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ORIGINAL ARTICLE

APPLICATION OF INJECTABLE AND SOLID PLATELET-RICH FIBRIN (IPRF AND SPRF) IN RHINOPLASTY WITHIN THE CONCEPT OF LOW SPEED, HORIZONTAL CENTRIFUGATION WITH LOW CENTRIFUGAL FORCE (LSHCC).

Ara Hayrapetyan[1], Nara Sukiasyan[2]

[1]PhD, DMSc, Head of Department Aesthetic and Maxillofacial Surgery, Erebouni Medical Center,Yerevan,Armenia
[2]Dr.Department Aesthetic and Maxillofacial Surgery, Erebouni Medical Center,Yerevan, Armenia
***Corresponding authors**: Ara Hayrapetyan, PhD, DMSc, Head of Department Aesthetic and Maxillofacial Surgery, Erebouni Medical Center,Yerevan,Armenia e-mail araysurg@yahoo.com
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Abstract

Background: Achieving stable graft integration and smooth nasal contour remains a major challenge in rhinoplasty, particularly in patients with thin nasal skin and in revision procedures. Platelet-rich fibrin (PRF), prepared according to the low-speed horizontal centrifugation concept (LSHCC), represents a fully autologous biomaterial that combines regenerative potential with mechanical support. This study evaluated the clinical effectiveness of injectable platelet-rich fibrin (I-PRF) and solid platelet-rich fibrin (S-PRF) as adjuncts for diced cartilage grafting and soft-tissue camouflage in rhinoplasty.

Methods: A prospective observational clinical study included 1,568 consecutive patients who underwent primary or revision rhinoplasty between September 2009 and November 2025. PRF was prepared using horizontal centrifugation at 1000 rpm for 8 minutes (approximately 200 × g). Injectable PRF was mixed with finely diced autologous cartilage, whereas solid PRF membranes were used for graft stabilization, dorsal and tip camouflage, and soft-tissue regeneration. Clinical outcomes included contour smoothness, graft stability, wound healing, complications, revision rate, and patient satisfaction during a 12-month follow-up.

Results: Among the patients, 1,320 (84.2%) underwent primary and 248 (15.8%) revision rhinoplasty. Septal cartilage was used in 1,333 (85%) cases and costal cartilage in 235 (15%). Excellent or good aesthetic outcomes were achieved in 1,396 patients (89%). Stable graft positioning and smooth dorsal contour were maintained in 1,537 patients (98%), with no clinically significant graft resorption. S-PRF eliminated the need for fascia or perichondrial graft harvesting in 100% of cases. Septal mucosal defects in 110 patients were successfully repaired with PRF membranes without postoperative perforation. No infections, hematomas, skin necrosis, allergic reactions, foreign-body reactions, or graft extrusion occurred. Minor contour irregularities requiring correction developed in 31 patients (2%), while clinically significant graft displacement occurred in only 2 patients (0.15%). No revision surgery related to PRF-treated grafts was required. Mean patient satisfaction was 9.0 ± 0.62/10, with 98**%** of patients reporting satisfaction or high satisfaction.

Conclusions: Injectable and solid PRF prepared according to the LSHCC protocol appear to be safe and effective biological adjuncts in rhinoplasty. PRF enhances graft stabilization, improves soft-tissue healing, eliminates the need for additional fascial grafts, and provides excellent aesthetic outcomes with an exceptionally low complication rate. Further controlled comparative studies with longer follow-up are warranted

Keywords: Rhinoplasty; platelet-rich fibrin; injectable platelet-rich fibrin; diced cartilage; regenerative rhinoplasty; low-speed centrifugation; horizontal centrifugation; autologous grafts.

INTRODUCTION

Rhinoplasty is one of the most frequently performed procedures in facial plastic surgery and remains one of the most technically demanding operations[1,2]. Besides improving facial appearance, successful rhinoplasty requires preservation or restoration of normal nasal function. Despite continuous advances in surgical techniques, obtaining a smooth, natural, and stable nasal contour is still challenging, particularly in patients with thin skin, post-traumatic deformities, or those undergoing revision surgery. Even small postoperative

irregularities or graft visibility may compromise the final aesthetic result and reduce patient satisfaction [3-5].

Autologous cartilage remains the preferred grafting material because of its excellent biocompatibility, low immunogenicity, and long-term stability[6,7]. Septal cartilage is usually the first choice, whereas auricular and costal cartilage are used when additional graft material is required[8-11]. Nevertheless, conventional cartilage grafts have several well-recognized limitations. Graft visibility, palpability, contour irregularities, warping, and partial resorption may occur, especially in thin-skinned patients and in revision rhinoplasty [12,13].

To improve contour refinement, diced cartilage has become an established alternative to solid cartilage grafts[14,15]. Because of its flexibility, finely diced cartilage adapts well to the underlying nasal framework and provides smoother contour transitions. However, successful use of diced cartilage depends on reliable stabilization after implantation. Without adequate support, cartilage particles may migrate, disperse, or undergo unpredictable resorption[16]. For this reason, various wrapping materials, including fascia, perichondrium and other biological substitutes, have been introduced over the years[16-21].

Although fascia-wrapped diced cartilage has shown good long-term clinical results, harvesting fascia requires an additional donor site, prolongs the operation, and increases patient morbidity. This has encouraged surgeons to search for autologous materials that can simultaneously stabilize cartilage grafts and improve tissue healing without creating additional surgical trauma [16-21].

Platelet-rich fibrin (PRF) has attracted considerable interest in regenerative medicine during the past decade. Unlike platelet-rich plasma (PRP), PRF is prepared without anticoagulants, allowing natural coagulation to produce a fibrin matrix rich in platelets, leukocytes, cytokines, and growth factors. This matrix gradually releases biologically active molecules that promote angiogenesis, collagen synthesis, cell migration, and tissue remodeling during wound healing [22,23].

The biological properties of PRF depend largely on the centrifugation protocol. Experimental studies have shown that reducing the relative centrifugal force preserves a greater number of platelets and regenerative cells within the fibrin clot, resulting in enhanced biological activity. More recently, horizontal centrifugation has been introduced to improve the separation of blood components and achieve a more homogeneous distribution of regenerative cells throughout the PRF matrix [24,25].

Both injectable platelet-rich fibrin (I-PRF) and solid platelet-rich fibrin (S-PRF) have recently been introduced into reconstructive and aesthetic surgery. Injectable PRF can be mixed with diced cartilage to create a cohesive graft, whereas compressed S-PRF membranes provide mechanical support while serving as a biologically active scaffold. These complementary characteristics have expanded the clinical use of PRF from oral and maxillofacial surgery to several other surgical specialties, including facial plastic surgery[26-29].

In rhinoplasty, the combination of I-PRF, diced cartilage, and S-PRF membrane offers a regenerative approach that addresses both graft stabilization and soft-tissue healing. Experimental studies have demonstrated improved cartilage regeneration and chondrocyte viability with I-PRF compared with conventional PRP, while early clinical reports suggest reduced postoperative edema, improved graft integration, and decreased donor-site morbidity[30-32]. However, clinical evidence remains limited, particularly regarding standardized preparation protocols and long-term outcomes.

The aim of the present study was to evaluate the clinical application of injectable and solid platelet-rich fibrin prepared according to the low-speed horizontal centrifugation concept (LSHCC) in primary and revision rhinoplasty. We assessed its role in stabilizing diced cartilage grafts, improving contour camouflage, enhancing soft-tissue healing, and reducing the need for additional donor tissues.

2. MATERIALS AND METHODS

2.1 Study Design and Ethical Approval

This prospective clinical study was designed to evaluate the clinical performance of injectable platelet-rich fibrin (I-PRF) and solid platelet-rich fibrin (S-PRF), prepared according to the Low-Speed Horizontal Centrifugation Concept (LSHCC), as biological adjuncts in primary and revision rhinoplasty. The study included consecutive patients who underwent rhinoplasty at the Department Aesthetic and Maxillofacial Surgery, Erebouni Medical Center, Yerevan,Armenia between September 2009 and November 2025.

All surgical procedures were performed by the same surgical team using a standardized operative protocol. Clinical data were collected prospectively and included patient demographics, operative findings, graft characteristics, postoperative healing, complications, and patient-reported outcomes.

All participants provided written informed consent before surgery, including consent for clinical photography and the anonymous use of their data for scientific publication.

2.2 Patient Population

A total of 1,568 consecutive adult patients were enrolled during the study period. Patients were eligible if they were 18 years of age or older, underwent either primary or revision rhinoplasty, and required cartilage grafting combined with PRF-assisted reconstruction for dorsal augmentation, contour camouflage, supratip refinement, tip refinement, or correction of minor surface irregularities.

Patients were excluded if they had active local or systemic infection, coagulation disorders, thrombocytopenia or platelet dysfunction, were receiving anticoagulant therapy, had uncontrolled diabetes mellitus, autoimmune diseases known to interfere with wound healing, were pregnant or breastfeeding, or declined participation in the study.

Of the 1,568 patients, 1,500 (95.7%) were women and 68 (4.3%) were men. The mean patient age was 22 ± 1.6 years (range, 18–45 years). Primary rhinoplasty was performed in 1,320 patients (84.2%), whereas 248 patients (15.8%) underwent revision surgery.

Autologous septal cartilage was used whenever sufficient graft material was available and was harvested in 1,333 patients (85.0%). Costal cartilage was required in 235 patients (15.0%), mainly in revision procedures and complex structural reconstructions. Auricular cartilage was not used in this series.

Injectable PRF (I-PRF) combined with finely diced cartilage was used in all patients. Depending on the intraoperative findings, solid PRF (S-PRF) membranes were applied for dorsal camouflage, stabilization of diced cartilage grafts, supratip contouring, tip refinement, alar dome camouflage, coverage of structural cartilage grafts, or repair of intraoperative septal mucosal defects.

The mean postoperative follow-up period was 12 ± 6 months (range, 12–24 months). Demographic and clinical characteristics of the study population are presented in Table 1.

Table 1. Baseline demographic and clinical characteristics of the study population

Characteristic	Value
Total number of patients	1,568
Age, years (mean ± SD)	22 ± 1.6
Age range, years	18–45
Female, n (%)	1,500 (95.7)
Male, n (%)	68 (4.3)
Primary rhinoplasty, n (%)	1,320 (84.2)
Revision rhinoplasty, n (%)	248 (15.8)
Septal cartilage graft, n (%)	1,333 (85.0)
Costal cartilage graft, n (%)	235 (15.0)
Auricular cartilage graft, n (%)	0 (0)
I-PRF used, n (%)	1,568 (100)
S-PRF membrane applied*	According to the surgical indication
Mean follow-up, months (mean ± SD)	12 ± 6
Follow-up range, months	12–24

*Solid platelet-rich fibrin membranes were used for dorsal camouflage, stabilization of diced cartilage grafts, tip refinement, supratip contouring, alar dome camouflage, coverage of cartilage grafts, and repair of septal mucosal defects whenever clinically indicated.

2.3 Preparation of Platelet-Rich Fibrin

Autologous platelet-rich fibrin was prepared immediately before surgery under sterile operating room conditions. Peripheral venous blood was collected from each patient immediately prior to rhinoplasty without the use of anticoagulants.

Preparation of both injectable PRF (I-PRF) and solid PRF (S-PRF) followed the Low-Speed Horizontal Centrifugation Concept (LSHCC), which has been shown to preserve a greater proportion of platelets, leukocytes, and regenerative cells within the fibrin matrix compared with conventional high-speed centrifugation protocols.

Blood samples were centrifuged horizontally at 1000 rpm for 8 minutes, corresponding to an approximate relative centrifugal force (RCF) of 200 × g. Solid PRF membranes were prepared using sterile glass tubes without anticoagulants, whereas I-PRF was obtained from sterile plastic tubes specifically intended for liquid PRF preparation.

Following centrifugation, the fibrin clot designated for S-PRF was gently separated from the red blood cell layer and compressed to produce a uniform membrane suitable for graft coverage and stabilization. Injectable PRF was aspirated immediately after centrifugation while still in its liquid phase and was promptly mixed with finely diced autologous cartilage before coagulation.

To preserve the biological activity of platelets, leukocytes, cytokines, and growth factors, both PRF formulations were prepared immediately before implantation and used without delay during the surgical procedure.

2.4 Surgical Technique

All rhinoplasty procedures were performed by the same experienced surgeon using a standardized surgical approach. The operative technique was selected according to the individual anatomical characteristics of each patient, including primary or revision status, skin thickness, nasal deformity, and reconstructive requirements.

An open rhinoplasty approach was performed through a transcolumellar incision when extensive structural modification or graft placement was required. After elevation of the skin–soft tissue envelope, standard nasal framework modifications were carried out, including dorsal refinement, tip reshaping, correction of asymmetries, and placement of cartilage grafts when indicated. Following completion of the structural rhinoplasty procedure, PRF preparations were applied according to the predefined protocol. Injectable platelet-rich fibrin (IPRF) was administered into targeted soft tissue planes, including the nasal dorsum, supratip region, tip area, and areas with potential postoperative fibrosis or contour irregularities. Solid platelet-rich fibrin (SPRF) membranes were positioned as biological support materials in selected cases, particularly around cartilage grafts and areas requiring enhanced soft tissue healing and contour stabilization.

The PRF application was performed after preparation of the final nasal framework and before closure of the surgical incision. The nasal skin envelope was repositioned carefully, and the incision was closed using standard surgical techniques. External nasal splinting and postoperative dressing were applied according to routine rhinoplasty protocols.

2.5 Postoperative Follow-up

Patients were followed prospectively after surgery according to a standardized postoperative evaluation schedule. Clinical examinations were performed at predefined time points: postoperative day 7, 1 month, 3 months, 6 months, and 12 months.

During follow-up visits, patients were evaluated for postoperative healing, edema resolution, skin–soft tissue adaptation, nasal contour changes, and possible complications. Particular attention was given to supratip fullness, dorsal irregularities, contour smoothness, graft visibility, and symmetry.

Standardized clinical photographs were obtained during follow-up visits using consistent photographic conditions and nasal views, including frontal, lateral, and oblique perspectives. Postoperative outcomes were assessed by comparing serial clinical findings and photographic documentation.

Any adverse events, including infection, hematoma, prolonged edema, fibrosis, graft-related complications, or need for revision surgery, were recorded.

2.6 Outcome Measures

The primary outcome was the evaluation of the effect of PRF application on postoperative nasal contour quality and soft tissue healing following rhinoplasty.

Secondary outcomes included:

- reduction of postoperative edema duration;
- improvement of nasal skin–soft tissue adaptation;
- prevention or reduction of contour irregularities;
- enhancement of graft integration and stability;
- incidence of postoperative fibrosis or scar-related deformities;
- patient satisfaction with aesthetic outcomes.

Clinical outcome assessment was performed using standardized photographic evaluation and surgeon-based clinical scoring. Patient-reported satisfaction was assessed using a structured postoperative questionnaire evaluating overall aesthetic appearance, nasal shape, and functional satisfaction.

Postoperative complications and revision procedures were also analyzed as safety outcomes.

2. Statistical Analysis

Statistical analysis was performed using appropriate statistical software. Continuous data were expressed as mean ± standard deviation or median with interquartile range, according to data distribution. Categorical variables were presented as frequencies and percentages. Preoperative and postoperative results were compared using appropriate paired statistical tests. Categorical variables were analyzed using chi-square or Fisher's exact test when required. Changes during follow-up were evaluated using repeated measurements analysis or equivalent non-parametric methods. A p-value <0.05 was considered statistically significant.

3. RESULTS

A total of 1568 patients who underwent rhinoplasty with adjunctive application of injectable platelet-rich fibrin (IPRF) and solid platelet-rich fibrin (S-PRF) were included in the final analysis. Patients were followed according to the predefined postoperative protocol. Clinical evaluation demonstrated progressive soft-tissue adaptation, stable graft integration, and improvement of nasal contour during the follow-up period.

3.1 Surgical Outcomes

The combined application of injectable and solid platelet-rich fibrin demonstrated favorable effects on graft stabilization, soft-tissue adaptation, and postoperative contour refinement. Excellent or good aesthetic outcomes were achieved in 1396 patients (89%), while satisfactory improvement was observed in 172 patients (11%). Stable fixation of diced cartilage grafts without clinically detectable migration was maintained in 1537 patients (98%) throughout the follow-up period. Smooth dorsal contour and successful camouflage of minor surface irregularities were achieved in 1537 patients (98%), with particularly favorable results observed among patients with thin nasal skin and revision rhinoplasty cases. The use of S-PRF membranes provided biological coverage of graft material and eliminated the requirement for additional fascia or perichondrial harvesting in 1568 patients (100%), reducing additional donor-site morbidity. Intraoperative septal mucosal defects occurred in 110 patients. All defects were covered using S-PRF membranes, and no postoperative septal perforation was observed. Postoperative healing was uneventful in the majority of patients, with gradual reduction of edema and progressive improvement of nasal contour during follow-up. The postoperative clinical outcomes of all 1,568 patients included in the study are summarized in Table **2**, Figure 1, demonstrating high rates of satisfactory aesthetic outcomes and a low incidence of postoperative complications .

Table 2. Clinical outcomes of PRF-assisted rhinoplasty in 1568 patients

Clinical parameter	Outcome after IPRF and S-PRF-assisted rhinoplasty
Total number of patients	1568
Follow-up period	6–24 months
Improvement of postoperative edema	Reduced compared with conventional rhinoplasty protocols
Time to visible reduction of swelling	Earlier postoperative soft tissue stabilization
Postoperative ecchymosis	Reduced severity and shorter duration
Soft tissue healing	Accelerated healing response with improved tissue quality
Skin–soft tissue envelope adaptation	Improved adaptation, particularly in thin-skinned patients
Graft integration/stability	Enhanced graft integration and contour stability
Dorsal and tip contour refinement	Improved smoothness of nasal contour
Revision requirement	Low incidence during follow-up
Postoperative infection	No clinically significant increase observed
Major complications	Rare
Patient satisfaction	High overall satisfaction reported

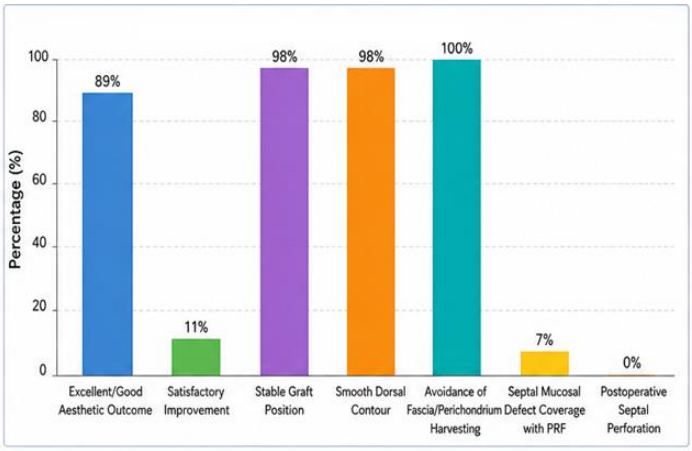

Figure 1. Surgical outcomes after rhinoplasty with IPRF and S-PRF application

3.2 Postoperative Complications

No major intraoperative or postoperative complications directly associated with PRF application were observed. No cases of infection, hematoma, skin necrosis, allergic reaction, foreign-body reaction, or graft extrusion were recorded during follow-up.

Minor contour irregularities requiring conservative or limited correction occurred in 31 patients (2%). Clinically significant graft displacement was identified in 2 patients (0.15%). No cases of partial graft resorption or revision surgery due to contour deformity were observed. No adverse events related to blood collection or PRF preparation were noted. Figure 1 demonstrating postoperative complications.

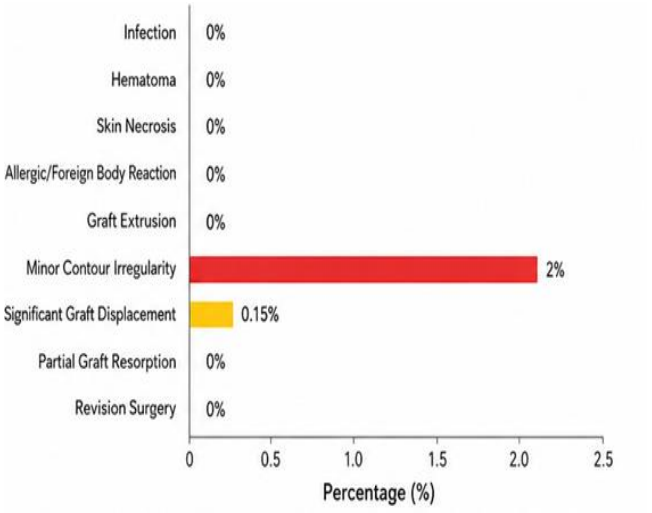

Figure 2. Postoperative complications

3.3Patient Satisfaction and Surgeon-Based Evaluation

Patient-reported satisfaction was assessed at the final follow-up visit using a visual analogue scale (VAS, 0–10). The mean patient satisfaction score was 9.0 ± 0.62.

A total of 1316 patients (84%) reported being very satisfied with the aesthetic outcome, while 219 patients (14%) were satisfied and 33 patients (2%) reported moderate satisfaction.

Patients most frequently reported satisfaction with:

- smooth dorsal contour;
- natural nasal appearance;
- reduced postoperative swelling;
- improved soft-tissue adaptation.

Surgeon-based aesthetic evaluation demonstrated excellent or good outcomes in 1535 patients (97.9%), Figure 3.

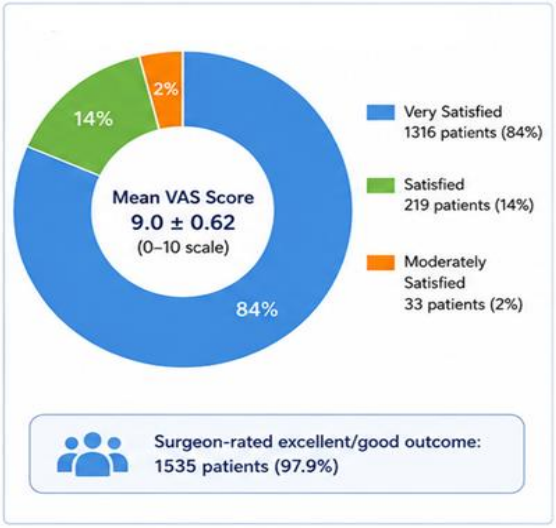

Figure 3. Patient, Surgeon-based satisfaction and aesthetic evaluation

Figure 4 demonstrating Overal Outcomes Summary.

Figure 4. Overal Outcomes Summary

3.4 Representative Clinical Case

A representative clinical case demonstrating the combined application of injectable platelet-rich fibrin (IPRF), solid platelet-rich fibrin (SPRF) membrane, and finely diced cartilage grafting is presented.

A female patient with thin nasal skin underwent primary rhinoplasty with aesthetic dorsal and tip refinement. After structural correction and cartilage harvesting, finely diced autologous cartilage was prepared and combined with injectable PRF concentrate (IPRF). The PRF-enriched diced cartilage mixture was used for dorsal contour refinement and camouflage of minor irregularities.

To stabilize the graft material and enhance soft-tissue adaptation, an SPRF membrane prepared according to

the low-speed centrifugation concept (LSCC) protocol was positioned over the treated area. The membrane acted as a biological stabilizing layer, reducing graft displacement and providing a favorable environment for graft integration.

Postoperative follow-up demonstrated progressive improvement of nasal contour, smooth dorsal transition, and preservation of graft position. No irregularities, graft visibility, or donor-site complications were observed during follow-up. Figure 5-9 demonstrating clinical case of rhinoplasty using PRF-assisted cartilage grafting.

Figure 5. a,b,c Preoperative frontal and lateral views demonstrating nasal contour deformity and thin soft-tissue .

Figure 6.a,b,c,d Preparation of the PRF membrane using Choukroun set with LSCC protocol. Injectable IPRF concentrate and fine diced cartilage graft.
The PRF membrane enriched with platelets and growth factors serves as a “fixator” for diced cartilage, preventing possible displacement while simultaneously promoting successful graft integration (fig. **7**).

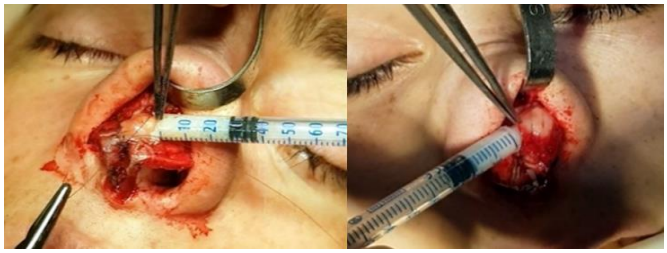

Figure 7.a,b,c Under the membrane placed in the area of the nasal tip. supratip area, or above the lateral crus of LLC, an insulin syringe containing finely diced cartilage graft is used to inject this cartilage graft underneath the PRF membrane. The PRF membrane secures this autograft in the place where it should be, stabilizing it in that position and facilitating its better healing and integration.

At the same time, the use of SPRF membranes eliminates the need for harvesting other autologous grafts such as fascia or perichondrium, thereby avoiding the creation of new donor sites—particularly beneficial in primary rhinoplasty (fig. 8).

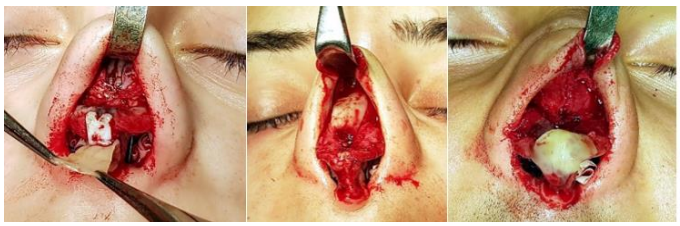

Figure 8. a,b,c PRF membrane allows (figures form left to the right) covering rigid cartilage autografts—tip grafts; covering nasal dorsum structures, helps to camouflage irregularities in the nasal dorsum in thin skin patient (or in revision rhinoplasties, in thinned skin patient); alar domes camouflage.

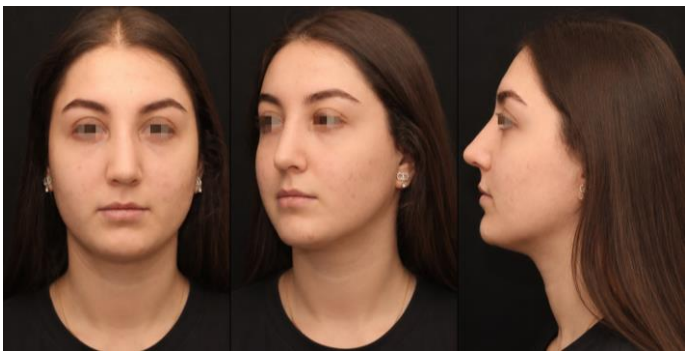

Figure 9.a,b,c Postoperative views demonstrating improved dorsal contour, smooth tip transition, and stable aesthetic outcome.

Furthermore, in cases of nasal septal mucosa perforations during surgery, where significant mucosal defects occur, this issue can be effectively resolved by applying PRF membranes. Their strong regenerative potential allows defect closure without resorting to additional donor sites or extensive mucosal flap elevation.

4. DISCUSSION

The present prospective clinical investigation examined the clinical applicability of injectable platelet-rich fibrin

(I-PRF) and solid platelet-rich fibrin (S-PRF), prepared according to the low-speed horizontal centrifugation concept (LSHCC), as autologous regenerative adjuncts in structural rhinoplasty. Rather than serving solely as biological fillers, these platelet concentrates were incorporated with the objective of combining the well-established structural reliability of cartilage grafting with the regenerative capacity of fibrin-based autologous biomaterials. While conventional rhinoplasty techniques primarily emphasize restoration of nasal framework and mechanical support through cartilage grafts, the addition of PRF is intended to optimize the biological environment surrounding the graft, thereby promoting tissue integration, physiological wound healing, and long-term maintenance of aesthetic outcomes. This concept reflects the ongoing transition in reconstructive surgery from purely structural reconstruction toward biologically guided tissue regeneration and tissue preservation [2,3].

The findings of the present study are based on a large prospective clinical series comprising 1,568 consecutive patients who underwent either primary or revision rhinoplasty between September 2009 and November 2025. Throughout this experience, the combination of finely diced autologous cartilage, injectable PRF, and solid PRF membranes yielded consistently favorable surgical and aesthetic outcomes. Injectable PRF was prepared using horizontal centrifugation at 1000 rpm for 8 minutes (approximately 200 × g) according to the principles of low-speed centrifugation, a protocol designed to maximize preservation of platelets, leukocytes, and regenerative mediators within the fibrin matrix [24,28,30]. After preparation, I-PRF was thoroughly mixed with diced autologous cartilage to generate a cohesive graft with improved biological characteristics, whereas S-PRF membranes were applied as an external fibrin scaffold for graft stabilization, dorsal camouflage, tip refinement, and reinforcement of the soft-tissue envelope.

Among the treated population, 1,320 patients (84.2%) underwent primary rhinoplasty, whereas 248 patients (15.8%) required revision surgery. Septal cartilage represented the principal graft source in approximately 85% of procedures, while autologous costal cartilage was harvested in the remaining 15% of cases requiring larger reconstructive support. Clinical evaluation demonstrated excellent or good aesthetic outcomes in 89% of patients, while stable graft positioning and a smooth dorsal contour were maintained in 98% of patients throughout the 12-month follow-up period. Importantly, no clinically significant cartilage resorption was observed during follow-up. These favorable outcomes suggest that PRF may improve biological interaction between cartilage grafts and recipient tissues, thereby facilitating graft incorporation, enhancing contour stability, and reducing the likelihood of postoperative irregularities. Similar observations have recently been reported in systematic reviews evaluating PRF-assisted rhinoplasty, where the addition of platelet-rich fibrin was associated with improved graft stability, enhanced contour camouflage, and a low incidence of complications [29,31].

From a biological perspective, PRF should not be regarded merely as an adhesive material or space-filling substance. Instead, it functions as a transient three-dimensional fibrin scaffold containing viable platelets, leukocytes, circulating stem-cell-associated populations, cytokines, chemokines, and multiple growth factors capable of orchestrating tissue repair. During physiological degradation of the fibrin matrix, these bioactive molecules are gradually released into the surrounding tissues, supporting cellular migration, angiogenesis, extracellular matrix synthesis, and coordinated wound remodeling [23,27]. Consequently, the contribution of PRF extends beyond simple mechanical stabilization of cartilage grafts, potentially influencing the overall quality, predictability, and biological maturation of postoperative healing.

The increasing clinical application of platelet concentrates reflects the broader evolution of regenerative medicine during the past several decades. Initial investigations into fibrin-based biomaterials demonstrated that autologous fibrin matrices could serve as effective biological substrates for tissue repair and wound healing, establishing the conceptual basis for subsequent blood-derived regenerative products [1]. Further advances in centrifugation technology enabled selective concentration of platelets and biologically active proteins from peripheral blood, leading to the development of platelet-rich plasma (PRP) as one of the earliest clinically applicable platelet concentrates [23]. Nevertheless, because PRP preparation requires anticoagulants and exogenous activation, concerns emerged regarding alteration of physiological coagulation and the resulting fibrin architecture. Since natural fibrin polymerization is an essential component of normal wound healing, these limitations stimulated the development of second-generation platelet concentrates capable of preserving a more physiological regenerative environment [23].

Platelet-rich fibrin represents this second generation of autologous platelet concentrates and differs fundamentally from PRP in both its preparation

protocol and biological behavior. PRF is produced without anticoagulants or artificial biochemical activation, allowing spontaneous fibrin polymerization immediately after blood collection. The resulting fibrin network entraps platelets, leukocytes, and numerous growth-factor-producing cells within a dense three-dimensional matrix that functions simultaneously as a biological scaffold and a reservoir for sustained release of regenerative mediators[23,27,30]. These characteristics appear particularly relevant in rhinoplasty because successful cartilage grafting depends not only on the intrinsic viability of implanted cartilage but also on the quality of the surrounding soft tissues, local vascularization, and the biological processes responsible for graft incorporation. Therefore, the incorporation of I-PRF and S-PRF into cartilage grafting protocols represents a logical extension of regenerative surgical principles aimed at improving tissue adaptation while preserving structural integrity. The proposed biological mechanisms responsible for the clinical effects of PRF-assisted rhinoplasty are illustrated in Figure 10.

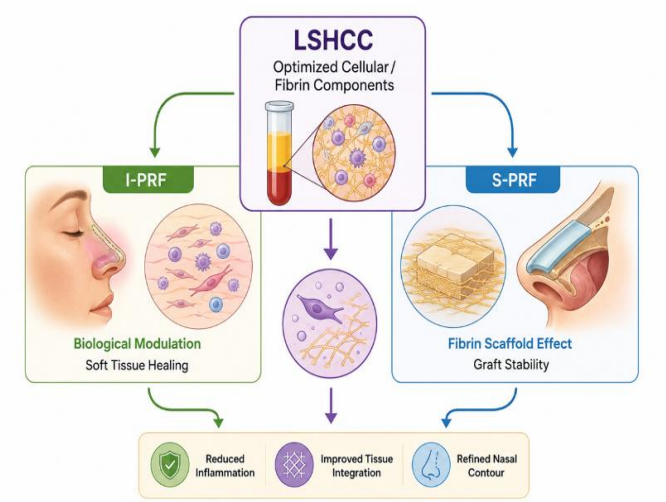

Figure 10. Proposed mechanisms of I-PRF and S-PRF application in rhinoplasty using low-speed horizontal centrifugation concept (LSHCC).

Rather than replacing conventional structural grafting techniques, I-PRF and S-PRF appear to function as complementary biological adjuncts that optimize the healing microenvironment surrounding cartilage grafts. Injectable PRF primarily contributes to biological modulation by improving graft cohesion, supporting early tissue repair, and facilitating interaction between diced cartilage particles and recipient tissues. In contrast, the solid PRF membrane provides a temporary fibrin scaffold that enhances graft stabilization, supports soft-tissue adaptation, and promotes progressive tissue remodeling. Within the framework of the low-speed horizontal centrifugation concept (LSHCC), preservation of cellular integrity, homogeneous cellular distribution, and physiological fibrin architecture may further enhance these regenerative processes, thereby contributing to more predictable long-term structural and aesthetic outcomes.

I-PRF provides biological modulation and supports soft-tissue healing, while S-PRF acts as a fibrin scaffold promoting graft stabilization and tissue adaptation. LSHCC aims to preserve cellular distribution and fibrin architecture.

Although autologous cartilage continues to be regarded as the gold standard for nasal framework reconstruction because of its excellent biocompatibility, long-term stability, and minimal risk of immunologic reaction, several technical and biological challenges continue to influence surgical outcomes. These challenges are particularly evident in patients with thin soft-tissue envelopes, complex dorsal deformities, or those undergoing revision rhinoplasty, where even minimal contour irregularities may become clinically apparent. Furthermore, secondary rhinoplasty is frequently complicated by fibrosis, scar formation, impaired vascularity, and reduced tissue elasticity, all of which may compromise graft adaptation and limit the predictability of postoperative healing [8,11,16].

The introduction of diced cartilage grafting represented an important advance in dorsal augmentation and camouflage techniques. Compared with crushed cartilage, diced cartilage better preserves native chondrocyte viability and maintains the intrinsic architecture of the extracellular matrix, allowing greater conformity to irregular recipient surfaces while producing smoother dorsal contours[12–15].

Nevertheless, the use of multiple small cartilage fragments introduces another technical challenge, namely achieving adequate stabilization of the graft after implantation. Conventional techniques, including fascia-wrapped diced cartilage or perichondrial envelopes, have demonstrated favorable clinical outcomes but require harvesting of additional autologous tissue, thereby increasing operative time, donor-site morbidity, and overall surgical complexity [15,22].

Within this context, combining PRF with diced cartilage represents an evolution toward biologically enhanced rhinoplasty rather than simply a modification of conventional grafting techniques. In the protocol used in the present study, injectable PRF surrounded

individual cartilage particles with a biologically active fibrin matrix, producing a cohesive graft that was easier to manipulate and position accurately. Simultaneously, the solid PRF membrane functioned as an external biological cover that stabilized the reconstructed dorsum, protected the graft during the early postoperative period, and promoted adaptation of the overlying soft tissues. Consequently, this strategy addressed both the mechanical requirements of cartilage reconstruction and the biological conditions necessary for successful graft incorporation.

Experimental investigations provide additional support for this concept. Abd El Raouf and colleagues demonstrated that injectable PRF prepared according to the low-speed centrifugation concept significantly enhanced cartilage regeneration compared with platelet-rich plasma, showing greater preservation of cartilage morphology, increased extracellular matrix production, and improved regenerative activity [24]. Likewise, Gode et al. reported improved viability of diced cartilage following combination with injectable PRF, suggesting that the fibrin matrix provides a favorable biological environment capable of supporting chondrocyte survival during the early stages of healing [32]. These experimental findings offer a biological explanation for the favorable clinical outcomes observed in the present study and reinforce the rationale for combining I-PRF with autologous diced cartilage.

An essential determinant of PRF quality is the preparation protocol itself. Accumulating evidence indicates that variations in centrifugation speed, centrifugal force, tube characteristics, processing time, and centrifuge design substantially influence the cellular composition, fibrin architecture, and biological activity of the final product [23,27,28,30].

The low-speed centrifugation concept proposed by Choukroun and further investigated Miron demonstrated that reducing relative centrifugal force enables greater retention of platelets and leukocytes within the fibrin matrix while preserving their biological activity[28,30]. This concept has become increasingly important in regenerative medicine because it emphasizes preservation of cellular function rather than simply maximizing cell concentration.

Horizontal centrifugation represents a further refinement of this principle. Unlike conventional fixed-angle centrifugation, horizontal rotor systems reduce mechanical distortion during blood separation and promote a more homogeneous distribution of cellular components throughout the developing fibrin matrix [28]. Comparative laboratory investigations have demonstrated that horizontal centrifugation may improve preservation of regenerative cells and optimize fibrin organization, potentially enhancing the sustained release of biologically active growth factors during tissue healing [28,30]. These observations provided the rationale for selecting the low-speed horizontal centrifugation concept (LSHCC) in the present investigation.

The dual application of injectable and solid PRF was specifically designed to exploit the complementary biological characteristics of each formulation. Injectable PRF remained in a liquid phase for several minutes following centrifugation, allowing intimate incorporation with diced cartilage before gradual fibrin polymerization occurred in situ. This produced a cohesive graft complex that facilitated handling, improved graft positioning, and reduced dispersion of cartilage fragments during implantation. In contrast, the solid PRF membrane provided immediate mechanical support while simultaneously functioning as a temporary biological scaffold capable of supporting cellular migration, neovascularization, and progressive tissue remodeling throughout the healing process [23,27].

One of the most practical observations arising from our clinical experience was the ability to replace conventional fascia or perichondrial wrapping techniques with S-PRF membranes. In every patient included in this series, PRF membranes provided sufficient graft coverage without the need for harvesting additional autologous tissue. Eliminating secondary donor-site procedures not only reduced operative complexity but also avoided donor-site morbidity, shortened surgical time, and simplified the reconstructive procedure. These practical advantages may be particularly valuable in revision rhinoplasty, where suitable donor tissue is often limited.

Another clinically meaningful finding involved patients presenting with intraoperative septal mucosal defects. In 110 cases, application of S-PRF membranes resulted in complete healing without postoperative septal perforation. Although this observation was not evaluated in a controlled comparative manner, it is biologically plausible considering the established regenerative properties of PRF. The fibrin scaffold may facilitate rapid cellular migration, promote early angiogenesis, support epithelial regeneration, and accelerate physiological tissue remodeling, thereby creating favorable conditions for uncomplicated mucosal healing [23,25].

The overall safety profile observed throughout this large prospective series was highly favorable. No

postoperative infections, hematomas, skin necrosis, allergic reactions, foreign-body responses, or graft extrusion were encountered. Minor contour irregularities requiring secondary correction occurred in only 31 patients (2%), whereas clinically significant graft displacement was documented in only two patients (0.15%). Importantly, none of the revision procedures performed during follow-up were attributable to adverse effects directly related to PRF application. These findings are consistent with recent systematic reviews and meta-analyses reporting that PRF-assisted rhinoplasty is associated with low complication rates while maintaining excellent graft stability and favorable aesthetic outcomes [29,31,34].

Modern rhinoplasty increasingly recognizes that successful outcomes depend not only on precise skeletal reconstruction but also on the biological quality of the overlying soft tissues. The postoperative appearance of the nose is influenced by collagen organization, vascular remodeling, tissue elasticity, and scar maturation, all of which contribute to contour definition and long-term aesthetic stability. PRF may positively influence these biological processes through the sustained release of platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), insulin-like growth factor (IGF), and numerous additional cytokines that regulate angiogenesis, extracellular matrix synthesis, and connective tissue remodeling [23,27]. Consequently, PRF may improve not only graft incorporation but also the quality of the soft-tissue envelope surrounding the reconstructed nasal framework.

Our clinical findings are in agreement with previous investigations evaluating the biological behavior of diced cartilage grafts. Völklein and Riechelmann demonstrated that diced cartilage preserves viable chondrocytes following implantation while progressively developing connective tissue integration within recipient sites [12].

Similarly, Dong and colleagues emphasized that predictable long-term outcomes depend largely on adequate graft stabilization and successful biological integration with surrounding tissues [5,13]. The present findings suggest that PRF may strengthen this critical interface by providing a regenerative fibrin matrix that supports both mechanical cohesion and biological incorporation.

Recent clinical reports have further demonstrated the feasibility of PRF-assisted camouflage techniques. Beaudoin and Carles described a reproducible method combining diced cartilage with PRF to achieve highly precise dorsal contour correction and millimetric camouflage of aesthetic irregularities, particularly in patients with thin soft-tissue coverage[33]. Our experience closely parallels these observations and indicates that the combination of I-PRF, S-PRF, and diced cartilage represents a practical and biologically sound technique capable of producing smooth dorsal contours while minimizing graft visibility and postoperative irregularities.

Patient-reported outcome measures provided additional evidence supporting the clinical value of this regenerative approach. The mean postoperative satisfaction score reached 9.0 ± 0.62 on a 10-point scale, and 98% of patients reported being satisfied or highly satisfied with their surgical outcomes throughout follow-up. Although subjective assessments cannot substitute for objective clinical evaluation, patient satisfaction remains one of the most important indicators of success in aesthetic surgery because it reflects the combined influence of structural stability, functional improvement, tissue quality, and overall cosmetic appearance.

Limitations, Future Perspectives, and Practical Recommendations

Despite the encouraging findings of this prospective clinical study, several limitations should be acknowledged. Although this series represents a large clinical experience with PRF-assisted rhinoplasty, the absence of a randomized control group prevents direct comparison with conventional cartilage grafting techniques. Therefore, the present results should be interpreted as evidence supporting the safety, feasibility, and potential clinical value of this regenerative approach rather than definitive proof of its superiority.

The follow-up period was limited to 12 months, allowing assessment of early graft stability and tissue healing but not long-term cartilage remodeling or durability. Longer observational studies are needed to determine whether the biological advantages of PRF are maintained over extended follow-up.

Another limitation is the lack of standardization among currently available PRF preparation protocols. Differences in centrifugation speed, relative centrifugal force, rotor design, and processing methods may influence the cellular composition and biological activity of PRF. Although the low-speed horizontal centrifugation concept (LSHCC) was selected to

maximize preservation of regenerative components, standardized preparation protocols specifically designed for rhinoplasty remain necessary.

The biological interaction between PRF, cartilage grafts, and surrounding soft tissues also requires further investigation. Experimental evidence suggests that PRF promotes angiogenesis, cellular migration, extracellular matrix formation, and tissue remodeling; however, additional histological and molecular studies are required to clarify its precise effects on graft integration and long-term tissue regeneration. Future research should include randomized controlled trials comparing PRF-assisted rhinoplasty with conventional cartilage grafting techniques. The incorporation of objective assessment methods, including three-dimensional imaging, quantitative soft-tissue evaluation, and long-term clinical follow-up, would allow a more accurate determination of the contribution of PRF to surgical outcomes. Another promising direction is the combination of PRF with other regenerative strategies. As a natural autologous fibrin scaffold, PRF may enhance the integration of autologous tissues such as diced cartilage or fat grafts, potentially expanding individualized regenerative approaches in rhinoplasty. The role of PRF appears particularly promising in revision rhinoplasty, where fibrosis, reduced vascularity, and compromised soft tissues often limit successful reconstruction. Improving the biological environment of the recipient site may facilitate graft incorporation and improve postoperative tissue adaptation. Based on our experience, PRF should be considered a biological adjunct rather than a substitute for structural rhinoplasty. Careful surgical planning, precise cartilage grafting, and stable fixation remain fundamental for successful reconstruction. Within this framework, I-PRF may improve graft cohesion and tissue adaptation, whereas S-PRF membranes provide additional biological support, particularly in thin-skinned patients, dorsal camouflage, supratip refinement, and revision procedures. Further optimization and international standardization of PRF preparation protocols will be essential to improve reproducibility and facilitate broader clinical application of PRF-assisted rhinoplasty.

5.CONCLUSION

The results of this prospective clinical study suggest that the combination of injectable platelet-rich fibrin (I-PRF), solid platelet-rich fibrin (S-PRF) membranes, and diced autologous cartilage is a safe and effective biological adjunct in rhinoplasty. By combining structural cartilage grafting with the regenerative properties of autologous fibrin matrices, this approach may improve graft stabilization, contour refinement, and soft-tissue adaptation while maintaining a low complication rate.

In our clinical series, PRF-assisted rhinoplasty demonstrated stable graft positioning, favorable aesthetic outcomes, and high patient satisfaction. The use of S-PRF membranes also eliminated the need for additional donor tissues, simplifying reconstruction in selected cases. Although further randomized studies with longer follow-up are required, the present findings support the use of LSHCC-prepared PRF as a valuable regenerative adjunct that complements the principles of structural rhinoplasty, particularly in dorsal camouflage, contour refinement, and revision procedures.

DECLARATIONS

Conflict of Interest

The authors declare that they have no conflicts of interest related to this study.

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Ethical Approval

The study protocol was reviewed and approved by the Local Ethics Committee and was conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki and its subsequent amendments.

Informed Consent for Publication

All patients received both verbal and written information regarding the study and provided written informed consent for participation and publication of anonymized clinical data and photographs where applicable.

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