ORIGINAL RESEARCH

Comparative Evaluation of Different Flaps Used in Apicoectomy Surgeries: An Original Research

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Abstract

Background: Apicoectomy remains a predictable treatment option for persistent apical periodontitis when nonsurgical retreatment is not feasible. While advances in endodontic microsurgery have improved periapical healing, the influence of flap design on soft-tissue outcomes and patient-centered parameters continues to be clinically relevant, particularly in esthetically sensitive regions.

Materials and methods: A prospective clinical study was conducted on 90 patients requiring apicoectomy in maxillary anterior and premolar teeth. Patients were equally allocated into three groups based on flap design: IS (n = 30), PBI (n = 30), and OL (n = 30). All surgeries were performed using standardized microsurgical protocols, including ultrasonic root-end preparation and bioceramic root-end filling. The primary outcome assessment included postoperative gingival recession at 3 months. Secondary outcomes comprised interdental papilla height changes, postoperative pain and swelling, scar visibility, and radiographic healing at 12 months. Data were statistically analyzed using appropriate parametric and nonparametric tests with significance set at $p < 0.05$.

Results: The IS demonstrated significantly greater gingival recession and papilla height loss compared to the other groups ($p < 0.001$). The gingival recession at 3 months was the predefined primary outcome. Measurements at 1 month were predefined secondary/exploratory time points intended to capture early trends in healing. The PBI group showed the most favorable soft-tissue outcomes, with minimal recession, superior papilla preservation, and lower postoperative pain scores. The Ochsenbein–Luebke (OL) flap exhibited limited gingival recession but a higher frequency of visible scarring. Radiographic healing at 12 months was high and comparable across all three groups, with no statistically significant differences.

Conclusion: Flap design significantly influences soft-tissue healing and esthetic outcomes following apicoectomy. The PBI provides optimal gingival and papillary preservation in esthetically demanding regions, while the OL flap remains a useful alternative in selected cases. Radiographic success is not compromised by flap selection when modern microsurgical techniques are employed.

Keywords: Apicoectomy, Endodontic microsurgery, Flap design, Gingival recession, Ochsenbein–Luebke flap, Papilla base incision, Periapical surgery, Soft-tissue healing.

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Introduction

Apicoectomy (root-end surgery) remains a tooth-preserving option for persistent apical periodontitis when nonsurgical retreatment is not feasible or has failed. The contemporary shift from traditional apical surgery to endodontic microsurgery—supported by magnification, ultrasonic root-end preparation, and biocompatible root-end materials—has markedly improved predictability, with pooled success rates commonly reported around or above 90% in meta-analytic evidence for microsurgical techniques.[1–3] While hard-tissue management (root resection, retropreparation, and retrofilling) is central to infection control, soft-tissue management is often decisive for esthetic outcomes, patient comfort, and periodontal stability.

Flap design in apicoectomy directly influences access, visibility, and the biologic response of marginal tissues. The conventional full-thickness IS (with triangular or rectangular designs) provides broad access and permits direct visualization of the crestal bone and root surface; however, marginal flaps inherently mobilize the gingival margin and interdental papillae, potentially increasing the risk of recession and papillary shrinkage.[4,5] This issue becomes particularly consequential in the maxillary esthetic zone, where even small changes in gingival margin position or papilla height may compromise smile harmony and lead to black triangles. Clinical evaluations of sulcular flap healing have documented measurable papilla height loss after apical surgery, underscoring the need for incision designs that preserve marginal architecture when esthetics is a priority.[5]

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To address these limitations, papilla-preserving approaches were developed. The papilla base incision (PBI), introduced to maintain papillary integrity through a split-thickness incision at the papilla base combined with full-thickness elevation apically, was proposed as a recession-minimizing alternative in periodontally healthy situations.[6,7] Clinical studies on PBI have reported predictable, rapid healing with minimal or no recession and improved incision invisibility during follow-up, supporting its use in esthetically sensitive regions.[6,7] Parallel to papilla-preserving marginal techniques, limited (submarginal) flaps such as the Ochsenbein–Luebke (OL) design aim to avoid crestal marginal tissues by placing the horizontal incision within attached gingiva, thereby theoretically reducing gingival margin recession around crowns and cervical restorations—provided adequate attached gingiva exists, and the lesion does not extend coronally to the incision line.[8,9]

Despite broad clinical adoption, the choice between sulcular, papilla-preserving, and submarginal designs remains a practical decision influenced by periodontal phenotype, width of attached gingiva, tooth location, restorative status, and esthetic demand. Expert guidance and reviews emphasize that incision selection should optimize access while minimizing iatrogenic soft-tissue trauma and ensuring stable wound closure.[10] Accordingly, this study aimed to comparatively evaluate three commonly used flap approaches—IS, PBI, and OL—in apicoectomy, focusing on recession, papilla stability, patient-reported morbidity, scar visibility, and radiographic healing.

Materials and Methods

Study Design and Setting

A prospective, parallel-group clinical study was conducted in a university dental hospital endodontic surgery unit. The protocol followed principles consistent with clinical research ethics; all participants provided written informed consent prior to enrollment. The present study was conducted as a prospective nonrandomized comparative clinical study. Allocation to flap groups was based on preoperative clinical criteria, including periodontal phenotype, width of attached gingiva, tooth position, and esthetic considerations, in order to ensure patient safety and flap feasibility. Random allocation was not performed because the OL flap is contraindicated in sites with inadequate attached gingiva or coronally extending lesions.

The study received approval from the Institutional Ethics Committee, and all procedures were conducted in accordance with the Declaration of Helsinki [RKDF/DC/PG/2024/176].

Participants

Patients aged 18–55 years requiring apicoectomy for persistent apical periodontitis of maxillary anterior teeth and premolars were screened. Indications included persistent periapical radiolucency and/or symptoms after adequate orthograde root canal treatment where nonsurgical retreatment was contraindicated, not feasible, or previously unsuccessful.

Inclusion Criteria

- Single-rooted maxillary anterior teeth or premolars planned for apicoectomy.
- Intact marginal periodontium (probing depth ≤3 mm; no active periodontal disease).
- Presence of intact papillae at the surgical site.
- Adequate oral hygiene and willingness for follow-up visits.

Exclusion Criteria

- Uncontrolled systemic disease, pregnancy/lactation
- Smoking or tobacco use (to minimize wound-healing confounding)
- Thin, fragile soft tissue with inadequate attached gingiva for OL design
- Combined periodontal–endodontic lesions, mobility > Grade I, or furcation involvement
- Lesions extending coronally to the planned submarginal incision line (for OL candidates)

Group Allocation (Flap Design)

Ninety eligible patients were allocated equally to three groups ($n = 30$ each):

- Group A: Conventional intrasulcular (IS) full-thickness flap (triangular or rectangular as anatomically required).
- Group B: PBI flap as described by Velvart (split-thickness at papilla base with full-thickness elevation apically).
- Group C: OL submarginal scalloped flap placed in attached gingiva (with vertical releases).

Surgical Protocol (Standardized)

All surgeries were performed under local anesthesia with a standardized microsurgical approach: full-thickness reflection as per assigned design, osteotomy, curettage, root-end resection (~3 mm), ultrasonic retropreparation, and the root-end filling was performed using mineral trioxide aggregate (MTA) (ProRoot® MTA; Dentsply Sirona, Tulsa Dental Specialties, USA). Flaps were repositioned and sutured with microsurgical interrupted sutures. Postoperative analgesics and instructions were standardized.

Outcomes and Follow-up

- Primary outcome: Change in midfacial gingival margin level (mm) from baseline to 3 months (gingival recession).
- Secondary outcomes: Papilla height change (mm), pain (VAS 0–10) at 24–72 hours, swelling score, scar visibility at 1 and 3 months, probing depth/clinical attachment changes, and radiographic healing at 12 months (standardized periapical radiographs).

The gingival recession at 3 months was the predefined primary outcome. Measurements at 1 month were predefined secondary/exploratory time points intended to capture early healing trends. Clinical measurements were performed using a UNC-15 periodontal probe, referenced from a fixed point on the cementoenamel junction (CEJ) to the midfacial gingival margin for recession, and from the papilla tip to a standardized reference line for papilla height. All clinical measurements were recorded by a single calibrated examiner who was blinded to group allocation during follow-up assessments. Intraexaminer reliability was assessed using repeated measurements in a subset of patients, yielding satisfactory agreement.

Postoperative pain was assessed using a VAS at 48 hours, and swelling was evaluated clinically at 48–72 hours postsurgery. All patients received standardized analgesic prescriptions, and no additional rescue medication was permitted during the assessment period. Swelling was assessed using a clinician-based categorical grading system (mild/moderate/severe) based on facial contour changes. Radiographic healing at 12 months was classified as complete, incomplete, or uncertain healing, based on established periapical healing criteria. Radiographs were evaluated by blinded examiners,

and agreement was assessed. Scar visibility was assessed clinically at follow-up visits using standardized intraoral examination; photographs were used for documentation. This clarification has been added (Fig. 1).

Statistical Analysis

Data were summarized as mean ± SD for continuous variables and frequency (%) for categorical variables. Intergroup comparisons used analysis of variance (ANOVA) (or Kruskal–Wallis where appropriate) with *post hoc* testing. Categorical outcomes used χ^2/Fisher's exact tests.

An a priori formal power calculation was not performed due to the lack of robust preliminary data comparing all three flap designs simultaneously. The sample size of 30 patients per group was determined based on feasibility and consistency with previously published prospective endodontic microsurgery studies.

This prospective observational clinical study was reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. All relevant checklist items applicable to the study design were addressed.

Results

Study Population

A total of 90 patients completed the study and were available for analysis, with 30 patients in each flap group. No patient was lost to follow-up during the 12-month observation period. All surgeries were completed as planned without intraoperative complications.

Demographic and Baseline Clinical Characteristics

Baseline demographic variables and clinical parameters were comparable across the three groups. There were no statistically significant differences in age distribution, gender ratio, tooth type operated, preoperative probing depth, or baseline gingival margin position ($p > 0.05$). This indicates adequate group homogeneity and minimizes confounding effects on postoperative outcomes (Table 1).

Changes in Gingival Margin Level (Gingival Recession)

Intergroup comparisons for gingival recession at 1 month were analyzed using the same statistical approach as for the 3-month data (ANOVA/Kruskal–Wallis as appropriate). The 1-month comparisons did not demonstrate statistically significant differences among the three flap groups ($p > 0.05$), indicating comparable early healing outcomes. At 3 months postoperatively, the IS group demonstrated the greatest mean gingival recession, whereas the PBI group showed the least recession. The difference among the three groups was statistically significant ($p < 0.001$). Pairwise comparison revealed significantly lower recession in the PBI group compared to IS, while OL showed intermediate results.

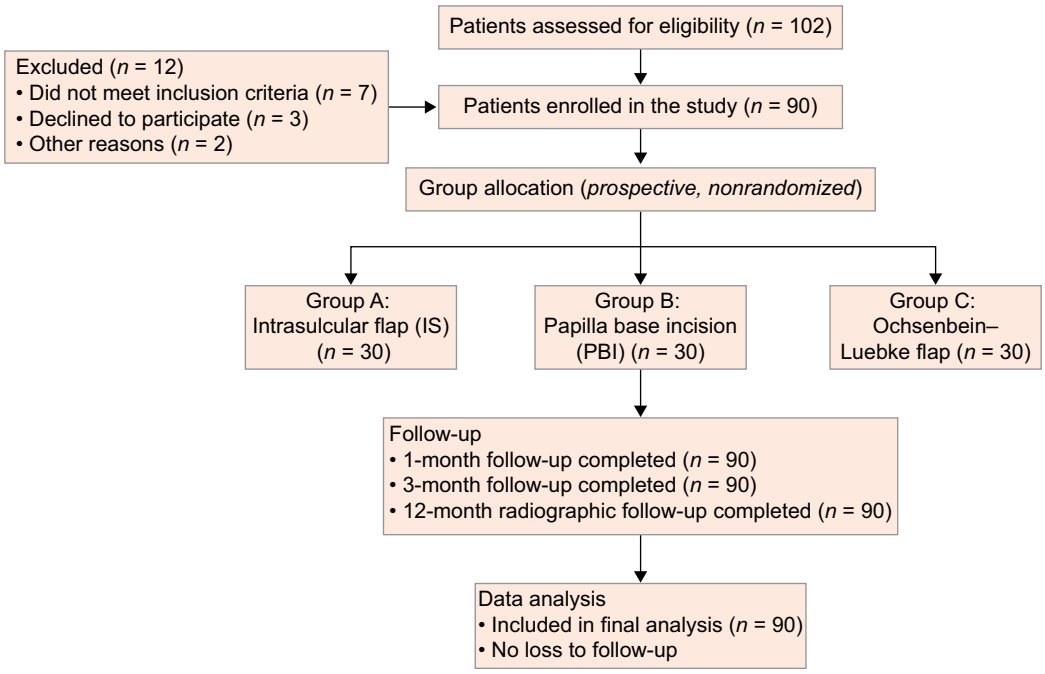

Fig. 1: Patient screening, eligibility assessment, nonrandomized group allocation, follow-up, and inclusion in final analysis

Table 1: Baseline demographic and clinical characteristics of study groups

Parameter	*Intrasulcular (IS) (n = 30)*	*Papilla base incision (PBI) (n = 30)*	*Ochsenbein–Luebke (OL) (n = 30)*	*p-value*
Mean age (years)	32.8 ± 7.4	31.9 ± 6.8	33.5 ± 7.1	0.71
Gender (M/F)	17/13	16/14	18/12	0.84
Tooth type (anterior/premolar)	21/9	22/8	20/10	0.78
Baseline probing depth (mm)	2.3 ± 0.4	2.2 ± 0.5	2.3 ± 0.4	0.66
Baseline gingival margin level (mm)*	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	—

*Baseline gingival margin recorded as reference level

Table 2: Postoperative gingival recession at 1 and 3 months

Group	*Recession at 1 month (mm)*	*Recession at 3 months (mm)*	*p-value (3 months)*
Intrasulcular (IS)	0.82 ± 0.31	1.12 ± 0.36	<0.001
Papilla base incision (PBI)	0.18 ± 0.14	0.24 ± 0.17	
Ochsenbein–Luebke (OL)	0.36 ± 0.22	0.42 ± 0.25	

Table 3: Changes in interdental papilla height at 3 months

Group	*Mean papilla height loss (mm)*	*Percentage of sites with visible papilla loss (%)*	*p-value*
Intrasulcular (IS)	0.96 ± 0.38	46.7%	<0.001
Papilla base incision (PBI)	0.12 ± 0.09	6.7%	
Ochsenbein–Luebke (OL)	0.28 ± 0.19	13.3%	

Table 4: Postoperative morbidity, scar formation, and radiographic healing

Outcome	*IS (n = 30)*	*PBI (n = 30)*	*OL (n = 30)*	*p-value*
Pain score (VAS, 48 hours)	4.6 ± 1.2	2.1 ± 0.9	2.8 ± 1.0	<0.001
Moderate–severe swelling (%)	40.0%	13.3%	20.0%	0.02
Visible scar at 3 months (%)	3.3%	0%	26.7%	<0.001
Complete radiographic healing at 12 months (%)	90.0%	93.3%	90.0%	0.81

These findings highlight the superiority of papilla-preserving and submarginal designs in minimizing recession.

Table 2 indicates that 1-month intergroup differences were analyzed but were not statistically significant; therefore, *p*-values are not separately displayed to avoid redundancy.

Interdental Papilla Height Changes

Papilla height loss was significantly greater in the IS group compared with both the PBI and OL groups. The PBI group demonstrated near-complete preservation of papilla height, with minimal mean reduction at 3 months.

Statistical analysis confirmed a highly significant difference among groups ($p < 0.001$), reinforcing the role of papilla-preserving incisions in maintaining interdental soft-tissue architecture (Table 3).

Postoperative Morbidity and Healing Outcomes

Postoperative pain scores at 48 hours were significantly higher in the IS group, while the PBI group reported the lowest pain levels. Swelling followed a similar pattern. Scar visibility at 3 months was most frequently observed in the OL group, though scars were confined to the attached gingiva and did not involve the marginal tissues. Radiographic healing at 12 months was high and comparable across all groups, with no statistically significant difference, indicating that flap design primarily influenced soft-tissue outcomes rather than periapical healing (Table 4).

Intergroup comparisons at 1 month were analyzed; however, no statistically significant differences were observed. This has now been clarified in the table footnote and narrative results. Only one surgical site per patient was included in the analysis; therefore, clustering effects were not applicable.

Discussion

The present study evaluated the influence of three commonly employed flap designs—IS, PBI, and OL—on soft-tissue and healing outcomes following apicoectomy. The findings demonstrate that flap design significantly affects postoperative gingival recession, papilla preservation, patient-reported morbidity, and esthetic sequelae, while radiographic healing remains comparable across designs.

The most clinically relevant finding was the significantly greater gingival recession observed in the IS group. This outcome is consistent with earlier clinical and histologic observations indicating that elevation of marginal tissues disrupts supracrestal fiber attachment and compromises vascular supply to the gingival margin, predisposing it to apical migration during healing.[11,12] Marginal incisions are particularly vulnerable in thin periodontal phenotypes, where even minimal trauma can result in measurable recession. Previous prospective evaluations of sulcular flaps in endodontic surgery have reported recession values ranging from 0.8 to 1.5 mm, which closely parallels the results of the present study.[12]

In contrast, the PBI demonstrated superior preservation of gingival margin and papilla height, with minimal recession and negligible papillary loss. These findings reinforce the biologic rationale behind PBI, which maintains papillary vascularization by avoiding direct incision through the papilla tip and instead utilizing a split-thickness incision at its base.[13] Clinical trials and case-controlled studies have consistently shown that papilla-preserving approaches result in faster epithelialization, improved wound stability, and superior esthetic outcomes when compared to conventional sulcular designs.[13,14] The near-absence of visible papilla loss in the present study further supports the use of PBI in esthetically demanding regions, particularly in the maxillary anterior segment.

The OL flap produced intermediate outcomes, characterized by limited gingival recession but a higher prevalence of visible mucosal scarring. This observation aligns with previous reports noting that while submarginal incisions effectively protect the marginal gingiva, they may heal with fibrous scar formation due to incision placement within attached gingiva.[15,16] Although scars were confined to the attached gingiva and did not compromise periodontal parameters, their visibility may be undesirable in patients with high smile lines. Moreover, the OL flap is technique-sensitive and contraindicated in cases with inadequate attached gingiva or coronally extended lesions, limiting its universal applicability.[16]

Postoperative morbidity findings further differentiated the flap designs. Patients treated with the IS reported significantly higher pain and swelling scores, likely attributable to broader tissue reflection and greater periosteal trauma.[17] Reduced postoperative discomfort in the PBI group may reflect improved flap stability and reduced tension at the incision line. These findings are in agreement with patient-centered outcome studies emphasizing that minimally invasive flap designs contribute to enhanced early healing and patient satisfaction.[17,18]

Importantly, radiographic healing at 12 months did not differ significantly among the three groups, indicating that flap design primarily influences soft-tissue outcomes rather than periapical bone healing. This observation is supported by systematic reviews and longitudinal studies demonstrating that modern endodontic microsurgery success is predominantly governed by effective root-end management, including adequate resection, ultrasonic preparation, and biocompatible root-end filling materials.[18–20] As all groups in the present study were treated using standardized microsurgical protocols, comparable osseous healing outcomes were expected.

From a clinical standpoint, these findings underscore the necessity of individualized flap selection. While the IS may still be appropriate in posterior regions or in cases where access is paramount and esthetic concerns are minimal, its routine use in the anterior maxilla should be approached cautiously. The PBI emerges as the flap of choice for esthetic zones with intact periodontal architecture, whereas the OL flap remains a valuable alternative when marginal tissue preservation is prioritized and attached gingiva is adequate.

The study's limitations include a single-center design, a nonrandomized study, and a focus on short- to medium-term soft-tissue outcomes. Future multicenter trials with longer follow-up and objective esthetic scoring systems may further refine flap selection guidelines. Nevertheless, the present findings contribute meaningful clinical evidence supporting biologically driven flap design in apicoectomy.

Conclusion

Flap design plays a decisive role in soft-tissue healing following apicoectomy. Within the limitations of this study, the PBI demonstrated the most favorable outcomes in terms of gingival margin stability, papilla preservation, and patient comfort, particularly in esthetically sensitive regions. The IS was associated with greater gingival recession and postoperative morbidity, while the OL flap offered marginal tissue protection at the expense of increased scar visibility. Radiographic healing was comparable across all designs, emphasizing that flap selection primarily influences esthetic and periodontal outcomes rather than periapical success.

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