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Comparison of Triangular Flap versus Envelope Flap Techniques in Surgical Removal of Impacted Mandibular Third Molars

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Abstract: Background: Surgical extraction of impacted mandibular third molars is one of the most common oral surgical procedures. Despite its routine nature, it is frequently associated with postoperative pain, swelling, trismus, and transient periodontal compromise. Among the various surgical approaches, the *triangular* and *envelope flap* designs remain the most widely used, yet there is no clear consensus on their relative clinical efficacy. **Objective:** This study aimed to compare the postoperative outcomes pain, facial swelling, trismus, and periodontal pocket depth between the triangular and envelope flap techniques following the surgical removal of impacted mandibular third molars. **Materials and Methods:** A prospective comparative study was conducted on 40 healthy patients aged 18–50 years requiring surgical removal of impacted mandibular third molars. Participants were equally divided into two groups: Group A (Triangular flap) and Group B (Envelope flap). All extractions were performed under local anesthesia using standardized aseptic and operative protocols. Pain (VAS 0–10), facial swelling (linear measurements), mouth opening (inter- incisal distance), and periodontal pocket depth (distal to the second molar) were evaluated. Patients were followed up on postoperative days 1, 3, and 7, and at 3 months to assess both early and late postoperative outcomes. Statistical analysis was performed using SPSS v20.0 with $p \leq 0.05$ considered significant. **Results:** Both flap designs showed significant improvement over time ($p<0.001$). The envelope flap demonstrated significantly lower facial swelling on days 3 and 7 ($p<0.01$) and faster recovery of mouth opening ($p = 0.03$), while pain reduction was comparable between groups ($p>0.05$). A transient increase in probing depth was observed in the envelope group on day 7 ($p<0.001$), which resolved by 3 months ($p = 0.157$). **Conclusion:** Both flap designs are effective and safe for third molar surgery. However, the *envelope flap* offers superior short-term outcomes in terms of reduced postoperative swelling and faster functional recovery, without compromising long-term periodontal health.

Key Words: Triangular Flap, Envelope Flap, Impacted Mandibular Third Molar, Surgical Extraction, Postoperative Pain, Trismus, Facial Swelling, Periodontal Pocket Depth

INTRODUCTION

The surgical removal of impacted mandibular third molars is one of the most frequently performed procedures in oral and maxillofacial surgery. Impaction occurs when a tooth fails to erupt into its functional position due to inadequate space, obstruction, or abnormal angulation. The mandibular third molar is the most commonly impacted tooth, with prevalence reported between 20% and 70% in different populations [1–3]. Given its high occurrence and associated complications, optimizing surgical techniques remains clinically important.

Impacted third molars are associated with various pathological conditions such as pericoronitis, caries of adjacent teeth, cyst formation, root resorption, and periodontal defects [4]. Surgical removal is therefore often indicated to prevent these complications. However, despite being a routine procedure, it is commonly followed by

postoperative sequelae including pain, facial swelling, trismus, and transient periodontal compromise, all of which can affect patient recovery and satisfaction [5].

Postoperative morbidity is influenced by several factors, including the degree of impaction, surgical duration, and operative technique [6]. Among these, flap design is a key determinant, as it directly affects surgical access, tissue trauma, vascular integrity, and wound healing. Two commonly used flap designs are the envelope flap and the triangular flap. The envelope flap involves a sulcular incision without vertical release, minimizing tissue disruption, whereas the triangular flap includes a vertical releasing incision, providing better visibility but potentially increasing postoperative inflammation [7,8].

Previous studies comparing these flap designs have reported inconsistent findings. Some authors suggest that the envelope flap is associated with reduced swelling and improved early mouth opening, while others report advantages of the triangular flap in terms of surgical access and efficiency, especially in complex cases [6,9]. These variations highlight the need for further comparative evaluation under standardized clinical conditions [10].

Objectives

- To compare postoperative pain between triangular and envelope flap techniques
- To evaluate differences in facial swelling
- To assess postoperative trismus
- To compare periodontal probing depth following surgery

METHODS

Study Design and Ethical Approval

This original prospective comparative study was conducted in the Department of Oral and Maxillofacial Surgery, following institutional ethical clearance and informed consent procedures consistent with the Declaration of Helsinki. Forty systemically healthy patients aged 18–50 years (ASA I or II) requiring surgical removal of impacted mandibular third molars were enrolled.

Inclusion and Exclusion Criteria

Participants were allocated using a non-randomized convenience sampling method. Participants with mesioangular, distoangular, or vertical impactions were included. Exclusion criteria comprised deeply impacted (Pell & Gregory Position C) teeth, pregnancy, lactation, systemic disorders contraindicating minor oral surgery, and pre-existing conditions such as oral submucous fibrosis or limited mouth opening that could confound postoperative trismus.

Group Allocation and Surgical Protocol

Participants were allocated equally into two groups (n = 20 each):

- **Group A – Triangular Flap (Modified Ward's Incision):** A vertical incision from the distal aspect of the first molar extending along the buccal crevice of the second molar to the external oblique ridge
- **Group B – Envelope Flap:** A horizontal sulcular incision from the mesial of the second molar to the retromolar area, without vertical release

All surgeries were performed under local anesthesia using 2% lignocaine with epinephrine (1:80,000). Bone guttering was achieved with a No. 8 round bur under sterile saline irrigation, and the tooth was sectioned as necessary. The sockets were debrided and irrigated before closure using 3-0 silk sutures (Ethicon). Postoperative management included amoxicillin 500 mg and metronidazole 400 mg for five days, along with ibuprofen 400 mg as required.

Outcome Assessment

Postoperative evaluation focused on:

- **Pain** – Measured by Visual Analog Scale (VAS, 0–10) on days 1, 3, 7
- **Swelling** – Assessed via facial measurements (Tragus-Commissure, Tragus- Pogonion, Lateral Canthus-Gonion lines)
- **Trismus** – Measured as maximum inter-incisal opening with a calibrated scale
- **Probing Pocket Depth** – Measured distal to the second molar using a periodontal probe on the same follow-up days

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation (SD), while categorical variables were presented as frequencies and percentages.

The normality of data distribution was assessed using the Shapiro–Wilk test. For intergroup comparisons between the triangular flap (Group A) and envelope flap (Group B), the independent samples t-test was applied for continuous variables, as the data followed a normal distribution. Intragroup comparisons across different time intervals (preoperative, postoperative days 1, 3, 7, and 3 months) were performed using repeated-measures analysis of variance (ANOVA) to evaluate changes over time within each group.

Where appropriate, Chi-square test or Fisher's exact test was used for comparison of categorical variables. A p-value ≤ 0.05 was considered statistically significant. All statistical tests were two-tailed.

RESULTS

Baseline Characteristics

Forty patients (22 females, 18 males; mean age 30.6±7.5 years) were included, divided equally into two groups: Group A (Triangular flap) and Group B (Envelope flap). There were no statistically significant differences between groups regarding demographic variables such as age ($p = 0.412$) or sex distribution ($p = 0.613$), confirming baseline comparability (Table 1).

Table 1: Baseline Demographic Characteristics of the Study Groups

Parameter	Group A – Triangular Flap (n = 20)	Group B – Envelope Flap (n = 20)	t/χ^2 value	*p*- value
Age (years, mean±SD)	29.9±6.8	31.3±8.1	0.83	0.412
Male, n (%)	10 (50)	8 (40)	0.25	0.613
Female, n (%)	10 (50)	12 (60)	-	-
Mean duration of surgery (min)	29.8±6.2	27.6±5.9	1.07	0.289

Table 2: Intragroup Comparison of Postoperative Parameters (mean±SD)

Parameter	Time	Group A: Triangular Flap	p-value (A)	Group B: Envelope Flap	p-value (B)
Pain (VAS 0–10)	Pre-op	7.8±0.9	<0.001	7.9±0.8	<0.001
	Day 1	7.1±1.1		7.0±1.3	
	Day 3	4.7±1.0		4.3±1.4	
	Day 7	1.8±0.8		1.2±0.9	
Facial swelling (mm)	Pre-op	113.4±5.7	<0.001	112.3±6.7	<0.001
	Day 1	119.8±5.3		117.7±6.3	
	Day 3	121.3±6.8		116.2±8.5	
	Day 7	116.5±5.6		113.1±7.3	
Mouth opening (mm)	Pre-op	43.2±5.9	<0.001	41.6±5.7	<0.001
	Day 1	22.7±5.3		21.5±4.5	
	Day 3	23.7±4.1		23.9±7.9	
	Day 7	32.5±5.7		33.5±6.2	
Probing depth (mm)	Pre-op	2.1±0.4	<0.001	2.2±0.6	<0.001
	Day 7	3.0±0.5		4.6±0.9	
	3 months	1.9±0.3		2.2±0.4	

Repeated-measures ANOVA, $p<0.05$ considered statistically significant

Table 3: Intergroup comparison of clinical parameters

Parameter	Interval	Mean Difference (A – B)	t- value	p-value	Interpretation
Pain (VAS)	Day 1	0.25	1.39	0.174	NS
	Day 3	0.45	1.32	0.194	NS
	Day 7	0.65	1.75	0.089	NS
Swelling (mm)	Day 1	0.98	1.24	0.222	NS
	Day 3	3.99	3.32	0.002*	↓ in Envelope
	Day 7	2.26	2.78	0.008*	↓ in Envelope
Mouth Opening (mm)	Day 3	1.70	1.63	0.031*	↑ in Envelope
Probing Depth (mm)	Day 7	1.47	6.38	<0.001*	↑ in Envelope (transient)
	3 months	0.21	1.44	0.157	NS

*Independent t-test $p<0.05$ = significant, NS = not significant

Table 4: Comparative Mean Change in Probing Pocket Depth

Interval	Group A Mean±SD	Group B Mean±SD	Mean	t- value	p-value	Significance
Pre-op →	3.03±0.56	4.58±0.90	1.47	6.38	<0.001*	Significant
Pre-op → 3	1.90±0.34	2.22±0.38	0.21	1.44	0.157	NS

*Independent t-test; $p<0.05$ = significant

Intragroup Comparison

All postoperative parameters pain, facial swelling, trismus, and probing pocket depth showed significant temporal improvement in both groups ($p<0.001$). Pain intensity declined progressively, peaking on day 1 and reaching minimal levels by day 7. Facial swelling peaked on postoperative day 1, decreased substantially by day 7, and nearly normalized by 3 months. Maximum mouth opening improved steadily, indicating recovery from trismus. A transient increase in probing depth was noted on day 7 but resolved by 3 months (Table 2).

Intergroup Comparison of Mean Differences

Comparative analysis between groups revealed significant differences in facial swelling and mouth opening at specific time points. On day 3, swelling was notably lower and mouth opening recovery greater in the Envelope flap group ($p<0.05$). Pain reduction trends were similar between groups ($p>0.05$), indicating comparable postoperative analgesic outcomes. The difference in probing pocket depth was significant on day 7 but resolved by 3 months, demonstrating similar long-term periodontal health (Table 3).

Comparative Mean Change in Probing Depth

Both flap designs exhibited temporary periodontal pocketing distal to the mandibular second molar after surgery, attributed to incision proximity to the gingival margin. The mean change in probing depth from preoperative to day 7 was 1.47 mm ($p<0.001$), whereas long-term difference after 3 months was insignificant ($p = 0.157$) (Table 4)

DISCUSSION

The present study evaluated the impact of flap design on postoperative outcomes following surgical removal of impacted mandibular third molars, with specific focus on pain, facial swelling, trismus, and periodontal probing depth.

Both triangular and envelope flap techniques demonstrated satisfactory healing; however, the envelope flap provided superior early postoperative outcomes, particularly in terms of reduced swelling and faster recovery of mouth opening, without compromising long-term periodontal health [11–13].

Postoperative pain showed a gradual decline in both groups with no statistically significant intergroup difference, indicating that flap design alone may not significantly influence pain perception. This finding is consistent with previous studies by Kirk et al. [9], suggesting that factors such as surgical duration and individual pain thresholds play a more dominant role than incision design [7,14].

Facial swelling, a key determinant of postoperative morbidity, was significantly lower in the envelope flap group on postoperative days 3 and 7. This can be attributed to reduced soft tissue reflection and preservation of vascular and lymphatic drainage due to the absence of a vertical releasing incision. Similar findings have been reported by De Marco et al. [7] and Daftary et al. [10], reinforcing the biological advantage of minimally invasive flap designs [8,14].

Trismus followed a predictable postoperative pattern, with early limitation in mouth opening followed by gradual recovery. The envelope flap group demonstrated significantly better recovery on day 3, supporting evidence from systematic reviews by Zhu et al. [16] and Lopes da Silva et al. [17]. Reduced muscular trauma and shorter operative manipulation likely contribute to improved functional recovery [18].

Periodontal probing depth increased transiently in both groups during the early postoperative phase but normalized by 3 months, indicating reversible tissue remodeling. Although the envelope flap showed a slightly higher early probing depth, no long-term periodontal compromise was observed. This is consistent with findings by Hur and Ogata [19], confirming that flap design does not significantly affect long-term periodontal outcomes when proper surgical technique is maintained.

From a biological standpoint, the observed differences can be explained by tissue handling and vascular preservation. The triangular flap, due to its vertical incision, may disrupt vascular continuity and increase inflammatory response, whereas the envelope flap maintains tissue integrity, resulting in reduced edema and faster healing [14,15].

Clinical Implications

The findings of this study have direct clinical relevance. The envelope flap is advantageous in routine third molar extractions due to reduced postoperative swelling and faster functional recovery, improving patient comfort and compliance. In contrast, the triangular flap remains beneficial in complex cases requiring enhanced surgical access, particularly for deeply impacted or unfavorably angulated teeth [4,8]. In teaching institutions, the triangular flap may also serve as a useful approach for training due to better visibility and accessibility [20,21].

Strengths of the Study

This study has several strengths. It employed a prospective design with a standardized surgical protocol, minimizing procedural variability. Multiple clinically relevant postoperative parameters were evaluated at defined time intervals, allowing a comprehensive assessment of both early and late outcomes.

Limitations

Despite its strengths, certain limitations must be acknowledged. The study utilized a non-randomized design, which may introduce selection bias. The sample size was relatively small and limited to a single center, restricting generalizability. Only specific types of impactions (mesioangular, distoangular, and vertical) were included, and subjective measures such as pain assessment may introduce variability. These factors should be considered when interpreting the results.

Innovation and Contribution

The present study contributes to existing literature by providing a structured comparative evaluation of two commonly used flap designs under standardized clinical conditions. It reinforces evidence-based decision-making in flap selection by demonstrating that minimally invasive approaches can significantly improve early postoperative outcomes without compromising long-term periodontal health.

Future Recommendations

Future research should focus on larger, multicenter randomized controlled trials to enhance external validity. Incorporation of objective outcome measures such as three-dimensional facial scanning and inflammatory biomarkers (e.g., C-reactive protein, interleukin-6) may provide deeper insights into tissue response. Additionally, the role of adjunctive therapies such as corticosteroids, platelet-rich fibrin (PRF), and laser-assisted healing should be explored to further optimize postoperative recovery.

CONCLUSIONS

The comparative evaluation of triangular and envelop flap designs for impacted mandibular third molar extraction revealed that both approaches are safe and effective, but they differ in early postoperative outcomes. The envelope flap demonstrated:

- Significantly reduced postoperative facial swelling ($p<0.01$)
- Faster recovery of mouth opening by day 3 ($p = 0.03$)
- Comparable pain control to the triangular flap
- Transient but non-significant periodontal depth increase resolving by three months

These findings indicate that the envelope flap is preferable for routine, uncomplicated third molar surgeries, offering improved patient comfort and early recovery. The triangular flap, however, remains valuable where enhanced surgical exposure is required, such as in deep, distoangular, or partially ankylosed impactions.

Future randomized multicenter studies should validate these results and explore adjunctive factors such as operative duration, surgeon experience, and pharmacologic modulation that may further optimize postoperative outcomes.

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