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Comparative efficacy of autologous platelet-rich fibrin and collagen membrane on clinical outcomes following vestibuloplasty: A randomized controlled trial

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ABSTRACT

Background: Adequate vestibular depth and attached gingiva are essential for successful periodontal and prosthetic rehabilitation. Vestibuloplasty is frequently performed to correct shallow vestibules; however, relapse due to scar formation remains a concern. Autologous platelet-rich fibrin (PRF) and collagen membranes are increasingly explored as biological wound dressing materials to improve healing outcomes. This randomized controlled trial compared the clinical efficacy of PRF and collagen membrane following vestibuloplasty.

Materials and methods: Thirty-four systemically healthy patients requiring mandibular anterior vestibuloplasty were randomly allocated into two groups: Group A (PRF, n = 17) and Group B (collagen membrane, n = 17). A standardized surgical protocol and postoperative regimen were followed. Clinical parameters assessed included postoperative pain (Visual Analog Scale), wound healing (Landry Healing Index), vestibular depth (VD), and width of attached gingiva (WAG) at baseline, Day 7, Day 15, 1 month, and 3 months. Statistical analysis was performed using Mann–Whitney *U* test for intergroup comparisons, and Friedman's test with Wilcoxon signed-rank test for intragroup comparisons. Significance was set at $p < 0.05$.

Results: PRF significantly reduced postoperative pain at all evaluated time points compared to collagen membrane ($p < 0.05$). Collagen membrane demonstrated superior wound healing scores on Day 15 and at 3 months ($p < 0.05$), with comparable outcomes between groups at 1 month. WAG increased significantly in both groups, with no intergroup differences. However, Group B exhibited significantly greater gains in VD at both 1 month ($p = 0.002$) and 3 months ($p = 0.001$).

Conclusion: PRF is advantageous in controlling immediate postoperative pain, while collagen membrane provides superior long-term wound healing and vestibular depth augmentation. Both materials are equally effective in maintaining attached gingiva width. The selection of dressing material should be guided by the clinician's primary objective—whether prioritizing postoperative comfort or enhancing regenerative outcomes.

1. Introduction

The concept of mucogingival surgery was first introduced in the 1950s to address issues such as inadequate attached gingiva, shallow vestibules, and aberrant frenal attachments by repositioning the gingiva relative to the oral mucosa. Miller (1996) later expanded this domain by introducing the term *periodontal plastic surgery* to encompass a broader range of corrective procedures.[1,2]

An adequate vestibular depth is critical for maintaining oral hygiene and ensuring long-term periodontal and prosthetic stability. Wennström and Pini Prato highlighted that a combination of insufficient vestibular depth and reduced width of attached gingiva predisposes patients to food impaction and poor plaque control, increasing the risk of periodontal breakdown.[3,4] Epidemiological data indicate relapse rates for vestibular depth are substantial: one retrospective case series reported relapse in vestibular depth at 23.3 %, compared to 48.3 % relapse in

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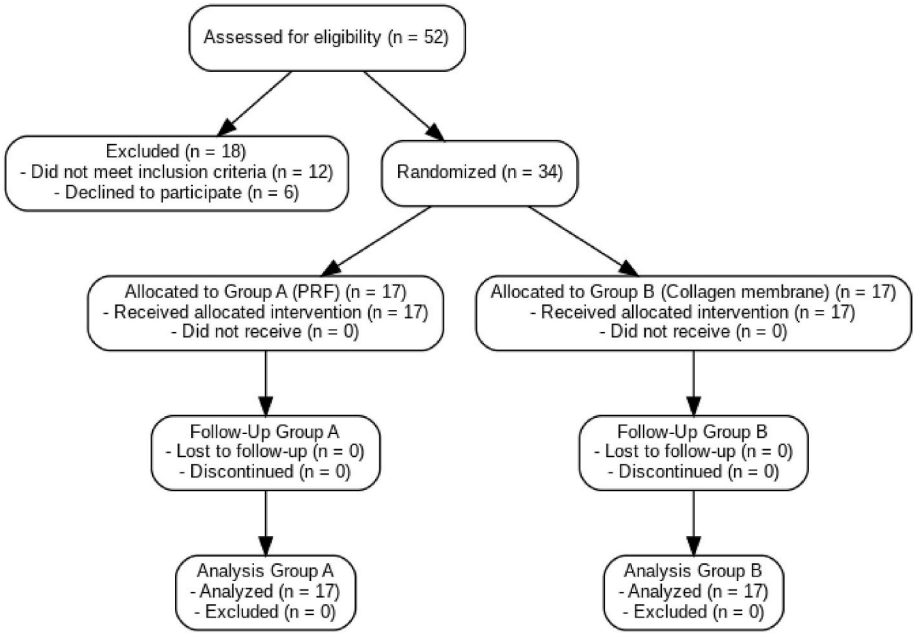

Fig. 1. CONSORT flow diagram.

keratinized gingiva over ~34 months following vestibuloplasty.[5,6]

Vestibuloplasty involves repositioning the mucosa and muscle attachments to deepen the oral vestibule and expose the osseous base of the jaws.[6] Classic techniques include Clark's pedicled flap (1953), minimizing the raw site on the lip, and Bohannan's modification, which reduces wound contracture by maintaining bone exposure.[7,8] Traditional prophylactic use of Coe-Pak dressings has been limited by delayed healing and hypersensitivity, driving the search for superior biological alternatives.[9]

Biological grafts such as free gingival grafts (FGG), introduced by Björn in 1963, have been used to augment attached gingiva and reduce relapse. However, FGGs are technique-sensitive and demand a secondary donor site, increasing postoperative morbidity.[10]

Platelet concentrates transformed regenerative therapy following the discovery of growth factors in the 1970s, promoting collagen synthesis, angiogenesis, and cell proliferation. Whitman et al. (1997) demonstrated the value of platelet-rich plasma (PRP) in oral surgery, though its use is complicated by bovine thrombin and associated immunologic risks.[11] In 2001, Choukroun et al. introduced platelet-rich fibrin (PRF), a fully autologous second-generation concentrate, synthesized without chemical additives. PRF establishes a fibrin matrix that enables sustained growth factor release, enhancing tissue healing and regeneration.[12] It has been widely applied in periodontal defects, palatal donor sites, and mucosal wound sites.[13]

Collagen, the body's most abundant structural protein, plays a pivotal role in tissue repair. Type I collagen membranes are utilized as resorbable scaffolds that stabilize clots, prevent epithelial migration, and support guided tissue regeneration in periodontal and oral surgery.[14] A Cochrane review (2013) underscored collagen membranes as effective alternatives to autogenous grafts in mucogingival procedures.[15] More recent literature continues to affirm their biocompatibility and clinical utility in oral reconstructive procedures.[16]

Despite widespread use, direct comparisons between PRF and collagen membranes as dressing materials after vestibuloplasty remain limited. This gap is especially pertinent in South Asia, a region with one of the highest burdens of oral cavity cancers globally, attributed primarily to smokeless tobacco use and areca nut consumption. In 2022, over 177,000 incident oral cancer cases and nearly 99,000 deaths were reported in South and Southeast Asia, underscoring the urgent need for effective regenerative treatments in mucogingival surgery, particularly post-oncologic resections.[17,18]

Therefore, the present randomized controlled trial was designed to compare the clinical efficacy of autologous PRF versus collagen membrane as wound dressing materials following vestibuloplasty. We hypothesized that PRF would offer superior pain reduction in the short term, while collagen membrane would deliver superior wound healing and vestibular depth outcomes in the long term.

2. Materials and Methods

2.1. Ethical considerations

The research protocol was reviewed and approved by the Institutional Scientific Review Board and subsequently cleared by the Institutional Ethics Committee (Approval No.: IEC 376072022, Version No.: 001, dated 04/07/2022). The study was conducted in accordance with the Declaration of Helsinki (2013 revision). Written informed consent was obtained from all participants prior to enrollment.

2.2. Study setting and sample

The study was conducted in the Department of Periodontics. Patients visiting the Outpatient Department of Periodontology with shallow vestibular depth, inadequate width of attached gingiva, and a positive tension test involving the mandibular labial frenum were considered for inclusion.

A total of 52 patients were screened for eligibility. Of these, 34 patients met the inclusion criteria and were randomized into two groups: Group A (vestibuloplasty with autologous PRF, n = 17) and Group B (vestibuloplasty with collagen membrane, n = 17). All patients completed the study; no dropouts occurred (Fig. 1: CONSORT flow diagram).

2.3. Inclusion and exclusion criteria

The inclusion criteria for the study comprised individuals aged 18 years and above who were systemically healthy, presenting with inadequate width of attached gingiva or insufficient vestibular depth in the mandibular anterior region, and willing to provide written informed consent for participation. Patients were excluded if they were non-

Fig. 2. Autologous PRF Collagen membrane.

compliant, current users of tobacco in any form (smoking or smokeless), pregnant or lactating women, or individuals with systemic diseases or metabolic disorders known to affect wound healing.

2.4. Withdrawal criteria

Participants retained the right to withdraw at any stage without any impact on their future dental treatment.

2.5. Study design and randomization

This study was designed as a parallel-group, randomized controlled clinical trial. Patients were randomized using a **computer-generated random sequence** in a 1:1 allocation ratio. Allocation concealment was maintained using **opaque, sequentially numbered, sealed envelopes** opened at the time of surgery.[19,20]

The clinical evaluator responsible for outcome assessment was **blinded** to group assignment, although due to the nature of interventions, surgeons and participants were not blinded (single-blind design).

2.6. Outcome measures

- **Primary Endpoint:** Postoperative pain at Day 3, measured using a 10-point Visual Analog Scale (VAS).
- **Secondary Endpoints:**
  - o Wound healing (Landry Healing Index) at Days 15, 1 month, and 3 months.
  - o Vestibular depth (VD) and width of attached gingiva (WAG), measured using a UNC-15 periodontal probe at baseline, 1 month, and 3 months.

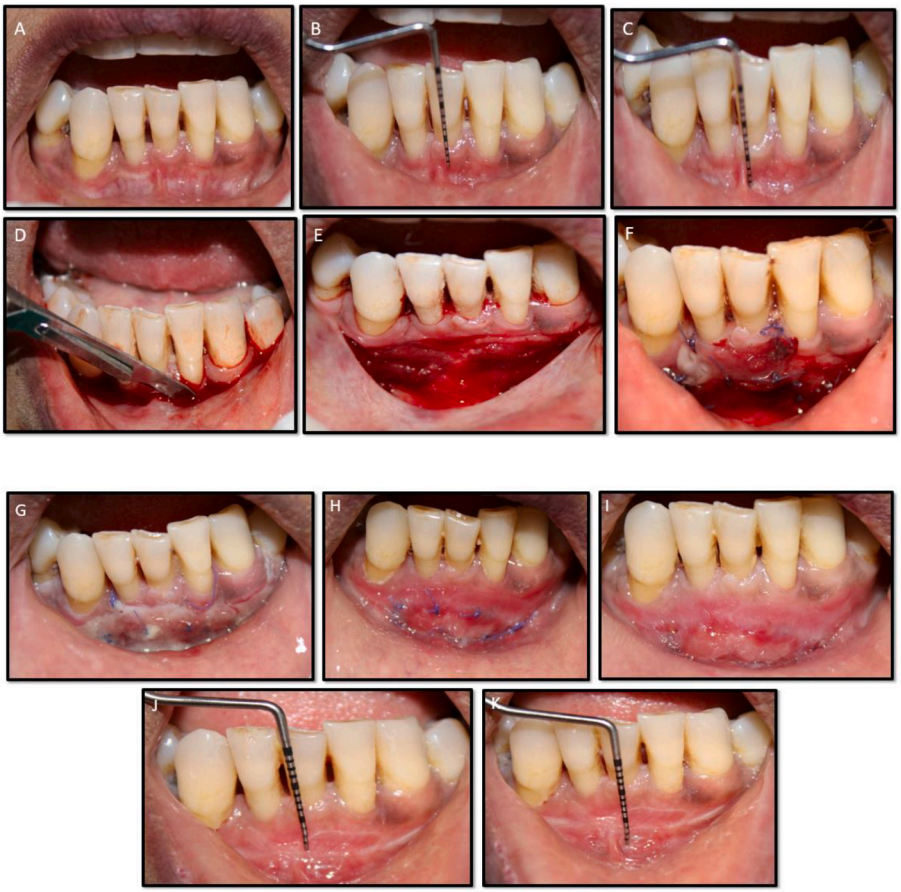

Fig. 3. Group A - A - Pre-operative width, B - Pre-operative width of attached gingiva, C - Pre-operative width of vestibular depth, D - Incision given at mucogingival junction, E – Mucoperiosteal flap elevated, F - PRF sutured over the exposed bone surface, G - 3rd day follow-up, H - 10th day follow-up, I - 15th day follow-up, J - 1 month follow-up width of attached gingiva, K - 1 month follow-up width of vestibular depth.

Fig. 4. Group B: A - Pre-operative width, B - Pre-operative width of attached gingiva, C - Pre-operative width of vestibular depth, D - Incision given at mucogingival junction, E – Mucoperiosteal flap elevated, F - Collagen membrane sutured over the exposed bone surface, G - 3rd day follow-up, H - 10th day follow-up, I - 15th day follow-up, J - 1 month follow-up width of attached gingiva, K - 1 month follow-up width of vestibular depth.

2.7. Preoperative Protocol

All participants underwent routine blood investigations [Complete Blood Count (CBC), Bleeding Time (BT), Clotting Time (CT), and Random Blood Sugar (RBS)] to confirm medical fitness. A full-mouth scaling and oral prophylaxis were performed one week before surgery (Fig. 2).[18–20]

2.8. Surgical procedure

Local anesthesia (2 % lignocaine hydrochloride with adrenaline 1:80,000) was administered via infiltration in the mandibular anterior region. A horizontal incision was made at the mucogingival junction, and a supraperiosteal flap was elevated. Muscle and loose connective tissue were dissected, and partial resection of the mentalis muscle was performed to reduce relapse. Horizontal fenestrations were created at the base of the new vestibule. The mucosal flap was stabilized at the periosteal margin using 4-0 absorbable sutures.[21,22]

- **Group A (PRF):** Ten milliliters of venous blood was collected from the antecubital vein into sterile tubes without anticoagulant. Samples were centrifuged at 2700 rpm (~400 g, rotor radius 10 cm) for 12 min (following Choukroun's protocol). The middle PRF clot was retrieved, compressed into a membrane, and sutured over the exposed periosteum with 4-0 absorbable sutures (Fig. 3).
- **Group B (Collagen membrane):** A sterile Type I collagen membrane (resorbable, porcine-derived) was trimmed to size and sutured over the exposed periosteum in a similar manner (Fig. 4).

2.9. Postoperative care and follow-up

All patients were instructed to avoid brushing the surgical site and were prescribed 0.2 % chlorhexidine mouth rinse twice daily for 15 days.[24] Analgesics (ibuprofen 400 mg + paracetamol 325 mg) were prescribed three times daily for three days. Sutures were removed on Day 10.

Follow-up assessments were scheduled on Day 3 (pain), Day 15 (healing), and at 1 month and 3 months (healing, VD, and WAG) (Figs. 3 and 4).[23,24]

2.10. Statistical analysis

Data were entered in Microsoft Excel (v2019) and analyzed using SPSS (v26.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean ± standard deviation (SD). The Shapiro–Wilk test revealed non-normal distribution; therefore, non-parametric tests were used. Intergroup comparisons were performed with the Mann–Whitney *U* test, while intragroup longitudinal comparisons were assessed using Friedman's test followed by Wilcoxon signed-rank test. A Bonferroni correction was applied to adjust for multiple comparisons. Statistical significance was set at $p < 0.05$, with α error of 5 % and β error of 20 %, ensuring 80 % study power.

3. Results & interpretation

3.1. Baseline characteristics

Baseline demographic and clinical characteristics were comparable between the two groups, with no statistically significant differences in age, gender distribution, baseline width of attached gingiva (WAG), and vestibular depth (VD) (Table 1, Fig. 5). This indicates that the randomization process achieved well-balanced groups at study entry.

3.2. Pain reduction (Inter-group comparison)

Pain levels were assessed on days 3, 10, and 15 post-procedure. Group A (PRF) exhibited significantly lower pain scores at all time points compared to Group B (Collagen Membrane). On Day 3, Group A reported a mean pain score of 3.65 ± 0.996 versus 4.65 ± 0.493 in Group B, with a mean difference of −1.00 (95 % CI: −1.52 to −0.48, p =

Table 1
Baseline characteristics and clinical outcomes.

Outcome/ Timepoint	Group A (PRF) Mean ± SD	Group B (Collagen Membrane) Mean ± SD	Mean Difference	95 % CI	p-value
Age (years)	32.8 ± 5.1	33.4 ± 4.9	−0.6	−2.8 to 1.6	0.59
Gender (M/F)	10/5	9/6	–	–	0.72
Baseline WAG (mm)	2.12 ± 0.49	1.76 ± 0.73	0.36	−0.12 to 0.84	0.14
Baseline VD (mm)	3.18 ± 0.51	3.59 ± 0.75	−0.41	−0.92 to 0.10	0.11
Pain Day 3	3.65 ± 0.99	4.65 ± 0.49	−1.00	−1.52 to −0.48	0.002
Pain Day 10	1.53 ± 0.72	2.88 ± 0.86	−1.35	−1.85 to −0.85	0.001[a]
Pain Day 15	0.29 ± 0.47	1.47 ± 1.07	−1.18	−1.66 to −0.70	0.001[a]
Healing Day 15	2.82 ± 0.39	3.24 ± 0.56	−0.42	−0.78 to −0.06	0.021
Healing 1 Month	3.53 ± 0.51	3.76 ± 0.44	−0.23	−0.56 to 0.10	0.157
Healing 3 Months	4.47 ± 0.51	4.82 ± 0.39	−0.35	−0.67 to −0.03	0.034
WAG 1 Month	2.65 ± 0.49	2.83 ± 0.73	−0.18	−0.74 to 0.38	0.52
WAG 3 Months	2.65 ± 0.49	2.88 ± 0.86	−0.23	−0.91 to 0.45	0.52
VD 1 Month	6.41 ± 0.51	7.24 ± 0.75	−0.83	−1.35 to −0.31	0.002
VD 3 Months	5.41 ± 0.62	6.41 ± 0.87	−1.00	−1.55 to −0.45	0.001[a]

[a] Chi-square test for categorical variable (Gender). Other variables compared using independent *t*-test.

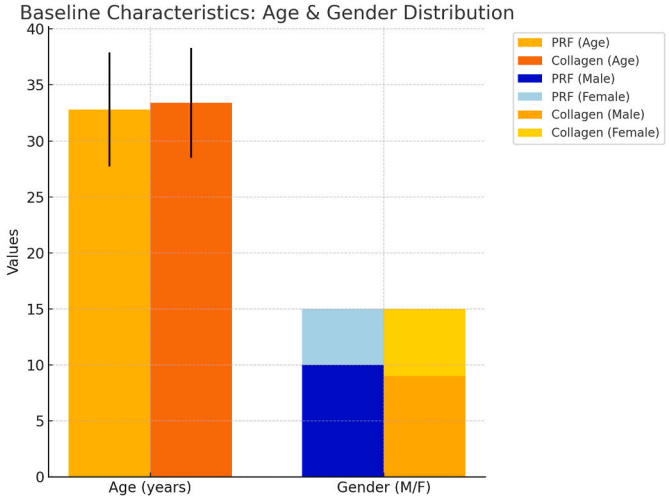

Fig. 5. Bar graph showing baseline characteristics – Age and gender distribution.

0.002). By Day 15, pain levels had drastically reduced in both groups, but Group A still showed significantly lower values (0.29 ± 0.470 vs. 1.47 ± 1.068; mean difference: −1.18, 95 % CI: −1.69 to −0.67, p < 0.001). These findings highlight that PRF provides superior short-term pain relief (Table 1, Fig. 6).

3.3. Wound healing (Landry's Index)

Landry's Wound Healing Score was assessed at Day 15, 1 month, and 3 months. At Day 15, Group B showed a significantly higher score (3.24 ± 0.562 vs. 2.82 ± 0.393; mean difference: 0.42, 95 % CI: 0.06–0.78, p = 0.021). At 1 month, the difference was not significant (p = 0.157). However, at 3 months, Group B again showed superior healing (4.82 ± 0.393 vs. 4.47 ± 0.514; mean difference: 0.35, 95 % CI: 0.03–0.67, p = 0.034). This suggests Collagen Membrane promotes better long-term wound healing (Table 1, Fig. 6).

3.4. Width of attached gingiva (WAG) gain

The width of attached gingiva was measured at baseline, 1 month, and 3 months. Both groups showed a gradual increase in WAG. At 1 month, Group A measured 2.65 ± 0.493 while Group B was 2.83 ± 0.728 (mean difference: −0.18, 95 % CI: −0.74–0.38, p = 0.520). At 3 months, Group A measured 2.65 ± 0.493 and Group B 2.88 ± 0.857 (mean difference: −0.23, 95 % CI: −0.91–0.45, p = 0.520). These results indicate no significant differences, suggesting both interventions are equally effective in preserving gingival width (Table 1, Fig. 7).

3.5. Vestibular depth (VD) gain

Vestibular depth gain was assessed at baseline, 1 month, and 3 months. At 1 month, Group B showed significantly greater gain (7.24 ± 0.752 vs. 6.41 ± 0.507; mean difference: 0.83, 95 % CI: 0.31–1.35, p = 0.002). At 3 months, Group B again showed superiority (6.41 ± 0.870 vs. 5.41 ± 0.618; mean difference: 1.00, 95 % CI: 0.45–1.55, p = 0.001). These findings highlight that Collagen Membrane is more effective for improving vestibular depth, which is clinically beneficial for prosthetic and periodontal outcomes (Table 1, Fig. 7).

PRF was found to significantly reduce post-operative pain, making it the material of choice for short-term patient comfort, while Collagen Membrane showed superior outcomes in long-term wound healing and vestibular depth gain, indicating better regenerative potential. Both approaches were comparable in terms of width of attached gingiva gain. Thus, the choice of technique may be guided by clinical priorities—PRF for immediate pain relief or Collagen Membrane for enhanced long-term regeneration.

4. Discussion

This study compared autologous platelet-rich fibrin (PRF) and collagen membrane as dressing materials following vestibuloplasty, with the hypothesis that their distinct biological mechanisms would yield different clinical outcomes. Our results supported this: PRF was more effective in reducing postoperative pain in the early healing period, while collagen membrane provided superior wound healing and vestibular depth (VD) gain during the later follow-up stages. The width of attached gingiva (WAG) remained comparable between groups.

The finding that PRF reduced postoperative pain resonates strongly with the work of **Ahmed et al. (2020)** and **de Almeida Barros Mourão et al. (2020)**, who both reported reduced pain in extraction sockets managed with PRF.[25,27] Similarly, **Hartlev et al. (2020)** showed less postoperative discomfort during ridge augmentation with PRF, albeit with confounders such as concomitant steroid use. Our study adds to this growing evidence that PRF's fibrin network, platelet-derived growth factors, and cytokine release attenuate the inflammatory cascade and nociceptor sensitization, leading to better early pain control.[26]

In terms of wound healing, our results mirror those of **Shanmugam et al. (2010)**, who observed enhanced epithelization and reduced donor site morbidity when collagen membranes were used in palatal wounds.[28,29] **Ahmad et al. (2021)** also reported favorable healing with

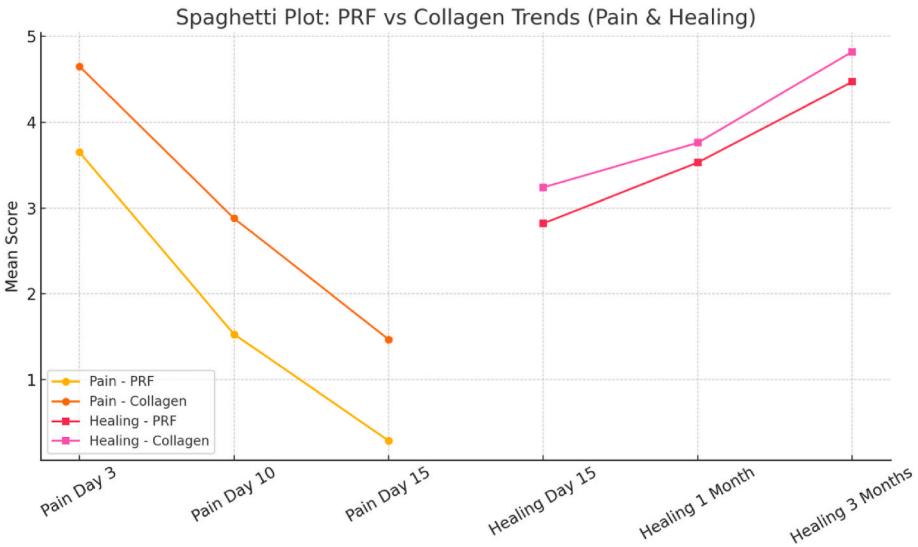

Fig. 6. Spaghetti plot showing pain and healing between study groups.

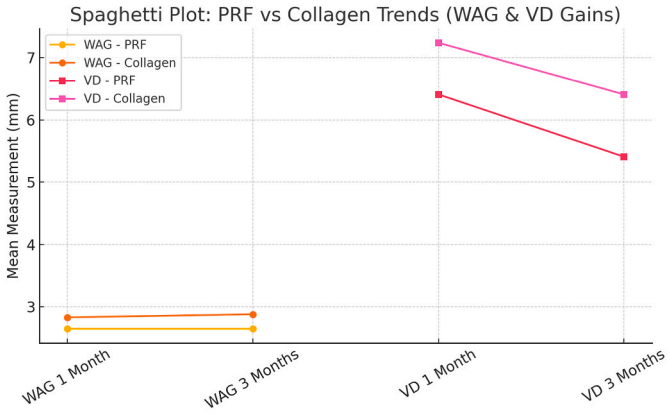

Fig. 7. Spaghetti plot showing WAG and VD among the study groups.

collagen membranes in oral mucosal defects, while **Rastogi et al. (2009)** highlighted collagen's biocompatibility and hemostatic properties in promoting mucosal regeneration. Consistent with these studies, the better wound healing scores in our collagen group can be attributed to its longer resorption time (30–45 days vs. 7–10 days for PRF), which provides a more durable scaffold for fibroblast activity and angiogenesis.[17,19]

Notably, some studies have reported contrasting outcomes. **Sharma et al. (2019)** found no significant difference in palatal wound healing between PRF and collagen dressings, while **Raval et al. (2022)** observed no significant improvements in periodontal indices or healing scores when PRF and xenogenic collagen matrices were used with coronally advanced flaps.[8,17] These discrepancies may reflect differences in surgical site, follow-up duration, or the specific collagen matrices employed. Nonetheless, our data align more closely with studies showing superior healing outcomes with collagen in vestibular and mucosal applications[30,31].

Regarding vestibular depth, our findings are in agreement with **Schmitt et al. (2016)** and **Ramanauskaite et al. (2023)**, who reported that collagen matrices can sustain gains in keratinized mucosa width and vestibular depth, though postoperative shrinkage remains a challenge.[23,32] **Temmerman et al. (2018)** further highlighted that PRF, while beneficial for keratinized mucosa augmentation, showed higher shrinkage rates compared to free gingival grafts (32.1 % vs. 23.6 %). These observations support our conclusion that collagen offers more stable vestibular depth gains than PRF.[33]

The clinical relevance of our effect sizes deserves emphasis. A 1.0–1.3 point reduction on the VAS is modest yet clinically meaningful, as the minimal clinically important difference (MCID) for acute dental pain typically lies around 1–2 points. Such a reduction may translate into reduced analgesic use and improved oral function. Similarly, a 0.3–0.4 point gain in Landry's wound healing score reflects statistically significant improvements in tissue maturation, while 0.8–1.0 mm gains in vestibular depth may meaningfully influence prosthetic stability and plaque control, especially in the mandibular anterior region.

Limitations must be acknowledged. The short three-month follow-up does not permit evaluation of long-term stability, particularly given the known risk of relapse due to muscle reinsertion and mucosal contracture. The small sample size and single-center design reduce generalizability, while the non-parametric analyses may have limited statistical power. Lack of assessor blinding and unmeasured variables such as smoking, oral hygiene compliance, and analgesic use could have confounded the outcomes.

Future research should focus on multicenter randomized controlled trials with larger sample sizes and longer follow-up (≥12 months) to assess stability of vestibular depth and gingival width. Incorporating histological or molecular analyses will elucidate the biological mechanisms underlying these differential outcomes. Cost-effectiveness analyses are also needed to guide clinical decision-making, particularly in resource-limited settings. Moreover, combination strategies—using PRF for immediate anti-inflammatory benefit and collagen for sustained scaffold support—merit investigation, as they may provide synergistic advantages.

Thus, our findings suggest that PRF and collagen membrane are not interchangeable but complementary: PRF is preferable when early pain control is paramount, while collagen membrane is superior for achieving sustained wound healing and vestibular depth gains. Tailoring the choice of dressing to the patient's clinical needs may optimize outcomes until more definitive evidence from larger and longer-term trials becomes available.

5. Conclusion

In this randomized controlled trial comparing autologous platelet-rich fibrin (PRF) and resorbable collagen membrane as dressings after mandibular vestibuloplasty, PRF provided superior early postoperative comfort with significantly lower pain scores at Days 3, 10 and 15, whereas the collagen membrane produced better tissue maturation and

more durable vestibular depth gains (significantly higher Landry healing scores at Day 15 and 3 months, and greater VD at 1 and 3 months); both materials achieved comparable increases in width of attached gingiva. Therefore, selection of dressing should be driven by clinical priorities—choose PRF when minimizing immediate postoperative pain is the primary goal, and choose collagen membrane when long-term wound stability and vestibular depth augmentation are paramount; clinicians may also consider combination or staged approaches to harness the complementary strengths of both materials.

Patient consent

The patient consent was obtained.

Ethical clearance

Ethical clearance was obtained from the Institutional Review Board (No. IEC 376072022).

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Declaration of competing interest

The authors declare that there is no conflict of interest.

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