, Uttar Pradesh, between March 2024 and April 2025. Ethical approval was obtained from the Institutional Ethical Committee prior to commencement of the study, and all procedures were performed in accordance with the Declaration of Helsinki (2013). Written informed consent was obtained from all participants and guardians wherever applicable in their vernacular language before initiation of treatment.

Nine patients requiring bilateral maxillary first premolar extraction as part of comprehensive orthodontic treatment were included, contributing eighteen quadrants for evaluation. Healthy male and female patients aged 14-30 years with periodontally healthy dentition, probing depths ≤3 mm, and no radiographic evidence of alveolar bone loss were selected. Patients with systemic illness, metabolic bone disorders, craniofacial anomalies, bleeding disorders, gingival or periodontal disease, previous orthodontic treatment, or use of medications known to affect bone metabolism or tooth movement, such as corticosteroids and bisphosphonates, were excluded.

Sample size estimation was performed using G*Power software version 3.1.9.7 based on the effect size reported by Gupta et al. Considering an effect size of 1.626, significance level of 5%, and power of 95%, the minimum required sample size was calculated to be nine samples per group. Owing to the split-mouth design, each participant contributed both experimental and control sites, thereby achieving the desired statistical power. The right maxillary quadrant was designated as the experimental side receiving I-PRF, while the contralateral side served as the control. Fixed allocation was followed to minimize potential crossover influence of biologically active growth factors.

Pretreatment records including intraoral and extraoral photographs, panoramic radiographs, and cone beam computed tomography scans wherever clinically indicated were obtained for all participants. Fixed orthodontic treatment was initiated using pre-adjusted edgewise appliances with 0.022″×0.028″ MBT prescription brackets bonded according to standard protocols. Following bilateral extraction of maxillary first premolars under local anaesthesia, a healing period of two weeks was allowed before initiation of canine retraction.

For preparation of I-PRF, 10 mL of venous blood was collected under aseptic conditions in plain anticoagulant-free tubes and immediately centrifuged using a swing-out centrifuge at 700 rpm for 3 minutes. Centrifugation yielded a lower red blood cell layer and an upper plasma fraction corresponding to I-PRF. The upper layer was aspirated using a 3 mL Luer-lock syringe fitted with a 27-gauge needle and utilized within 60 seconds to preserve cellular viability and fibrin integrity.

Immediately before initiation of canine retraction, 0.3 mL of freshly prepared I-PRF was injected into the periodontal ligament region surrounding the right maxillary canine at mesial, distal, and mid-root sites, with 0.1 mL delivered at each site. A second injection following the same protocol was administered at the eighth week to maintain the biologic effect.

Anchorage reinforcement was maintained using a transpalatal arch in conjunction with mandibular anchorage support to minimize mesial movement of posterior teeth. Canine retraction was performed on 0.019″×0.025″ stainless steel working archwires using 9 mm nickel-titanium closed-coil springs delivering a constant force of 150 g, which was verified at each visit using a Correx® force gauge. Retraction mechanics were reviewed and reactivated at four-week intervals.

OTM was evaluated using three-dimensional digital model analysis. Impressions were obtained at baseline (T0) and subsequently at monthly intervals for three months (T1-T3). Dental casts were fabricated using type IV dental stone and digitized using a 3Shape D2000 structured-light scanner. Measurements were performed using 3Shape OrthoAnalyzer™ software. Digital model superimposition was carried out using stable palatal landmarks, namely the inferior tip of the incisive papilla and the medial ends of the third palatal rugae. The amount of canine retraction was measured at each interval using the superimposition technique.

Statistical analysis was performed using the statistical package for social sciences (SPSS) software. Descriptive statistics, including mean and standard deviation, were calculated for all study variables. As the study followed a split-mouth design, intergroup comparisons between experimental and control quadrants were carried out using the paired t test.

Intra-group comparisons across different time intervals were analyzed using repeated measures analysis of variance (ANOVA), followed by Bonferroni post-hoc correction for pairwise comparisons. A p value of less than 0.05 was considered statistically significant.

RESULTS

OTM progressively increased across all evaluated intervals in both the I-PRF and control groups. Repeated measures ANOVA demonstrated a statistically highly significant difference in tooth movement across different time intervals within the experimental group, indicating significant variation in the rate of canine retraction over time (Table 1).

Similarly, the control group demonstrated progressive canine movement throughout the observation period, with repeated measures ANOVA revealing statistically highly significant differences between the evaluated intervals (Table 2).

Intergroup comparison demonstrated consistently greater OTM in the I-PRF group compared to the control group at all evaluated intervals. A statistically significant difference was observed during the initial phase of retraction as well as in cumulative tooth movement from baseline to the third month. However, differences during the intermediate intervals were not statistically significant (Table 3).

Bonferroni post-hoc analysis in the I-PRF group demonstrated a statistically significant increase in tooth movement between the initial and second intervals, whereas comparisons between the remaining intervals did not show significant differences (Table 4).

In the control group, Bonferroni post-hoc analysis revealed statistically significant differences between the initial interval and subsequent intervals, while no significant difference was observed between the later phases of retraction (Table 5).

Table 1: Descriptive statistics of tooth movement in the I-PRF group at different time intervals.

I-PRF							ANOVA
Time interval	**N**	**Mean**	**SD**	**Std. error of mean**	**Minimum**	**Maximum**	**P value**
T0- T1	9	0.36	0.08	0.03	0.24	0.51	
T1- T2	9	0.65	0.23	0.08	0.31	1.12	
T2-T3	9	0.56	0.17	0.06	0.33	0.80	0.000
T0-T3	9	1.40	0.39	0.13	0.88	2.34	
Total	36	0.75	0.46	0.08	0.24	2.34	

Table 2: Descriptive statistics of OTM in the control group across different time intervals.

Control							ANOVA
Time interval	**N**	**Mean**	**SD**	**Std. error of mean**	**Minimum**	**Maximum**	**P value**
T0-T1	9	0.23	0.10	0.03	0.01	0.37	
T1-T2	9	0.57	0.27	0.09	0.28	1.18	
T2-T3	9	0.49	0.15	0.05	0.38	0.83	0.000
T0-T3	9	1.29	0.43	0.14	0.80	2.23	
Total	36	0.65	0.48	0.08	0.01	2.23	

Table 3: Comparison of mean OTM between I-PRF and control groups across different time intervals.

Time interval	Group	N	Mean	SD	Std. error mean	Paired t test, (p value)
T0-T1	I-PRF	9	0.36	0.08	0.03	0.004
	Control	9	0.23	0.10	0.03	
T1-T2	I-PRF	9	0.65	0.23	0.08	0.099
	Control	9	0.57	0.27	0.09	
T2-T3	I-PRF	9	0.56	0.17	0.06	0.251
	Control	9	0.49	0.15	0.05	
T0-T3	I-PRF	9	1.58	0.43	0.14	0.006
	Control	9	1.29	0.43	0.14	

Table 4: Multiple comparisons of mean tooth movement across time intervals in I-PRF group (Bonferroni post-Hoc test).

I-PRF group multiple comparisons						
Time interval	**(J) TI**	**Mean difference (I-J)**	**Std. error**	**Sig.**	**95% confidence interval**	
					Lower bound	**Upper bound**
T0-T1	T1-T2	-0.288444*	0.081	0.005	-0.496	-0.081
	T2-T3	-0.200889	0.081	0.060	-0.408	0.006
T1-T2	T0-T1	0.288444*	0.081	0.005	0.081	0.496
	T2-T3	0.087556	0.081	0.863	-0.120	0.295
T2-T3	T0-T1	0.200889	0.081	0.060	-0.006	0.408
	T1-T2	-0.087556	0.081	0.863	-0.295	0.120

*The mean difference is significant at the 0.05 level.

Table 5: Multiple comparisons of tooth movement across time intervals in control group (Bonferroni post-hoc test).

Control group multiple comparisons						
Time interval	**(J) TI**	**Mean difference (I-J)**	**Std. error**	**Sig.**	**95% confidence interval**	
					Lower bound	**Upper bound**
T0-T1	T1-T2	-0.344889*	0.089	0.002	-0.574	-0.116
	T2-T3	-0.266000*	0.089	0.019	-0.495	-0.037
T1-T2	T0-T1	0.344889*	0.089	0.002	0.116	0.574
	T2-T3	0.078889	0.089	1.000	-0.150	0.308
T2-T3	T0-T1	0.266000*	0.089	0.019	0.037	0.495
	T1-T2	-0.078889	0.089	1.000	-0.308	0.150

*The mean difference is significant at the 0.05 level.

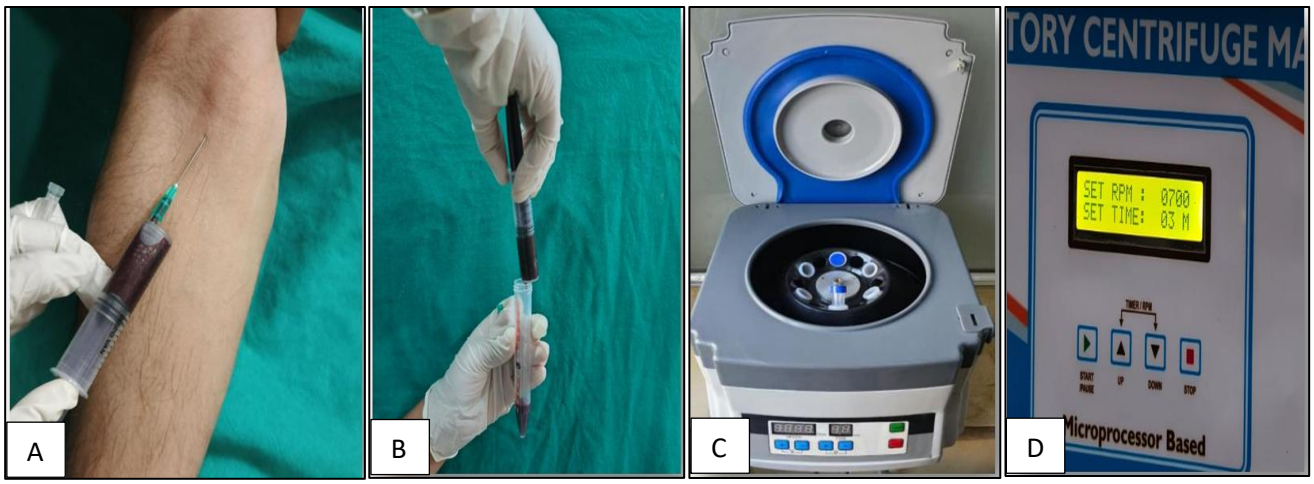

Figure 1 (A-D): Armamentarium and procedural steps involved in I-PRF preparation, including collection of 10 mL venous blood, transfer into vacutainer tubes, symmetrical placement of tubes within the centrifuge, and centrifugation parameters used for I-PRF preparation.

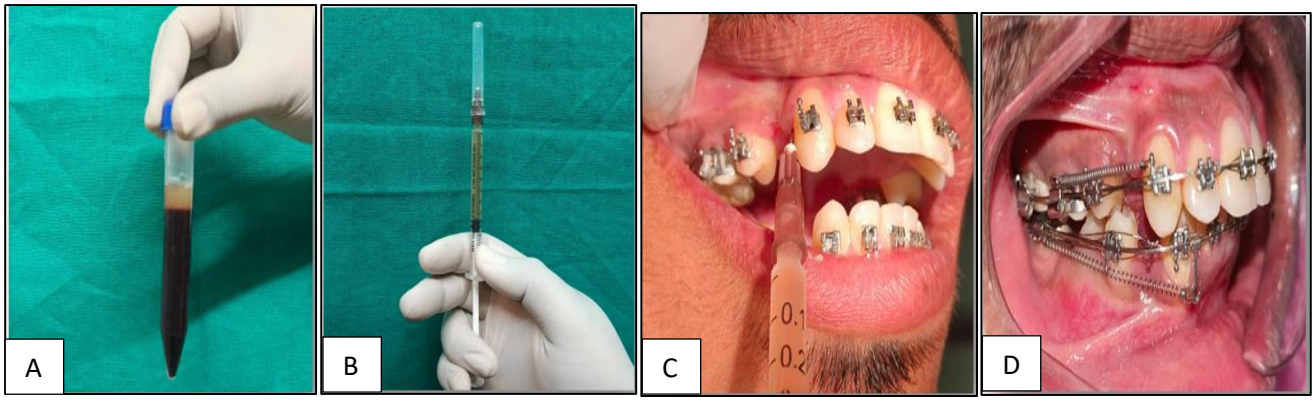

Figure 2 (A-D): Clinical procedure demonstrating preparation and administration of I-PRF, including prepared I-PRF, collection into a 1 mL 26-gauge syringe, intraligamentary injection around the maxillary canine, and canine retraction using nickel-titanium closed-coil spring mechanics.

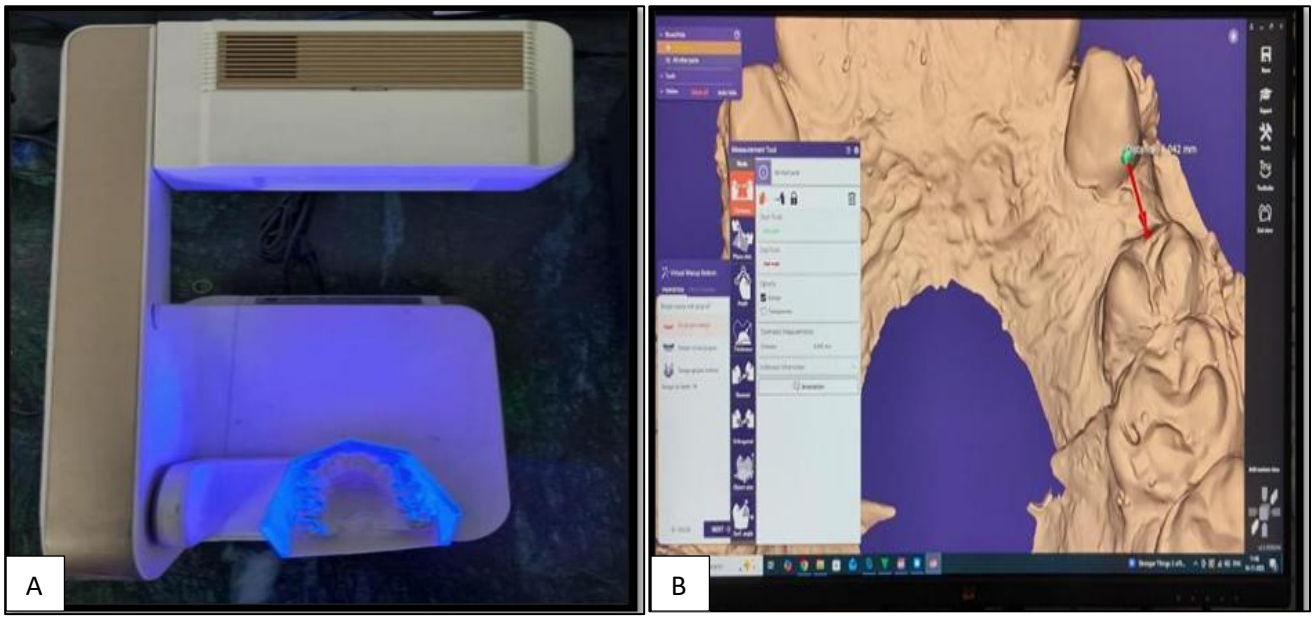

Figure 3 (A and B): Digital assessment of OTM showing scanning of dental models using a structured-light digital scanner and measurement of canine retraction using three-dimensional software analysis.

DISCUSSION

The present prospective split-mouth clinical study evaluated the effectiveness of I-PRF as a biologic adjunct for accelerating OTM during maxillary canine retraction. The findings demonstrated consistently greater canine movement in the I-PRF group compared to the control group throughout the observation period, with the most pronounced effect observed during the early phase of retraction. A significantly greater cumulative movement was also observed in the experimental quadrants, suggesting that I-PRF may enhance alveolar bone remodeling and periodontal ligament turnover during orthodontic treatment.

The accelerated tooth movement observed in the present study may be attributed to the biologically active composition of I-PRF. Choukroun and Ghanaati reported that low-speed centrifugation protocols produce platelet concentrates enriched with leukocytes, platelets, cytokines, and regenerative cells capable of sustained growth factor release.[9] Unlike conventional PRP, I-PRF undergoes natural fibrin polymerization without anticoagulants, thereby allowing gradual release of growth factors such as PDGF, TGF-β1, VEGF, and IGF. This sustained biologic activity may contribute to prolonged stimulation of angiogenesis, osteoclastic activation, and tissue remodeling, which clinically manifests as accelerated OTM.

The biologic mechanism underlying the observed acceleration is likely related to modulation of inflammatory and osteoclastic pathways. Erdur et al demonstrated that I-PRF enhances the expression of IL-1β, MMP-8, and RANKL while simultaneously reducing osteoprotegerin levels, thereby altering the RANKL/OPG balance in favor of osteoclastogenesis.[8] Since OTM fundamentally depends on coordinated bone resorption

and deposition, enhancement of osteoclastic activity by I-PRF may explain the significantly greater movement observed during the initial stages of canine retraction in the present study. Although biochemical markers were not evaluated directly, the clinical pattern of increased early movement aligns closely with these molecular observations.

The findings of the present investigation also support the biologic principles associated with the RAP. Frost originally described RAP as a transient increase in bone remodeling activity following localized tissue stimulation. Subsequent investigations by Alikhani et al, Baloul et al and Yaffe et al established that accelerated remodeling can be induced through surgical, mechanical, or biologic stimuli, thereby facilitating faster orthodontic tooth displacement.[10-12] Conventional RAP-based methods such as corticotomy, piezocision, and micro-osteoperforations are effective but are frequently associated with postoperative discomfort, morbidity, and reduced patient acceptance. In contrast, I-PRF represents a minimally invasive autologous alternative capable of enhancing bone remodeling without surgical trauma.

The temporal pattern of tooth movement observed in this study was comparable to the findings reported by Zeitounlouian et al who suggested that repeated I-PRF administration may produce cumulative biologic stimulation despite gradual hydrolysis of the fibrin scaffold.[13] In the present study, a second injection administered at the eighth week appeared to maintain the acceleration effect throughout the observation period. Similar biologic persistence was reported by Kobayashi et al who demonstrated prolonged release of growth factors from advanced platelet concentrates compared with PRP formulations.[14]

The results of the present study are also in agreement with the clinical findings reported by Tehranchi et al, Nemtoi et al, Rashid et al and Priya et al all of whom observed enhanced OTM following the use of PRF derivatives.[15-18] Although differences existed in study design, injection protocol, and measurement techniques, the overall trend consistently favored biologically enhanced acceleration with PRF-based modalities. Similarly, Sharan et al in a systematic review of randomized clinical trials, concluded that PRF demonstrates a generally positive effect on OTM despite heterogeneity among available studies.[19] These observations further support the findings of the present investigation while emphasizing the need for standardized protocols.

In contrast, certain earlier studies such as those by Akbulut et al failed to demonstrate statistically significant acceleration following PRF application.[20] These discrepancies may be related to methodological limitations including small sample sizes, inconsistent force systems, inadequate follow-up duration, and less accurate measurement techniques. In the present study, several methodological factors may have contributed to improved reliability of the findings. The split-mouth design minimized inter-individual biologic variability, while simultaneous bilateral extractions eliminated unilateral inflammatory bias related to extraction socket healing, as emphasized by Alikhani et al.[10] Furthermore, the use of three-dimensional digital superimposition based on stable palatal landmarks improved measurement precision, as recommended by Jang et al.[21]

Another important observation from the present study was the absence of clinically significant adverse effects during canine retraction. The biologic acceleration produced by I-PRF did not appear to compromise anchorage control or biomechanical stability. These findings are consistent with those of Naji et al who reported that platelet concentrates do not significantly influence unwanted rotational tendencies or compromise sliding mechanics.[5,8] This suggests that I-PRF may accelerate tooth movement while preserving overall treatment control.

Compared with PRP, I-PRF may offer superior biologic predictability and clinical convenience. Ammar et al noted that PRP often produces short-lived bursts of growth factor release because of rapid activation and degradation, whereas PRF formulations provide a slower and more sustained biologic effect.[22] Moreover, PRP preparation requires anticoagulants and biochemical additives that may alter platelet membrane integrity, as described by Marx.[23] The natural fibrin matrix and additive-free preparation of I-PRF may therefore explain the greater cumulative acceleration observed in the present study compared with earlier PRP-based investigations.

Despite the encouraging findings, certain limitations should be acknowledged. The relatively small sample size and short observation period may limit generalization of the results. Biochemical assessment of inflammatory mediators was not performed, preventing direct confirmation of the molecular pathways responsible for acceleration. Additionally, although split-mouth studies reduce biologic variability, systemic diffusion of cytokines cannot be entirely excluded. Future investigations incorporating larger multicenter randomized trials, biochemical analyses, CBCT-based volumetric assessment, and standardized centrifugation protocols are necessary to establish the long-term clinical effectiveness and reproducibility of I-PRF-assisted orthodontic acceleration.

CONCLUSION

Within the limitations of the present clinical study, I-PRF demonstrated a positive effect on accelerating OTM during maxillary canine retraction. The I-PRF group exhibited greater early tooth movement, sustained acceleration throughout the retraction phase, and higher cumulative displacement compared to the control group. The findings suggest that intraligamentary I-PRF may serve as an effective, minimally invasive, and biologically favorable adjunct for enhancing orthodontic

treatment efficiency without compromising biomechanical control or periodontal stability.

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