Narrative Review

Periosteal Releasing Incision and its Modifications for flap Advancement: A Narrative Review

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KEY WORDS
Periosteum;
Oral surgery;
Dental implants;
Guided Bone Regeneration;
Wound Closure Techniques;

Received: 21 October 2025;
Revised: 28 December 2025;
Accepted: 10 May 2026;

ABSTRACT

Guided bone regeneration (GBR) is a well-established method to augment the alveolar bone before or during implant placement. Tension-free primary closure of the flap is a critical requirement for the success of GBR, and failure to achieve it can lead to numerous complications, including wound infections, membrane exposure, and graft loss. Periosteal-releasing incision (PRI) is a straightforward and predictable flap advancement method that achieves tension-free flap closure in bone augmentation procedures such as GBR. In this method, the mucoperiosteal flap is elevated beyond the mucogingival junction, and then a PRI is made in the area apical to the mucogingival junction from distal to mesial. Complications like swelling, hematoma, lingual and mental nerve injury, and reduction of vestibular depth are reported for PRI. Modifications of this technique are proposed to improve efficiency and reduce associated complications. This narrative review aims to evaluate the PRI technique and its modifications, with the goal of better understanding these methods and their proper application to achieve successful surgical treatment outcomes.

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Cite this article as:

Introduction

The use of dental implants as a safe solution for tooth replacement has long been accepted [1]. Since long-lasting tooth loss often results in local hard and soft tissue deficiencies, tooth replacement treatment with dental implants is challenging, as severe ridge resorption may interfere with the placement of dental implants in a properly functional and esthetic position [2-4]. Guided bone regeneration (GBR) was introduced to provide sufficient bone volume for implant placement and long-term biological stability. GBR has evolved and is a well-established method to augment the alveolar bone before or during implant placement [4-6].

For successful GBR, one major factor that must be considered is tension-free primary wound closure during healing, which can be achieved through sufficient flap advancement. Wound dehiscence in GBR, which may result in complications such as wound infections, membrane exposure, graft loss, or implant failure, is a consequence of failure in achieving primary closure [7]. It is shown that when flap tension is minimal (<0.05 N), 100% wound closure is achieved. However, by exceeding flap tension from 0.1N, the likelihood of wound dehiscence increases by 40 to 100 percent [8].

Periosteal releasing incision (PRI), also known as periosteal scoring incisions, is one of the flap advance-

ment techniques and a gold standard method, which is widely used in surgical procedures such as oroantral fistula closure or GBR [6, 9]. PRI is a straightforward, predictable, and easy procedure that can be performed by most experienced physicians [6, 10]. With increased use of dental implants and the need for bone regeneration in recent years, the use of PRI has received more attention, and some modifications are made to improve it and reduce complications. This study aims to review the PRI technique and its modification for flap advancement.

Search Strategy

This narrative review focused on the assessment of current evidence on PRI and its modification during flap advancement for GBR. To determine PRI modifications, complications, and advantages compared to other techniques in flap advancement for GBR , an electronic search was conducted through PubMed, Scopus, and Web of Science up to June 2025 with search query of (Periosteal releasing incision OR PRI OR periosteal scoring incisions) AND (flap advancement OR guided bone regeneration OR GBR). The included studies were limited to English-language articles. All articles regarding PRI techniques, PRI modification, management of PRI complications, and comparisons with other techniques were included. Abstracts, letters, and book chapters were excluded from the study. After removing duplicates, all titles and abstracts were reviewed based on the eligibility criteria. The full texts of selected articles were assessed carefully and categorized.

Results

Electronic and manual search, after the elimination of duplicates, yielded a total of 113 potentially relevant titles and abstracts. Finally, 17 studies were included in this review. Romanos [9] presented the guidelines for the successful performance of PRI for GBR. Three studies represented modifications of the PRI technique, and one study classified the periosteum for PRI [1, 11-13]. Three studies were randomized clinical trials on the PRI technique, and the study of Bahaa *et al*. [14] was a long-term follow-up of one RCT [6, 15-16]. Table 1 summarizes the RCTs that compare the PRI with other flap

Table 1: Summary of randomized clinical trials comparing PRI with other flap advancement techniques

Author(s), Year	Patients and site characteristics	Study Groups (N)	Outcomes
Ogata *et al*. [14] (2013)	-Age: 43-71Y -M/F= 0.6 -Non-smoker -2 or 3 missing teeth -Posterior mandible (15 cases) & maxilla (1 case)	- PRI (12) - DFI (11)	• Flap advancement: -Mean flap advancement (mm): PRI= 7.13±1.45, DFI= 9.46± 0.92 -DFI resulted in a mean of 2.51 mm more flap advancement (statistically significant) • Patient discomfort: DFI resulted in significantly less pain and swelling score. •Post-operative complications: Not statistically significant between groups.
Shahnaz *et al*. [15] (2018)	-M/F= 0.5 -Non-smoker -Single missing teeth -Anterior maxilla (bicuspids forwards)	- PRI (9) - LAPRI (9)	• Post-operative pain: Significantly lower In LAPRI during the first four postoperative days resulted in less NSAIDs consumption. • Swelling: Statistically significant lower in LAPRI group
Zazou *et al.* [6] (2020) *Bahaa *et al.* [16] (2022)	Age: ≥ 21Y -Non-smoker -More than 2 missing teeth -Posterior mandible -No evidence of vertical loss	- PRI (10) - DFI (10) - CALF (10) - MPRI (10)	• Flap advancement: -Mean flap advancement (mm): PRI= 10.2±1.7, DFI= 14.4±2., CALF= 19.9±5.0, MPRI= 10.7±3.4 -CALF group showed a statistically significant difference compared to all other groups. • Mean pain score: MPRI group had the highest, while the DF group had the lowest • Swelling score: The difference between groups was insignificant. • Mesh exposure: PRI group showed the highest percentage. Paresthesia: found in PRI (3 cases), MPRI (2 cases), and DFI (one case) groups. ** Bone Gain: Mean clinical and radiographic bone gain was significantly higher in the CALF compared to the other groups.

*= The study was the long-term follow-up of Zazou *et al.* [6]. ** The result of Bahaa *et al.* [16]
CALF= Coronally advanced lingual flap, DFI= Double-flap incision, F= Female, LAPRI = Laser- assisted periosteal releasing incision, M= Male, MDT= Mucosal detachment technique, MPRI= Modified periosteal releasing incision, NSAIDs= Nonsteroidal anti-inflammatory drugs, PRI= Periosteal releasing incision

advancement techniques. Iwagava *et al*. [17] presented an anatomical study with a focus on complications, and three other studies recommended modifications for critical areas (especially the mental foramen) [18-20]. One prospective cohort study [10] and three animal studies [3-4, 21] were also relevant. According to the included studies, we first explain the PRI technique, then three modifications. Possible complications of the technique and suggested methods to reduce these complications are also discussed. Eventually, studies comparing PRI with other flap advancement techniques are discussed.

Discussion

Periosteum is a membrane that covers the outer layers of almost all bones (Figure 1), and histopathologically, consists of two layers. The outer fibrous layer has a superficial, inelastic, rather acellular portion, and a deep portion (the fibroelastic layer) that contains many elastic fibers but few cells and blood vessels [22]. An inner cell-rich (the cambium) layer contains mesenchymal progenitors, differentiated osteogenic progenitor cells, osteoblasts, and fibroblasts in a scant collagenous matrix [22]. The periosteum is almost up to 0.375 mm thick, and due to the lack of elastic fibers is not very flexible. During the execution of PRI, the blade penetrates to the inner side of the flap by 1-3 mm. Therefore, the periosteum is penetrated first, and after that, the underlying submucosa consists of varying densities and thicknesses of connective tissue [19].

For the successful performance of the PRI technique (Figure 2), Romanos [9] recommended the following surgical guidelines. First, a mucoperiosteal flap should extend apically, at least 10 mm beyond the mucogingival junction (MGJ). Then, the amount of flap tension is assessed while covering the augmentation site. Second, the periosteal incision is made using a new blade (number 15 or 15c), from the distal to the mesial area at an angle of 60 to 90 degrees, with a depth ranging from 1 to 3 mm, in one motion (without stopping). The incision should be made in an area apical to the MGJ to prevent perforation of the keratinized tissue. The tension-free flap advancement is then reassessed, and if the flap is not sufficiently stretched, a new PRI can be made apical to the previous incision and parallel to it, or a deeper incision can be made in the muscle layer. Finally, the buccal flap margin should overlap the lingual or palatal site by 3-5 mm. The lack of this overlap indicates excessive tension in the flap and, consequently, inadequate closure [9].

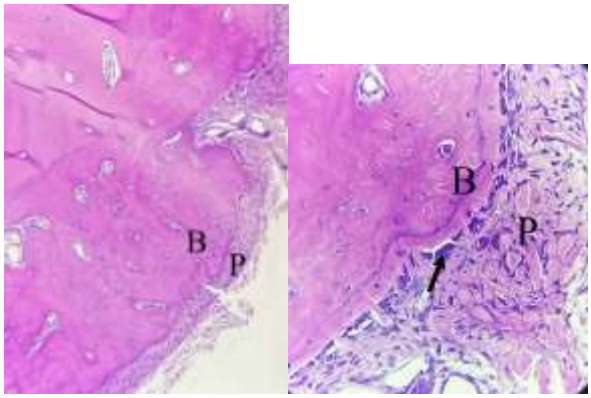


Figure 1: Histopathologic view of periosteum. **a**: Section shows cortical bone of jaw (B) and periosteum (P) (H& E, ×100). **b**: Cortical bone (b), inner layer of periosteum (P) containing osteoblasts (black arrow) (H& amp;E, ×400)

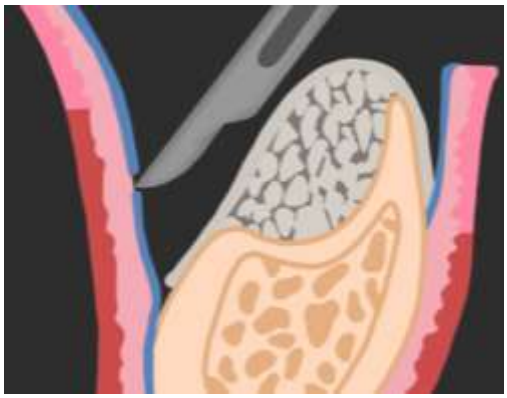


Figure 2: Schematic illustration of conventional periosteal releasing incision

PRI is usually used with two vertical incisions; therefore, two vertical releasing incisions are made on the mesial and distal sides of the flap before reflection [20]. Traboulsi-Garet *et al*. [21] in an animal model showed that the PRI in combination with envelope, triangular, and trapezoidal flaps can provide an average extension of 7.37 mm, which is significantly higher than each flap design alone. They showed that flap advancement of the trapezoidal flap with PRI is significantly greater and suggested using this type of flap in combination with PRI wherever tension-free primary closure is required [21]. Park *et al*. [10] evaluated the effect of vertical incisions and PRI (incision near the base of the flap with a depth of 1 mm) on the extension of buccal trapezoidal flaps. Coronal advancement is reported 1.1± 0.6 mm after the first vertical incision, 1.9±1mm after the second vertical incision, and 5.5±1.5 mm with adding PRI, which is 113.4%, 124.2%, and 171.3%, respec-

tively, more than the original flap length. Surprisingly, there is no statistically significant difference in flap advancement with respect to gender, surgeon's experience, or jaw (maxilla vs. mandible) [10].

Urban *et al*. [13] classified the periosteum based on tissue quality into three classes including class (1) native periosteum with no scar tissue present, class (2) mildly fibrotic periosteum with the presence of scar tissue, and class (3) thick, fibrotic, stone-like periosteum with pronounced scarring and foreign substances embedded. Urban *et al*. [13] recommended the periosteo-elastic technique after PRI, which separates the elastic fibers through blunt dissection using a 45-90 degree rotated scalpel (debundling). They claimed that, in class 1, only the PRI and periosteo-elastic technique is sufficient for flap advancement. In class 2, the PRI with more extensive debundling or multiple PRI and periosteo-elastic technique is recommended. Class 3, which is the most difficult tissue for flap advancement, not only needs multiple PRI associated with periosteo-elastic technique, but also requires removal of the scarred tissue containing foreign bodies (periosteoplasty) [13].

In laser-assisted PRI (Figure 3), after mucoperiosteal flap reflection, the PRI is made using a diode laser (940 or 810 nm) [12, 16]. Moslemi *et al*. [12] suggested setting of 2 W for a 940 nm diode laser in pulsed mode and contact mode, which enhanced the precision and tactile feedback [12]. When using a laser for incision, care must be taken to avoid any laser irradiation to the underlying bone. For this reason, the laser beam should be kept almost parallel to the buccal bone [16]. Laser-assisted PRI minimizes bleeding during surgery, which significantly improves the surgeon's vision. Moreover, reduced postoperative swelling and pain, along with

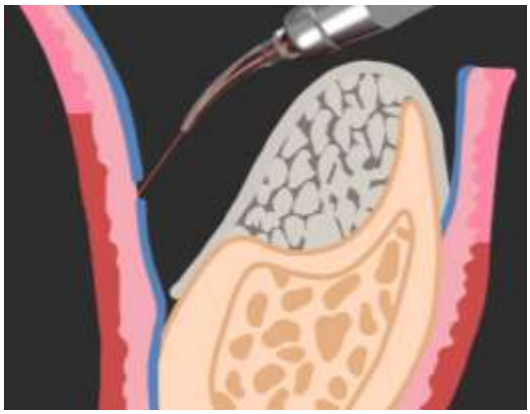
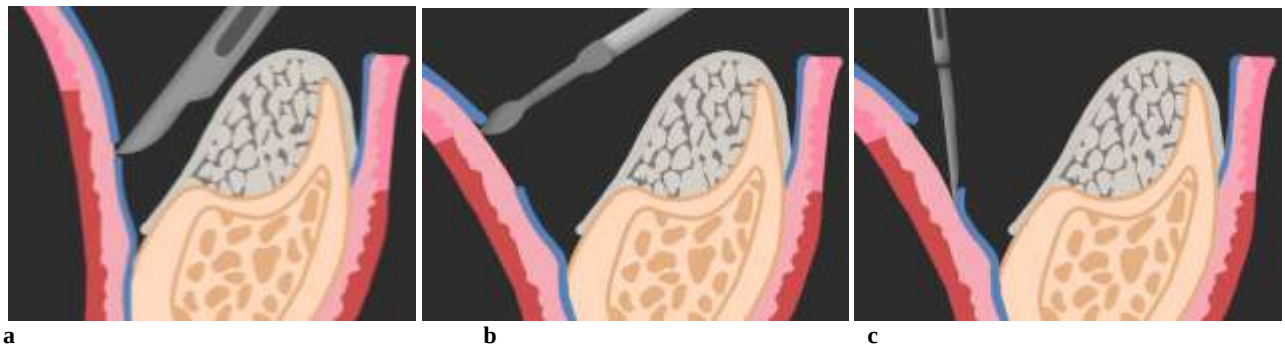


Figure 3: Schematic illustration of laser-assisted periosteal releasing incision

tension-free primary closure, were achieved in all cases [12, 16].

If the flap advancement is insufficient, using the PRI technique and multiple or deeper incisions are associated with increased surgical complications; then alternative methods should be considered. The modified periosteal-releasing incision (MPRI) technique is described by Hur *et al*. [11] (Figure 4). In this technique, after reflecting the full-thickness mucoperiosteal flap, an incision is made near the base of the flap with a depth of less than 0.5mm, divided into two segments (coronal and apical segments). The depth of the incision must be shallow to avoid damaging the submucosal layer. The flap is then stretched laterally using two periodontal forceps. Lateral stretching is performed by a blunt instrument with a sweeping motion on the coronal segment. Depending on the force applied during this sweeping motion, flap advancement of 3 and 7mm can be expected. Because the apical segment is close to the alveolar bone, it is impossible to stretch in the apical direction without releasing tension from the dense connective tissue of the periosteum. Consequently, an "axi-



a **b** **c**

Figure 4: Schematic illustration of modified periosteal-releasing incision (MPRI). **a:** A Shallow first incision is made near the base of the flap. **b:** Lateral stretching of the coronal segment using a blunt instrument with a sweeping motion. **c:** Axial detaching incision was made to separate the periosteum from the apical segment

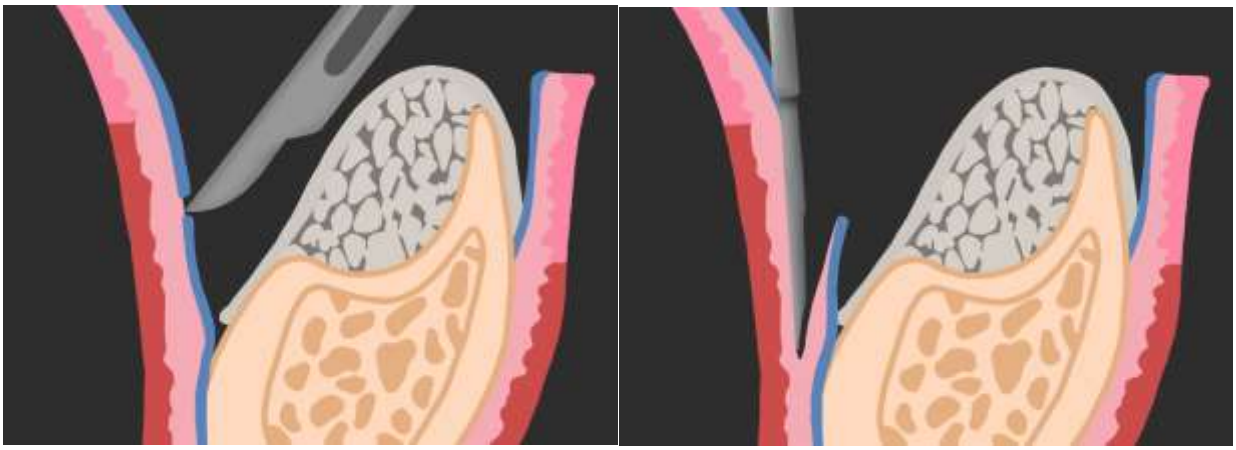


Figure 5: Schematic illustration of the two-step periosteal releasing incision method. **a:** A shallow incision is made 1-2 mm apical to the mucogingival junction (MGJ), from the vertical incision on one side to the vertical incision on the other. **b:** With the blade parallel to the flap, the second incision extends from the first horizontal periosteal incision apically and immediately below the outer

al detaching incision" is performed to separate the periosteum from the apical segment. After this step is complete, flap advancement of more than 15mm can be expected with this method [11].

Neira *et al*. [1] presented the two-step PRI technique (Figure 5) in which a full-thickness flap is elevated by extending one tooth on either side of the edentulous site, using a 15c blade and a buser periosteal elevator. Two vertical releasing incisions are made on both sides of the flap, which should extend to the MGJ. A single suture is placed in the middle of the coronal margin of the flap to facilitate measurement. The first horizontal incision is made using a new blade, 1-2 mm apical to the MGJ, from the vertical incision on one side to the vertical incision on the other. This incision should be very shallow to cut only the periosteum and not damage deeper tissues. The second incision, holding the blade parallel to the flap, extends from the first horizontal periosteal incision apically and immediately below the outer surface of the flap to separate all remaining fibers from the periosteum to the underlying tissue. Care should also be taken to avoid the deeper muscle plane [1].

Complication like swelling, bleeding, hematoma, and nerve and arterial injuries are reported when using PRI for flap advancement [6, 17]. Non-steroidal anti-inflammatory drugs or corticosteroids are usually prescribed to prevent complications after surgeries to reduce swelling and pain [16]. Excessive bleeding during the surgical procedure, which is a common complication of this technique, can lead to impaired vision for the clinician and displacement of bone graft particles. Using lasers instead of scalpels in the PRI has been proposed to prevent bleeding during surgery, although it reduces postoperative pain and swelling [12, 16].

Considering nerve and arterial injuries, the posterior maxilla is usually a safe area [19]; however, parotid duct damage for the maxillary buccal flap has also been reported [17]. In the palatal aspect, the height of the palatal vault should be evaluated to avoid injury to the palatal artery [19]. The lingual aspect of the mandible is an important area because of the lingual nerve (especially in the region of the third molars) and submental and sublingual arteries in the anterior section [19, 23].

One of the most considerable areas during PRI is the mental nerve and its branches, which are recommended to be identified with cone beam computed tomography (CBCT) before surgery [13]. Some studies recommend techniques aimed at reducing the risk of mental nerve injury and paresthesia, all of which emphasize the use of shallow incisions [18-20].

As mentioned earlier, the periosteum has a 0.37-0.38 mm thickness; therefore, an approximately 0.5mm incision can perforate the periosteum [13]. Greenstein *et al.* [19] presented a practical technique in which the PRI starts from the distal aspect of the flap, approximately 3 mm distal to the area of the mental nerve root. The incision changes to a dome-shaped incision around the foramen, preserving the 3 mm distance from the mental nerve coronally and mesially. To prevent injury to mental nerve branches, whose exact positions are obscure, the coronal and mesial incisions should be made superficially [19]. Inoko *et al.* [20], in cases with potential damage to nerves or blood vessels, suggested the “upward-motion scissors technique” involving a series of

shallow PRI in 1-mm intervals. In this technique, a shallow PRI is made; after that, the periosteum is incised with an upward motion of a pair of scissors, which is inserted between the periosteum and the underlying soft tissue. Then another PRI is placed 1 mm apical to the first incision, and the same procedure is repeated, and so on. The authors suggested the Goldman Fox scissors for this technique [20]. Recently, Hur *et al*. [18] provided an update on the MPRI for mental nerve visualization. They suggested making a shallow initial incision first and then trying to locate the mental nerve root while stretching the flap laterally. After confirmation of nerve location by further stretching, a careful apical detaching incision parallel to the flap around the mental nerve is made for more flap tension relief. A push motion apically using the lateral border of a scalpel blade or periosteal elevator is applied to finalize nerve visualization. Flap management is continued carefully with the original technique. The authors claimed that, for flap advancement, the straight incision design of the MPRI is more efficient than the dome-shaped incision [18].

Moreover, reduction of vestibular depth and loss of keratinized mucosa over the edentulous ridge may occur after flap advancement using PRI, which can result in esthetic and functional problems [24]. This reduction in vestibular depth can be managed during implant placement or during second-stage surgery using pre-prosthetic mucogingival surgeries [25].

Several animal and human studies compared PRI with different flap advancement techniques; however, evidence about this issue is limited [4, 6, 14, 16]. It can be concluded from randomized clinical trials that PRI can advance the flap for GBR, with mean advancements reported as 5.5±1.5mm [10], 7.13±1.45mm [24], and 10.2±1.7mm [6]. Nevertheless, in cases where more flap advancement is required, other techniques like coronally advanced lingual flap or double-flap incision are suggested [6, 15]. It should be noted that for the coronally advanced lingual flap technique, which is specifically used in the posterior mandible, experienced manipulation of the lingual flap and detailed knowledge about the anatomy of that area are essential to avoid injuries to vital structures [6, 26]. Postoperative pain and swelling, which are more after using the PRI or MPRI technique, can be managed by laser-assisted PRI [16].

Bahaa *et al*. [14] showed that the mean radiographic bone gain has a significant direct correlation with the total flap advancement and an inverse correlation with the percentage of mesh exposure. These findings emphasize the importance of the amount of flap advancement and flap tension-free closure in enhancing bone gain in GBR [14]. They also find an inverse correlation between postoperative swelling and flap advancement. This result accentuates the prominent effect of reducing postoperative swelling by minimizing trauma to the tissue during surgery, performing correct and precise procedures, and providing proper post-operative instructions to the patients [14].

In an animal study, Steigmann *et al*. [4] showed that PRI results in statistically higher flap advancement than a trapezoidal full-thickness flap with two vertical incisions. However, mucosal detachment techniques in their research had better results in flap advancement than PRI, while maintaining optimal tissue tensile strength. They reported a linear relation between flap advancement and mucosal exposure, with the ratio of every 10 mm 2 increase in exposed mucosal surface resulting in a 0.62 mm increase in coronal flap displacement [4]. Raabe *et al*. [3] reported that the type of flap advancement technique (MPRI versus mucosal detachment technique) had no significant effect on graft stability. However, they suggested using periosteal suturing in combination with these flap advancement techniques for reducing graft material displacement during primary wound closure [3].

Limitations and Recommendations for Future Research

This narrative review has some limitations that should be acknowledged. First, the included studies were heterogeneous in terms of study design, surgical techniques, and outcome measurements, which limit direct comparison between studies. Second, the number of randomized clinical trials investigating PRI and its modifications is limited. In addition, most available studies have relatively small sample sizes or are based on animal or observational designs.

Future studies should focus on well-designed randomized clinical trials with standardized measurement methods for flap advancement and postoperative outcomes. Comparative studies evaluating PRI and its modifications with other flap advancement techniques in different clinical situations would also provide more robust evidence.

Conclusion

PRI is a straightforward and successful technique for flap advancement in oral surgeries such as GBR. However, patient selection for this technique is crucial and it is recommended in cases where less than 10mm flap advancement is needed. This helps to avoid postoperative complications such as membrane exposure and treatment failure. Laser-assisted PRI can also reduce postoperative pain and swelling.

Acknowledgements

The authors thank Melika Tofighi for preparing digital figures.

Credit authorship contribution statement

Hamidreza Eghbalikhosro: Investigation, Writing- riginal draft, Writing−review & editing. **Fazele Atarbashi-Moghadam:** Conceptualization, Writing−original draft, Writing- review & editing. **Saede Atarbashi-Moghadam:** Supervision, investigation, Writing- original draft, Writing- review & editing.

Declarations

Funding

None

Declaration of competing interest

The authors declare that they have no known competing interests.

Declaration of generative AI and AI-assisted technologies

None

Data availability

The data that support the findings of this study are available from the corresponding author

Consent statement/Ethical approval

Not required.

Conflict of Interest

Authors declare no Conflict of interest statement.

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