

Systematic Review

EFFECT OF SURGICAL FLAP DESIGNS ON POSTOPERATIVE COMPLICATIONS FOLLOWING MANDIBULAR THIRD MOLAR SURGERY: A SYSTEMATIC REVIEW

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ABSTRACT

Objectives: To evaluate the results following various surgical flaps designs for mandibular third molar surgery to determine surgical flap designs are associated with better postoperative recovery.

Materials and Methods: In this systematic review, different flap designs were analyzed based on postoperative symptoms, following the PRISMA guidelines. We systematically reviewed comparative studies analyzing flap designs based on postoperative symptoms. Main flap designs included the envelope flap, triangular flap, modified envelope flap, modified triangular flap, Szmyd flap, triangular transposition flap and flapless design.

Results: Twenty-one studies comprising 1346 patients were analyzed, and the least satisfactory results were observed with conventional flaps (i.e., envelope and triangular flaps), whereas most studies reported more favorable postoperative outcomes with flapless designs. Apart from the flapless design, the Szmyd flap and the triangular transposition flap showed the best results among the flaps.

Conclusion: Minimally invasive and flap-preserving procedures have shown lower postoperative morbidity than conventional flaps, although there are significant clinical and methodological variability and design of a universally superior procedure is not recommended.

Key words: Impacted Third Molar; Pain; Postoperative Complications; Surgical Flaps; Tooth Extraction; Trismus; Wound Healing

Cite as: Akram Z, Aamer SA, Naeem S, Kaleem R, Karamat A, Hassan G. Effect of Surgical flap designs on postoperative complications following mandibular third molar surgery: A Systematic Review. Journal of Khyber College of Dentistry Sep 2026, Vol. 16, No. 3. <http://doi.org/10.33279/jkcd.v16i03.1037>

INTRODUCTION

Wisdom teeth or third molars are the most common impacted teeth in the oral cavity¹. The prevalence of mandibular third molar impaction

continues to increase, reaching up to 90%, and almost 30% of the population has at least one impacted third molar². So, mandibular third molar surgery is the most frequently performed procedure in the oral and maxillofacial surgery department³. However, it is generally associated with various postoperative complications, including swelling, pain, trismus, and periodontal defects on the distal surface of the second molar⁴. Such complications basically arise from surgical trauma, flap reflection and inflammatory response⁵. Among the several factors that influence postoperative outcomes, the design of the surgical

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Date Submitted: April 2026

Date Revised: July 2026

Date Accepted: August 2026

flap plays a pivotal role because it determines the degree of soft-tissue trauma, visibility of the surgical field, ease of bone removal, operative time, and the pattern of wound healing².

Multiple flap designs are widely used to optimize surgical access and minimize postoperative complications. These include the traditional envelope flap, triangular flap, modified triangular flap, Szmyd flap, comma-shaped flap, and several other minimally invasive surgical flaps or flapless techniques⁶. Each flap has different incision directions, tissue elevation, blood supply preservation, and surgical site tension⁷. The triangular flap provides greater visibility but may increase tension and risk of dehiscence. However, the envelope flap offers wider access with minimal incisions. In recent years, several newer flap techniques have grabbed more attention than conventional flaps. These mainly involve minimally invasive, papilla-preserving flaps, triangular transposition flaps (TTF), and other flapless approaches⁸. These designs contain the potential to reduce postoperative discomfort and preserve periodontal health around the adjacent second molar⁹.

Despite the increasing number of randomized controlled trials in evaluating flap designs, the literature remains inconsistent. Some studies report significant reductions in pain, swelling, or wound dehiscence with modified incisions, whereas others find no meaningful differences between conventional and innovative flaps¹⁰. Heterogeneity in study designs, surgical techniques, operator experience, tooth impaction types, and postoperative assessment methods contributes to the overall dissimilar findings³. This lack of consensus creates uncertainty among clinicians about which flap design is preferred for optimal patient outcomes.

Previous systematic reviews have mainly compared conventional envelopes and triangular flap designs. Several novel procedures have been evaluated through recent randomized controlled trials, such as modified envelope flaps, modified triangular flaps, Szmyd flaps, papilla-preserving techniques, triangular transposition flaps, comma incisions, and flapless approaches. These modern approaches have not been synthesized in one place, and the best design for a flap for minimizing postoperative complications is not known.

We hypothesized that when patients underwent

mandibular third molar extraction in adults, those who received modified or minimally invasive flaps experienced less postoperative morbidity when compared with patients receiving traditional envelope or triangular flaps. This systematic review aimed to compare the outcomes of the postoperative period (pain, swelling, trismus, wound healing and periodontal parameters) between the modified or minimally invasive flap design and the conventional envelope or triangular flaps in this patient population.

MATERIALS AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines were followed to ensure clear reporting and reproducible selection, data extraction, and synthesis of evidence from the studies. The purpose of this review was to systematically and critically evaluate and synthesize the clinical evidence concerning the differently applied surgical flap design and postoperative complications in the removal of third molars and their comparison.

The review question was developed in a PICO manner: Adult patients (aged ≥ 18 years) undergoing surgical extraction of impacted mandibular third molars. Modified or non-traditional surgical designs of flaps, e.g., modified envelope flap; modified triangular flap; Szmyd flap; triangular transposition flap; papilla-preserving flap; comma incision and flapless procedures. Comparisons were of conventional surgical flap designs, including the envelope flap and triangular flap. Outcomes included postoperative pain, swelling, trismus, wound healing, wound dehiscence and infection, periodontal pocket depth, clinical attachment loss, bleeding on probing, and other periodontal outcomes.

An extensive electronic literature search was conducted in PubMed (MEDLINE), and Google Scholar for relevant studies since 2015 till 2026 May. The last study search was carried out on 31st May 2026. The reference lists of all included studies and relevant review articles were hand-searched for additional studies to ensure completeness.

Boolean operators (AND, OR) were used between Medical Subject Headings (MeSH) and free-text keywords to achieve the highest search sensitivity. Contains the following search terms in the PubMed search strategy: ("Molar, Third"[MesSH

Terms] OR “third molar” [Title/Abstract] OR “mandibular third molar” [Title/Abstract] OR “wisdom tooth” [Title/Abstract] OR “wisdom teeth” [Title/Abstract]) AND (Surgical Flaps” [MeSH terms] OR “envelop flaps” [Title/Abstract] OR “triangular flap” [Title/Abstract] OR “modified envelop flap” [Title/Abstract] OR “modified envelop flap” [Title/Abstract] OR “modified transposition flap” [Title/Abstract] OR “papilla-preserving flap” [Title/Abstract] OR “papilla preserving” [Title/Abstract] OR “modified papilla-preserving” [Title/Abstract] OR “flapless” [Title/Abstract] OR “single incision access” [Title/Abstract] OR “comma incision” [Title/Abstract] AND (“Postoperative Complications” [MeSH Terms] OR “pain” [Title/Abstract] OR “swelling” [Title/Abstract] OR “oedema” [Title/Abstract] OR “trismus” [Title/Abstract] OR “wound dehiscence” [Title/Abstract] OR “infection” [Title/Abstract] OR “wound healing” [Title/Abstract] OR “periodontal pocket” [Title/Abstract] OR “clinical attachment loss” [Title/Abstract] OR “bleeding on probing” [Title/Abstract] OR “alveolar osteitis” [Title/Abstract] OR “dry socket” [Title/Abstract]).

The equivalent keyword string was adapted for Google Scholar. Boolean operators, truncation and/or phrase searching were used, where appropriate, to improve the retrieval of relevant publications.

Studies were eligible for this systematic review if they met all of the following criteria: (1) original human clinical studies involving adult patients (≥ 18 years) undergoing surgical extraction of impacted mandibular third molars; (2) randomized controlled trials (RCTs), randomized clinical trials, prospective or retrospective comparative studies, or controlled clinical trials; (3) comparison of two or more surgical flap designs reporting at least one clinically relevant postoperative outcome such as pain, swelling, trismus, wound healing, wound dehiscence, infection, alveolar osteitis, periodontal pocket depth, clinical attachment loss, bleeding on probing, or periodontal bone changes); (4) articles published in English between 2015 and 2026 were included.

Studies were excluded if they: (1) involved only maxillary third molars or included patients under 18 years; (2) were animal, laboratory, or cadaveric studies, case reports, case series, narrative or systematic reviews, conference abstracts, editorials, letters, or expert opinions were excluded; (3) did not report

postoperative clinical outcomes separately for impacted mandibular third molars were excluded; (4) involved cysts, tumors, fractures, or other concurrent surgical techniques were excluded; (5) lacked a comparison group, had duplicate publication, or presented insufficient clinical outcome data were excluded.

All records identified in the electronic database search were transferred to reference management software before duplicates were removed to avoid duplicate records during screening. Two reviewers independently screened all retrieved studies for eligibility based on titles and abstracts. Full-text articles of potentially relevant studies were then independently assessed for inclusion/exclusion based on the predetermined criteria. Where the two reviewers differed in their judgment of eligibility, they discussed the studies until they reached a consensus. If consensus was not reached, the third reviewer consulted and made the final decision.

The study selection process was described using the PRISMA-2020 flow chart, indicating the number of records identified, records excluded due to duplicates, records screened for eligibility, full articles assessed for eligibility, reasons for exclusion of articles, and the number of articles included in the qualitative synthesis.

A data extraction form was created before data

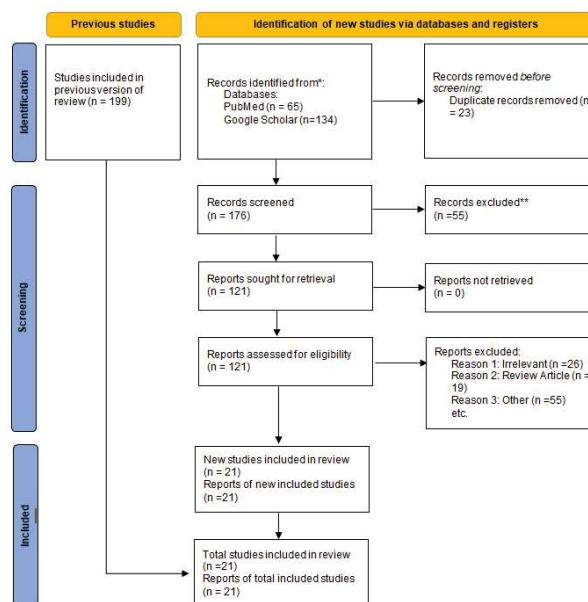


Fig 1: PRISMA 2020 flow diagram of the study selection process.

collection to ensure the data collected were uniform and coherent across all studies included in the study. Each eligible study was used to obtain data independently by the reviewers. Information extracted consisted of first author, year of publication, country of origin, study design, sample size, age and sex distribution of patients, type of impaction, type of surgical flap used, postoperative complications assessed, duration of follow-up, main findings and conclusions from the study authors. Discrepancies were checked during data extraction and addressed through discussion and reviewer consensus.

Two independent reviewers used the Cochrane Risk of Bias 2 (RoB 2) to assess methodological quality of the included RCTs (randomized controlled trials). Bias from the randomization procedures, bias from deviation from intervention, bias from loss of outcome data, bias from measurement of outcomes and bias from reporting of outcomes were assessed for each methodological domain. The Cochrane RoB 2 principal criteria were used to determine risk of bias within the studies, which were classified as low, some concerns, and high risk of bias. Reviewers discussed disagreements; if they could not be resolved, a third reviewer was consulted. Table 4 shows the overall risk-of-bias assessment for each included study. A quantitative meta-analysis was considered inappropriate because of wide variation in study designs among the included studies, including how patients received their flaps, the surgical procedure, the outcome and evaluation measures used, the length of follow-up, and the reported findings. For this reason, a structured narrative synthesis was used to bring the findings together.

Because of the marked clinical and methodological diversity of the studies included, each of which presented different flap design, surgical technique, measures of outcomes, and lengths of follow-up, it was preemptively determined that a quantitative analysis, or meta-analysis, with effect estimates across studies was undesirable. Outcome measures varied from unidimensional VAS (0-10 cm) to multidimensional facial swelling metrics (linear tape measurements, 3D scanners, or 3D scanner, 2D photographic analysis), and follow-up from 5 days to 6 months. Give the anticipated high rates of intra/interresearcher agreement ($I^2 > 75\%$) for all outcomes, we carried out a structured narrative synthesis, with the results presented for each domain of postsurgical

outcome grouped (surgery-related pain, surgery-related swelling, trismus, wound healing, infection, periodontal health) and summarized in terms of the direction and size of effects reported per study.

Because of the wide variety of clinical and methodological differences between the included studies, such as variations in flap designs, surgical procedures, outcome-measurement methods, and follow-up lengths, a quantitative meta-analysis with pooled effect estimates was considered unsuitable. Outcome measures ranged from a single dimension (VAS 0-10 cm scale) to multi-dimensional assessment (with facial swelling assessed by linear tape measures, 3D measurements via scan, or 2D photographic analysis), and follow-up ranged from 5 days to 6 months. Given the prior expectations of $I^2 > 75\%$ for all outcomes, a structured narrative synthesis of findings was performed, grouping findings into six categories: postoperative pain, postoperative swelling, postoperative trismus, postoperative wound healing, postoperative infection, and postoperative periodontal health. Direction and magnitude of the effects reported in each study were summarized.

The included studies were categorized based on the outcome measured after surgery such as pain, swelling, trismus, wound healing, wound dehiscence, infection and periodontal health. Study findings were summarized by reporting the number of studies that found the experimental flaps to be more effective than the control flaps and/or the number of studies reporting a lack of a statistically significant difference between the experimental flaps and the control flaps.

RESULT

The search strategy identified 199 relevant research articles. Twenty-three research papers were duplicates, 18 were not in English, 37 were older than 2015, and 45 were excluded based on the screening of titles and relevance to the topic. The remaining 21 research articles became part of the systematic review. These 21 research articles were randomized controlled trials, randomized clinical trials or comparative studies.

Based on the included research articles as described in Table 1, a total of 1346 patients were analyzed for postoperative complications of mandibular third molar surgery. All the patients included in the primary studies were healthy, as reported in

the primary studies. The patients' age range differed across studies, but it was between 18 and 60 years in all included studies. The follow-up period differed across studies, ranging from a minimum of 5 days to a maximum of 6 months. Moreover, it included randomized controlled trials, randomized clinical trials, comparative studies and retrospective studies. The main flap designs included were the modified envelope flap, envelope flap, modified triangular flap, triangular flap, Szmyd flap, and several others. Similarly, the main outcomes measured were pain, swelling, trismus, wound dehiscence, infection and periodontal health.

Of the 21 studies included (1,346 patients), the most common outcome tested was postoperative pain. Eight studies reported significantly less postoperative pain with some modified surgical techniques (modified envelope, minimally invasive envelope, comma, flapless, and single incision). In contrast, 5 studies that tested conventional envelope and triangular flap geometry found no statistically significant difference in postoperative pain, suggesting that conventional flap geometry is unlikely to significantly affect pain perception.

This same trend was also observed for postoperative swelling. Seven studies showed a significant decrease in swelling with a minimally invasive or modified flap design, and four studies showed no significant difference between conventional flap designs. Collectively, the data in this review indicate a general trend toward decreased postoperative swelling with tissue-preserving surgical techniques, but not a consistent trend across studies.

Five studies reported increased mouth opening after a minimally invasive or modified flap technique and 6 studies reported no statistically significant differences between the flap designs being compared for trismus. These conflicting results may be due to differences in technical difficulty, surgery duration, and methods of measuring maximum mouth opening.

As for wound healing and wound dehiscence, three studies showed better results with the Szmyd flap or the triangular transposition flap (TTF), as they had fewer instances of wound dehiscence and better soft-tissue healing than envelope flaps. In contrast, when comparing conventional envelope and triangular flaps, similar wound-healing results

were usually found.

Several studies evaluated periodontal outcomes with the following measurements: bleeding on probing (BOP) and bone level measurements. Four studies consistently found that papilla preservation resulted in better periodontal probing depth (PPD), clinical attachment loss (CAL), bleeding on probing (BOP), and bone level measurements. Four studies consistently found that papilla preservation resulted in better periodontal healing, with the Szmyd flap, modified triangular flap and triangular transposition flap showing the least distal periodontal pocket depth and the best preservation of periodontal attachment around the adjacent second molar.

Together, the evidence suggests a consistent trend towards reduced early postoperative morbidity and improved periodontal outcomes with minimally invasive, tissue-preserving flap designs. However, the magnitude of these benefits has varied widely across studies because of differences in flap technique, the nature of impaction, outcome measures, follow-up duration, and methodological approach.

The primarily analyzed postoperative outcomes were pain, swelling, trismus, wound dehiscence, infection and periodontal health. Analyzed postoperative findings suggest that the flapless designs or minimally invasive surgical methods tend to reduce immediate postoperative pain, swelling, and trismus. Apart from less invasive surgical techniques, the szmyd flap and transposition-based techniques demonstrate notable advantages in minimizing wound dehiscence and protecting the periodontal health of the second molar. However, no significant difference was observed in the postoperative pain, swelling, trismus or wound dehiscence in the envelope or triangular flap design. Table 3 presents details of the postoperative outcomes for different flap designs.

Table 4 shows the methodological quality of the included RCTs was summarized using Cochrane Risk of Bias 2. Most studies had a low overall risk of bias, indicating they were methodologically acceptable. A small number of studies were rated as having some concerns, mainly because of poor reporting of allocation concealment, blinding and selective outcome reporting. Overall, the quality assessment indicated that the evidence included in this review is

generally reliable, and the identified methodological limitations need to be considered when interpreting the review findings.

Table 1: Characteristics of Included Studies

Author & Year	Country	Study Design	Sample Size	Flap Design(s)	Comparison	Outcomes Measured	Follow-up	Main Findings
Xie et al., 2021 ¹¹	China	Randomized controlled trial	40	Modified envelope flap	Modified triangular flap	Pain, swelling, trismus, wound healing	7 days	Modified envelope flap reduced swelling and pain.
Daftary et al., 2025 ¹²	India	Comparative study	40	Envelope flap	Triangular flap with modified Ward's incision	Pain, swelling, trismus	3 months	Envelope flap decreased postoperative swelling and pain.
Hassan et al., 2020 ¹³	Syria	Randomized clinical trial	34	Lingual-based four-cornered flap	Conventional triangular flap	Pain and discomfort	5 days	Reduced pain and discomfort with lingual-based four-cornered flap.
Zhao et al., 2023 ¹⁴	China	Randomized controlled trial	100	Modified triangular flap	Triangular flap	PPD, PI, BOP, inflammatory markers	8 weeks	The triangular flap showed greater PPD, IL-1 β , and infection.
Alqahtani et al., 2017 ¹⁵	Saudi Arabia	Comparative study	60	Modified envelope flap	Modified triangular flap	Pain, dehiscence, swelling	3 months	Modified envelope flap reduced swelling and pain.
Shahi et al., 2024 ¹⁶	India	Randomized controlled trial	88	Buccal-based triangular flap	Lingual-based triangular flap	Pain, swelling, trismus	28 days	Buccal-based flap lowered pain and swelling.
Costa et al., 2022 ⁵	Brazil	Randomized clinical trial	60	Minimally invasive envelope flap	Conventional envelope flap	Swelling, pain, trismus	7 days	Less pain, swelling and speech discomfort.
Chiramel et al., 2018 ¹⁷	India	Randomized clinical study	50	Szmyd flap	Envelope flap	Healing, dehiscence, distal PPD	14 days	Better healing and lower distal PPD.
Elo et al., 2016 ¹⁸	USA	Randomized clinical trial	196	Envelope flap	Modified triangular flap	Dehiscence, infection	7 days	Less dehiscence and infection.
Lohana et al., 2024 ⁹	Pakistan	Randomized clinical trial	126	Comma flap	Modified Ward's flap	Trismus, swelling, pain	7 days	Comma flap reduced pain, swelling and trismus.
Ahmad et al., 2021 ¹⁹	Saudi Arabia	Randomized controlled trial	60	Envelope flap	Szmyd flap	PPD, CAL, bone levels	6 months	Szmyd flap improved attachment and bone stability.
Rahman et al., 2021 ²⁰	Pakistan	Randomized controlled trial	70	Envelope flap	Triangular flap	Healing, pain	7 days	Similar outcomes in both groups.
Mobilio et al., 2017 ²¹	Italy	Randomized controlled trial	25	Envelope flap	Triangular flap	Pain, trismus, swelling	7 days	No difference.
Rahpeyma et al., 2015 ²²	Iran	Randomized controlled trial	60	Envelope flap	Triangular transposition flap	Dehiscence, infection, dry socket	1 month	TTF reduced wound dehiscence.
Karpe et al., 2025 ²³	Saudi Arabia	Randomized controlled trial	120	Flapless	Buccal flap	Swelling, pain, discomfort, pocket depth	7 days	Flapless approach improved outcomes.

Table 1: Characteristics of Included Studies

Sridharan et al., 2020 ²⁴	India	Randomized comparative study	50	Oblique anterior releasing incision	Vertical anterior releasing incision	Pain, swelling, trismus, PPD, healing	1 month	No significant differences.
Materni et al., 2021 ²⁵	Italy	Randomized clinical study	12	Flapless surgical approach	Traditional envelope flap	Discomfort, pain, oedema	8 weeks	Less pain and oedema.
Materni et al., 2023 ⁴	Italy	Randomized controlled clinical trial	42	Flapless surgical approach	Single incision access	Pain, oedema, pocket depth	7 days	SIA showed faster healing and less pain/oedema.
da Silva et al., 2020 ³	Brazil	Randomized clinical trial	49	Envelope flap	Triangular flap	Pain, oedema, trismus, dehiscence	7 days	No significant differences.
Glera-Suárez et al., 2020 ²	Spain	Randomized clinical trial	43	Envelope flap	Triangular flap	Pain, trismus, swelling	7 days	No significant differences.
Zhu et al., (26)2019 ²⁶	China	Randomized controlled trial	21	Envelope flap	Triangular flap	Pain, trismus, swelling, dehiscence	7 days	Envelope flap reduced pain and trismus.

Table 3: Summary of postoperative outcomes associated with different flap designs in mandibular third molar surgery

Outcome	Flap types with better results	Flap types with no difference	Strength of Evidence
Pain	Modified envelope, minimally-invasive envelope, lingual-based four-cornered flap, comma flap, flapless/ SIA showed reduced pain in several studies ^{4,5,9,11,13,27}	Many large RCTs found no difference between conventional envelope and triangular flaps ^{2,3,21}	Moderate - Trend favours minimally invasive and flapless approaches, but findings are heterogeneous.
Swelling	Modified envelope, minimally invasive envelope, comma flap, and flapless approaches reported less swelling.	Several studies reported no significant difference between conventional flaps ^{2,3}	Low-Moderate – Consistent trend, though not universal across studies.
Trismus (mouth opening)	Comma flap and some minimally invasive flaps reported less trismus ^{5,9,11}	Many studies reported similar trismus across conventional flaps ^{3,27}	Low – Strongly influenced by operative time and surgical difficulty.
Wound dehiscence & infection	Szmyd flap and some TTF showed less dehiscence and better healing ^{11,19,20}	Envelope vs triangular often shows no difference in several trials.	Moderate – Consistent benefit observed for Szmyd and transposition-based flaps.
Periodontal health (2nd molar)	Szmyd and papilla-preserving flaps showed better periodontal healing and less increase in PPD ^{14,17,19}	Some envelope vs triangular comparisons showed no long-term periodontal difference.	Moderate – Multiple studies report measurable periodontal advantages.
Overall Conclusion	Minimally invasive / papilla-preserving / flapless approaches often trend better for soft-tissue morbidity; szmyd / transposition flaps better for preventing dehiscence and preserving periodontal health.	Multiple larger RCTs report no difference for many early outcomes (pain/swelling).	Pattern exist, but heterogeneous study designs and outcome measures preclude definitive universal recommendations without formal quantitative pooling or structured narrative synthesis.

DISCUSSION

There remains considerable debate regarding the most appropriate flap design for the surgical removal of mandibular third molars to minimize

postoperative complications. Despite extensive clinical experience and a growing body of literature, no universal consensus has been reached on the optimal flap design, making this topic an ongoing focus of clinical research¹⁵. Postoperative complications

Table 2: Summary of Postoperative Clinical Results, Follow-up Period, and Principal Findings of Included Studies:

Study	Outcomes reported	Interpretation	Total time duration of the study
Xie et al., 2021 ¹¹	Pain, swelling, trismus, healing	Modified envelope reduced swelling and pain.	7 days
Daftary et al., 2025 ¹²	Pain, swelling, trismus	Decrease postoperative swelling and pain (envelope vs triangular with modified Ward's incision)	3 months
Hassan et al., 2020 ¹³	Pain and discomfort	Lingual-based four-cornered flap reduced pain and discomfort.	5 days
Zhao et al., 2023 ¹⁴	PPD, PI, BOP, and inflammatory markers.	Both groups worsened after 1-4 weeks; the triangular flap group had greater PPD increase, higher IL-1 β , and more infection.	8 weeks
Alqahtani et al., 2017 ¹⁵	Pain, dehiscence, swelling.	Modified envelope reduced swelling and pain.	3 months
Shahi et al., 2024 ¹⁶	Pain, swelling, trismus.	Buccal-based triangular flap lowered pain and swelling.	28 days
Costa et al., 2022 ⁵	Swelling, pain, trismus.	Minimally invasive envelope reduced pain and swelling; slight speech discomfort reported.	7 days
Chiramel et al., 2018 ¹⁷	Wound healing, dehiscence, and distal PPD.	The szmyd flap had easier wound healing, less dehiscence, and lower distal PPD.	14 days
Elo et al., 2016 ¹⁸	Wound dehiscence, infection.	The envelope flap had less wound dehiscence and infection	7 days
Lohana et al., 2024 ⁹	Trismus, swelling, and pain.	Comma flap: less pain, swelling and trismus.	7 days
Ahmad et al., 2021 ¹⁹	PPD, CAL, and bone levels.	The Szmyd flap showed better soft tissue attachment and bone stability.	6 months
Rahman et al., 2021	Wound healing and pain.	Similar results between envelope and triangular flaps.	7 days
Mobilio et al., 2017 ²⁰	Pain, trismus, swelling.	No significant difference between the envelope and the triangular.	7 days
Rahpeyma et al., 2015 ²²	Wound dehiscence, infection, dry socket.	The TTF prevented more wound dehiscence than the envelope flap.	1 month
Karpe et al., 2025 ²³	Swelling, pain, discomfort, pocket depth.	The flapless group had decreased swelling, pain, discomfort and pocket depth.	7 days
Sridharan et al., 2020 ²⁴	Pain, swelling, trismus, PPD, and wound healing.	Insignificant differences between incision types.	1 month
Materni et al., 2021 ²⁵	Discomfort, pain, and oedema.	Flapless surgical approach produced significantly less pain and oedema.	8 weeks
Materni et al., 2023 ²⁷	Pain, oedema, and pocket probing depth.	SIA had speedy wound healing, less Pain, and oedema.	7 days
da Silva et al., 2020 ³¹	Pain, oedema, trismus, dehiscence.	No significant difference between the envelope and the triangular.	7 days
Glera-Suárez et al., 2020 ²	Pain, trismus, swelling.	No significant difference between flaps.	7 days
Zhu et al., 2019 ²⁶	Pain, trismus, swelling, and dehiscence.	Envelope flap had lower trismus and pain; swelling differences were insignificant.	7 days

Table 4: Risk of Bias Assessment of Included Studies Using the Cochrane RoB 2 Tool

Study	Randomization	Deviations from Intervention	Missing Outcome Data	Outcome Measurement	Selective Reporting	Overall Risk
Xie et al., 2021 ¹¹	Low	Low	Low	Low	Low	Low
Daftary et al., 2025 ¹²	Some concerns	Low	Low	Low	Low	Some concerns
Hassan et al., 2020 ¹³	Low	Low	Low	Low	Low	Low

such as pain, oedema, trismus, and wound-related issues continue to be a primary concern for oral and maxillofacial surgeons, as these outcomes directly affect patient recovery and satisfaction²⁷. These mainly include the lack of a standard to measure postoperative symptoms and the individual response to each symptom³. Therefore, the study was designed to evaluate the postoperative complications among different flap designs.

To answer this question, we have included²¹ relevant studies for the systematic review. The higher heterogeneity among studies for postoperative symptoms is due to a lack of standards for measuring these symptoms³. For instance, pain is a highly subjective variable with different feelings of pain even with the same level of swelling²¹. Instead of evaluation on the basis of different molecular inflammatory factors and chemokines, it is just based on questioning. Similarly, some dentists analyze three-dimensional swelling while others analyze it two dimensionally.

Most studies show no significant difference in postoperative symptoms between the conventional envelope and triangular flap. This conclusion has been drawn by Mobilio et al. 2017, Zhu et al. 2019, Glera-Suárez et al. 2020, da Silva et al. 2020 and Rahman et al. 2021^{2,3,20,21,26}. All these studies found insignificant results for pain, swelling and trismus, except Zhu et al. 2019²⁶, which had significant results for trismus and pain in favor of the envelope flap. It seems that both flap designs have insignificant geometrical differences but no major differences in surgical flap or operation time, resulting in similar swelling, pain, and trismus²⁹. However, the triangular flap was expected to be more prone to dehiscence than the envelope flap, as it has three edge tips and is more complex to suture and reposition.

In contrast, the modified envelope flap has significantly fewer postoperative issues than the modified triangular flap, as described in Elo et al. 2016,

Alqahtani et al. 2017, Xie et al. 2021, and Daftary et al. (2025) modified envelope flaps demonstrated significantly fewer postoperative complications than modified triangular flaps in studies by Alqhani et al. 2017 and xie et al. 2021^{11,12,15,18}. Both studies found less swelling, pain, trismus, and wound dehiscence after mandibular third molar surgery with the modified envelope flap. This is due to the minimal invasiveness and vascular-preserving nature of the modified envelope flap, which results in reduced inflammatory response⁹. Elo et al. 2016 similarly reported less wound dehiscence and infection with the conventional envelope flap compared with the modified triangular flap, underscoring the advantage of envelope-based designs over modified triangular variants¹⁸.

In contrast to the anatomical differences between the envelope and triangular flap, the modified envelope flap has shown better results than the conventional envelope flap, as described in Costa et al. 2022⁵. Similarly, the modified triangular flap has remarkably better postoperative outcomes than the conventional triangular flap, as explained in Zhao et al. 2023¹⁴. This is likely because traditional envelope or triangular flaps are more invasive, resulting in higher inflammation, whereas modified flaps are designed to be minimally invasive. Therefore, modified flaps show less swelling, pain, trismus and wound dehiscence.

Flapless surgical techniques have remarkably appreciable results compared with other surgical methods for third molar surgery. These techniques are least invasive with short operation time, which leads to reduced periosteal detachment and tissue elevation, resulting in a smaller inflammatory response³⁰ as reported in recent flapless trials^{4,23,25}. Flapless methods were applied on 174 patients in Materni et al. 2021 and 2023 and Karpe et al. 2025^{4,23,27} and found prominently significant results

in all three studies.

Periodontal pocket depth (PPD), clinical attachment loss (CAL), and bone levels (BL) had been notably improved in the szmyd flap and triangular transposition flap as described by Chiramel et al. 2018 & Ahmad et al. 2021^{17,19}. Zhao et al. 2023 further showed that the modified triangular flap preserved distal periodontal health better than the conventional triangular flap, with significantly lower PPD and inflammatory markers at 1 and 4 weeks postoperatively. Collectively, these studies have shown easier wound healing, less wound dehiscence, lower distal periodontal pocket depth, better soft tissue attachment (PPD and CAL) and bone stability⁶. Therefore, it is important for long-term periodontal stability.

Tissue tension is the major player in postoperative wound healing⁹. Several studies included in this review demonstrate that flap designs engineered to reduce mechanical tension, such as the Szmyd flap and triangular transposition flaps, are associated with lower rates of wound dehiscence and more stable soft-tissue healing. These flap designs preserve the interdental papilla and distribute traction forces more evenly, preventing excessive pulling at the distal aspect of the second molar, which is a common site for dehiscence⁹. In contrast, conventional triangular flaps and certain releasing incisions may create localized tension when repositioned, especially in cases requiring extensive bone removal, increasing the risk of wound breakdown. Because wound dehiscence can lead to delayed healing, increased postoperative pain, and greater susceptibility to infection, minimizing incision tension is a key biological consideration⁹.

This systematic review has several limitations. First, significant clinical and methodological variation among the included studies prevented a meta-analysis due to differences in surgical flap design, outcome measures, and study methodology. Secondly, different measurement scales were used to evaluate postoperative outcomes, including pain, and follow-up durations differed significantly between studies, preventing comparisons. Thirdly, there may have been some heterogeneity because the included studies were small, and there was some risk of bias, possibly affecting the strength and generalizability of the evidence. Fourthly, the lack of quantitative pooling limits the certainty of this study's conclusions;

this study strongly recommends that future investigators adopt standardised core outcome sets (e.g., COSMIN) and report data in formats amenable to meta-analysis to enable pooled effect estimates.

CONCLUSION

Current evidence suggests that there are fewer postoperative side effects with the use of minimally invasive flap designs: flapless approaches, the Szmyd flap, and the triangular transposition flap as compared to the conventional approaches: triangular flaps. However, considerable clinical and methodological variation makes it difficult to provide a single definitive recommendation on the superiority of any one flap design. Higher certainty evidence and quantitative pooling are warranted through future multicenter randomized controlled trials with standardized outcome measures and a longer follow-up period.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
GRANT SUPPORT AND FINANCIAL DISCLOSURE
None declared.

AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

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Acquisition, Analysis or Interpretation of Data: ZA, SAA, SN, RK, AK, GH

Manuscript Writing & Approval: ZA, SAA, SN, RK, AK, GH

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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