Microneedling Alone Versus Microneedling Combined with Injectable Platelet-Rich Fibrin for Interdental Papilla Augmentation in Thin Periodontal Phenotype: A Randomised Controlled Clinical Trial

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ABSTRACT

Background: Interdental papilla loss ("black triangles") is a prevalent aesthetic and functional deficit with limited non-surgical treatment options.[1,4] Microneedling (MN) and injectable platelet-rich fibrin (i-PRF) individually promote soft tissue regeneration;[5,6] however, their combined efficacy relative to MN alone has not been rigorously compared.

Objective: To compare the clinical efficacy of MN alone versus MN combined with i-PRF for interdental papilla augmentation and gingival thickness improvement in patients with Class II papilla loss and thin periodontal phenotype.

Materials and Methods: Twenty systemically healthy patients with Class II interdental papilla loss (Nordland and Tarnow classification) were randomly allocated to Group A (MN only, n = 10) or Group B (MN + i-PRF, n = 10). Both groups received four treatment sessions at 10-day intervals commencing 14 days after oral prophylaxis. i-PRF was prepared by centrifugation of 10 mL autologous venous blood at 700 rpm for 3 minutes[9] and delivered immediately following MN. Primary outcomes were gingival thickness (transgingival probing) and Nordland and Tarnow class (standardised clinical photography) at baseline, 1 month, 3 months, and 6 months. Statistical analysis was performed using paired t-test (within-group) and independent t-test (between-group), with significance set at $p < 0.05$.

Results: Both groups demonstrated statistically significant improvements in gingival thickness from baseline ($p < 0.05$). Group B showed significantly greater gains at 3 months (1.61 ± 0.13 mm vs 1.42 ± 0.11 mm, $p = 0.001$) and 6 months (1.82 ± 0.15 mm vs 1.49 ± 0.12 mm, $p < 0.001$) compared with Group A. Net gingival thickness gain was +0.63 mm in Group B versus +0.28 mm in Group A. Papilla class improved to Class I in 80% of Group B participants versus 30% in Group A at 6 months. No serious adverse events were recorded in either group.

Conclusion: MN combined with i-PRF is significantly more effective than MN alone for interdental papilla augmentation and gingival thickness improvement in patients with thin periodontal phenotypes. This protocol constitutes a promising minimally invasive, autologous drug delivery strategy for non-surgical soft tissue regeneration in aesthetic periodontics.

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1. INTRODUCTION

Interdental papilla loss, clinically referred to as "black triangles," remains one of the most challenging aesthetic problems in periodontics and restorative dentistry.[1] The interdental papilla occupies the gingival embrasure between adjacent teeth, contributing to dental aesthetics, phonetics, and food impaction prevention.[4] Loss of papillary volume compromises all three functions and is a frequent complaint among patients presenting for smile rehabilitation.

Papillary recession arises from a multifactorial aetiology including periodontal attachment loss, triangular crown morphology, divergent root forms, orthodontic tooth movement, age-related soft tissue atrophy, thin periodontal phenotype, and iatrogenic restorative or prosthetic contours.[1,4] The 2017 World Workshop classification replaced the term "gingival biotype" with "periodontal phenotype," encompassing both the gingival phenotype (keratinised tissue width and gingival thickness) and the bone morphotype (buccal bone plate thickness).[3] Patients with a thin periodontal phenotype carry an elevated susceptibility to papillary loss and demonstrate reduced regenerative responses at affected sites.[2]

Predictable papilla reconstruction is anatomically demanding, dependent on favourable bone levels, inter-proximal contact point position, and adequate blood supply—prerequisites often compromised at sites of established papilla loss.[4] Surgical approaches, including pedicle flaps,[10] semilunar coronally repositioned techniques,[11] and subepithelial connective tissue grafts,[12] yield variable clinical outcomes and are associated with patient morbidity. Non-surgical alternatives have gained interest as patient-friendly options, but rigorous comparative evidence remains limited.

Injectable platelet-rich fibrin (i-PRF) is a second-generation autologous platelet concentrate produced using a low-speed centrifugation protocol (700 rpm, 3 minutes).[9] Its liquid pre-gelation state allows injection into tissue defects, providing a sustained release of growth factors including TGF-β, VEGF, PDGF, and EGF.[5] Compared to platelet-rich plasma (PRP) and conventional PRF, i-PRF delivers a higher concentration of regenerative cells, leukocytes, and growth factors, conferring superior biological potency for soft tissue regeneration.[5,9]

Microneedling (MN) is a percutaneous collagen induction therapy creating controlled micro-injuries that activate a wound-healing cascade—stimulating fibroblasts, platelets, and growth factor release, promoting neocollagenesis and extracellular matrix remodelling.[6,7] A critical mechanistic advantage of MN is the transient generation of microchannels that substantially increase tissue permeability, facilitating deeper penetration and sustained retention of locally delivered bioactive agents.[7,8] When used as a drug delivery platform, MN has the potential to significantly enhance the local bioavailability of adjunctive agents such as i-PRF.[8]

While both MN and i-PRF have individually demonstrated efficacy in promoting gingival thickness and papillary augmentation,[14,16] no randomised controlled trial has directly compared MN alone versus MN with i-PRF for interdental papilla augmentation. The present study was designed to address this gap. We hypothesised that the combination of MN with i-PRF would yield superior clinical outcomes compared to MN alone in patients with Class II interdental papilla loss and thin periodontal phenotype.

2. MATERIALS AND METHODS

2.1 Study Design and Ethical Approval

This parallel-arm, randomised controlled clinical trial was conducted in the Department of Periodontology. The study was performed in accordance with the

Declaration of Helsinki (2013 revision). Institutional ethical committee approval was obtained prior to commencement. The trial was prospectively registered in a clinical trial registry. Written informed consent was obtained from all participants.

2.2 Sample Size

A sample size of 10 participants per group (total n = 20) was determined based on pilot data indicating a mean difference of 0.30 mm in gingival thickness between groups (SD 0.15 mm), with 80% power and a two-tailed significance level of $\alpha = 0.05$, consistent with methodology employed in comparable periodontal RCTs.[14,16]

2.3 Eligibility Criteria

Inclusion criteria: systemically healthy adults (18–45 years); Class II interdental papilla loss (Nordland and Tarnow classification)[14] in the anterior maxillary region; probing depths ≤2 mm; absence of active periodontal disease and tooth mobility; thin periodontal phenotype (gingival thickness <1.5 mm).[2] Exclusion criteria: tobacco use; systemic conditions affecting wound healing (e.g., diabetes mellitus, immunosuppression); anticoagulant or antiplatelet therapy; pregnancy or lactation; prior papilla augmentation surgery; restorations or crowns in the study area.

2.4 Randomisation and Allocation

Eligible participants were randomly allocated in a 1:1 ratio to Group A (MN only) or Group B (MN + i-PRF) using a computer-generated randomisation sequence with sealed opaque envelopes. The primary investigator performing clinical assessments was blinded to group allocation throughout the study.

2.5 Baseline Assessment

All participants underwent comprehensive periodontal examination, standardised clinical photography, and gingival thickness assessment by transgingival probing using a No. 15 K-file at the mid-papillary aspect of the interdental defect, recorded to the nearest 0.1 mm.[14] Papillary fill was classified according to Nordland and Tarnow's criteria.[14] Baseline oral prophylaxis and scaling and root planing were performed; oral hygiene instructions were reinforced. Treatment sessions commenced 14 days thereafter. Table 1 summarises baseline demographics and clinical parameters.

Table 1: Baseline Patient Demographics and Clinical Parameters (n = 10 per group)

Parameter	Group A – MN only (n = 10)	Group B – MN + i-PRF (n = 10)	p-value
Age (years), mean ± SD	27.3 ± 4.1	26.8 ± 3.7	0.76
Sex (F/M)	8 / 2	7 / 3	0.62
Nordland & Tarnow Class	Class II (all)	Class II (all)	—
Baseline gingival thickness (mm), mean ± SD	1.21 ± 0.09	1.19 ± 0.11	0.61
Baseline probing depth (mm)	≤2 (all)	≤2 (all)	—
Periodontal phenotype	Thin (all)	Thin (all)	—

NS = not significant; SD = standard deviation; MN = microneedling; i-PRF = injectable platelet-rich fibrin.

2.6 Treatment Protocol

Treatment was administered in four sessions at 10-day intervals (Table 2). At each session, MN was performed using a sterile derma-pen device calibrated to a needle depth appropriate for individual gingival tissue thickness.[6] Three to four

passes were applied over the interdental papilla to create controlled microchannels.

In Group B, immediately following MN, 10 mL of autologous venous blood was drawn by antecubital venepuncture and divided into two sterile plastic tubes (5 mL each), centrifuged at 700 rpm for 3 minutes at room temperature using the low-speed centrifugation concept.[9] The liquid i-PRF supernatant was aspirated into a sterile disposable syringe and injected directly into the interdental defect through the MN-generated microchannels.[14] In Group A, equivalent saline irrigation was applied following MN to standardise procedural handling. A periodontal dressing (Coe-Pak) was placed in both groups after each session.

Table 2: Treatment Protocol by Group

Session	Timing	Group A – MN only	Group B – MN + i-PRF
Pre-treatment	Day 0	Scaling & root planing, oral prophylaxis	Scaling & root planing, oral prophylaxis
1	Day 14	MN (derma-pen, 3–4 passes) + saline irrigation + periodontal dressing	MN (3–4 passes) → i-PRF injection (700 rpm, 3 min) → periodontal dressing
2	Day 24	MN + saline + periodontal dressing	MN + i-PRF + periodontal dressing
3	Day 34	MN + saline + periodontal dressing	MN + i-PRF + periodontal dressing
4	Day 44	MN + saline + periodontal dressing	MN + i-PRF + periodontal dressing
Follow-up	Monthly × 6	Clinical photography; transgingival probing; Nordland & Tarnow classification	Clinical photography; transgingival probing; Nordland & Tarnow classification

2.7 Post-operative Instructions

All participants were instructed to avoid brushing at the treated site for 24 hours, maintain a soft diet for 48 hours, and continue routine oral hygiene practices at untreated sites. No analgesics or antibiotics were prescribed routinely.

2.8 Outcome Measures

Primary outcomes: (i) gingival thickness (mm) by transgingival probing at baseline, 1, 3, and 6 months; (ii) Nordland and Tarnow papilla classification[14] from standardised clinical photographs at each time point. Secondary outcomes: patient-reported tolerability (Visual Analogue Scale, 0–10) and adverse events recorded at each session and follow-up visit.

2.9 Statistical Analysis

Data were tested for normality using the Shapiro-Wilk test. Gingival thickness data (normally distributed) were analysed using paired t-tests for within-group comparisons and independent t-tests for between-group comparisons at each time point. Papilla class distribution was compared using the chi-square test. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS version 26.0 (IBM, USA).

3. RESULTS

3.1 Participant Flow and Demographics

Twenty participants (17 female, 3 male; mean age 27.1 ± 3.9 years) were enrolled and randomised equally between groups. All 20 participants completed all four treatment sessions and the 6-month follow-up; there were no dropouts. Baseline demographics and clinical parameters were comparable between groups (Table 1; all $p > 0.05$).

3.2 Gingival Thickness

Both groups demonstrated statistically significant improvements in gingival thickness from baseline (within-group $p < 0.05$ at all post-treatment time points). Group B (MN + i-PRF) exhibited progressively greater gingival thickness gains compared with Group A (MN alone) from 3 months onwards (Table 3). The net mean gain at 6 months was +0.63 mm for Group B versus +0.28 mm for Group A, representing a 2.25-fold greater improvement. Between-group differences were statistically significant at 3 months ($p = 0.001$) and 6 months ($p < 0.001$). These results are consistent with findings from comparable RCTs.[14,16]

Table 3: Gingival Thickness (mm) at Each Time Point by Group

Time Point	Group A – MN only mean ± SD (mm)	Group B – MN + i-PRF mean ± SD (mm)	Between-group p-value
Baseline	1.21 ± 0.09	1.19 ± 0.11	0.61 (NS)
1 Month	1.28 ± 0.10	1.35 ± 0.12	0.14 (NS)
3 Months	1.42 ± 0.11	1.61 ± 0.13*	0.001*
6 Months	1.49 ± 0.12	1.82 ± 0.15*	<0.001*
Within-group p-value (baseline vs 6M)	0.003*	<0.001*	—
Net gain (baseline → 6M)	**+0.28 mm**	**+0.63 mm**	—

*p < 0.05 compared to baseline within group; between-group significance by independent t-test. NS = not significant; MN = microneedling; i-PRF = injectable platelet-rich fibrin.

3.3 Papillary Fill (Nordland and Tarnow Classification)

At baseline, all 20 participants presented with Class II papilla loss.[14] At the 6-month follow-up, 80% (8/10) of Group B participants improved to Class I, compared with 30% (3/10) in Group A. No participant in either group regressed to Class III. The difference in papillary class distribution between groups at 6 months was statistically significant (chi-square, $p = 0.03$). Table 4 presents the full classification data.

Table 4: Nordland and Tarnow Papillary Classification at Baseline and 6 Months

Nordland & Tarnow Class	Group A – Baseline	Group A – 6M	Group B – Baseline	Group B – 6M
Class I (complete fill)	0 / 10	3 / 10 (30 %)	0 / 10	8 / 10 (80 %)
Class II (tip of papilla	10 / 10 (100 %)	7 / 10 (70 %)	10 / 10 (100 %)	2 / 10 (20 %)

visible)				
Class III (no papilla visible)	0 / 10	0 / 10	0 / 10	0 / 10

3.4 Tolerability and Adverse Events

Both interventions were well-tolerated (Table 5). Mean Visual Analogue Scale scores for procedural discomfort were 2.4 ± 0.8 in Group A and 2.7 ± 0.9 in Group B ($p = 0.34$). No serious adverse events, infections, or systemic reactions were recorded in either group. Two participants in Group B experienced self-limiting postoperative swelling that resolved within 48 hours without intervention.

Table 5: Adverse Events by Group

Adverse Event	Group A – MN only	Group B – MN + i-PRF
Transient procedural discomfort	4 / 10 (40%) – mild, resolved	5 / 10 (50%) – mild, resolved
Postoperative swelling	1 / 10 (10%) – self-limiting	2 / 10 (20%) – self-limiting
Infection / hypersensitivity	0 / 10	0 / 10
Dropouts	0 / 10	0 / 10

4. DISCUSSION

This randomised controlled trial provides direct comparative evidence that MN combined with i-PRF is significantly superior to MN alone for interdental papilla augmentation and gingival thickness improvement in patients with thin periodontal phenotypes.[14,16] The 2.25-fold greater gingival thickness gain and the substantially higher rate of Class I papillary fill in Group B underscore the additive regenerative contribution of i-PRF when delivered via MN-generated microchannels.

The mechanistic basis for this superiority lies in the synergistic drug delivery architecture of the combined protocol. MN creates a network of transient microchannels through the gingival epithelium that act as conduits, enabling i-PRF to penetrate deeply into the connective tissue compartment rather than remaining superficially.[7,8] This dramatically enhances the local bioavailability and retention time of i-PRF's growth factor payload.[15] In Group A, MN alone stimulated a wound-healing response through platelet and fibroblast activation,[6,7] but lacked the sustained growth factor reservoir provided by i-PRF in Group B.

The superior outcomes in Group B are further explained by the biological kinetics of i-PRF. The low-speed centrifugation protocol (700 rpm, 3 minutes) used in the present study is consistent with the slow-speed centrifugation concept, which yields a higher concentration of circulating stem cells, leukocytes, and growth factors compared with conventional PRF preparation.[9] i-PRF releases TGF-β, VEGF, PDGF, and EGF for up to 10 days following injection.[5,9] These mediators orchestrate fibroblast migration (day 5 through week 8), neocollagenesis (types I and III), elastin synthesis, glycosaminoglycan production, and angiogenesis—collectively contributing to connective tissue volume gain and papillary fill.[5] Collagen production peaks within two weeks of MN-induced injury,[7] aligning precisely with the i-PRF release window and maximising synergistic biological activity.

The significantly greater improvement in Nordland and Tarnow classification[14] observed in Group B (80% Class I at 6 months vs 30% in Group A) has direct clinical relevance. Class I papilla fill

represents complete embrasure closure to the inter-proximal contact point—the aesthetic benchmark for successful papilla augmentation.[1,4] The 50-percentage-point difference between groups in achieving this endpoint represents a clinically meaningful advantage of the combined protocol.

Our findings are consistent with and extend the literature. The randomised controlled trial by Ozsagir et al.[14] demonstrated that i-PRF with MN produced significantly greater gingival thickness gains than standalone i-PRF in thin periodontal phenotype patients. Soundarajan and Malaippan[16] similarly reported superior gingival augmentation with combined MN and i-PRF versus i-PRF alone. The systematic review by Morrow et al.[18] concluded that MN with adjunctive agents consistently yields increased interdental papilla height, enhanced gingival thickness, greater collagen deposition, and reduced inflammation compared with MN alone. Ahuja et al.[17] further demonstrated the potential of MN as a delivery platform using locally administered Vitamin C for papillary deficiency. The present study adds a direct head-to-head comparison between MN alone and MN with i-PRF, providing a higher level of evidence than previous case reports or uncontrolled series.

The absence of serious adverse events in both groups, coupled with comparable tolerability scores, confirms that both protocols are safe for clinical application. The self-limiting swelling in two Group B participants is consistent with the expected biological response to autologous blood product injection[5] and did not require any pharmacological intervention.

From a drug delivery perspective, the present study validates MN as an effective platform for localised i-PRF delivery in the periodontium.[8] The microchannel network created by MN functions analogously to a transient intradermal drug delivery system, enabling the bioactive payload of i-PRF to bypass the barrier of intact epithelium and reach fibroblast-rich connective tissue directly.[7,8] This principle has broad implications for the development of minimally invasive biologic delivery strategies in periodontics and oral medicine.[8]

Limitations of the present study include the modest sample size (n = 10 per group), single-centre design, absence of histological validation, and 6-month follow-up horizon. Patients and treating clinicians could not be blinded to the additional i-PRF injection in Group B, although outcome assessors were blinded to group allocation. Larger multi-centre randomised controlled trials with longer follow-up and volumetric outcome measures (e.g., cone-beam computed tomography or optical coherence tomography) are needed to confirm and extend these findings.[14,18]

5. CONCLUSION

This randomised controlled trial demonstrates that MN combined with i-PRF is significantly more effective than MN alone for achieving interdental papilla augmentation and gingival thickness improvement in patients with Class II papilla loss and thin periodontal phenotype.[14,16] The combination protocol yielded a 2.25-fold greater gingival thickness gain and an 80% rate of complete papillary fill at 6 months, with an excellent safety and tolerability profile.[5,9] These results support MN as a validated drug delivery platform for localised i-PRF administration in aesthetic periodontics.[7,8] The combined protocol represents a clinically accessible, minimally invasive, and biologically rational non-surgical treatment option. Further multi-centre randomised trials with extended follow-up are warranted to consolidate evidence for routine clinical adoption.

DECLARATIONS

Financial Support: None.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: Institutional ethical committee approval was obtained.

Informed Consent: Written informed consent was obtained from all participants prior to enrolment.

Data Availability: Data supporting the findings are available from the corresponding author on reasonable request.

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