REVIEW ARTICLE

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Injectable platelet-rich fibrin based interventions for treatment of gingival black triangles: systematic review of clinical evidence

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Abstract (J Korean Assoc Oral Maxillofac Surg 2026;52:167-178)

Gingival black triangles, resulting from loss of the interdental papilla (IDP), adversely affect esthetics, phonetics, and periodontal health, and injectable platelet-rich fibrin (i-PRF) a growth factor–rich platelet concentrate, has emerged as a promising minimally invasive regenerative approach for papilla reconstruction. This study evaluates the clinical effectiveness of i-PRF in the management of gingival black triangles and IDP deficiencies. A systematic review was conducted according to PRISMA 2020 guidelines and registered in PROSPERO (CRD420261321819). Electronic searches of studies including human studies were performed for studies published between 2020 and 2025. Risk of bias was assessed using the Cochrane risk-of-bias tool for randomized trials and the JBI checklists for case reports and series. Fourteen studies met the inclusion criteria, including randomized controlled trials (RCTs), pilot studies, case series, and case reports. Most studies reported improvements in papillary height, papilla presence index, and reduction in black triangle dimensions following i-PRF therapy. Clinical outcomes were generally comparable to hyaluronic acid injections and connective tissue graft procedures, with reduced invasiveness and postoperative discomfort. i-PRF appears to be a promising minimally invasive option for managing gingival black triangles; however, larger RCTs with longer follow-up are needed to confirm long-term effectiveness.

Key words: Platelet-rich fibrin, Periodontal regeneration, Dental papilla, Esthetics, Gingiva

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I. Introduction

Gingival black triangles, also known as open gingival embrasures, are triangular spaces between adjacent teeth caused by the loss or absence of the interdental papilla (IDP). They are most noticeable in the maxillary anterior region, where even minimal papillary loss can compromise smile esthetics. The presence of the IDP is closely related to the distance between the contact point and the underlying alveolar bone crest. Tarnow et al.[1] demonstrated that when this distance exceeds 5 mm, the likelihood of complete papillary fill decreases significantly, increasing the risk of black triangle formation.

The etiology of gingival black triangles is multifactorial. Periodontal attachment loss and alveolar bone resorption are the primary causes, especially in patients with periodontitis. Other contributing factors include a thin gingival phenotype, age-related tissue shrinkage, triangular tooth morphology, orthodontic tooth movement, improper restorative contours, and traumatic oral hygiene practices[1,2]. As esthetic awareness has increased, these defects are now considered an important clinical concern because they affect appearance, oral hygiene, and patient satisfaction.

Several classification systems have been proposed to evaluate IDP loss, including the Nordland and Tarnow classification[3], Jemt papilla index[4], Cardaropoli classification[5], Nemcovsky classification[6], and the dimensional classification described by Cho et al.[7]. Among these, the Nordland and Tarnow classification is the most widely accepted[8]. It classifies papillary loss into three categories based on the position of the papilla relative to the contact point and the cementoenamel junction (CEJ), helping guide prognosis and treatment selection.

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Untreated gingival black triangles may result in food impaction, plaque accumulation, gingival inflammation, phonetic difficulties, and compromised smile esthetics. They may also contribute to localized periodontal inflammation, making treatment important for both functional and esthetic reasons[2].

Several treatment options have been proposed to reconstruct the IDP. Surgical techniques, including connective tissue grafts, papilla preservation procedures, and microsurgical reconstruction, have shown favorable results but are technique-sensitive, invasive, and less predictable in advanced defects[9,10]. Restorative and orthodontic approaches, such as contact point modification, composite additions, interproximal enamel reduction, and tooth repositioning, have also been used, although they may require prolonged treatment or irreversible tooth modification[2].

More recently, minimally invasive biologic therapies have gained attention. Platelet-rich fibrin (PRF), a second-generation platelet concentrate, contains a fibrin matrix enriched with platelets, leukocytes, and growth factors that promote angiogenesis and soft tissue regeneration[11,12]. Unlike platelet-rich plasma, PRF does not require anticoagulants and provides a sustained release of growth factors that support wound healing[13]. Clinical studies have reported promising outcomes with PRF in periodontal regeneration and papilla reconstruction[14-16].

Injectable platelet-rich fibrin (i-PRF), prepared using low-speed centrifugation, remains in liquid form before clotting, allowing direct injection into soft tissues[17]. It enables minimally invasive delivery of autologous growth factors that may enhance fibroblast activity, collagen synthesis, and angiogenesis. Unlike hyaluronic acid (HA), which mainly provides volumetric enhancement, i-PRF has the potential to promote true soft tissue regeneration.

Although several clinical studies have evaluated i-PRF for managing gingival black triangles, the available evidence remains heterogeneous with respect to treatment protocols, injection frequency, outcome measures, and follow-up duration. To date, no comprehensive systematic review has specifically synthesized the clinical evidence on i-PRF for IDP reconstruction.

Therefore, this systematic review aims to critically evaluate the available clinical evidence on the use of i-PRF for the management of gingival black triangles, assess the methodological quality of the included studies, and determine its effectiveness and predictability. The findings may help guide clinical decision-making, support standardized treatment protocols, and identify priorities for future research in esthetic periodontology.

II. Methodology

This systematic review was conducted to evaluate the clinical effectiveness of i-PRF in the management of gingival black triangles (IDP deficiencies). A pre-registered protocol (CRD420261321819) was established in the PROSPERO database. The review protocol was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines[18].

1. Study design

Following PRISMA guidelines, this systematic review sought to synthesize existing evidence on the papilla reconstruction using i-PRF. This systematic review was conducted from January 2026 to March 2026, encompassing publications from 2020 to 2025. The search strategy utilized Boolean operators (AND/OR/NOT) in search strategies to capture all relevant articles. The Population, Intervention, Comparison, Outcome, and Study design/Setting (PICOS) question of this systematic review could be clarified as “Does i-PRF effectively augment IDP and reduce gingival black triangles in patients compared to other treatment modalities or no intervention?”

2. PICOS format

The focused research question was structured using the PICOS format as follows:

P (Population): Patients with gingival black triangles

I (Intervention): i-PRF

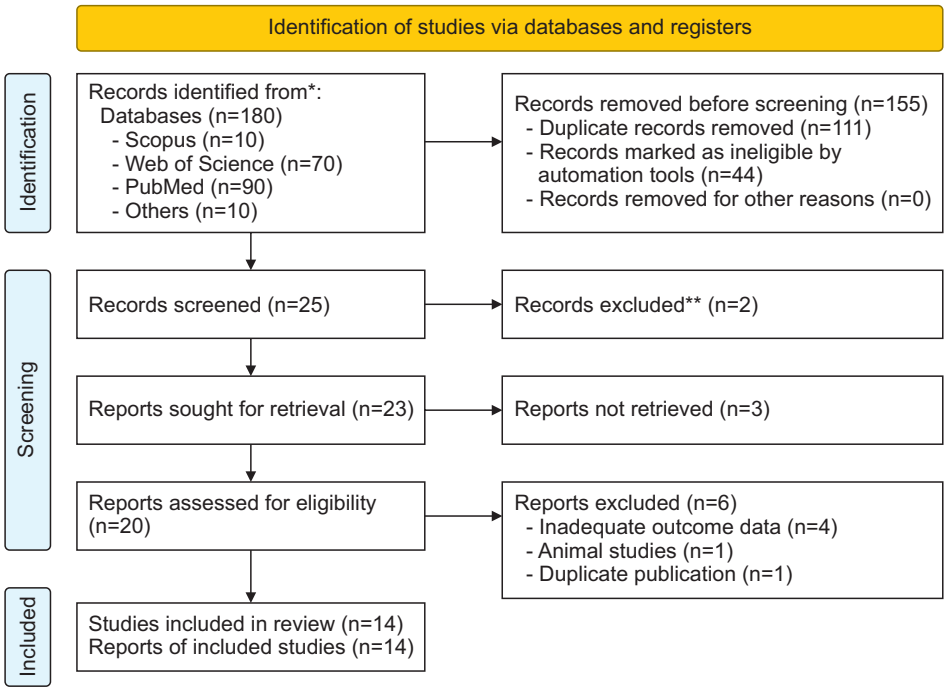
C (Comparison): Placebo, no treatment, or conventional surgical/biologic interventions

O (Outcome): Papilla fill, black triangle reduction, esthetic outcomes, clinical stability

S (Study design/setting): any studies in humans (ranging from case reports, cohort studies to randomised controlled trials).

3. Search strategy

A comprehensive electronic search was conducted in the following databases such as PubMed/MEDLINE, Scopus, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL). The search included all studies published



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart.
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from 2020 to 2025 without restriction on publication year. Only articles published in English were included. The search strategy combined Medical Subject Headings (MeSH) and free-text terms using Boolean operators (AND/OR). The keywords included "Injectable platelet-rich fibrin" OR "i-PRF" ([All Fields] AND "Platelet-rich fibrin" [MeSH Terms] OR "periodontitis" [All Fields] AND "interdental papilla", "Gingival black triangle" OR "Open gingival embrasure" [All Fields] OR "Papilla reconstruction" OR "Papilla augmentation".

4. Screening and data selection

All identified records were imported into reference management software, and duplicates were removed. Study selection was performed in two stages. Two independent reviewers (M.G. and J.V.) screened titles and abstracts for relevance according to predefined eligibility criteria. Full-text articles of potentially eligible studies were retrieved and independently assessed by the same reviewers. Any disagreements between reviewers were resolved through discussion or consultation with a third reviewer (R.B.). The study selection process was documented using a PRISMA flow diagram as depicted in Fig. 1.

5. Eligibility criteria

Inclusion criteria: Studies were included if they were human clinical investigations evaluating i-PRF for the treatment of gingival black triangles in patients with IDP loss in natural dentition. Eligible study designs comprised randomized controlled trials (RCTs), controlled clinical trials, prospective studies, and case series that reported quantitative clinical outcomes related to papillary fill, had a minimum follow-up period of one month, and were published in English.

Exclusion criteria: Studies were excluded if they were animal or *in vitro* investigations, evaluated only PRF membranes without i-PRF, were case reports with insufficient clinical outcome data, or were review articles, editorials, or opinion papers. Additionally, studies focusing solely on peri-implant papilla (unless separately reporting natural teeth) or lacking measurable outcome parameters were excluded.

III. Assessment of Risk of Bias

The revised Cochrane risk-of-bias tool for randomized trials (RoB 2)[19] was employed to evaluate the quality and RoB of the effective studies included in the review[12]. The assessment comprised five domains: (1) Randomization process

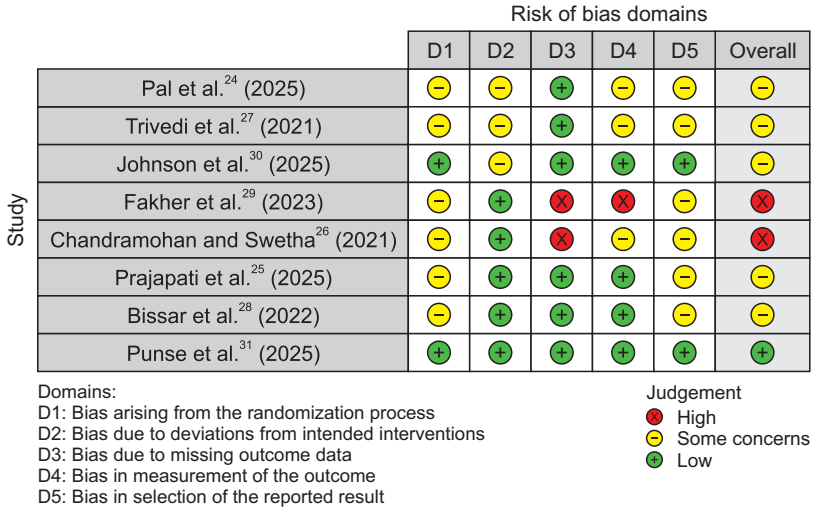


Fig. 2. Traffic plot for assessing the risk of bias for randomized controlled trial's included in the study using ROBVIS-tool.
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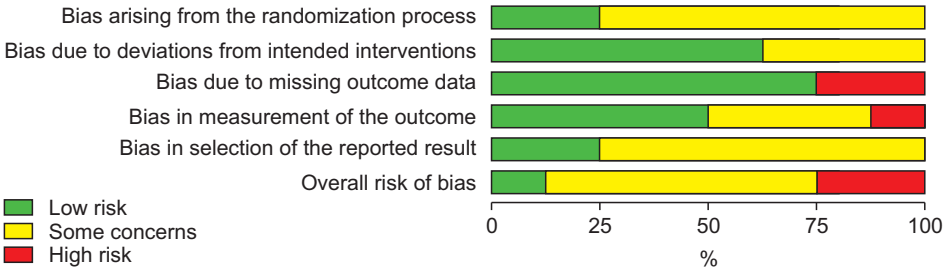


Fig. 3. Summary plot for assessing the risk of bias for randomized controlled trial's included in the study using ROBVIS-tool.
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(Domain 1); Evaluating the RoB arising from the randomization process. (2) Deviation from intended interventions (Domain 2); Assessing the RoB due to deviations from the intended interventions. (3) Missing outcome data (Domain 3); Evaluating the RoB due to missing outcome data. (4) Measurement of outcomes (Domain 4); Assessing the RoB in the measurement of outcomes. (5) Selection of reported results (Domain 5); Evaluating the RoB in the selection of reported results. For each domain, specific signalling questions were used, with response options including: Yes (Y), Probably yes (PY), Probably no (PN), No (N), No information (NI).

Based on these responses, an overall risk of bias judgement was made for each article, categorizing it as low risk, some concerns and high risk of bias. Inter-evaluator reliability was assessed using Kappa statistics, with any discrepancies resolved through discussion among the authors. Fig. 2 shows the traffic plot and Fig. 3 shows the summary plot of the included studies. Majority of the studies have fulfilled the domains as low risk, but some studies reported with concerns and high risk and concerns.

The methodological quality of the included studies was evaluated using the Joanna Briggs Institute (JBI)[20] critical appraisal checklists for case reports and case series. Two independent reviewers assessed each study to ensure transparency and consistency in reporting. The checklist for case reports included eight domains, while the checklist for case series comprised ten domains, focusing on clear patient description, diagnostic procedures, intervention details, follow-up, and outcome reporting.

All included case reports satisfied all eight appraisal criteria, and the case series fulfilled all ten criteria. No major methodological concerns were identified. Overall, the included studies were considered to be of high methodological quality with a low risk of bias and were therefore deemed suitable for qualitative synthesis. Any minor discrepancies in assessment were resolved through discussion between the reviewers.

IV. Characteristics of Included Studies

A total of 14 studies published between 2020 and 2025 were included in this systematic review evaluating the effec-

tiveness of i-PRF for IDP reconstruction or management of gingival black triangles. The included studies comprised of three case reports[21-23], two blinded RCT's[24,25], one pilot interventional study[26], RCT's[24,25,27-31], and three case series[32-34].

The sample size varied considerably, ranging from single-patient case reports to 44 sites in clinical trials, with most interventional studies including 10 to 30 participants. Participants were generally systemically healthy adults presenting with IDP deficiency, with reported age ranges between 18 and 55 years. Both male and female participants were included across studies.

All studies evaluated i-PRF as the primary intervention, administered either as a single injection[22,25,27,30-32,34] or multiple injections[21,23,24,26,28,29,33] at intervals ranging from 1 to 3 weeks. In comparative studies, i-PRF was evaluated against HA injections[24,25,27,29], connective tissue grafts[28,30], free gingival graft[21] and semilunar flap with tuberosity graft techniques[31].

The follow-up duration ranged from 1 to 6 months, with most studies assessing outcomes at baseline, 1 month, 3 months, and 6 months. Commonly reported outcomes included papilla presence index (PPI)[25,27], black triangle height[24,25,30,31], width[25] or area[24,27,34], papillary height[21,28-30,33,34], plaque index[25,27,28,30], and gingival index[25,27,28,33,34], bleeding scores[30,33], gingival thickness[21], soft tissue closure[22,23,32], probing pocket depth[25,30,31,34], clinical attachment loss[30], visual analogue scale[30], percentage of papillary fill[33,34] and patient satisfaction scores[26,29]. Overall, most studies reported improvement in papillary fill and reduction in black triangle dimensions following i-PRF therapy.

V. Results

A total of 14 studies evaluated the effectiveness of i-PRF in the reconstruction of IDP and management of gingival black triangles. Table 1 gives the detailed description of author, study title, study design, sample size, age groups and study groups. Table 2 gives the detailed description of author, i-PRF protocol, intervention time periods, follow-up period, outcome assessment, study results, study conclusion.

The follow-up periods across studies ranged from weeks to 6 months, and most studies reported improvements in papillary height, PPI, and reduction in black triangle dimensions following i-PRF therapy.

RCT's comparing i-PRF with HA demonstrated significant improvements in clinical parameters such as PPI, black triangle height, and black triangle area in both treatment groups. In the trial by Trivedi et al.[27], the PPI in the i-PRF group decreased from 2.25±0.44 at baseline to 1.05±0.22 at 1 and 3 months, while the HA group showed a reduction from 2.20±0.41 to 1.25±0.44. The black triangle area in the i-PRF group reduced significantly from 376.45±46.46 pixels at baseline to 89.90±25.92 pixels at 1 month and 85.95±24.56 pixels at 3 months, compared with 371.70±55.46 to 116.05±56.77 pixels in the HA group (P<0.05). Similarly, Pal et al.[24], reported significant reductions in black triangle height in both groups, with reductions of 1.20 mm, 1.80 mm, and 2.27 mm at 1, 3, and 6 months in the i-PRF group compared with 0.80 mm, 1.47 mm, and 2.00 mm in the HA group (P<0.001). However, Fakher et al.[29], reported higher patient satisfaction scores in the HA group (3.8±0.8 to 9.1±0.9) compared with the i-PRF group (3.7±0.5 to 7.8±0.8) at six months, with greater papillary fill observed in the HA group.

Comparative trials evaluating i-PRF and connective tissue graft techniques also demonstrated significant improvements in papillary dimensions. In the RCT by Bissar et al.[28], comparing i-PRF with subepithelial connective tissue graft (SECTG), the mean volumetric change was 0.25±0.17 in the i-PRF group and 0.31±0.21 in the SECTG group, with no statistically significant difference (P=0.517). However, postoperative pain scores were significantly higher in the SECTG group (5.08±2.15) compared with the i-PRF group (1.17±0.94) (P<0.001). Similarly, Johnson et al.[30], reported that black triangle height decreased from 2.13±0.83 to 0.87±0.74 at 3 months in the i-PRF group, while IDP height increased from 3.73±0.79 to 5.00±1.00, showing results comparable to connective tissue graft techniques.

The double-blind randomized clinical trial by Prajapati et al.[25], demonstrated significant improvements in PPI, black triangle height, and black triangle width from baseline to 1, 3, and 6 months, with i-PRF showing a greater reduction in black triangle dimensions compared with HA (P<0.05).

Case reports and case series generally demonstrated favourable outcomes with i-PRF therapy. Oswal and Kour[21] reported increased papillary height and gingival thickness at 6-month follow-up following repeated i-PRF injections. Roy et al.[22], observed complete closure of the black triangle by 3 months, with stable results at 6 months. Similarly, Mayangjati et al.[23], reported partial closure within one week and complete soft-tissue closure within one month after i-PRF injection.

However, not all studies demonstrated positive outcomes. Al Salkhadi et al.[33], reported no statistically significant improvement in papillary height after 3 months, with the mean papillary dimension changing only from 5.55±1.05 at baseline to 5.43±0.99 (P=0.171).

Table 1. Detailed description of author, study title, study design, sample size, age group and study group

Author	Study title	Study design	Sample size (n)	Age group	Study group
Oswal and Kour[21] (2020)	Free gingival graft along with i-PRF for recession coverage and interdental papilla augmentation: a case report	Case report	1	42 years old healthy female patient	Free gingival graft placement followed by i-PRF
Chandramohan and Swetha[26] (2021)	Evaluation of i-PRF injection technique as an alternative for reconstruction of interdental papillae - a pilot study	Single arm interventional study	10	25-55 years	i-PRF
Trivedi et al.[27] (2021)	Comparative evaluation of injectable-platelet rich fibrin and hyaluronic acid injections in the treatment of gingival black triangles	Randomized controlled trial	3	18-55 years	Group A: i-PRF Group B: HA injection
Puri et al.[32] (2022)	A novel injectable platelet-rich fibrin reinforced papilla reconstruction technique	Case series	4	-	i-PRF
Bissar et al.[28] (2022)	Volumetric soft tissue changes after using injectable platelet-rich fibrin (i-PRF) versus subepithelial connective tissue graft in interdental papillae defects: a randomized controlled clinical study	Randomized controlled trial	24	18-40 years	Group A: SECTG technique Group B: i-PRF
Fakher et al.[29] (2023)	Use of injectable hyaluronic acid gel and injectable platelet-rich fibrin in the treatment of gingival black triangles: a randomized clinical trial	Randomized controlled trial	18	20 up to 50 years old	Group 1: 0.2 mL HA gel injection. Group 2: i-PRF. Group 3: Combination of 0.2 mL HA gel injection and i-PRF.
Roy et al.[22] (2024)	Reconstruction of interdental papilla using i-PRF: case report of a novel technique	Case report	1	36-year-old female patient	i-PRF
Mayangjati et al.[23] (2024)	The use of injectable platelet-rich fibrin as an alternative treatment for interdental papilla reconstruction in black triangle case	Case report	1	20-year-old female patient	i-PRF
Johnson et al.[30] (2025)	Efficacy of injectable platelet-rich fibrin for interdental papilla reconstruction compared with connective tissue grafts: a randomized controlled clinical trial	Randomized controlled trial	15	18 years and over	Test group: i-PRF microneedling Control group: CTGs using the tunnelling technique
Pal et al.[24] (2025)	Comparative evaluation of hyaluronic acid and injectable platelet-rich fibrin as a non-surgical approach for management of black triangle	Randomized controlled trial single blinded	30	In both groups 60% female in the HA group and 53.3% in the i-PRF group. Male representation was 40% and 46.7%, respectively. In both groups were younger than 30 years (60%), with the remaining 40% aged 30 or older	Test group: i-PRF Intervention group: 0.1 mL of HA dermal filler
Prajapati et al.[25] (2025)	Comparative study of efficacy of injectable platelet rich fibrin and hyaluronic acid for interdental papillary reconstruction	Double blinded, randomised clinical trial	44 sites	18-55 years	Group A: i-PRF Group B: HA injection
Al Salkhadi et al.[33] (2025)	Efficacy of injectable platelet-rich fibrin in reconstruction of interdental papilla: a case series	Case series	8	20-35 years	i-PRF
Patel et al.[34] (2025)	Nonsurgical papilla reconstruction using injectable platelet rich fibrin	Case series	4	18-45 years	i-PRF
Punse et al.[31] (2025)	Comparison of injectable platelet-rich fibrin and semilunar flap with tuberosity graft for gingival black triangles: a randomized clinical trial	Randomized controlled trial	20	18-45 years	Group 1: i-PRF Group 2: Semilunar flap with tuberosity graft

(-: not applicable, i-PRF: injectable platelet-rich fibrin, HA: hyaluronic acid, SECTG: subepithelial connective tissue graft, CTG: connective tissue graft)

Table 2. Detailed description of author, i-PRF protocol, intervention time periods, follow-up period, outcome assessment, study results, study conclusion

Author	i-PRF protocol	Intervention time period	Follow-up period	Outcome assessment	Study result	Study conclusion
Oswal and Kour[21] (2020)	3 mL of blood was collected under aseptic conditions from the patient and put into a blood collecting tube without any additives. It was then centrifuged at 700 rpm (60 g) for 3 minutes	i-PRF injection was injected into the facial gingival tissue and interdental papilla 3 months after the FGG procedure for about 6 times with 15 days gap.	3 months, 6 months	Height of the interdental papilla, thickness of gingiva	After the root coverage was done for the recession, i-PRF was used for papilla reconstruction by repeated injection of i-PRF over a period of 3 months until favourable results were obtained which seemed to be stable at 6 months follow up.	A definite increase in the height of interdental papilla and thickness of gingiva was observed after 6 months.
Chandramohan and Swetha[26] (2021)	Two plastic tubes of 5 mL of whole blood each without anticoagulant was centrifuged at 700 rpm for 3 minutes (60×g) at room temperature in a Centrifuge.	Multiple shots of i-PRF injections at an interval of 3 weeks, for 2 times.	3 weeks, 3 and 6 months	Soft tissue closure in the black triangle region.	Mutilple doses of this autologous formulation prove to be a non-invasive alternative for the treatment of minimal interdental papilla loss	This technique may prove to be helpful only in cases of minimal loss of inter-dental papillae and not beyond.
Trivedi et al.[27] (2021)	The required quantity of blood is drawn into 10-mL test tubes without an anticoagulant and centrifuged immediately. Blood is centrifuged for 3 minutes at 2,700 rpm.	Single application of i-PRF	At baseline (prior to injection) At 1 month follow-up At 3 months follow-up	1. Plaque Index (Silness and Loe, 1964) 2. Gingival Index (Loe and Silness, 1963) 3. Papillae Presence index (Cardaropoli et al., 2004) 4. Black triangle area	The mean PPI in Group A decreased from 2.25±0.44 at baseline to 1.05±0.22 at 1 and 3 months, while in Group B it reduced from 2.20±0.41 to 1.25±0.44 at 1 and 3 months, with significant intragroup reductions (P<0.05) but no significant intergroup difference (P>0.05). The mean BTA in Group A reduced from 376.45±46.46 pixels at baseline to 89.90±25.92 pixels at 1 month and 85.95±24.56 pixels at 3 months. In Group B, BTA decreased from 371.70±55.46 pixels to 119.60±56.48 pixels at 1 month and 116.05±56.77 pixels at 3 months. Although baseline differences were non-significant (P>0.05), Group A showed significantly greater reduction compared to Group B at 1 and 3 months (P<0.05).	i-PRF can be a viable alternative to HA in treatment of gingival black triangles
Puri et al.[32] (2022)	10 mL of intravenous blood was withdrawn from antecubital region and was centrifuged using plastic tubes (without any additives) in a centrifuge (REMI® Laboratories, India) at 700 rpm for 3 minutes.	Single application of i-PRF	1, 3, and 6 months	Photographic evaluation of variation in the surface area of the black triangle	i-PRF improved the soft tissue fill after 6 months.	The use of novel nonsurgical injectable PRF technique allows clinician to successfully treat deficient interdental papilla.
Bissar et al.[28] (2022)	According to the low-speed centrifugation concept (LSCC) the relative centrifugal force to 60 g and the use of plastic tubes allowed for the introduction of an i-PRF matrix without using anticoagulants. The collected i-PRF maintains its fluid phase for up to 10 to 15 minutes after centrifugation.	Total of four times at 15-day intervals.	Baseline, 2, 4, and 6 -weeks	Plaque index, gingival index, papillary height, and TP-CP distance were all assessed volumetric analysis	Group A (5.08±2.15) had a significantly higher mean pain score value than group B (1.17 ±0.94) (P<0.001). Group B (0.31 ±0.21) had a higher mean value of volumetric changes at the interdental papillae than group A (0.25±0.17), yet the difference was not significant (P=0.517)	i-PRF produced results comparable to SECTG in Nordland class I defects when administered once every 15 days for two months. Patients treated with i-PRF reported higher satisfaction with both the procedure and the outcomes compared to those treated with SECTG.
Fakher et al.[29] (2023)	3 mL of serum samples under aseptic conditions before being centrifuged for 3 minutes at 700 rpm in a glass tube without any additives	i-PRF at 0, 3, and 6 week interval. HA gel at 0 (baseline) and repeated after 3 and 6 weeks	VAS and the black triangle height measurement was assessed before treatment, after each injection interval (1, 3, 6 weeks) and 3, 6 months follow-up	1) Patient satisfaction 2) Black triangle height	In the HA group, mean scores improved from 3.8±0.8 at baseline to 9.1±0.9, showing the highest satisfaction. The i-PRF group increased from 3.7±0.5 to 7.8±0.8, while the HA+i-PRF mix group showed a similar improvement from 3.7±0.5 to 7.8±0.8. Black triangle height showed statistically significant differences among the three groups at 6 months indicating superior improvement in papillary fill in the HA group.	HA injections and injectable platelet-rich fibrin was considerably effective for gingival black triangles
Roy et al.[22] (2024)	One plastic tube containing 10 mL of whole blood without an anticoagulant was centrifuged in a centrifuge for 3 minutes (60×g) at 700 rpm at room temperature, with the tubes angled at 33 degrees to the axis of rotation. Using an insulin syringe, the upper liquid layer was collected as i-PRF	Single application of i-PRF	3 months and 6 months	Soft tissue closure in the black triangle region.	After 3 months, the healing was found to be satisfactory and complete closure of the black triangle was noticed. The patient did not report of any adverse effect associated with injection of i-PRF. The patient was re-assessed after 6 months, and there was no recurrence observed.	i-PRF could be considered as a promising treatment option for reconstruction of interdental papilla.
Mayangjati et al.[23] (2024)	A total of 10 mL of blood was collected from the median cubital vein and transferred into a vacutainer tube without anticoagulant. The sample was then centrifuged at 700 rpm for 3 minutes at room temperature	i-PRF injection was given at baseline and after 1 week	1 week and 1 month	Soft tissue growth and closure	Authors confirm that partial closure was seen after 1 week and complete soft tissue closure was achieved after 1 month	The use of i-PRF can be an alternative non-surgical option for the treatment of interdental papilla reconstruction.

Table 2. Continued

Author	i-PRF protocol	Intervention time period	Follow-up period	Outcome assessment	Study result	Study conclusion
Johnson et al.[30] (2025)	10 mL of each patient's whole blood without an anticoagulant was centrifuged in a plastic tube at 700 rpm for 3 minutes in a Choukroun centrifuge (DUO Quattro, LifeCare Devices®) with a relative centrifugal force of 55 g and an r-max of 110 mm.	Single application of i-PRF	Baseline, 1 month and 3 months	Full-mouth plaque score, the full mouth bleeding score, the probing pocket depth, the clinical attachment level, the interdental papilla height (IDPH), and the BTH, VAS	BTH and IDPH from baseline to 1 and 3 months (P<0.05), with no significant difference between groups. BTH reduced from 2.13±0.64 to 0.73±0.70 (1 month) and 0.80±0.67 (3 months) in the CTG group, and from 2.13±0.83 to 0.93±0.70 (1 month) and 0.87±0.74 (3 months) in the i-PRF group. IDPH increased from 3.20±0.77 to 4.53±0.64 (CTG) and from 3.73±0.79 to 4.93±0.96 (1 month) and 5.00±1.00 (3 months) in the i-PRF group. VAS scores decreased in both groups, with slightly greater reduction in CTG (2.67±1.36) than i-PRF (2.00±0.81)	i-PRF microneedling was comparable to CTGs using the tunnelling technique in improving papillary dimensions in patients with interdental papilla deficiency
Pal et al.[24] (2025)	10 mL of blood was drawn from the antecubital region and divided into two 5 mL sterile plastic tubes without any anticoagulants. These tubes were then placed in a centrifuge machine and spun at 700 rpm for 3 minutes.	i-PRF and HA fillers at baseline, 3 weeks, and 6 weeks.	Baseline to 3 and 6 months	Intergroup comparison: a) Black triangle height b) Black triangle area	Both HA and i-PRF groups showed significant reductions in black triangle height and area over 6 months. HA reduced height by 0.80 mm at 1 month (P=0.067), 1.47 mm at 3 months (P<0.001), and 2.00 mm at 6 months (P<0.001). i-PRF demonstrated greater reductions of 1.20 mm (P=0.003), 1.80 mm (P<0.001), and 2.27 mm (P<0.001) at corresponding intervals. Area reduction followed a similar trend, with no significant intergroup differences.	HA and i-PRF were clinically and photographically evaluated. Both showed steady reductions in black triangle height and area, with no significant intergroup differences over 6 months. HA demonstrated strong early improvement, was easy to handle, and provided stable outcomes.
Prajapati et al.[25] (2025)	5 mL of blood was withdrawn into test tubes and centrifuged for 3 minutes at 700 rpm	Single application of i-PRF	1 month, 3 months and 6 months	Plaque index, gingival index, periodontal probing depth, papilla presence index, black triangle height and width	Statistical analysis showed significant improvements in both groups in PPI, Black triangle height, and black triangle width from baseline to 1 month, 3 months, and 6 months (P<0.05). Interdental papilla reconstruction with i-PRF resulted in a significantly greater reduction in Black Triangle Height and Width compared to the other group.	i-PRF is a suitable alternative to HA injections during interdental papilla reconstruction.
Al Salkhadi et al.[33] (2025)	10 mL of blood was placed in a dry, sterile, and anticoagulant-free tube. The sample was immediately centrifuged using centrifuge device (centrifugal) with speed of 700 rounds per minute for 3 minutes.	Baseline, after 2 weeks then after 4 weeks	3 months	PI, GI, GB, HPD, MHPD, and PHPD	After three months, the mean papillary dimension slightly decreased from 5.55±1.05 at baseline to 5.43±0.99, with no statistically significant difference (P=0.171). No significant gender-based differences were observed in HPD, MHPD, or PHPD (P>0.05). Both males (6.00±0.76 to 5.88±0.83) and females (5.25±1.14 to 5.13±1.00) showed slight, non-significant reductions. PI and GI improved after three months.	i-PRF injection technique was ineffective in managing recessed interdental papillae three months posttreatment.
Patel et al.[34] (2025)	10 mL of intravenous blood was withdrawn from antecubital region and was centrifuged using plastic tubes (without any additives) in a centrifuge at 700 rpm for 3 minutes.	Single application of i-PRF	Baseline, 1 month, and 3 months	Distance from the CP to PT using Gutta Percha points distance percentage papillary fill, MGI, probing depth, and contour of interdental papilla	By 3 months, 4 sites showed complete (100%) fill, with a significant reduction in CP-PT distance and improvement in MGI (P=0.002). No significant changes in probing depth were observed.	i-PRF is a safe, effective, and minimally invasive alternative for interdental papilla reconstruction, offering promising aesthetic outcomes.
Punse et al.[31] (2025)	10 mL of blood was placed in a dry, sterile, and anticoagulant-free tube. The sample was immediately centrifuged using centrifuge device (centrifugal) with speed of 700 rounds per minute for 3 minutes.	Single application of i-PRF	At baseline, 3, and 6 months	Papillary height, black triangle decrease, and periodontal pocket depth	Both groups showed improved clinical outcomes and patient satisfaction. The i-PRF group healed faster and was more comfortable, while the SCPF with TCTG group gave better aesthetics and closed black triangles more effectively, but caused more pain and took longer to heal.	The i-PRF and SCPF with TCTG are effective in managing gingival black triangles

(i-PRF: injectable platelet-rich fibrin, FGG: free gingival graft, PPI: papilla presence index, BTA: black triangle area, HA: hyaluronic acid, PRF: platelet-rich fibrin, LSCC: low-speed centrifugation concept, SECTG: subepithelial connective tissue graft, TP: tip of the papilla, CP: contact point, VAS: visual analogue scale, IDPH: interdental papilla height, BTH: black triangle height, CTG: connective tissue graft, PI: plaque index, GI: gingival inflammation index, GB: gingival bleeding index, HPD: height of papillary deficiency, MHPD: measure of change in the height of papillary deficiency, PHPD: percentage of change in the height of papillary deficiency, PT: papillary tip, MGI: modified gingival index, SCPF: semilunar coronally positioned flap, TCTG: tuberosity connective tissue graft)

Overall, the majority of included studies demonstrated significant improvements in papillary dimensions and reduction in black triangle size following i-PRF therapy. The outcomes were generally comparable to HA injections and connective tissue graft techniques, while i-PRF offered advantages such as minimal invasiveness, reduced postoperative discomfort, and higher patient comfort. However, the effectiveness varied depending on defect severity, treatment protocol, and follow-up duration.

VI. Discussion

Loss of the IDP leading to gingival black triangles is a common esthetic and periodontal concern in clinical practice[35]. The severity of papillary loss is most commonly assessed using the Nordland and Tarnow classification[3], which remains one of the most widely accepted clinical systems for evaluating IDP deficiencies. This classification is based on three anatomical landmarks: the interdental contact point, the facial CEJ, and the interproximal CEJ. In the normal condition, the IDP completely fills the embrasure space up to the contact point. Class I represents mild papillary loss where the papilla tip lies between the contact point and the interproximal CEJ. In class II, the papilla tip is located at or apical to the interproximal CEJ but remains coronal to the facial CEJ, whereas class III represents severe papillary loss where the papilla tip lies at or apical to the facial CEJ. This classification is clinically valuable as it helps determine the severity of papillary deficiency and guides the selection and predictability of therapeutic approaches.

The IDP plays an essential role in both esthetic harmony and periodontal health. In the anterior region, even minor papillary deficiencies can create visible dark spaces known as gingival black triangles, which negatively affect smile aesthetics and patient self-confidence. From a periodontal perspective, the papilla acts as a protective barrier that prevents food impaction and plaque accumulation in the interproximal area. Loss of the papilla may therefore predispose patients to plaque retention, gingival inflammation, phonetic disturbances, and patient discomfort[35,36]. Consequently, correction of gingival black triangles is important not only for esthetic improvement but also for maintaining periodontal stability and oral hygiene.

The predictability of IDP presence is strongly influenced by the vertical distance between the contact point and the alveolar bone crest. Tarnow et al.[1] demonstrated that when this distance is 5 mm or less, complete papillary fill is highly predictable. However, when the distance exceeds 5 mm, the likelihood of papillary loss increases significantly, resulting in open gingival embrasures[37]. This anatomical limitation makes reconstruction of IDP one of the most challenging aspects of periodontal plastic surgery.

Traditionally, several surgical techniques have been proposed for papilla reconstruction, including connective tissue grafts, papilla preservation flaps, coronally advanced flaps, semilunar flap procedures, and microsurgical papilla reconstruction techniques. Although these methods may provide satisfactory outcomes in selected cases, they are often technique-sensitive, invasive, and associated with variable clinical predictability[38]. Surgical procedures frequently involve donor-site morbidity, postoperative pain, and longer healing periods, which may reduce patient acceptance and increase treatment complexity[39].

Because of these limitations, minimally invasive non-surgical approaches have gained increasing attention in recent years. Non-surgical therapies aim to enhance soft-tissue volume, stimulate regeneration, or modify the morphology of the interdental space without surgical intervention. These approaches are particularly useful in mild to moderate papillary deficiencies where regeneration or augmentation of soft tissue can be achieved with minimal trauma. Non-surgical methods are advantageous because they reduce postoperative discomfort, eliminate donor-site complications, shorten treatment time, and improve patient acceptance while still achieving clinically meaningful esthetic improvements.

The injectable form of PRF is produced using low-speed centrifugation protocols, resulting in a liquid formulation that can be directly injected into soft tissues before clot formation. This property enables minimally invasive delivery of autologous growth factors, which may stimulate soft-tissue regeneration and improve papillary contour. The regenerative potential of i-PRF has therefore attracted considerable attention in esthetic periodontology[40,41].

The present systematic review evaluated the effectiveness of i-PRF in the management of gingival black triangles and IDP deficiencies. A total of 14 clinical studies published between 2020 and 2025 were included, comprising RCT's, pilot studies, case series, and case reports. Overall, the findings suggest that i-PRF is a promising minimally invasive therapeutic approach for papilla reconstruction, with most studies demonstrating improvements in papillary height, PPI, and reduction in black triangle dimensions.

Several RCT's compared i-PRF with HA injections, demonstrating significant improvements in papillary fill and

reductions in black triangle dimensions in both treatment groups. For example, Trivedi et al.[27] reported that the PPI decreased from 2.25±0.44 to 1.05±0.22 in the i-PRF group within three months, accompanied by a reduction in black triangle area from 376.45±46.46 pixels to 85.95±24.56 pixels. Similarly, Pal et al.[24] observed progressive reductions in black triangle height over 6 months, with a 2.27-mm reduction in the i-PRF group compared with 2.00 mm in the HA group. These findings indicate that i-PRF may provide clinical outcomes comparable or slightly superior to HA injections in terms of papillary augmentation.

Comparative studies evaluating i-PRF and surgical grafting procedures further highlight the clinical potential of this therapy. In the randomized trial conducted by Bissar et al.[28], i-PRF demonstrated volumetric improvements comparable to SECTG, with mean volumetric changes of 0.25±0.17 and 0.31±0.21, respectively. Importantly, postoperative pain scores were significantly lower in the i-PRF group (1.17±0.94) compared with the surgical group (5.08±2.15), suggesting greater patient comfort and reduced morbidity. Similar findings were reported by Johnson et al.[30], who observed an increase in IDP height from 3.73±0.79 mm to 5.00±1.00 mm following i-PRF therapy. These results suggest that i-PRF can achieve outcomes comparable to surgical grafting techniques while avoiding donor-site morbidity and surgical trauma.

Evidence from case reports and case series also supports the regenerative potential of i-PRF. Studies have reported increased gingival thickness, improvement in papillary height, and even complete closure of black triangles following repeated i-PRF injections[21-23]. However, not all studies demonstrated significant improvements. For instance, Al Salkhadi et al.[33] reported minimal changes in papillary dimensions after 3 months of treatment. This variability may be attributed to differences in defect severity, injection protocols, number of treatment sessions, centrifugation parameters, and follow-up durations.

Another important observation from this review is the heterogeneity in outcome assessment methods across studies. Various parameters such as PPI, papillary height, black triangle height and width, photographic measurements, and patient-reported satisfaction scores were used to evaluate treatment outcomes. Although most studies reported improvements in clinical parameters, the lack of standardized measurement techniques and uniform follow-up intervals limits direct comparison between studies.

Despite these limitations, the overall evidence suggests that i-PRF is a promising biologically based therapy for the management of gingival black triangles. Its autologous origin, minimally invasive application, ease of preparation, and regenerative potential through sustained growth factor release make it an attractive treatment option in esthetic periodontology. Furthermore, i-PRF therapy is associated with reduced postoperative discomfort and high patient acceptance compared with conventional surgical procedures.

However, the findings of this review should be interpreted with caution. The included studies exhibited considerable heterogeneity in study design, sample size, injection protocols, and follow-up duration. Many studies had relatively small sample sizes, and several were case reports or case series, which inherently provide a lower level of evidence compared with RCT's. Additionally, follow-up periods were relatively short, typically ranging from 1 to 6 months, which limits the evaluation of long-term stability of reconstructed papillae.

Future research should therefore focus on well-designed RCT's with larger sample sizes, standardized injection protocols, and longer follow-up periods to better determine the predictability and long-term stability of i-PRF-mediated papilla regeneration. Standardized outcome measures and digital imaging techniques may also improve comparability among future studies.

VII. Conclusion

Within the limitations of this systematic review, i-PRF appears to be a promising minimally invasive treatment for gingival black triangles and IDP deficiencies. Most included studies reported improvements in papillary height, PPI, and reduction in black triangle dimensions, likely due to the regenerative effects of autologous growth factors that promote angiogenesis and soft-tissue healing. Clinical outcomes were generally comparable to HA injections and connective tissue grafts, while offering advantages such as minimal invasiveness, reduced postoperative discomfort, and better patient acceptance. However, the current evidence is limited by small sample sizes, heterogeneous study designs, variations in treatment protocols, and short follow-up periods. Further well-designed RCTs with larger sample sizes and longer follow-up are needed to confirm the long-term effectiveness and predictability of i-PRF in IDP reconstruction.

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Authors' Contributions

M.G. contributed to the study design, data collection, and manuscript preparation. J.V. and R.B. were involved in data analysis and the literature review. L.K.K. and R.D. participated in the critical revision of the manuscript. K.K.K. contributed to the statistical analysis and final corrections of the manuscript. All authors reviewed and approved the final version of the manuscript.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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