

Original Research

Minimally invasive technique for regeneration of deficient interdental papilla using injectable platelet-rich fibrin and vitamin C: A randomized parallel-arm clinical study

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ABSTRACT:

Background: Deficiency of the interdental papilla leads to unaesthetic gingival black triangles, causing esthetic compromise, phonetic difficulty, and food impaction. Conventional surgical approaches for papilla reconstruction are invasive and often unpredictable, necessitating the exploration of minimally invasive regenerative alternatives. **Aim:** To evaluate and compare the effectiveness of injectable platelet-rich fibrin (i-PRF) and injectable vitamin C administered via intrapapillary mesotherapy for regeneration of deficient interdental papilla. **Materials and Methods:** A randomized, parallel-arm, open-label clinical study was conducted on 20 interdental sites with papillary deficiency in the maxillary anterior region. Following oral prophylaxis, sites were randomly allocated into two study groups: Group I received injectable i-PRF and Group II received injectable vitamin C. Clinical measurements and standardized photographic assessments were recorded at baseline, 1 month, 3 months, and 6 months. Interdental papilla deficiency was assessed clinically using a UNC-15 probe, and black triangle area was measured using ImageJ software. Statistical analysis was performed using repeated measures ANOVA, with $P < 0.05$ considered statistically significant. **Results:** Both study groups demonstrated a statistically significant reduction in interdental papilla deficiency and black triangle area from baseline to 6 months ($P < 0.05$). The i-PRF group exhibited greater early improvement, whereas the vitamin C group showed gradual and sustained enhancement over the follow-up period. No adverse events were reported. **Conclusion:** Injectable i-PRF and injectable vitamin C delivered via intrapapillary mesotherapy are effective minimally invasive modalities for interdental papilla regeneration. i-PRF provides faster early regenerative outcomes, while vitamin C offers consistent and sustained improvement.

Keywords: Interdental papilla; Injectable platelet-rich fibrin; Vitamin C; Black triangle; Mesotherapy; Periodontal regeneration

Received: 12 October, 2025

Accepted: 16 November, 2025

Published: 11 December, 2025

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This article may be cited as: U.S Harita, J Kavippriyan, Saravanan D, V.K Vijay, M Senthilkumar. Minimally invasive technique for regeneration of deficient interdental papilla using injectable platelet-rich fibrin and vitamin C: A randomized parallel-arm clinical study. *J AdvMed Dent Sci Res* 2025; 13(12):131-136.

INTRODUCTION

The interdental papilla plays a vital role in anterior dental esthetics and periodontal health. Loss of interdental papilla results in open gingival embrasures, commonly referred to as gingival “black

triangles,” which compromise smile esthetics, phonetics, and promote food accumulation.[1,2] The etiology of papillary loss is multifactorial and includes periodontal disease, traumatic oral hygiene practices, tooth malposition, and malocclusion. Beyond its

esthetic importance, the interdental papilla serves as a biological seal that protects the underlying periodontal tissues, emphasizing the need for its preservation and regeneration.[3]

Reconstruction of deficient interdental papilla, particularly in the esthetic zone, remains one of the most challenging aspects of periodontal therapy. Various surgical approaches, including pedicle flaps and connective tissue grafts, have been proposed; however, these techniques are invasive, technique-sensitive, and yield unpredictable outcomes.[4,5] As a result, minimally invasive, nonsurgical regenerative techniques have gained increasing attention.

Platelet-rich fibrin (PRF) is an autologous biomaterial widely utilized in periodontal regeneration due to its ability to deliver growth factors that promote angiogenesis and soft-tissue healing.[6] Injectable platelet-rich fibrin (i-PRF), prepared using low-speed centrifugation, contains a higher concentration of platelets, leukocytes, and growth factors in a liquid form, allowing direct injection into target tissues. i-PRF forms a dynamic fibrin scaffold that facilitates fibroblast proliferation, collagen synthesis, and tissue remodeling, making it a promising modality for interdental papilla regeneration.[7,8]

Vitamin C (ascorbic acid) is a potent antioxidant and an essential cofactor in collagen biosynthesis. It enhances fibroblast proliferation, promotes collagen maturation, reduces oxidative stress, and induces differentiation of periodontal ligament progenitor cells.[9–12] Injectable vitamin C administered via mesotherapy has been explored for gingival esthetic enhancement; however, limited evidence exists regarding its role in interdental papilla regeneration. Therefore, the present study aimed to evaluate and compare the effectiveness of injectable i-PRF and injectable vitamin C delivered via intrapapillary mesotherapy for the regeneration of deficient interdental papilla.

MATERIALS AND METHODS

Study design and ethical approval

Group I – Injectable platelet-rich fibrin

10 ml of venous blood was collected and centrifuged at 700 rpm for 3 minutes. The upper liquid fraction (i-

A randomized, parallel-arm, prospective clinical study was conducted in the Department of Periodontology, R.V.S Dental College and Hospital, Coimbatore.

Ethical clearance was obtained from the Institutional Ethical Committee prior to initiation of the study.

Written informed consent was obtained from all participants.

Study population

Twenty interdental sites presenting with papillary deficiency in the maxillary anterior region were included. The study duration was 6 months.

Inclusion criteria

Systemically healthy individuals

Age between 25 and 55 years

Presence of at least one deficient interdental papilla (Nordland and Tarnow Class I or II)

Plaque index and gingival index scores between 0 and 1

Exclusion criteria

Periodontal pockets, clinical attachment loss, or malocclusion

Pregnant or lactating women

History of smoking or tobacco use

Periodontal therapy within the previous 6 months

Known allergy to study materials

History of blood disorders

Randomization and grouping

Selected sites were randomly allocated into two parallel study groups:

Group I: Injectable platelet-rich fibrin (i-PRF)

Group II: Injectable vitamin C

No untreated control group was included.

CLINICAL PROCEDURE

All patients underwent full-mouth scaling and root planing followed by individualized oral hygiene instructions. A two-week maintenance phase was observed prior to baseline evaluation.

PRF) was aspirated and injected using an insulin syringe.

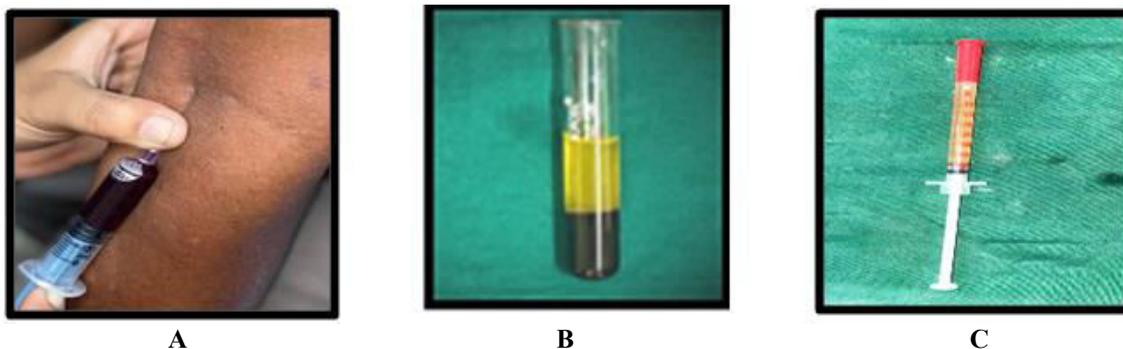


Figure 1 : A)10ml of venous blood drawn from patient ,B)Centrifuged at 700rpm for 3 mins and i-PRF obtained ,C) Obtained i-PRF loaded in insulin syringe.

Baseline measurements of interdental papillary loss sites and clinical photographs were recorded after 2 weeks. LA is administered.

The needle was inserted at a **45° angle, 2–3 mm apical to the interdental papilla tip.**

A **single-point injection technique** - the bevel of the injection needle was applied sloping upward.

Each involved papilla was injected with an amount **till blanching** was visible (1–1.5 mL).

Injection followed by gentle massage of the area for 1 minute.

Each papillary area was evaluated through photograph and clinically at baseline (prior to the injection) and at 1st month, 3rd month and 6th month.



FIGURE 2 : Clinical pictures of Group-I

Group II – Injectable vitamin C

Injectable vitamin C (Lifestar®, Mankind Pharma Pvt. Ltd., India) was administered using a 30-gauge insulin syringe. Approximately 1–1.5 mL was injected at a 45° angle, 2–3 mm apical to the deficient papilla until blanching occurred, followed by gentle massage.



FIGURE 3 : Clinical pictures of Group- II

CLINICAL EVALUATION

Clinical measurements and standardized intraoral photographs were recorded at:

- Baseline
- 1 month
- 3 months
- 6 months

Interdental papilla deficiency was assessed clinically using a UNC-15 probe.

BLACK TRIANGLE HEIGHT

Clinically measured the distance between the contact point and deficient papilla tip . Using a UNC-15 periodontal probe and a modified custom-made occlusal stent.

BLACK TRIANGLE AREA

Black triangle area was quantified using ImageJ software.

Clinical images of the teeth of interest will be taken perpendicular to them, then transferred to a computer and processed utilizing (ImageJ)® analysis.

The black triangle portion to be measured demarcated on the image and converted automatically to millimeters.

STATISTICAL ANALYSIS

Data were analyzed using statistical software. Repeated measures ANOVA was used to assess intra- and intergroup changes over time.

A *P* value < 0.05 was considered statistically significant.

RESULTS

Both study groups demonstrated a statistically significant reduction in interdental papilla deficiency and black triangle area from baseline to 6 months (*P*< 0.05). Improvement was evident at 1 month and continued progressively at 3 and 6 months.

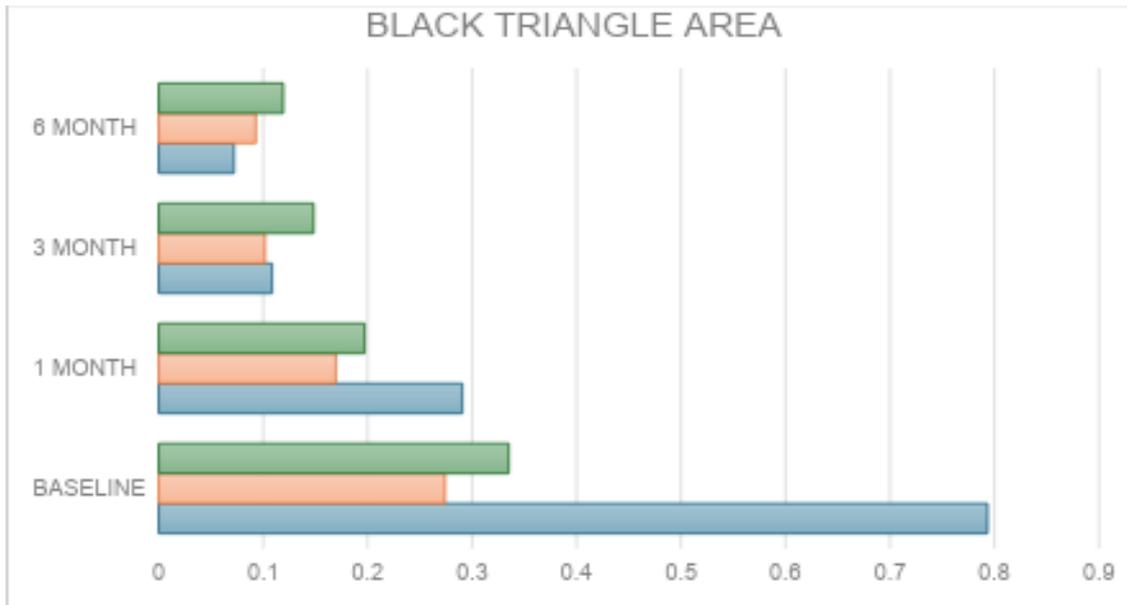


TABLE 1 : Illustration of results - Black triangle area

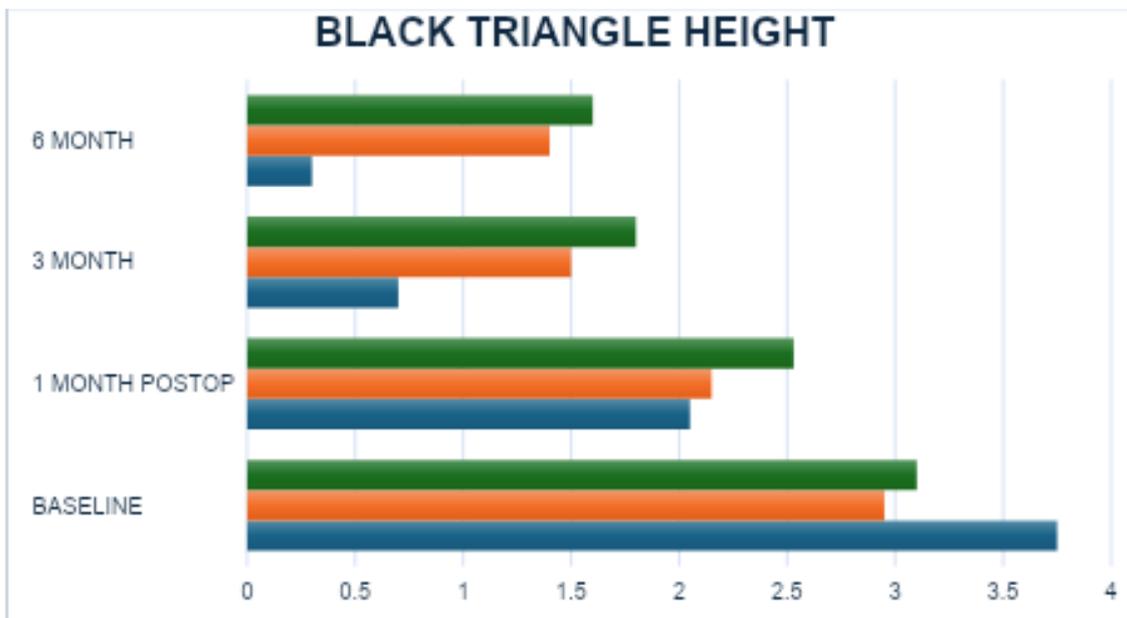


TABLE 2: Illustration of results - Black triangle height.

The i-PRF group showed greater early improvement in papillary fill, whereas the vitamin C group exhibited gradual and sustained enhancement over

time. No adverse effects or complications were observed in either group.

DISCUSSION

Reconstruction of the interdental papilla remains one of the most challenging objectives in periodontal esthetic therapy due to the limited vascularity, anatomical constraints, and high susceptibility of the papilla to inflammation and trauma. The present randomized parallel-arm clinical study evaluated and compared two minimally invasive regenerative approaches—injectable platelet-rich fibrin (i-PRF) and injectable vitamin C—administered via intrapapillary mesotherapy for the management of deficient interdental papilla over a 6-month follow-up period.

Both treatment modalities demonstrated statistically significant improvement in papillary fill and reduction in black triangle area from baseline to 6 months. These findings indicate that biologically driven, nonsurgical interventions can effectively stimulate soft-tissue regeneration in the interdental region, thereby overcoming several limitations associated with conventional surgical techniques.

The earlier and more pronounced improvement observed in the i-PRF group may be attributed to its unique biological composition and mechanism of action. i-PRF is obtained through low-speed centrifugation, which allows higher retention of platelets, leukocytes, and circulating stem cells within a loosely organized fibrin matrix.[7,8] This matrix functions as a three-dimensional scaffold that not only supports cell migration and proliferation but also enables sustained release of key growth factors such as platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), and transforming growth factor- β (TGF- β). These mediators play a pivotal role in angiogenesis, fibroblast proliferation, collagen deposition, and extracellular matrix remodeling—processes essential for early volumetric enhancement of the interdental papilla.

The findings of the present study are consistent with previous reports that have demonstrated the efficacy of PRF and i-PRF in soft-tissue augmentation and papilla reconstruction. Arunachalam et al. reported successful papilla reconstruction using PRF, highlighting its regenerative potential in esthetically demanding areas.[13] Similarly, Puri et al. described favorable outcomes with injectable PRF in papilla augmentation, emphasizing its minimally invasive nature and predictable early results.[14] Pandya et al. compared i-PRF with hyaluronic acid and reported comparable or superior reductions in black triangle dimensions with i-PRF, supporting its role as a biologically active injectable scaffold.[15]

In contrast, injectable vitamin C demonstrated a gradual yet sustained improvement in papillary fill throughout the 6-month observation period. Vitamin C plays a fundamental role in collagen biosynthesis by acting as a cofactor for prolyl and lysyl hydroxylase enzymes, which are critical for collagen maturation and stabilization.[9,10] Additionally, vitamin C enhances fibroblast proliferation, reduces

oxidative stress, and improves endothelial cell function, thereby contributing to improved connective tissue quality rather than rapid volumetric expansion.

The sustained improvement observed in the vitamin C group may also be explained by its ability to induce differentiation of periodontal ligament progenitor cells via activation of the extracellular signal-regulated kinase (ERK) signaling pathway, as demonstrated by Yan et al.[12] Unlike i-PRF, which primarily acts as a growth-factor reservoir and scaffold, vitamin C appears to exert its effects through metabolic and cellular modulation, leading to slower but steady connective tissue regeneration. This difference in biological action likely explains the variation in the rate and pattern of clinical improvement observed between the two study groups.

From a clinical perspective, both treatment modalities offer distinct advantages. Injectable i-PRF provides rapid early improvement, making it particularly suitable for patients seeking quicker esthetic outcomes. However, it requires venipuncture, centrifugation, and strict chairside protocols. Injectable vitamin C, on the other hand, is easy to administer, cost-effective, and does not require blood handling, making it a viable alternative for patients unwilling or unsuitable for autologous blood-derived therapies. The absence of adverse effects in both groups further supports the safety and patient acceptability of these minimally invasive approaches.

The progressive improvement observed up to 6 months in both groups suggests that intrapapillary mesotherapy can induce stable soft-tissue remodeling rather than transient tissue swelling. This is clinically significant, as relapse and loss of papillary height are common concerns following surgical papilla reconstruction. Although not evaluated in the present study, the combination of i-PRF and vitamin C could theoretically produce synergistic effects by integrating a biologic scaffold with enhanced collagen synthesis, representing an area for future investigation.

Despite its encouraging findings, the present study has certain limitations. The relatively small sample size limits generalizability, and the absence of histologic or biomarker analysis restricts direct confirmation of the underlying regenerative mechanisms. Furthermore, long-term stability beyond 6 months could not be assessed. Future randomized controlled trials with larger sample sizes, extended follow-up periods, and objective volumetric analyses are warranted to validate and expand upon these findings.

LIMITATIONS

The limitations of the study include a small sample size and absence of histological evaluation. Long-term stability beyond 6 months could not be assessed.

CONCLUSION

Within the limitations of the study, both injectable platelet-rich fibrin and injectable vitamin C administered via intrapapillary mesotherapy were

effective in regenerating deficient interdental papilla over a 6-month follow-up period. i-PRF demonstrated faster early regenerative response, while vitamin C showed consistent and sustained improvement. Both modalities can be considered minimally invasive and clinically viable options for esthetic management of interdental papilla deficiency.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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