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SYSTEMATIC REVIEW

Do different flap designs have negligible impacts on the removal of mandibular third molars?

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ABSTRACT

This study aims to evaluate various flap incision techniques utilized in the mandibular third molar removal surgery. A systematic review with a qualitative approach was conducted. Data were obtained from published journals through manual database searches via Scopus, ScienceDirect, and PubMed covering the period from 2000 to 2024, using predetermined keywords related to the topic. The PRISMA statement guidelines were followed, including the use of the official flow chart. Twenty-one journals were identified and analyzed to compare different flap designs in mandibular third molar extraction procedures, focusing on their relationship with wound healing processes and complication rates. Comparative analysis of flap incision techniques was performed through systematic evaluation of multiple journal data. Both envelope and triangular flaps demonstrated comparable healing times in third molar extraction procedures. The envelope flap, while minimally invasive, showed association with dry socket occurrence. The triangular flap provided superior surgical access and demonstrated pain reduction following mandibular third molar surgery. The pedicle flap showed effectiveness in preventing dry socket and alveolar osteitis. In addition, the Lingual-based triangular flap proved superior to buccal-based triangular flap in controlling postoperative pain, swelling, and trismus while reducing overall complications. This analysis demonstrates that flap design selection significantly influences postoperative outcomes in mandibular third molar surgical procedures. Both triangular and envelope flap can be considered for the procedure of mandibular wisdom teeth removal.

Keywords: flap design; mandible; odontectomy; third molar

INTRODUCTION

Mandibular third molar, commonly referred to as wisdom teeth, frequently appear in malpositioned or impacted conditions. If left untreated, this conditions can lead to serious consequences. Plaque accumulation and pressure from opposing teeth can trigger gum inflammation. Inflammation that continues and is not treated immediately will result in several problems, such as prolonged swelling, difficulty opening the mouth, pain when swallowing, chewing disorders, and interference with daily activities. In some cases, inflammation can also be accompanied by bacterial infection, which can then develop into an abscess that can spread to adjacent areas such as the neck, chin, or submandibular area.[1]

Surgical removal of mandibular third molars, known as odontectomy, is a commonly performed surgery to treat this problem. Odontectomy aims to reduce inflammation, control infection, alleviate trismus, and prevent the spread of infection, which can occasionally become life-threatening. The success of this surgical procedure is closely related to the flap incision technique used during the procedure.[2]

Various postoperative complications may occur following the extraction of the impacted third molar. Postoperative pain, swelling, and trismus are among the most common sequels to third molar extraction. These responses are primarily caused by inflammatory reactions in the surgical field, leading to vasodilation and the arrival of strong pro-inflammatory mediators. The occurrence and severity of these complications vary among patients and are not uniformly observed in all cases.[1,3]

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Every odontectomy procedure is associated with the selection of the flap design. Each type of flap design or incision technique serves a specific purpose based on the clinical indications of each case, which will naturally affect postoperative outcomes including potential complications, such as infection, and dry socket (alveolar osteitis).[2,3] Analysis of the types of flap incision techniques is commonly conducted through a study comparing data in journals specifically for journals with the Randomized Controlled Trials (RCT) technique. However, previous studies have reported inconsistent findings in postoperative result associated with various flap designs, and no clear consensus has been established regarding appropriate flap design. Several studies had analyzed flap incision techniques by comparing data from published journal, particularly those employing RCT methodologies. Nevertheless, existing reviews are limited to comparisons of certain flap designs and often draw conclusions from studies with different methodologies and various outcomes. These variations may contribute to uncertainty in interpreting the effects of flap design on postoperative outcomes.

Therefore, further analysis based on comparative data from RCT-based studies is required to provide clearer empirical evidence. This study aims to compare the postoperative sequelae of complication and wound healing after odontectomy procedure with various flap designs and techniques. The objective of this study is to identify the best flap design of flap that offers optimal wound healing while minimizing postoperative complication.

MATERIALS AND METHODS

This study aims to compare and evaluate different flap incision designs in mandibular third molar removal procedures, using a systematic review of randomized controlled trials (RCTs).

A qualitative literature review approach was employed. The data sources consisted of peer-reviewed journal articles published online. This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

PICO (population, intervention, comparator, outcomes) question

The protocol for executing this scoping systematic review, including selection, data extraction, and risk of bias assessment phases, was guided by the formulated PICO framework for this study::

Population : Patients requiring mandibular third molar removal surgery

Intervention : Surgical removal of mandibular third molars

Comparator : Different flap designs used during third molar surgery

Outcome : Postoperative wound healing and complication outcomesThe formulated PICO question was: "*In patients requiring mandibular third molar surgery, are there differences in postoperative wound healing and complications associated with different flap designs?*". The focused PICO question was: "*Do different flap designs significantly influence postoperative outcomes following mandibular third molar removal?*"

Study selection criteria

Only prospective randomized controlled trials (RCTs) involving patients with clinically diagnosed impacted mandibular third molars undergoing surgical extraction were included. The studies had to primarily compare the clinical outcomes of impacted mandible wisdom teeth removal using different surgical flap techniques (such as envelope flaps, Szmyd flaps, and triangular flaps). Furthermore, studies had to report clinical outcomes associated with wound healing and postoperative complications.

Literature search

A literature search was conducted using Medical Subject Headings (MeSH) based on free-text keywords including: "mandibular third molar surgery," "mandibular wisdom teeth surgery", "mandibular third molar flap design," "mandibular wisdom teeth flap design", "flap incision", "flap design", "third molar removal surgery," OR "odontectomy".

Articles were retrieved through manual database searches in Scopus, ScienceDirect, and PubMed using relevant keywords. The search

covered publications from 2000 to 2024 and was based on predefined keywords relevant to the study topic.

Quality assessment of the included studies

This systematic review was performed in accordance with the statement of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 20 and was prospectively registered in PROSPERO (Registration No. CRD420251146187). No deviations from the original protocol were made. The methodological quality of the included studies was assessed using the Cochrane Collaboration risk-of-bias assessment tool for RCTs.[4] This tool evaluates six domains: randomization, allocation concealment, blinding of patients and assessors, completeness of outcome data, and risk of selective outcome reporting. Each domain was rated as having a low, high, or unclear risk of bias when insufficient information was provided A summary of the risk-of-bias assessment across all included studies was tabulated. Two authors independently assessed the studies, and inter-investigator agreement was evaluated using the kappa correlation coefficient.

Data extraction and synthesis

Data obtained from database searches were screened and sorted based on inclusion and exclusion criteria. The exclusion criteria included journals that were not freely accessible; journals published before the year 2000; and articles without a Digital Object Identifier (DOI). Studies were included if they met the following criteria: randomized controlled trial (RCT) design; discussion of flap incision techniques; focus on odontectomy procedures; investigation of mandibular third molar or wisdom tooth surgery; and free full-text availability. Relevant data were then extracted from selected articles according to search results based on research objectives. The extracted data were then synthesized using a narrative approach, grouping findings according to flap design and postoperative outcomes.

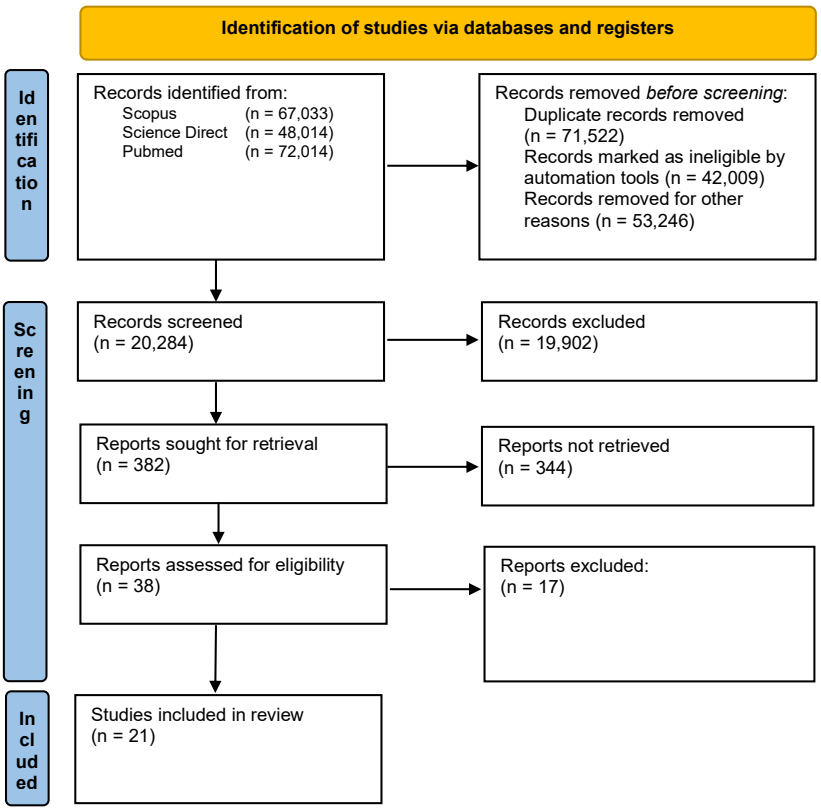

Figure 1. Flowchart of Literature Selection (n = 21)

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DATA COLLECTION AND ANALYSIS

A total of 21 studies were included for qualitative and quantitative analysis. All of these focused on mandibular wisdom tooth removal and evaluated different surgical flap designs, such as envelope flaps, Szmyd flaps, and triangular flaps. Each flap design was analyzed in relation to wound healing and postoperative complications following mandibular third molar surgery.

RESULTS

Table 1. Comparative analysis between types of flap in Odontectomy Procedure of Impacted Mandibular Wisdom Teeth

NO	AUTHOR, YEAR	JOURNAL	SUBJECT	ANALYSIS
1.	Baqain ZH, Al-Shafii A, Hamdan AA, Sawair FA., 2012	Flap design and mandibular third molar surgery: a split mouth randomized clinical study	Envelope Flap	Fast wound healing.[5]
			Triangular Flap	Fast wound healing, no dry socket occurs.[5]
2.	Briguglio F, Zenobio EG, Isola G, Briguglio R, Briguglio E, Farronato D, 2011	Complications in surgical removal of impacted mandibular third molars in relation to flap design: clinical and statistical evaluations	Envelope Flap	Healing is slightly faster, pain is minimal, infection and inflammation are minimal.[6]
			Triangular Flap	Healing is good, still within normal limits, for post-op conditions it is not much different from envelop flap.[6]
3.	Desai, 2014	Comparison of two insision designs for surgical removal of impacted mandibular third molar: a randomised comparative clinical study	Envelope Flap	Healing is slightly faster, pain is minimal, infection and inflammation are minimal.[7]
			Triangular Flap	Healing is good, still within normal limits, for post-op conditions it is not much different from envelop flap.[7]
4.	Erdogan O, Tatli U, Ustun Y, Damlar I., 2011	Influence of two different flap designs on the sequelae of mandibular third molar surgery	Envelope Flap	There is not much difference between envelope and triangular flap.[8]
			Triangular Flap	There is not much difference between envelope and triangular flap.[8]
5.	Goldsmith SM, De Silva RK, Tong DC, Love RM., 2012	Influence of a pedicle flap design on acute postoperative sequelae after lower third molar removal	Pedicle Flap	It can reduce the incidence of dry socket, but dehiscence can also occur.[9]
			Envelope Flap	Any dry socket occurs.[9]
6.	Jakse, 2002	Primary wound healing after lower third molar surgery: evaluation of 2 different flap designs	Envelope Flap	There is a risk of dehiscence.[10]
			Triangular Flap	Good wound healing.[10]
7.	Korkmaz, 2015	Does laterally rotated flap design influence the short-term periodontal status of second molars and postoperative discomfort after partially impacted third molar surgery ?	Envelope Flap	Faster healing of periodontal areas.[11]
			Triangular Flap	Good results, post op conditions are not much different from envelope flap.[11]

NO	AUTHOR, YEAR	JOURNAL	SUBJECT	ANALYSIS
8.	Koyuncu, 2013	Short-term clinical outcomes of two different flap techniques in impacted mandibular third molar surgery	Envelope Flap	Good wound healing, reducing the incidence of dry socket.[12]
			Triangular Flap	Healing is good, but more people experience dry socket, but less pain after surgery D+2.[12]
9.	Mavrodi, 2015	Influence of two different surgical techniques on the difficulty of impacted lower third molar extraction and their post-operative complications	Triangular Flap	Good wound healing.[13]
			Triangular flap with lingual extension	Healing takes longer, there is a risk of nerve injury.[13]
10.	Rabi, 2017	Comparative evaluation of two different flap designs and postoperative outcome in the surgical removal of impacted mandibular third molar	Envelope Flap	Good wound healing.[14]
			Triangular Flap	Access during surgery is more optimal, post-operative healing results are also good.[14]
11.	Renton, 2005	A randomised controlled clinical trial to compare the incidence of injury to the inferior alveolar nerve as a result of coronectomy and removal of mandibular third molars	Envelope Flap	It is best to avoid trauma to the inferior alveolar nerve in the mandible.[15]
12.	Rosa, 2002	Influence of flap design on periodontal healing of second molars after extraction of impacted mandibular third molars	Szmyd Flap	Good wound healing, risk of periodontitis.[16]
			Triangular Flap	Wound healing is good, the same risk, periodontitis occurs.[16]
13.	Şimşek Kaya G, Yapıcı Yavuz G, Saruhan N., 2019	The influence of flap design on sequelae and quality of life following surgical removal of impacted mandibular third molars: a split-mouth randomized clinical trial	Envelope Flap	Healing is good, but pain levels are higher post-operatively.[17]
			Triangular Flap	Access during surgery is more optimal, post-operative healing results are also good, pain is more minimal.[17]
14.	Yolcu, 2015	Comparison of a new flap design with the routinely used triangular flap design in third molar surgery	Buccal Based Triangular Flap	Good results, incidence of complications is very minimal.[18]
			Lingual Based Triangular Flap	Good results, minimal incidence of complications, less bleeding.[18]
15.	Arindra, P. K., Indrapradana, A., 2018	Comparison of three flap designs on postoperative complication after third molar surgery	Reverse Triangular Flap	Post-operative healing was good with minimal complication rates.[19]
16.	Zhu, 2019	Comparison of postoperative outcomes between envelope and triangular flaps after mandibular third molar surgery: a systematic review and meta-analysis	Envelope Flap	Good results for class A and B impactions, minimally invasive.[20]
			Triangular Flap	Good results, adequate surgical access.[20]
17.	Xie, Q., Wei, S., Zhou, N., Huang, X., 2021	Modified envelope flap, a noval incision design, can relieve complications after extraction of fully horizontal impacted mandibular third molar	Modified Envelop Flap	Can reduce complications in odontectomy of impacted teeth with a horizontal position.[21]

NO	AUTHOR, YEAR	JOURNAL	SUBJECT	ANALYSIS
18.	Kumar, J., Kumaran, S., 2021	Evaluation of five different flap designs used in the surgical extraction of the impacted mandibular third molar	Envelope Flap	Healing at the gingival margin is better, but causes greater pain.[22]
			Ward Flap	Access during surgery is more optimal, but causes periodontal pockets in the second molar.[22]
			Modified Ward Flap	Access during surgery is more optimal, but causes periodontal pockets in the second molar.[22]
			Koma Flap	Post-operative complications are lower, access during surgery is less than optimal.[22]
			Bayonet Flap	Access during surgery is better, but can cause vascularization disorders.[22]
19.	Rajendran, 2023	Comparison of buccal based triangular flap and lingual based triangular flap on post operative course after impacted mandibular third molar surgery : a prospective randomized controlled study	Buccal Based Triangular Flap	Good wound healing.[23]
			Lingual Based Triangular Flap	Post-operative complications are minimal, pain, swelling, and trismus are minimal.[23]
20.	Zhao, J., Zhang, Y., Cheng, Y., Xie, S., Li, D.D., Zhang, P.F., Ren, X.Y., Wang, X., 2023,	Effects of modified triangular flap for third molar extraction on distal periodontal health of second molar: a randomized controlled study	Modified Triangular Flap	It can reduce the occurrence of periodontal damage to second molar.[24]
21.	Shahi AK, Vishal, Sharma S, Prajapati VK, Prakash O, Khaitan T., 2024	Comparison of Buccal and Lingual-Based Triangular Flap During Mandibular Third Molar Extraction for Reducing Postoperative Complications: A Randomized Controlled Trial	Buccal Based Triangular Flap	It has better results in reducing post-operative pain and swelling.[25]

DISCUSSION

Analysis of flap incision techniques can be performed by comparing data from multiple studies. This study aimed to evaluate postoperative outcomes in relation to pain, swelling, mouth opening, and wound healing in three types of closure techniques: primary, secondary, and a buccal mucosal-advancement flap technique after mandibular third molar surgery.[3] Flap design greatly determines the outcome of an odontectomy, particularly in the mandibular third molar.

The triangular flap is among the most commonly used designs in mandibular third molar surgery. However, findings from several studies indicate that triangular flaps may be associated with challenges in achieving rapid primary wound closure, since it carries a higher risk of prolonged healing and potential nerve injury compared with envelope flaps.[13]

Nevertheless, other investigations have found no statistically significant differences in postoperative outcomes between triangular and envelope flap designs.[5]

The authors suggested that inadequate flap mobilization over the buccinator muscle may contribute to postoperative edema and reduced vertical release patency. Modified triangular flaps were therefore considered

Table 2. Wound healing analysis

No.	Journal, Year	Analysis
1.	Baqain et al, 2012	Wound healing between triangular and envelope flaps was equally rapid.
2.	Briguglio et al., 2011	With the envelope flap, wound healing occurs slightly faster and the incidence of infection is minimal compared to the triangular flap.
3.	Desai, 2014	With the envelope flap, wound healing occurs slightly faster and the incidence of infection is minimal compared to the triangular flap.
4.	Erdogan et al, 2011	Post-op wound healing on triangular and envelope flaps showed similar results and were not much different.
5.	Mavrodi, 2015	The use of a triangular flap incision with lingual extension has the risk of longer healing and nerve injury.
6.	Rabi, 2017	Envelop and triangular flaps have the same healing rate, but triangular flaps are easier to access for surgery.
7.	Arindra et al, 2018	The Reverse Triangular Flap showed good postoperative wound healing results with minimal complication rates.
8.	Zhu, 2019	The envelope flap is suitable for grade A and B impactions with minimal invasion.

less prone to wound dehiscence.[3,7] Research by Zhu suggested that envelope flaps are more suitable for class A and B impactions with minimal invasion.[20] Similarly, studies by Briguglio and Desai showed that envelop flaps had slightly faster wound healing and minimal infection compared to the triangular flap.[6,7] In modified triangular flap designs, where the anterior vertical release is left unsutured and only a single coronal suture is placed distal to the second molar, no significant differences were observed in postoperative pain and swelling when compared with envelope flaps. The authors highlighted that inadequate flap mobilization over the buccinator muscle may

Table 3. Postoperative complication analysis

No.	Journal, Year	Analysis
1.	Goldsmith et al., 2012	Pedicel flaps are able to reduce the incidence of dry socket compared to envelope flaps.
2.	Jakse, 2002	Envelope flap incisions are more likely to experience dehiscence than triangular flaps.
3.	Korkmaz, 2015	Although they cause periodontitis, triangular and envelope flaps show post-op healing results that are not much different.
4.	Koyuncu, 2013	In triangular flap incisions during odontectomy, there is a greater risk of dry socket than envelope flaps.
5.	Renton, 2005	The use of an envelope flap incision can prevent injury to the inferior alveolar nerve.
6.	Rosa, 2002	Both the Szmyd and triangular flap incisions showed complications of periodontitis in the adjacent teeth.
7.	Yolcu, 2015	In the triangular flap incision towards the lingual direction, less bleeding was observed compared to the triangular flap incision towards the buccal direction.
8.	Simsek et al., 2019	The use of triangular flaps results in higher levels of post-operative pain than envelope flaps.
9.	Rajendran, 2023	The use of lingual-based triangular flaps has shown minimal post-operative complications, minimal pain, swelling, and trismus.
10.	Shahi et al., 2024	The use of buccal-based triangular flaps showed better results than lingual-based triangular flaps in terms of reducing postoperative pain and swelling. However, both flaps did not show different results in terms of mouth opening width or trismus incidence after mandibular third molar odontectomy.

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contribute to postoperative edema and reduced vertical release patency. It was concluded that the modified triangular flap was significantly less prone to wound dehiscence.[3,7]

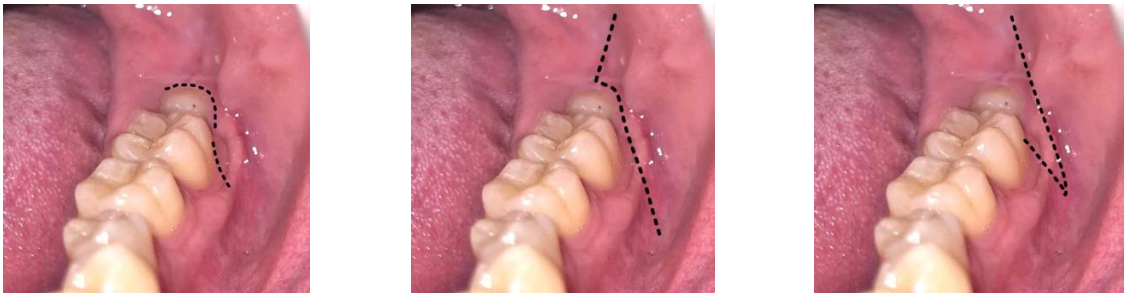
The triangular flap incisions during odontectomy were at greater risk of dry socket than envelope flaps. This may be attributed to the wider incision, greater wound area, and increased bone removal associated with triangular flap designs, which can predispose the surgical site to alveolar osteitis.[12] In addition, the use of triangular flaps resulted in higher postoperative pain due to the longer incision extension than envelope flaps. Envelop flap incisions are more prone to wound dehiscence than triangular flaps. Although triangular flaps have been associated with periodontal complications, no significant differences have been consistently observed between triangular and envelope flaps in terms of periodontal outcomes.[10,11,17]

The reverse triangular flap is a modification of the conventional triangular flap. It is created by making a vertical releasing incision on the distal aspect, extending from the lingual to the buccal side through the external oblique ridge in the retromolar area of the mandibular third molar, combined with a sulcular horizontal incision on the distobuccal surface of the mandibular second molar. This design allows the flap to be reflected as a short triangular flap, which facilitates primary wound closure and improves visibility on the distal aspect of an impacted third molar. The length of the sulcular incision along the buccal aspect of the second molar can also be extended when required. However, a major drawback of this flap is the increased risk of bleeding and potential lingual nerve injury, particularly when the retromolar trigone is thin or when the incision is not placed directly over the underlying bone.[19]

The Szmyd flap would provide better outcomes, particularly for bone level, because it preserves a strip of mucosa on the buccal surface of the second molars. Bone resorption is generally

(A) (B) (C)

Figure 2. Design of (A) envelope flap, (B) triangular flap, (C) reverse triangular flap on partial eruption lower third molar



(A) (B) (C)

Figure 3. Flap designs used in impacted mandibular third molar extraction: (A) szmyd flap, (B) buccal based triangular flap, (C) lingual based triangular flap

more intense and clinically important in areas where the alveolar bone is thinner, such as in the anterior region of the mandible and all of the maxilla, but not at the buccal region of the mandibular second molars. However, during the removal of the wisdom teeth with a great mesiodistal or horizontal angulation, which were the majority, both the ostectomy and the use of dental elevators traumatized the strip of mucosa preserved by the Szmyd flap. This may contribute to delayed periodontal healing, and may partially explain the outcomes observed with this flap design. On this basis, the Szmyd flap would provide better results when used for removing impacted third molars.[16]

There is no universal consensus in the literature regarding the ideal flap design for mandibular third molar extraction. Nevertheless, the flap technique plays a vital role in postoperative pain, swelling, and trismus. Elevation of the flap beyond the external oblique ridge is one of the contributing factors to the development of trismus after surgical third molar extraction. In recent years, several modified and innovative flap designs have been proposed. Some studies comparing a pedunculated flap with envelope flaps have reported that pedicle flaps demonstrated fewer incidences of wound dehiscence, dry socket, and a better quality of life.[25]

Several studies have shown that triangular flap designs are associated with better postoperative interincisal opening compared with envelope and other flap designs. In contrast, postoperative wound dehiscence has been reported more frequently with envelope flaps than with triangular flaps. The main advantage of the envelope flap is that it can provide sufficient viewing space on the surgical side and allow the elongation of the incision to the anterior if necessary, while maintaining good blood supply and facilitating suturing. However, its main disadvantage lies in the sulcular incision around the tooth, which can disrupt the periodontal ligament. This disruption may increase osteoclastic activity during elevation of the mucoperiosteal flap and raise the risk of wound dehiscence. Dehiscence may occur in the envelope flap due to a tense flap on the anterior side with intersulcular suture, postoperative hematoma formation, and masticatory movements, all of which contribute to soft tissue breakdown.[19, 21]

The modified triangular flap design is more conservative because it prevents the trauma of the buccal side tissue of the second molars. The triangular flap design generates tension-free closure and supports primary wound closure, whereas primary closure is generally not achievable with the envelope flap. Triangular flap produces a better viewing field and is wider than the flap envelope, due to a vertical releasing incision but will result in swelling and other signs of postoperative complications.[19,22,] The reverse triangular flap is a variation of the triangular flap, created by a vertical releasing incision on the distal aspect extending from the lingual to the buccal side through the external oblique ridge in the retromolar area of the mandibular third molar, combined with a sulcular horizontal incision on the distobuccal surface of the mandibular second molar.[23,24]

The type of tissue closure after third molar removal surgery has been shown to influence the reduction of pain, oedema, and trismus postoperatively. Two types of closure have been reported in literature: primary closure and secondary closure. In secondary closure, the third molar socket remains open, communicating with the oral cavity, while in primary closure, the socket is sealed by the mucosal flap. Numerous studies have shown that secondary closure, facilitated by the drainage of inflammatory exudate, leads to less postoperative pain and oedema and improved mouth opening, compared with primary closure.[21,25,26] However, secondary closure has disadvantages, including an open third molar socket exposed to the oral cavity resulting in food accumulation and a prolonged healing period, which requires meticulous wound care until the socket undergoes contraction with secondary intention. On the other hand, a hermetically sealed primary closure eliminates communication with the oral cavity but may result in increased postoperative swelling, pain, and trismus due to the lack of drainage.[19,21,24,27]

CONCLUSION

The selection and use of flaps during mandibular third molar extraction procedures should be tailored to the specific needs and conditions of each case. Both envelope and triangular flaps can be used during third molar removal procedure. While each has distinct advantages and disadvantages, wound healing outcomes are comparable between the two techniques. The envelope flap can cause dry socket, but are minimally invasive, reducing complications in other areas. On the other hand, the triangular flap can reduce pain after odontectomy, better surgical access, and good wound healing outcome. Overall, flap designs play an important role in postoperative outcomes following surgical removal of mandibular third molars.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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