

Albumin-Platelet Rich Fibrin as an Autologous Biomaterial in Oral and Maxillofacial Surgery: Current Evidence and Clinical Perspectives

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ABSTRACT

Albumin-platelet rich fibrin (Alb-PRF), also referred to as extended platelet-rich fibrin (e-PRF), is an emerging autologous biomaterial designed to overcome the relatively rapid degradation of conventional platelet-rich fibrin (PRF). The technique combines a thermally denatured albumin gel derived from platelet-poor plasma with a cellular liquid PRF fraction, producing a biologically active matrix with substantially prolonged structural persistence. This combination provides a potentially stable scaffold while retaining platelets, leukocytes and regenerative mediators within the PRF component. Recent laboratory studies suggest that Alb-PRF may influence inflammatory signalling, angiogenesis, fibroblast activity and osteoblast-related responses. Clinically, its use has expanded from periodontal applications to extraction socket management, ridge preservation, guided bone regeneration, sinus augmentation and implant surgery. Recent randomised and controlled studies have demonstrated encouraging results for early soft-tissue healing and selected peri-implant outcomes, whereas evidence for superior hard-tissue regeneration remains inconsistent. A 2026 systematic review identified only seven eligible in vivo or clinical studies and concluded that current evidence is stronger for early soft-tissue healing and postoperative comfort than for predictable hard-tissue regeneration. This narrative review summarizes the biological basis, preparation, biomaterial characteristics, clinical applications, limitations and future research directions of Alb-PRF in oral and maxillofacial surgery. Current evidence supports Alb-PRF as a promising autologous adjunct and prolonged-persistence biological membrane, but not yet as a replacement for established bone grafts or barrier membranes.

Keywords: Albumin-PRF; extended platelet-rich fibrin; e-PRF; platelet-rich fibrin; autologous biomaterial; tissue regeneration; wound healing; bone regeneration; alveolar ridge preservation; periodontal regeneration; guided bone regeneration; sinus augmentation; dental implants; oral and maxillofacial surgery.

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1. Introduction

Regeneration of oral and maxillofacial tissues requires coordinated control of inflammation,

angiogenesis, extracellular matrix formation, cellular migration and tissue maturation. Conventional surgical techniques may restore anatomy, but predictable regeneration of deficient bone and soft tissue frequently requires additional biological or biomaterial-based interventions.

Autologous platelet concentrates have attracted considerable interest because they provide a patient-derived source of platelets, leukocytes, fibrin and signalling molecules without requiring synthetic additives. Platelet-rich fibrin (PRF) differs from platelet-rich plasma in that fibrin polymerization occurs during preparation, creating a three-dimensional matrix capable of supporting cellular migration and gradual release of biologically active molecules. PRF has subsequently been investigated across extraction socket management, periodontal regeneration, sinus augmentation, guided bone regeneration and soft-tissue surgery.^{1,2}

Despite these advantages, conventional PRF has an important limitation: relatively rapid degradation. Conventional PRF membranes generally lose structural integrity within approximately 2–3 weeks, which may be shorter than the period required for maturation of newly forming tissues. This limitation stimulated the development of extended PRF technology, in which albumin within the platelet-poor plasma fraction is thermally denatured to produce a more slowly resorbing albumin-based matrix.³

Albumin-platelet rich fibrin therefore represents an evolution of the conventional PRF concept. Rather than simply increasing the concentration of platelets or growth factors, the principal innovation is modification of the biomaterial's physical persistence. The resulting material may provide a longer-lasting scaffold while retaining the cellular and biological components of the liquid PRF fraction.^{4,3}

The growing literature has created considerable enthusiasm surrounding Alb-PRF; however, clinical evidence remains relatively immature. Importantly, a 2026 systematic review identified only seven eligible studies—six clinical and one animal study—comprising 156 human participants and 24 animal samples. The authors concluded that evidence was more consistent for early soft-tissue healing and postoperative comfort, while evidence for hard-tissue regeneration remained limited and inconclusive.⁵

The purpose of this narrative review is therefore to critically examine Alb-PRF as an autologous biomaterial in oral and maxillofacial surgery,

emphasising the distinction between its biological rationale and demonstrated clinical effectiveness.

2. From conventional PRF to Alb-PRF

The development of Alb-PRF can be understood as an attempt to address one of the fundamental limitations of conventional PRF: its relatively short functional lifespan.³

Conventional PRF contains a fibrin network incorporating platelets and leukocytes, with growth factors released progressively as the matrix undergoes degradation. This biological architecture contributes to wound healing and tissue regeneration but also results in relatively rapid resorption.^{6,7}

The Alb-PRF concept was introduced through the combination of thermally modified autologous albumin with liquid PRF. Fujioka-Kobayashi et al. demonstrated that platelet-poor plasma heated at approximately 75°C for 10 minutes undergoes albumin denaturation and forms an albumin gel. This gel can subsequently be mixed with the cellular liquid PRF fraction.^{4,3}

The resulting material is therefore fundamentally different from conventional PRF. Its prolonged persistence is attributable primarily to the albumin-derived component, while the unheated PRF fraction provides the cellular and platelet-rich biological component.^{4,3}

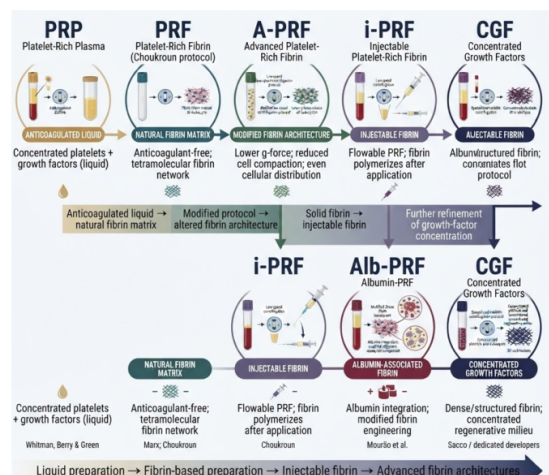


Figure 1. Evolution and classification of platelet concentrates, illustrating the development toward Alb-PRF

3. Preparation and biomaterial characteristics

Although preparation protocols vary between studies, the general principle involves centrifugation of venous blood, separation of the platelet-poor

plasma and cellular PRF fractions, thermal treatment of the plasma fraction and subsequent recombination.^{4,3}

A commonly described protocol involves centrifugation followed by collection of the upper plasma fraction. The plasma is heated to approximately 75°C for 10 minutes to denature albumin, after which it is allowed to cool. Liquid PRF containing the buffy-coat-derived cellular component is then combined with the albumin gel.⁴

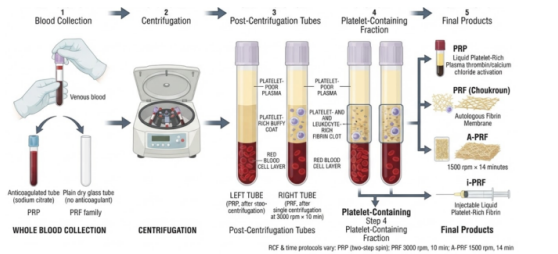


Figure 2. Blood collection, centrifugation and fractionation of platelet concentrates used in PRF preparation

Recent work has demonstrated that heating and albumin denaturation can extend the functional persistence of the resulting material from the approximate 2–3-week lifespan of conventional PRF toward approximately 4–6 months under experimental conditions.³

However, this prolonged persistence should not be interpreted as equivalent to prolonged biological activity. Recent experimental work indicates that heating substantially reduces the biological activity of the heated plasma fraction. A 2025 study examining gene-expression responses in gingival fibroblasts found markedly diminished cellular responses to heated platelet-poor plasma compared with native plasma.⁸

This observation is important because it demonstrates a central trade-off in Alb-PRF technology: thermal treatment improves structural stability but may alter the biological properties of the heated fraction. The subsequent addition of unheated cellular PRF is therefore essential to the biological concept of the material.⁸

Table 1. Conventional PRF versus Alb-PRF

Characteristic	Conventional PRF	Alb-PRF/e-PRF
Source	Autologous blood	Autologous blood

Principal matrix	Fibrin	Fibrin + denatured albumin
Thermal modification	No	Yes
Structural persistence	Relatively short	Substantially prolonged
Platelets/leukocytes	Present	Present in unheated PRF component
Potential barrier function	Limited by rapid resorption	Potentially prolonged
Major proposed advantage	Biological activity	Biological activity + prolonged stability
Current evidence	Extensive PRF literature	Emerging
Evidence for hard-tissue superiority	Variable	Currently inconclusive

Table 2. Comparison of preparation characteristics and persistence of major platelet concentrates.

Concentrate	Anticoagulant	Key preparation	Physical form	Approx. persistence
PRP	Usually required	Two-step centrifugation; activation may be required	Liquid / activated gel	Hours–days
PRF / L-PRF	None	Single centrifugation with native clotting	Fibrin clot / membrane	~1–2 weeks
A-PRF	None	Low-speed single	Fibrin clot /	~1–2 weeks

		centrifugation	membrane	
i-PRF	None	Very-low-speed centrifugation; remains liquid initially	Liquid → soft gel	Days
Alb-PRF	None; PPP heat-treated	PRF preparation + PPP heating (~75°C/10 min) + recombination with liquid PRF	Composite albumin-fibrin membrane	Weeks – months
CGF	None	Variable-speed centrifugation protocol	Dense fibrin clot	Weeks

4. Biological properties

4.1 Growth-factor and cytokine profile

PRF is biologically active because it contains platelets and leukocytes embedded within a fibrin matrix. Platelet-derived mediators include PDGF, TGF-β and VEGF, among others, which participate in cell recruitment, angiogenesis, matrix production and tissue remodeling.^{7,9}

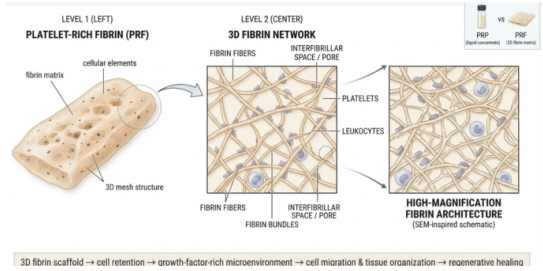


Figure 3. Three-dimensional fibrin architecture of PRF, showing the fibrin network and incorporated cellular elements.

Recent work specifically examining Alb-PRF demonstrated a biphasic, highly cellularized

structure with differences in cytokine and growth-factor release compared with leukocyte PRF. Alb-PRF demonstrated lower levels of several inflammatory cytokines and higher PDGF and VEGF release in the experimental model. The investigators also reported enhanced alkaline phosphatase activity, mineralisation, and a more favourable OPG/RANKL expression pattern in osteoblast-like cells.¹⁰

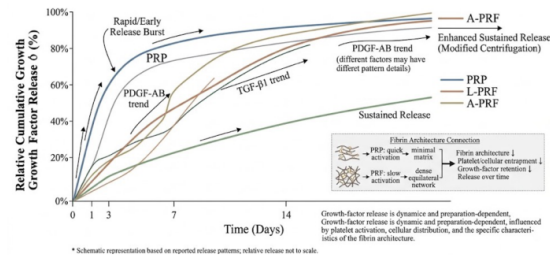


Figure 4. Schematic comparison of cumulative growth-factor release kinetics among selected platelet concentrates.

These findings support the biological plausibility of Alb-PRF as a regenerative biomaterial, but they should not be interpreted as evidence of clinically superior bone formation.^{10,5}

4.2 Fibroblast activity and wound healing

Soft-tissue regeneration may represent one of the most promising applications of Alb-PRF.^{9,5}

An in-vitro study investigating ascorbic-acid-augmented Alb-PRF found enhanced gingival fibroblast viability, proliferation and wound closure compared with Alb-PRF alone. Although the modified preparation cannot be equated with standard Alb-PRF, the findings provide evidence that the Alb-PRF platform may be adaptable to specific regenerative applications.¹¹

A separate 2026 experimental study reported enhanced endothelial function and wound-healing responses with Alb-PRF compared with PRF and horizontal PRF, providing additional support for a potential role in angiogenesis and early tissue repair.¹²

5. Clinical applications in oral and maxillofacial surgery

5.1 Extraction sockets

Post-extraction healing is a clinically relevant application because both soft-tissue closure and

preservation of the alveolar ridge are important for subsequent implant rehabilitation.^{13,14}

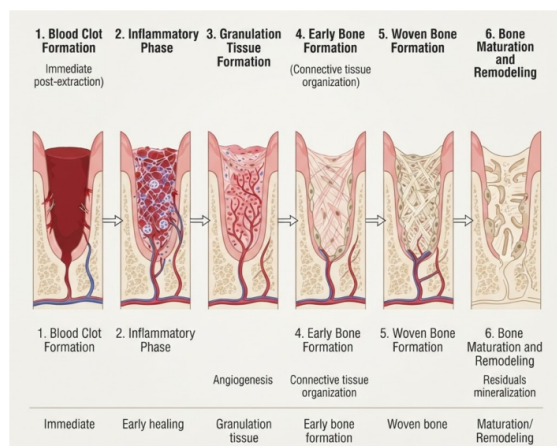


Figure 5. Sequential phases of extraction socket healing from clot formation through bone maturation and remodelling.

A split-mouth randomized clinical study involving mandibular third-molar extraction compared Alb-PRF with L-PRF. Pain and trismus were not significantly different between groups, but Alb-PRF was associated with reduced swelling at day 7 and differences in local inflammatory mediator profiles.¹⁵

More recent work has expanded this evidence. A 2026 controlled study examining horizontal and extended PRF following impacted mandibular third-molar extraction specifically assessed soft-tissue healing and postoperative outcomes, further highlighting the increasing clinical interest in extended PRF within oral surgery.¹⁶

The available evidence therefore suggests that the most immediate clinical advantage of Alb-PRF may be related to modulation of early wound healing rather than demonstrably enhanced bone regeneration.^{15,16}

5.2 Alveolar ridge preservation

The prolonged resorption period of Alb-PRF is particularly attractive for ridge preservation because conventional PRF may disappear before soft-tissue closure and early bone maturation are complete.^{3,17}

A recent case series evaluated extended PRF as a solo barrier membrane for ridge preservation. All extraction sites healed without postoperative complications, and changes in ridge dimensions were reported over follow-up. The authors concluded that the material was feasible as a barrier membrane but emphasised the need for randomised controlled trials.¹⁷

More importantly, a subsequent randomised clinical trial compared four extended-PRF membrane configurations with collagen membranes in socket grafting. At three months, the e-PRF configurations produced comparable horizontal and vertical ridge dimensions and soft-tissue thickness, while selected e-PRF groups demonstrated significantly better early wound healing.¹⁸

These findings suggest that Alb-PRF may have potential as a biological barrier membrane, although its role should currently be considered adjunctive rather than a definitive replacement for established membranes.^{18,5}

5.3 Periodontal and intrabony defects

The biological properties of Alb-PRF provide a rationale for its use in periodontal defects, particularly where stabilisation of the wound and support for cellular migration are required.^{4,19}

A 2025 randomised controlled study compared open-flap debridement combined with Alb-PRF against conventional PRF in 20 intrabony defects. Both groups improved clinically at one month. The Alb-PRF group demonstrated a mean probing-depth reduction of 3.2 mm and clinical attachment gain of 2.8 mm compared with 2.9 mm and 2.5 mm, respectively, in the PRF group. However, the very small sample size and short follow-up substantially limit interpretation.²⁰

The 2026 systematic review of Alb-PRF in periodontal and peri-implant regenerative surgery similarly concluded that clinical evidence remains heterogeneous and that hard-tissue regenerative effects cannot currently be established with confidence.⁵

5.4 Guided bone regeneration and implant surgery

A major proposed application of Alb-PRF is its use as a prolonged-persistence biological membrane in guided bone regeneration.^{3,17}

In a preliminary 2026 randomised clinical trial involving immediate implants in the maxillary anterior region, Alb-PRF was compared with a synthetic collagen membrane when both were used with a β -tricalcium phosphate/calcium sulphate graft. Alb-PRF was associated with higher Pink Aesthetic Scores and lower marginal bone loss, whereas the collagen membrane demonstrated better preservation of labial bone thickness.²¹

These findings illustrate an important principle: Alb-PRF may provide advantages in selected clinical outcomes without necessarily being superior for every regenerative endpoint.

A separate 2026 randomised trial compared extended PRF with an autogenous dentine-derived barrier membrane for guided bone regeneration around immediate implants. The study followed patients for 24 months and directly examined clinical and radiographic outcomes, further expanding the evidence base for e-PRF as a membrane technology.²²

Another exploratory 2026 randomised study compared e-PRF with allograft as a space-filling material around immediate implants. At 12 months, no statistically significant differences were detected between the groups in implant stability, marginal bone loss or buccal bone thickness.²³

Together, these implant-related studies indicate that Alb-PRF/e-PRF has been investigated as a biological membrane or space-maintaining adjunct, while the comparative evidence remains insufficient to support replacing particulate bone grafts.^{21,23}

5.5 Sinus augmentation

Sinus augmentation provides another logical indication because membrane stability is required during graft maturation.

A 2025 multicentre case series involving 22 patients investigated extended PRF as the sole membrane for lateral-window sinus augmentation. Thirty-one implants were subsequently placed, with uneventful healing reported in all cases. The mean postoperative sinus height was 12.3 mm, with a mean endosinus bone gain of 8.0 mm at approximately six months.²⁴

Although these results are encouraging, the study was a case series without a collagen-membrane control group. Therefore, it demonstrates feasibility rather than comparative effectiveness.²⁴

6. Evidence specifically relevant to oral and maxillofacial surgery

The current clinical evidence can be summarized as follows:

Table 3. Summary of current clinical evidence for Alb-PRF/e-PRF in oral and maxillofacial surgery.

Clinical application	Study design	Comparator / intervention	Main findings	Evidence interpretation	Ref.
Third-molar extraction	Split-mouth RCT	Alb-PRF vs L-PRF	Pain and trismus were not significantly different; reduced swelling at day 7 reported with Alb-PRF.	Possible benefit in early wound-healing modulation.	15
Ridge preservation	Case series + recent RCT	Extended PRF vs collagen membrane	Comparable horizontal/vertical ridge dimensions in selected protocols; some e-PRF groups showed better early wound healing.	Promising biological membrane; comparative evidence remains emerging.	17,18
Intraoral defects	Small RCT	Alb-PRF vs conventional PRF	At 1 month, PD reduction and clinical attachment gain favored Alb-PRF numerically (3.2 vs 2.9 mm; 2.8 vs 2.5 mm).	Preliminary finding limited by small sample and short follow-up.	20

Immediate implant surgery	Preclinical RCTs	Alb-PRF/e-PRF vs collagen or other materials	Selected studies report favorable esthetic/peri-implant outcomes; some endpoints favored comparative membranes.	Potential adjunctive role; no consistent superiority across endpoints.	21,23
Sinus augmentation	Multi-center case series	Extended PRF membrane; no control	Uneventful healing reported; mean postoperative sinus height 12.3 mm and endosinus bone gain 8.0 mm at ~6 months.	Demonstrates feasibility, not comparative effectiveness.	24
Cystic bone defects	Randomized controlled trial	Albumin gel-PRF mixture vs control	No definitive superiority for bone regeneration.	Hard-tissue regenerative benefit remains inconclusive.	27

Overall, the available clinical evidence supports a cautious interpretation: Alb-PRF/e-PRF is being explored primarily for modification of the early wound environment and for use as a prolonged biological barrier.^{3,5}

7. Alb-PRF as a membrane versus a bone substitute

An important distinction in the literature is whether Alb-PRF should be considered primarily a membrane or a bone-regenerative substitute.^{3,25}

Its prolonged structural persistence provides a strong rationale for membrane applications. A barrier membrane is intended primarily to exclude undesirable cellular infiltration, maintain a protected healing compartment and support the regenerative process.³

Current comparative clinical evidence does not establish Alb-PRF as equivalent to established particulate grafting materials.^{21,23}

In immediate implant therapy, e-PRF has been evaluated both as a membrane and as a space-filling material, but available comparative findings remain mixed.^{21,23}

Accordingly, the most defensible current classification is that Alb-PRF is a biological membrane and regenerative adjunct, rather than a stand-alone replacement for conventional bone grafts.^{3,5}

8. Advantages of Alb-PRF

The principal advantages of Alb-PRF include:

- Autologous origin
- Absence of xenogeneic or synthetic membrane components
- Potentially prolonged structural persistence
- Presence of platelets and leukocytes within the unheated PRF fraction
- Potential release of growth factors and cytokines
- Biological compatibility
- Potential barrier function
- Relatively low material cost
- Ability to prepare the biomaterial chairside
- Potential adaptability to different surgical applications

The combination of autologous origin and prolonged persistence represents the major conceptual advantage over conventional PRF.^{4,3}

9. Limitations and controversies

Despite increasing clinical use, several limitations must be addressed before Alb-PRF can be considered an established regenerative biomaterial.

9.1 Lack of protocol standardization

Studies differ in centrifugation speed, relative centrifugal force, blood volume, heating time, temperature, albumin-to-PRF ratio and final membrane configuration. These variables can substantially alter the biological and mechanical properties of the final material.^{3,26}

9.2 Small clinical samples

Many available studies involve approximately 10–40 patients. Small samples limit statistical power and increase the possibility that apparently favorable results represent random variation.

9.3 Short follow-up

A considerable proportion of studies primarily evaluate outcomes within weeks or several months. Long-term implant survival, peri-implant bone stability and histologically confirmed regeneration require longer observation.

9.4 Limited histological evidence

Clinical radiographic bone density or dimensional measurements do not necessarily establish histologically mature bone formation. Human histological studies remain particularly important for determining whether Alb-PRF genuinely enhances bone regeneration.

9.5 Thermal processing

Heating improves structural stability but may reduce the biological activity of the heated plasma fraction. Recent transcriptomic evidence reinforces the need to understand exactly which biological components survive the heat-treatment process.⁸

9.6 Evidence heterogeneity

The 2026 systematic review found only seven eligible clinical/in-vivo studies and emphasized considerable methodological heterogeneity. The authors concluded that current evidence is stronger for early soft-tissue healing than for hard-tissue regeneration.⁵

10. Future research directions

Future research should focus on standardisation and comparative effectiveness rather than simply demonstrating feasibility.

First, studies should report centrifugation using relative centrifugal force (RCF) rather than

rpm alone because rpm cannot be compared between centrifuges with different rotor radii.²⁶

Second, future trials should standardise:

- blood volume;
- centrifugation parameters;
- heating temperature;
- heating duration;
- cooling time;
- albumin-to-PRF ratio;
- membrane thickness; and
- handling characteristics.

Third, appropriately powered multicentre randomised controlled trials should compare Alb-PRF directly with established collagen and PTFE membranes and, where relevant, with particulate grafting materials.^{3,5}

Fourth, future studies should incorporate objective three-dimensional imaging, particularly CBCT or volumetric analysis, when bone regeneration is the primary endpoint.^{27,21}

Finally, histological and molecular studies are needed to clarify whether the apparent clinical benefits of Alb-PRF result primarily from improved wound stability, angiogenesis, inflammation modulation, mechanical barrier function or genuine enhancement of osteogenesis.^{10,8}

11. Clinical perspective

The current evidence supports a shift in how Alb-PRF should be conceptualised. Rather than viewing it simply as a “stronger PRF,” it may be more appropriate to consider it a patient-derived biomaterial platform combining a prolonged-persistence protein matrix with a cellular platelet-rich compartment.^{3,4}

This distinction has practical implications. In soft-tissue procedures, extraction sockets and membrane-based regenerative procedures, prolonged persistence may be clinically advantageous. In contrast, current clinical evidence does not justify expecting Alb-PRF to replace an appropriate osteoconductive graft in large osseous defects solely on the basis of its platelet and growth-factor content.^{3,5}

Recent clinical trials support feasibility and selected benefits, but comparative evidence does not establish universal superiority over collagen membranes or grafting materials.^{5,21}

12. Conclusion

Albumin-platelet rich fibrin represents an important evolution in autologous platelet-concentrate technology. By combining thermally modified albumin with liquid PRF, the material provides a substantially more persistent matrix than conventional PRF while retaining cellular and platelet-derived biological components.^{4,3}

Current evidence supports potential applications in extraction socket healing, ridge preservation, periodontal therapy, guided bone regeneration, implant surgery and sinus augmentation. The strongest clinical signal currently concerns early wound healing, soft-tissue behaviour, and barrier function, whereas evidence for predictable enhancement of hard-tissue regeneration remains limited.^{3,5}

Therefore, Alb-PRF should currently be regarded as a promising autologous regenerative adjunct and prolonged-persistence biological membrane rather than an established substitute for bone grafts or conventional barrier membranes.^{3,5}

Future multicentre randomised controlled trials with standardized preparation protocols, adequate sample sizes, long-term follow-up, three-dimensional imaging and histological validation are required to determine the precise role of Alb-PRF within contemporary oral and maxillofacial regenerative surgery.^{3,5}

Broader classification and advanced platelet-concentrate literature provides additional context for the evolution of PRF biomaterials.^{28,29}

Further work describing advanced and injectable PRF formulations contributes to the background of modified PRF technologies.^{30,31}

Foundational descriptions of injectable PRF and the wider PRF concept also provide background for the present discussion.^{32,33}

References

1. Dohan Ehrenfest DM, Bielecki T, Mishra A, Borzini P, Inchingolo F, Sammartino G, et al. In search of a consensus terminology in the field of platelet concentrates for surgical use: platelet-rich plasma (PRP), platelet-rich fibrin (PRF), fibrin gel polymerization and leukocytes. *Curr Pharm Biotechnol.* 2012;13:1131-1137. doi:10.2174/138920112800624328.
2. Saluja H, Dehane V, Mahindra U. Platelet-rich fibrin: a second-generation platelet concentrate and a new friend of oral and maxillofacial surgeons. *Ann Maxillofac Surg.* 2011;1:53-57. doi:10.4103/2231-0746.83158.
3. Miron RJ, Pikos MA, Estrin NE, Kobayashi-Fujioka M, Espinoza AR, Basma H, et al. Extended platelet-rich fibrin. *Periodontol* 2000. 2024;94:114-130. doi:10.1111/prd.12537.
4. Fujioka-Kobayashi M, Schaller B, Mourão CF, Zhang Y, Sculean A, Miron RJ. Biological characterization of an injectable platelet-rich fibrin mixture consisting of autologous albumin gel and liquid platelet-rich fibrin (Alb-PRF). *Platelets.* 2021;32:74-81. doi:10.1080/09537104.2020.1717455.
5. Bıçakçioğlu HA, Çolak G. Clinical effectiveness of albumin-enriched platelet-rich fibrin (Alb-PRF) in periodontal and peri-implant regenerative surgery: a systematic review. *Odontology.* 2026. doi:10.1007/s10266-026-01388-2.
6. Dohan Ehrenfest DM, Rasmusson L, Albrektsson T. Classification of platelet concentrates: from pure platelet-rich plasma (P-PRP) to leucocyte- and platelet-rich fibrin (L-PRF). *Trends Biotechnol.* 2009;27:158-167. doi:10.1016/j.tibtech.2008.11.009.
7. Dohan Ehrenfest DM, de Peppo GM, Doglioli P, Sammartino G. Slow release of growth factors and thrombospondin-1 in Choukroun's platelet-rich fibrin (PRF): a gold standard to achieve for all surgical platelet concentrates technologies. *Growth Factors.* 2009;27:63-69. doi:10.1080/08977190802636713.
8. Huang X, Panahipour L, Rassi Faghihi D, Miron RJ, Gruber R. Extended PRF: impact of heat on gene expression in gingival fibroblasts. *Int J Mol Sci.* 2025;26:9120. doi:10.3390/ijms26189120.
9. Miron RJ, Fujioka-Kobayashi M, Bishara M, Zhang Y, Hernandez M, Choukroun J. Platelet-rich fibrin and soft tissue wound healing: a systematic review. *Tissue Eng Part B Rev.* 2017;23:83-99. doi:10.1089/ten.TEB.2016.0233.
10. Lourenço ES, Rocha NRS, de Lima Barbosa R, Mello-Machado RC, de Souza Lima VH, Leite PEC, et al. Investigating the biological efficacy of albumin-enriched platelet-rich fibrin: a study on cytokine dynamics and osteoblast behavior. *Int J Mol Sci.* 2024;25(21):11531. doi:10.3390/ijms252111531.
11. Kulkarni M, Nk S, Gv G, Mg T. Effects of ascorbic acid augmented albumin platelet-rich fibrin on the wound healing activity of human gingival fibroblasts: an in vitro trial. *J Korean Assoc Oral Maxillofac Surg.* 2024;50:206-215. doi:10.5125/jkaoms.2024.50.4.206.

12. Shen F, Chai J, Wei M, Qian X, Shen M. Next-generation platelet concentrate: Alb-PRF outperformed PRP and H-PRF in promoting endothelial function and wound healing. *Sci Rep.* 2026;16:13934. doi:10.1038/s41598-026-44659-2.
13. Miron RJ, Zucchelli G, Pikos MA, Salama M, Lee S, Guillemette V, et al. Use of platelet-rich fibrin in regenerative dentistry: a systematic review. *Clin Oral Investig.* 2017;21:1913-1927. doi:10.1007/s00784-017-2133-z.
14. Choukroun J, Diss A, Simonpieri A, Girard MO, Schoeffler C, Dohan SL, et al. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part IV: clinical effects on tissue healing. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101:e56-e60. doi:10.1016/j.tripleo.2005.07.011.
15. Javid K, Mourão CF, Mello-Machado RC, Sartoretto SC, Torres M, Lourenço ES. Clinical and biochemical evaluation of the use of Alb-PRF versus L-PRF in mandibular third molar extractions: a split-mouth randomized clinical trial. *J Funct Biomater.* 2023;14:505. doi:10.3390/jfb14100505.
16. Haskic A, Hadziabdic N, Miron RJ. Effect of horizontal and extended platelet-rich fibrin on soft tissue healing and outcomes after impacted mandibular third molar extraction: a controlled trial. *Int J Oral Maxillofac Surg.* 2026;55:1113-1122. doi:10.1016/j.ijom.2026.04.011.
17. Estrin NE, Espinoza AR, Ahmad P, Imber JC, Farshidfar N, Miron RJ, et al. The evolution of extended platelet-rich fibrin membranes for socket grafting: Part One—technical development of protocols. *Dent J (Basel).* 2025;13:604. doi:10.3390/dj13120604.
18. Estrin NE, Ahmad P, Tran TB, Espinoza AR, Holmes R, Imber JC, et al. The evolution of extended platelet-rich fibrin membranes for socket grafting: Part Two—a randomized clinical trial comparing these membranes with collagen membranes. *Dent J (Basel).* 2026;14(1):45. doi:10.3390/dj14010045.
19. Miron RJ, Moraschini V, Fujioka-Kobayashi M, Zhang Y, Kawase T, Cosgarea R, et al. Use of platelet-rich fibrin for the treatment of periodontal intrabony defects: systematic review and meta-analysis. *Clin Oral Investig.* 2021;25(5):2461-2478. doi:10.1007/s00784-021-03825-8.
20. Kumari S, Sharma AK, Sunil MKS, Koppula SK, Sharma S. A randomized controlled study comparing albumin-enriched platelet-rich fibrin and conventional platelet-rich fibrin for the treatment of intrabony defects. *J Pharm Bioallied Sci.* 2025;17(Suppl 2):S1619-S1621. doi:10.4103/jpbs.jpbs_190_25.
21. Alsabahi H, Mowafey B, Kandil I, Elgohary N, Youssef J. Clinical and radiographic evaluation of autologous albumin-rich platelet-rich fibrin membrane versus synthetic collagen membrane for immediate dental implant placement in the maxillary esthetic zone: a preliminary randomized clinical trial. *BMC Oral Health.* 2026;26:292. doi:10.1186/s12903-026-07683-2.
22. Abdelsameaa SE, Alruwaili AM, El-Gohary N, Elsheikh HAE. Dentine-derived barrier membrane versus extended platelet-rich fibrin for guided bone regeneration: a 2-year randomized clinical trial. *BMC Oral Health.* 2026;26:960. doi:10.1186/s12903-026-08582-2.
23. Elnaggar HMMA, El-Gohary N, Yaseen AAM, Tawfik MAM. Extended platelet-rich fibrin versus allograft as a space filling material in immediate dental implant placement. *BMC Oral Health.* 2026;26:1130. doi:10.1186/s12903-026-08891-6.
24. Estrin NE, Basma H, Espinoza AR, Pinto MAC, Pikos MA, Miron RJ. Extended platelet-rich fibrin as a membrane for lateral window sinus lifts: a case series. *Clin Implant Dent Relat Res.* 2025;27:e13427. doi:10.1111/cid.13427.
25. Miron RJ, Gruber R, Farshidfar N, Sculean A, Zhang Y. Ten years of injectable platelet-rich fibrin. *Periodontol* 2000. 2024;94:92-113. doi:10.1111/prd.12538.
26. Miron RJ, Pinto NR, Quirynen M, Ghanaati S. Standardization of relative centrifugal forces in studies related to platelet-rich fibrin. *J Periodontol.* 2019;90:817-820. doi:10.1002/JPER.18-0553.
27. Shokry MME, Melek LNF, Amer TA. Three-dimensional volumetric analysis of bone regeneration following jaw cyst enucleation with and without an autologous albumin gel-platelet-rich fibrin mixture: a randomized controlled clinical trial. *BMC Oral Health.* 2025;25:693. doi:10.1186/s12903-025-06027-w.
28. Dohan Ehrenfest DM, Andia I, Zumstein MA, Zhang CQ, Pinto NR, Bielecki T. Classification of platelet concentrates (platelet-rich plasma-PRP, platelet-rich fibrin-PRF) for topical and infiltrative use in orthopedic and sports medicine: current

- consensus, clinical implications and perspectives. *Muscles Ligaments Tendons J.* 2014;4:3-9.
29. Balan Santos Pereira V, Lago CAP, Almeida RAC, Barbirato DS, Vasconcelos BCE. Biological and cellular properties of advanced platelet-rich fibrin compared to other platelet concentrates: systematic review and meta-analysis. *Int J Mol Sci.* 2024;25:482. doi:10.3390/ijms25010482.
 30. Ghanaati S, Booms P, Orłowska A, Kubesch A, Lorenz J, Rutkowski J, et al. Advanced platelet-rich fibrin: a new concept for cell-based tissue engineering by means of inflammatory cells. *J Oral Implantol.* 2014;40:679-689. doi:10.1563/aaid-joi-D-14-00138.
 31. Miron RJ, Fujioka-Kobayashi M, Hernandez M, Kandalam U, Zhang Y, Ghanaati S, et al. Injectable platelet rich fibrin (i-PRF): opportunities in regenerative dentistry? *Clin Oral Investig.* 2017;21:2619-2627. doi:10.1007/s00784-017-2063-9.
 32. Choukroun J, Ghanaati S. Reduction of relative centrifugation force within injectable platelet-rich-fibrin (PRF) concentrates advances patients' own inflammatory cells, platelets and growth factors: the first introduction to the low speed centrifugation concept. *Eur J Trauma Emerg Surg.* 2018;44:87-95. doi:10.1007/s00068-017-0767-9.
 33. Miron RJ, editor. *Understanding platelet-rich fibrin.* Batavia (IL): Quintessence Publishing; 2021.