GRADUATION PROJECT

Degree in Dentistry

THIRD MOLARS EXTRACTION: COMPLICATIONS AND MANAGEMENT

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RESUMEN

Introducción: La exodoncia quirúrgica de los terceros molares representa una parte significativa de los procedimientos llevados a cabo en la práctica de la cirugía oral. Pese a su carácter rutinario, la morbilidad postoperatoria, caracterizada por síntomas inflamatorios y alteraciones periodontales, sigue constituyendo un desafío clínico. En este contexto, el diseño del colgajo mucoperióstico continúa siendo objeto de debate y ha sido repetidamente propuesto como un determinante que influye en la dinámica de cicatrización postoperatoria. **Objetivos:** Este estudio se propuso analizar críticamente el impacto de los abordajes quirúrgicos sin colgajo y mínimamente invasivos fuente a los diseños convencionales de colgajo de espesor total sobre las complicaciones postoperatorias tras la extracción de terceros molares impactados. **Métodos**: Se efectuó una búsqueda bibliográfica estructurada en la base de datos biomédica PubMed como principal fuente de evidencia, utilizando ecuaciones de búsqueda y criterios de elegibilidad predefinidos. Los estudios que comparaban diferentes diseños de colgajo fueron seleccionados, tras lo cual se procedió a la extracción y síntesis cualitativa de los datos pertinentes relativos a los parámetros quirúrgicos y la morbilidad postoperatoria. **Resultados:** El análisis incluyó diecinueve estudios, que evaluaban abordajes sin colgajo, colgajo tipo sobre (envelope), triangular, pediculado y diversas incisiones modificadas. Los abordajes sin colgajo y mínimamente invasivos mostraron la mayor proporción de reducción en los parámetros inflamatorios postoperatorios, particularmente en el dolor y el edema. Los diseños de colgajo modificados mostraron mejoras moderadas en algunos resultados, mientras que los colgajos convencionales tipo sobre y triangular presentaron una reducción comparativamente limitada de la morbilidad postoperatoria. La evidencia relativa a la dehiscencia de la herida y a los resultados periodontales permaneció inconclusa debido a la heterogeneidad metodológica entre los estudios analizados. **Conclusiones**: La evidencia disponible no respalda la superioridad universal de un diseño de colgajo sobre otro, aunque los enfoques innovadores y mínimamente invasivos parecen ofrecer beneficios potenciales en la disminución de los eventos adversos postoperatorios tras la extracción quirúrgica de terceros molares. La minimización del tiempo operatorio y del trauma quirúrgico se mantiene como uno de los factores más determinantes. No obstante, la ausencia de estandarización metodológica entre los estudios disponibles pone de manifiesto la necesidad de realizar ensayos clínicos aleatorizados robustos con el fin de establecer recomendaciones quirúrgicas estandarizadas.

PALABRAS CLAVE

Odontología, Tercer molar impactado, Extracción quirúrgica, Cirugía mínimamente invasiva, Colgajo mucoperióstico, Morbilidad postoperatoria

ABSTRACT

Introduction: Surgical management of third molars accounts for a substantial proportion of procedures performed in oral surgery. Despite its routine clinical execution, postoperative morbidity, characterized by inflammatory symptoms and periodontal alterations, remains a clinical challenge. Within this context, mucoperiosteal flap design remains a subject of ongoing debate, and has been repeatedly proposed as determinant of postoperative healing dynamics. **Objectives**: The current study was conducted to critically evaluate the impact of flapless or minimally invasive approaches relative to conventional mucoperiosteal flap designs on postoperative morbidity associated with surgical impacted third molar extraction. **Methods**: A structured literature search was performed in PubMed database as the principal source of evidence, using predefined search equations and eligibility criteria. Studies assessing various flap designs were screened and relevant data focused on surgical parameters and postoperative outcomes were subsequently extracted and qualitatively synthetized. **Results**: The analysis included nineteen studies investigating flapless, envelope, triangular, pedicle and multiples modified incisions. Flapless and minimally invasive approaches demonstrated the highest proportion of reported reduction in postoperative inflammatory parameters, particularly in pain and edema. Modified flap designs showed moderate improvements in selected outcomes, while conventional envelope and triangular flaps showed comparatively limited reduction in postoperative morbidity. Evidence regarding wound dehiscence and periodontal outcomes remained inconclusive due to heterogeneity across study methodologies. **Conclusions**: Current evidence does not support a universal superiority of one flap over another, although innovative minimally invasive flap designs appear to offer potential benefits in reducing postoperative complications following third molar extraction. The minimization of operative time and trauma remain the most critical factors. Nevertheless, the absence of methodological standardization among available studies underscores the need for further robust randomized controlled trials to establish consistent surgical recommendations.

KEY WORDS

Dentistry, Impacted third molar, Surgical extraction, Minimally invasive surgery, Mucoperiosteal flap, Postoperative morbidity

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1. INTRODUCTION

1.1. Context and importance of third molar surgery

The inherent challenge in addressing the topic of third molar extraction (TME) is readily evident, given that the subject has been the focus of numerous investigations and represents a matter of ongoing concern for virtually all dental professionals (1–10). TME, seemingly routine intervention, due to the complex anatomical relationships, heightens the potential for intra-operative complications and leads to remarkably diverse spectrum of postoperative morbidity (2,5–9,11–13), thereby complicating the accurate prediction of patient-specific outcome (5,11). The decision to extract asymptomatic included wisdom tooth is influenced by complex interplay of demographic and clinical factors. This decision-making process is challenged by the absence of unified professional agreement to the most appropriate course of management. Both, orthodontists and maxillofacial surgeons recognize the importance of preventive management of impacted third molar (ITM), but their motivations and clinical priorities differ. Orthodontists tend to favour prophylactic removal of fully ITM, primarily, to advert potential late anterior dental crowding. In contrast, some surgeons, such as Guldiken *et al.*, focus on prevention of focal or systemic infection (14). Extraction decision regarding asymptomatic ITM rarely relies on one isolated criterion but rather on the nature of individualized risk that varies according to the impaction status and the clinician's filed-specific approach. While some experts support prophylactic TME to avert potential pathologies, such as tumor development, others contend that the potential hazards of the procedure surpass its anticipated benefits. Consequently, the issue continues to fuel considerable controversy within the scientific community, and despite these divergent perspectives, a notable decline in number of such interventions has been observed across multiple nations (5).

1.2. Evolution

Humans have undergone continues evolutionary development since the initial appearance of early hominins, roughly three millions years ago (10). Recent anthropological and dental research reveals a remarkable transformation in human jaw structure and size, mostly caused by a shift towards softer or processed diet (8,10). Consequently, the mechanical demands on the jaws decreased, which is believed to have the highest contribution to the evolutionary reduction in size, resulting in mismatch between arch length and the tooth size, leading to overcrowding. Subsequently, a significant portion of individuals experience third molar (TM) impaction and related pathologies (10).

1.3. Epidemiology

Development of TM typically starts during late childhood between ages of 8 and 15; and generally emerges between 17 and 22 years. This notably delayed eruption contributes to high incidence of impaction (15). The highest rates of global TM impaction are reported in Asian population, reaching up to 43,1% (16). According to recent epidemiological studies approximately 35,9% to 58,7% of adults, possess at least one impacted wisdom tooth, predominantly in the mandible (8,16). Variations in prevalence are largely attributed to variables including racial background, age distributions and dietary habits (16). The epidemiological data suggest that females have slightly higher risk of impaction, possibly related to the smaller average mandibular dimension compared to men. Such impactions extend beyond anatomical anomalies, frequently causing clinical issues including inflammation, crowding, damage to the adjacent teeth but also cyst formation and in rare cases mandibular fracture (9,10). Partially impacted teeth are more frequently subject to prophylactic removal than those fully retained (14). Additionally, women identify higher carious risk of the adjacent second molar, conversely men are more prone to the pericoronitis (14). When considering age, individuals aged under 30 have usually greater potential development of pathology around fully impacted teeth than older ones (12,14). Among all teeth, mandibular TM exhibit the highest extraction rate, representing about 18% of all cases (15).

1.4. Anatomical and surgical considerations

1.4.1. Mandible

The lower jaw forms mobile component of facial skeleton. By articulating with temporomandibular joint, it constitutes essential structure for mastication and speech. Its sensory innervation derives from mandibular nerve (V3). Compared to maxilla, the mandible has denser cortical plates and a less vascularized compact trabecular network, features that make extractions technically more demanding and provokes slower healing (17). Anatomically, TM occupied distal extremity of the mandibular body where it merges with the ascending ramus, which constitute a biomechanical weakness zone, that predispose the mandible to fracture under excessive elevating pressure. Lower wisdom tooth is encased between a thick buccal and a thin lingual cortical plate (LCP), in some cases the roots are intimately related or perforate lingual cortex. Additionally, the proximity of variable retromolar foramen located few millimetres posterior to the TM and adjacent second molar on the mesial side, are also susceptible to iatrogenic injury. TM proximity to the major neural pathways remains leading factor of sensory morbidity. Lingual nerve (LN) lies in highly vulnerable position, as anatomical studies indicate that the average distance between LN and lingual alveolar crest is approximately 4.45mm and it run medially and close to the LCP, from which it is frequently separated only by

thin periosteal layer. Similarly, inferior alveolar nerve, which traverses mandibular canal providing sensory supply to the lower dentitions, represents a major surgical concern because of its proximity with the teeth apices. Notably, anatomically, the region provides several potential pathways for accidental displacement of tooth or root fragment (18).

1.4.2. Maxillae

The maxilla refers to the upper jaw, forming the midfacial skeleton and housing the upper dentition. Superiorly, it constitutes a structural boundary splitting oral cavity from nasal floor and maxillary sinus compartments. Innervation arises from the maxillary division (V2), a purely sensory branch of the trigeminal nerve (17). Coronoid process with the overlaying muscular and soft tissue layers constitutes a significant anatomical obstacle which restricts visibility and direct access. When the mouth is fully opened, indicated structures tend to overlap and obscure the surgical field, obligating the clinician to operate semi-blind with the mouth partially closed, relying on tactile feedback. Extraction of maxillary wisdom teeth is generally less complex than that of mandibular counterparts; however, the inherent fragility of the maxillary tuberosity, attributed to its low-density trabecular bone, creates a specific risk of fracture. Owning to the relative bone softness in posterior maxilla, the access requires minimal bone removal, often achieved without rotatory instrumentation or odontotomy (19). In addition, if roots are contiguous with or penetrate the maxillary sinus floor, it will define an anatomical configuration inherently predisposed to procedural susceptibility (17,19).

1.5. Radiographic examination

A patient-specific preoperative assessment has become indispensable in guiding the most suitable therapeutic course, with the contemporary research stressing the value of the optimal planning and judicious patient selection, as fundamental elements of successful TM surgery (2,5,9,11–13,20–22). While diverse automated approaches have been introduced in the field of TME, none to date have succeeded in reliability anticipating both procedural challenges and postoperative sequalae (2,13,20).

Orthopantomography (OPG) serves as fundamental initial imaging modality for the diagnosis of multiple dental conditions and plays a crucial role in the preoperative assessment of TM impaction, owing to its low radiation exposure and its ability to provide a comprehensive overview of dentoalveolar structures (21). OPG remains first-line imaging tool that provides moderate reliability, however its two-dimensional nature limits diagnostic precision due to distortion and overlapping anatomical structures, restricting its accuracy in visualizing complex morphologies (22). Variability in OPG imaging arise from several parameters, including resolution and geometric configuration of radiographic apparatus and unvoluntary patients'

movements through the exposure process, causing motion artifacts. To obtain optimal diagnostic reliability, such variables should be standardized and controlled to the greatest extend possible (22–25). In contrast, cone beam computed tomography (CBCT) offers superior accuracy through three-dimensional, high resolution, distortion-free technique, enabling precise assessment of spatial relationship. Nonetheless, given its higher radiation dose, CBCT should be prescribed judiciously and must comply with the ALARA principle, ensuring that its use is reserved for cases where the diagnostic benefit clearly outweighs the radiological risk (22).

1.6. Classification systems

Extraction complexity is largely determined by the vertical depth and angular orientation of impacted tooth, commonly classified according to Pell & Gregory and Winter systems (2,5,11,12).

Pell & Gregory classification distinguish TM impaction through a dual-criterion framework. The first criterion, evaluates anteroposterior relationship of the tooth crown to the anterior border of mandibular ramus, assigning Classes I, II and III. The second, considers its vertical alignment with respect to occlusal plane of adjacent second molar, defining Classes A, B and C, according to increasing depth of impaction (11,12).

Winters' system classifies impacted TM according to their inclination with respect to long axis of the adjacent molar, serving as an important indicator of surgical complexity (2,5,9,20). The classification provides several angulation types: vertical, mesioangular, horizontal, distoangular (5,20). Less common configurations include transverse position, where the tooth is directed to the lingual or vestibular plate and inverted impaction, characterized by complete reversal tooth position (20).

From clinical perspective, extraction difficulty may be hierarchically stratified into four-level grading system, ranging from vertical eruption (VE) to complete bony impaction (CBI), with intermediate stages of soft tissue impaction (STI) and partial bony impaction (PBI) (20).

1.7. Extraction techniques

Dental extraction is a part of oral surgery which refers to deliberate removal of a tooth from its alveolar socket. Non-surgical technical extraction sequence involves controlled and progressive dilatation of the alveolus to facilitate tooth's mobilization and removal using forceps (17).

Surgical extraction, which lies on the core of the present investigation, refers to the removal of a tooth through flap elevation, most commonly designed as an envelope or triangular incision. Bone removal follows, using burs with irrigation, chisels, or piezoelectric instruments, depending on the clinical situation. After the tooth extirpation, healing is managed through either primary

or secondary closure, with optional use of adjunctive measures, as drains or platelet concentrates (24).

1.8. Controversy and clinical dilemma

From functional perspective, extraction may be required as an adjunctive measure to enable successful orthodontic, prosthetic or orthognathic procedures. Removal of symptomatic TM enhance masticatory comfort and translates into measurable long-term improvement in overall patients' quality of life. While TME effectively resolves pathological conditions, it remains associated with several drawbacks, notably postoperative morbidity and prolonged convalescence. Evidence suggests that preexisting symptoms impair postoperative recovery; paradoxically, even in absence of pathology, extraction may still compromise some specific parameters, particularly periodontal integrity of the adjacent second molar. Although major complications are infrequent, performing extractions without justified indication remains problematic, consequently the decision to extract should be based on a balanced appraisal of expected benefits versus potential risks (25).

While absolute contraindications to dental extraction are rare, certain systemic and anatomical factors necessitate prior multidisciplinary optimization. Although uncontrolled systemic disorder, such as hypertension, epilepsy, vasculopathy, advanced renal failure or immunosuppression increase considerably peri-operatory potential for complications, the major risk concern pose medication related to osteonecrosis of the jaw (MRONJ). Similarly, patients previously irradiated in the head and neck region are highly predisposed to osteoradionecrosis (17).

2. OBJECTIVE

2.1. Justification of the study

Third molar extraction (TME) constitutes a major component of oral surgery practice and remains associated with a notable rate of postoperative complications, reported around 10%, both for its ubiquity and substantial prevalence of third molar impaction (12,26). Despite the extensive body of literature covering the topic of surgical approach and its respective outcomes, prior research has predominantly focused on factors such as the extent of bone removal, degree or type of impaction, and patient-related variables. Conversely, the role of incision design has received relatively limited attention and remains comparatively underexplored. TME morbidity potential continue to generate clinical debate due to the diversity of adverse events and given the high frequency of the procedure and variability in surgical approaches, understanding the influence of different flap designs remains clinically relevant. Improving risk assessment, preventions and therapeutic approach is indispensable to ensure patient safety and satisfaction.

Conducting a systematic analysis of complications and management strategies is relevant for strengthening scientific knowledge, promoting standardization of care and reducing unfavourable outcomes (26). A comprehensive knowledge of the nature and frequency of undesirable events, along with the elements that increase their likelihood, is fundamental to support informed decision-making process. Patients' expectations and awareness had increased in recent years, therefore by offering a critical and structured review of current literature on flap design, this work seeks to contribute not only from academic perspective but also to daily clinical practice. Accordingly, the present study addresses exclusively surgical extraction of impacted third molar, aiming to clarify the extent to which different incision design contributes to clinical outcomes.

2.2. Principal objective

To evaluate the influence of flap design on postoperative morbidity following surgical TME.

2.3. Specific objectives

1. To identify the most frequently reported postoperative adverse event following TME.
2. To determine appropriate management strategy for the most prevalent postoperative complication.

2.4. Research hypothesis

In line with the objectives of this study, a central hypothesis is proposed:

No significant differences in the incidence or severity of postoperative morbidity are expected between flapless or minimally invasive techniques and conventional flap-based modality in patients undergoing surgical TME.

3. MATERIAL AND METHODS

3.1. Focused question

The present investigation set out to comparatively evaluate outcomes of impacted third molars surgical extraction, contrasting minimally invasive techniques with conventional flap-based methods. The guiding question was structured according to the PICO framework, as follows:

P (Population)	**I** (Intervention)	**C** (Comparison)	**O** (Outcome)
Patients with at least one impacted third molar to be surgically extracted	Flapless or minimally invasive approach	Conventional flap-based technique (triangular/Ward, envelope)	Postoperative complications

- Among patients undergoing surgical extraction of at least one impacted third molar (P), does a flapless or minimally invasive approach (I), compared with a conventional flap-based technique (C), reduce postoperative complications? (O)?

3.2. Study research

3.2.1. Source of information and search strategy

Structured research for retrieval of solid scientific evidence was conducted using PubMed as the main database, chosen for its extensive biomedical and dental research coverage. Relevant publications, with language restriction to English and involving human subjects, were duly selected in electronic bibliographic sources. All data sources were carefully vetted with an inclusion criterion, to be published in last 5 years, with an aim to keep this review up to date as possible.

3.2.2. Research query

As a research strategy, a combination of specialized vocabulary relevant to the topic was elected. The research formula comprised the following Medical Subject Headings [MeSH] terms, free-text keyword [tiab], boolean operators AND and OR to structure the query, and wildcards (*) used to include words variations:

(Third Molar[MeSH] OR third molar*[tiab] OR wisdom tooth*[tiab]) AND (flap*[tiab] OR flapless[tiab] OR sutureless[tiab] OR "envelope flap"[tiab] OR "triangular flap"[tiab] OR "modified triangular flap"[tiab] OR ward[tiab] OR "modified ward"[tiab] OR bayonet[tiab] OR Szmyd[tiab] OR comma-shaped[tiab] OR "minimally invasive"[tiab])

The research strategy was deliberately structured to prioritize population and surgical intervention terms to maximize sensitivity. Postoperative outcomes were evaluated during the screening phase.

3.2.3. Inclusion and exclusion criteria

Inclusion criteria:

- Studies published from January 1, 2021 to February 23, 2026
- Human studies
- Studies evaluating minimally invasive/flapless technique with conventional flap-based surgery of third molars (TM)
- Studies involving included maxillary and/or mandibular TM
- Studies reporting at least one of following outcomes: pain, edema, trismus, alveolar osteitis, wound dehiscence, probing depth distal to second molar

Exclusion criteria:

- Meta-analyses, systematic reviews
- Narrative reviews, editorials
- Preclinical studies (in vitro and ex vivo)
- Animal studies
- Publications in languages other than English
- Studies focusing on teeth other than TM
- Studies documenting non-included TM
- Studies not reporting clear outcome data related to postoperative complications
- Studies published before January 1, 2021

3.2.4. Applied filters

PubMed search was limited to:

- Date : from 01/01/2021 up to 23/02/2026
- English
- Human studies

Only peer-reviewed journals were considered.

3.2.5. Study selection process

A three-stage selection process was undertaken:

1. An initial screening of titles was performed to discard publications unrelated to the scope of the review.
2. Subsequently, abstracts were examined to identify and retain studies of higher relevance.
3. Finally, full-text reading was conducted to confirm the eligibility of selected studies for inclusion.

3.2.6. Data extraction

From each included study, the following general variables were systematically collected: DOI, authors, year of publication, country, study design, sample size, sex distribution, age (years), tooth location (maxilla/mandible), extraction method (flapless/ flap-based), main complications, management, surgical time and follow up period (days, weeks, months), main findings.

The clinical outcomes extracted were as follows:

- type of postoperative complications, including but not limited to pain, edema, trismus, wound dehiscence, probing depth distal to second molar
- healing and postoperative recovery time, based on clinical follow-up.

3.2.7. Data synthesis

Given the substantial heterogeneity in collected data and outcomes reporting a qualitative synthesis was undertaken. When possible, analogies were drawn between types of surgical methods and frequency of reported problems.

4. RESULTS

4.1. Study selection. Flow chart

Following application of the research query in advanced settings, the initial PubMed research identified 413 records. A sequential application of predefined filters was then performed. First, restriction by publication date reduced the number of records to 163. Restricting to English-language publications reduced the number of articles to 152. After limiting to studies conducted in humans, 79 records were eligible for screening and are represented in the PRISMA flow diagram. All retrieved references were exported in .nbib format and imported into dedicated Zotero collection created exclusively for the PRISMA selection process, without data loss or technical complications. For precision, references used for elaboration of introduction were managed separately. A duplicate detection process was performed prior to screening in accordance with PRISMA 2020 recommendations, however no duplicate records were identified. Additionally, three studies were identified through manual searching, though ResearchGate and ScienceDirect. Subsequently, titles and abstract screening resulted in 47 records excluded as clearly irrelevant, due to study design and irrelevance to the research question. Thirty-six full-text reports were sought for retrieval, of which one could not be assessed. Thirty-five full text articles assessment resulted ultimately in 19 meeting predefined inclusion and exclusion criteria and were included in the final review. The detailed selection process is provided in Figure 1.

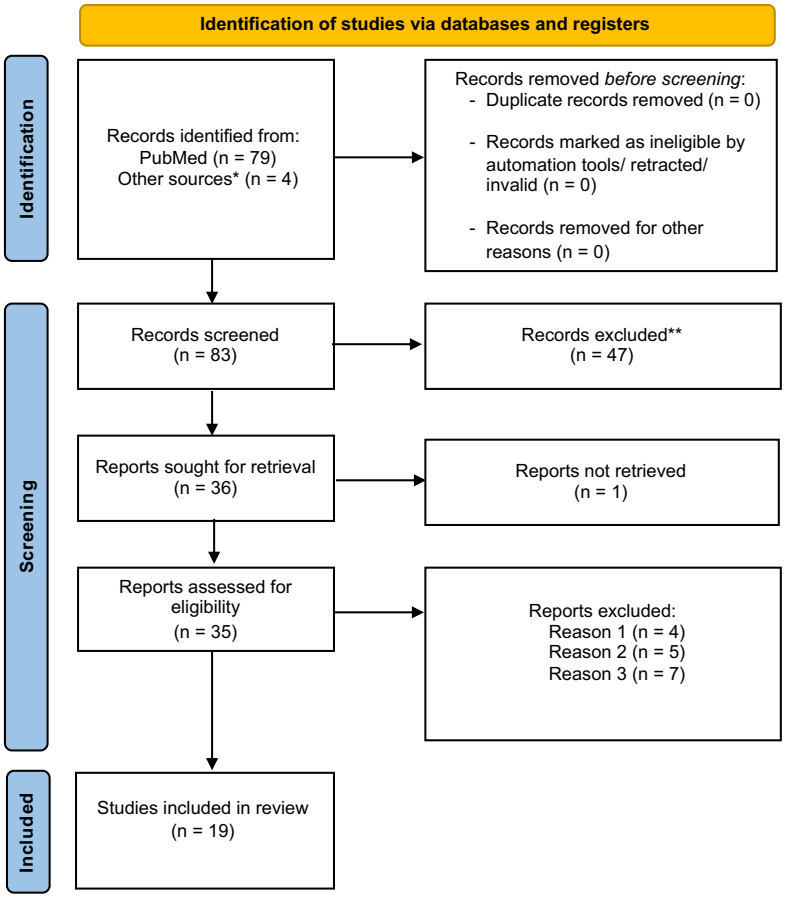


Figure 1. PRISMA 2020 flow diagram for systematic reviews showing database search, article identification, screening, eligibility assessment and final inclusion to the present review.

Source :
Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

Legend
*ResearchGate and ScienceDirect
** Records excluded at title/abstract screening stage
Reason 1: Wrong outcomes, wrong procedure, not surgical extraction
Reason 2: Wrong intervention or comparator
Reason 3: Insufficient, unclear data

4.2. Characteristics of included studies

Ultimately, 19 studies were retained for the qualitative synthesis, comprising 1,369 participants and 1,851 extracted third molars (TM). Most investigated studies were randomized controlled trials (RCT) (13/19, 68.4%), several utilizing split-mouth methodology facilitating intra-patient comparisons of surgical techniques. Remaining six studies were observational or retrospective. Although the predominance of RCTs strengthens the evidence base, methodological heterogeneity remains present. Study samples sizes demonstrated considerable

variability, ranging from 2 to 300 subjects. The pooled population comprised 698 females and 649 males, with one study failing to report sex distribution, resulting in overall relatively balanced representation. Across studies, reported mean ages was largely concentrated within the third decade of life, consistent with the epidemiological peak of TM removal. The overall age range extended from 17 to 75 years, reflecting both, typical young adult presentations and occasional inclusion of older individuals. From geographical perspective, included articles demonstrate broad international representation, with the highest contribution from Italy. Some investigations were conducted through international collaboration. Notably, anatomical distribution was markedly unbalanced, as 17 of 19 articles (89,5%) focused exclusively on mandibular third molars, consequently, the synthetized findings predominantly reflect outcomes associated with mandibular TM surgery, limiting applicability to maxillary procedures.

Table 1. Characteristics of included studies.

DOI	AUTOR/ YEAR	COUNTRY	STUDY DESING	SAMPLE SIZE	n TEETH	SEX	AGE	ARCH
10.1007/s10006-024-01287-2	Sen (2024)	India	RCT	101	101	F46/ M55	27.4y +/- 7.2y vs 27.6y +/- 5.6y	Md U/L
10.1016/j.joms.2021.07.010	Khiabani (2021)	Iran	RCT Single-blinded	34	68	F12/ M22	22yo +/- 12.9y	Md B/L
10.4317/medoral.25425	Costa (2022)	Brazil	RCT Double-blind	60	60	F30/ M30	21.63yo +/- 5.14y (18-40y)	Md U/L
10.3390/jcm12051995	Materni (2023)	Italy	Randomized Blinded Clinical Trial Split-mouth	42	84	F24/ M18	23,8 +/- 7.9 (17-49y)	Md U/L
10.4103/jpbs.jpbs_915_24	Karpe (2024)	Saudi Arabia, India	Prospective Randomized Study Split-mouth	120	240	NS	20-40y	Md U/L
10.1007/s12663-023-02092-2	Shahi (2024)	India	RCT	88	88	F29/ M59	mean 26.4y LBTF/ 25.9y BBTF	Md U/L

10.7759/cureus.91573	Daftary (2025)	India	Non-Randomized Prospective Comparative Study	40	40	F18/M22	group 1: 28.7 +/- 6.23y group 2: 32.8 +/- 8.75y	Md U/L
10.3390/dj12060184	Materni (2024)	Italy	Retrospective Split-mouth Study	30	60	F14/M16	32.1 +/- 10.8	Mx B/L
10.3390/mps8050101	Pippi (2025)	Italy	RCT	56	56	F38/M18	23.7 +/- 4.48y	Md U/L
10.3390/jcm10040593	Materni (2021)	Italy	Retrospective Clinical Study Split-mouth	12	24	F6/M6	23+/- 4y (17-30y)	Md U/L
10.1016/j.jobcr.2022.08.012	Choudhury (2022)	India, Saudi Arabia	Randomized Case-control Clinical Trials (Double-blind)	50	50	F21/M29	25.98y (18-40y)	Md U/L
10.1016/j.heliyon.2023.e16161	Zhao (2023)	China	RCT	80	80	F42/M38	21.3 +/- 2.6y	Md U/L
10.1016/j.ajoms.2025.06.005	Naruse (2025)	Japan	RCT Multicenter, Single-blind	188	188	F113/M75	31.3y (20-75y)	Md H U/L
10.3390/ijerph18094465	Ahmad (2021)	Pakistan, Saudi Arabia	Randomized Controlled Trials	60	60	F25/M35	23.22 +/- 3.17y	Md
10.1016/j.cpsurg.2024.101675	Gumrukcu (2024)	Turkey	RCT Single-blind	38	38	F30/M8	22.4 +/- 3.6y	Md V or MA U/L
10.55519/JAMC-02-12544	Lohana (2024)	Pakistan	Randomized Controlled Trials	126	126	F78/M48	31.16 +/- 9.29y	Md MA U/L
10.7759/cureus.34799	Kukreja (2023)	India	Randomized Comparative Clinical Study	40	40	(based on %) F18/22M	18-60y	Md U/L
10.5125/jkaoms.2023.49.2.91	Ku (2023)	South Korea	Comparative Split-mouth Case Report	2	8	F0/M2	20yo and 21y	Mx & Md B/L
10.3390/dj11100238	Albanese (2023)	Italy	Retrospective Study	300	300	F154/M146	27.9y (A) 26.2y (B)	Md U/L

Legend:

F – female / M - man
Md – mandible / Mx - maxilla
U/L - unilateral impaction
B/L - bilateral impaction
MA - mesioangular impaction
V - vertical impaction
H - horizontal impaction
NS - not specified

4.2.1. Influence of flap design on postoperative complications

The collected data were systematically screened and summarized in a structured table reporting respective outcomes and whenever superiority was reported, or no clear consensus could be established.

Table 2. Different flap design influence on postoperative complications.

AUTOR/ YEAR	SAMPLE SIZE	ARCH	INTERVENTION	COMPARATOR	INTERVENTION OUTCOME	COMPARATOR OUTCOME	SUPERIORITY
Sen (2024) (27)	101	Md U/L	Standard Ward Incision + Multiples sutures (SWI+MS)	Standard Ward Incision + Sutureless (SWI+S)	↓ bleeding — ↑ trismus ↓ healing	↓ trismus ↓ ST ↑ drainage — ↑ PD 2M	SWI+S ↑ recovery ↓ morbidity BOTH: = pain = edema
Khiabani (2021) (28)	34	Md B/L	Minimally Invasive Envelope Flap (MIEF)	Conventional Envelope Flap (CEF)	↓ pain ↓ edema ↓ trismus ↓ WD ↓ morbidity	gold standard easier	MIEF ↑ QoL
Costa (2022) (29)	60	Md U/L	Minimal-Invasive Envelope Flap (MIEF) (5mm visibility)	Conventional Envelope Flap (CEF)	↓ edema ↓ INF ↓ ST ↑ healing — ↑ speech discomfort ↑ difficult for unexperimented	gold standard easier	MIEF ↑ QoL BOTH: = trismus = swallowing = chewing
Materni (2023) (30)	42	Md U/L	Flapless Surgical Approach (FSA)	Single Incision Access (SIA)	↓ ST ↑ safety NMC — ↓ recovery	↑ healing ↓ invasive ↓ min pain ↓ min edema	SIA ↑ recovery ↑ QoL BOTH: ↓ PD pain & edema : NC age or sex AO & INF NR
Karpe (2024) (31)	120	Md U/L	Flapless (F)	Buccal Flap (Triangular Ward + suture) (BF)	↓ pain ↓ edema ↓ trismus ↓ ST ↑ recovery ↓ morbidity	↑ A&V — ↑ trismus ↑ ST	F ↑ QoL ↑ recovery ↓ INF ↓ min ST ↓ V&A better for less complex cases

Shahi (2024) (32)	88	Md U/L	Buccal Base Triangular Flap (BBTF)	Lingual Base Triangular Flap (LBTF)	↓ pain ↓ edema	↑ pain ↑ edema ↑ INF	BBTF ↓ INF ↓ morbidity BOTH = trismus = pain W1
Daftary (2025) (33)	40	Md. U/L	Triangular Flap with Modified Ward's Incision (TF)	Envelope flap (EF)	↑ V&A ↓ AO risk — ↑ edema ↑ tissue trauma	↓ edema ↓ trismus ↓ dehiscence ↑ conservative — ↑ AO	EF for uncomplicated extractions TF for complex cases
Materni (2024) (19)	30	Mx B/L	New technique (NT) (single oblique incision, no flap elevation, cyanoacrylate glue)	Traditional access (TA) (flap elevation + sutures)	↓ pain ↓ ST ↓ invasive ↑ healing ↑ comfort (adhesive closure) — need + studies	standard — ↑ pain (6/30 pain-free W1) ↓ healing (17/30 wound closed W4) suture required ↑ ST ↑ trauma	NT ↓ pain ↑ healing ↑ comfort ↑ QoL BOTH NMC = difficulty of extraction
Pippi (2025) (34)	56	Md U/L	Intrasulcular Bayonet Flap (IBF)	Envelope Flap (EF)	↓ pain ↓ dehiscence	↑ pain ↑ edema ↑ dehiscence	IBF ↑ QoL ↓ dehiscence BOTH routine = edema D14
Materni (2021) (35)	12	Md U/L	Flapless Surgical Approach (FSA)	Traditional Approach Envelope Flap (TA)	↓ pain ↓ edema ↑ healing ↓ PD ↓ ST no sutures	standard — ↑ ST ↑ discomfort sutures	FSA NSR + studies need
Choudhury (2022) (36)	50	Md U/L	Buccal Envelope Flap (BEF-A)	Pedicle Flap (PF-B)	↑ A&V — ↑ dehiscence 48% ↑ 20% AO	↑ healing ↓ dehiscence 12% 0% AO	PF-B ↑ QoL BOTH: = pain = edema = trismus
Zhao (2023) (37)	80	Md U/L	Minimally Invasive Extraction + Modified Triangular Flap (incision 1-2mm apically) (MTF)	Minimally Invasive Extraction + Traditional Triangular Flap (incision along gingival sulcus) (TTF)	↓ tissue damage ↓ PD ↓ INF — ↓ ST	↑ accessibility — ↑ PD ↑ bleeding	MTF ↓ damage ↓ PD ↓ biological stress
Naruse (2025) (38)	188	Md H U/L	Modified Envelope Flap (mEF) with osseous reduction & crown-root separation	Triangular Flap (TF) with osseous reduction & crown-root separation	↓ pain ↓ invasive — ↓ V&A	↑ wide SV — ↑ pain ↑ INF ↑ invasive	mEF ↓ pain ↓ trauma current evidence inadequate to recommend flap design
Ahmad (2021) (39)	60	Md. U/L	Szmyd Flap (SF)	Envelope Flap (EF)	↑ healing ↓ PD	↑ A&V — ↑ PD ↑ WD 30%	SF ↓ PD ↑ healing (min disruption to blood supply)

Gumrukcu (2024) (40)	38	Md V or MA U/L	Buccal-based Modified Triangular Flap (BBMTF)	Lingual-based Tongue-shaped Flap (Berwick) (LBTSF)	↑ simplicity & speed ↑ conservative tension-free closure (inclusion of vertical releasing incision) — incision over bone defect created by extraction = flap collapse = dehiscence risk & bacterial invasion	↓ dehiscence (incision on intact bone) ↑ healing (+bone density) — ↑ ST	Complications & QoL are independent of flap type. surgeons' preference & technical sensitivity
Lohana (2024) (41)	126	Md. MA U/L	Comma-shaped Incision (CSI)	Modified Ward's (MW)	↓ pain ↓ edema ↓ trismus ↑ healing ↓ WD ↓ traumatic no disadvantages explicitly listed	served primarily as group control, advantage not specified — ↑ pain ↑ trismus ↑ INF ↑ difficult to suture ↑ hematoma ↑ bone reabsorption ↑ DP	CSI ↑ QoL ↓ COMPS
Kukreja (2023) (42)	40	Md. U/L	Comma-shaped incision (CSI-B)	Ward's Incision (WI-A)	↓ pain ↓ edema ↓ trismus ↑ healing — ↑ ST ↓ A&V	standard ↑ A&V — ↑ trismus (cuts through temporalis ligament) ↑ infection ↓ recovery (lies directly over bone defect after extraction)	CSI — superior = "distolingual-based" = does not come close to retromolar pad or temporalis attachment, nor overlie resulting bone deformity ↑ QoL ↓ COMPS
Ku (2023) (43)	2	Mx & Md B/L	Mandibular: Modified Triangular Flap with Vertical Incision (MTF) Maxillary: Simple extraction	Mandibular: Envelope Flap without Vertical Incision (EF) Maxillary: Simple extraction	↑ surgical field — ↑ edema	↓ edema — ↓ SV ↑ ST	EF ↓ COMPS
Albanese (2023) (44)	300	Md U/L	Modified Triangular Flap + Odontomy (MTFO- A)	Envelope Flap without Odontomy (EFWO-B)	0% paresthesia ↑ SV — ↑ COMPS (14%) ↑ PA (2,67%) ↑ AO (4,67%) ↑ ST > 45min ↑ osteotomy	↓ ST < 45min ↓ COMPS (12%) ↑ cicatrization — ↑ paresthesia risk 5,33% ↑ exerted pression ↓ SV	No consensus - to minimize AO = EFWO-B - to avoid paresthesia = MTFO-A

Legend
AO - alveolar osteitis
PA - purulent alveolitis
WD - wound dehiscence
PD - probing depth
ST - surgical time
SV - surgical view
QoL - quality of life
2M - second molar
NR - not reported
INF - inflammation
A&V - access and visibility
NMC - no major complications
NC - no connection
min - minimum
+ - more
NSR - not statistically relevant
SR - statistically relevant
COMPS - complications

An additional table was created to determine whenever reported differences in outcomes reached statistical significance.

Table 3. Statistical significance of outcomes by surgical technique.

SURGICAL TECHNIQUE COMPARISON	STATISTICALLY SIGNIFICANT OUTCOME ($p < 0.05$)	NOT STATISTICALLY SIGNIFICANT OUTCOME ($p > 0.05$)	CONCLUSION
Flapless (FSA) vs Traditional Envelope (TE) (31,35)	↓ pain ↓ edema ↓ ST ↑ improved AG levels	Final PPD	FSA significantly mitigates immediate postoperative morbidity and reduces surgical duration without compromising long-term periodontal health of adjacent molar.
Single incision Access (SIA) vs Flapless (FSA) (30)	↑ wound healing time (SIA 1W faster)	Pain, edema, PPD, AG levels	SIA accelerates recovery and patients' comfort.
Pedicle Flap (PF) vs Envelope Flap (36)	↓ incidence of AO ↓ WD ↑ QoL	Pain, edema, trismus, SD	PF provides superior wound stability and enhances QoL by significantly reducing incidence of localized complications: AO and WD.
Comma-shaped vs Ward's/Modified Ward's (41,42)	↓ pain ↓ edema ↓ trismus ↑ WH	—	Comma more effective at attenuating inflammatory cascade (pain, edema) and promoting functional mouth opening.
Modified triangular vs Standard Triangular (37)	↑ improved PPD (W1-W4) ↓ inflammation	Bleeding ST	Modified design significantly preserves gingival sulcus and maintains microbial homeostasis.
Szmyd Flap vs Envelope Flap (39)	↑ enhanced CAL ↑ bone level stability	Distal attachment loss	Szmyd optimizes long-term periodontal homeostasis and enhances alveolar bone stability.

Minimally Invasive vs Conventional Envelope (28,29)	↓ pain ↓ edema ↓ ST ↓ hygiene interference ↑ QoL	Trismus Chewing/ swallowing Long-term pain (D7)	MIE = reducing length of incision limit pain, edema and hygiene interferences, overall QoL
Suture-less vs Multiple Suture Closure (27)	↓ (significant) trismus ↓ fewer cases of delayed WH	Pain, edema, lingual nerve function	Omitting sutures facilitates natural drainage, which specifically improves trismus and reduces cases of delayed WH.
Envelope vs Triangular (Modified Ward's) (33,44)	↓ edema ↑ faster recovery from trismus ↑ risk of paresthesia	Pain PPD (M3)	Envelope may be associated with higher incidence of transient neurosensory changes but results in lower soft tissue complications. Envelope is preferable for routine extractions and triangular more complicated cases.
Modified Triangular vs Berwick Flap (40)	↓ ST (triangular faster)	Pain, edema	Comfort and healing parameters are largely independent of specific flap design, but atypical architecture of Berwick may prolong surgical duration.
New maxillary tech (Glue) vs Traditional (suture) (19)	↓ pain ↑ faster ST ↑ faster wound closure	Edema, bleeding	Glue significantly contributes to reduce pain and faster wound closure.
Modified Envelope vs Triangular Flap (38)	↓ pain (low difficulty cases)	ST	In low extraction difficulty cases, minimizing vertical incisions through modified envelope design significantly reduces early pain without affecting surgical efficiency.
Envelope vs Bayonet Flap (34)	Root morphology and dehiscence	WD QoL Age correlation Gender correlation	Specific clinical differences in wound healing exist but the choice of flap design does not significantly influence the overall postoperative QoL.
Lingual-based vs Buccal-Based Triangular Flap (32)	↑ pain ↑ edema	Trismus	Lingual-based offer no clinical advantages and increase pain and edema.
Vertical incision (modified triangular vs Envelope incision (43)	↑ edema (deep buccal and facial spaces)	pain, trismus	Avoiding vertical releasing is recommended to prevent edema propagation into deeper buccal spaces.

Legend:
AG – attached gingiva
PPD – periodontal probing depth
AO – alveolar osteitis
ST – surgical time
QoL – quality of life
WH – wound healing

4.2.2. Flap designs distribution across included studies and reduction of postoperative morbidity according to flap configuration

Across the 19 included comparative studies, a total of 38 intervention arms were analyzed, as each trial employed a two-arm design. The relative frequency of each flap type was calculated as a proportion of the total number of arms. In contrast, for outcome analysis, evaluation was performed within each specific flap category, meaning that the number of study arms reporting a reduction in given outcome was expressed relative to the total number of arms investigating that specific flap design.

Table 4. Flap designs distribution across included studies and frequency-based synthesis of postoperative outcomes according to flap design.

FLAP TYPE	DESIGN	FLAP n %	PAIN ↓ %	EDEMA ↓ %	TRISMUS ↓ %	DEHISCENCE ↓ %	DP 2M ↓ %	SURGICAL TIME ↓ %	QoL ↑%
Flapless	No flap elevation	10,5 % 4/38	75 % 3/4	50 % 2/4	50 % 2/4	NR	50 % 2/4	75 % 3/4	100 % 4/4
Minimally invasive	Reduced reflection, limited access	10,5 % 4/38	100 % 4/4	75 % 3/4	25 % 1/4	NR	NR	25 % 1/4	50 % 2/4
Envelope	Sulcular, no vertical release	23,7 % 9/38	22 % 2/9	22 % 2/9	11 % 1/9	11 % 1/9	0 % 0/9	11 % 1/9	22 % 2/9
Triangular/ Ward-type	Envelope + vertical release	26,3 % 10/38	10 % 1/10	20 % 2/10	0% 0/10	20 % 2/10	10 % 1/10	10 % 1/10	20 % 2/10
Modified Incision Desing	Comma, Szmyd, Bayonet	26,3 % 10/38	70 % 7/10	40 % 4/10	20 % 2/10	20 % 2/10	20 % 2/10	20 % 2/10	60 % 6/10
Pedicle	Rotational access	2,6 % 1/38	0% 0/1	0% 0/1	NR	100 % 1/1	NR	0% 0/1	100 % 1/1

Legend:
NR – not reported

4.2.2.1. Distribution of flap design across included studies

Flap design distribution was calculated based on the number of intervention arms rather than number of included studies, as most of trials contribute to more than one category. To facilitate segregation of the data, flap designs were classified into six predefined categories based on incision morphology and flap elevation pattern. Classical triangular/ Ward-type flaps and modified flap designs were the most represented approaches (26,3% each), closely followed by envelope incision incisions (23,7%). Flapless and minimally invasive techniques were less frequently investigated, each accounting for 10,5% of intervention arms. Pedicle flaps were the least represented category (2,6%). This distribution indicates a clear predominance of conventional and modified flap-based approaches in the current literature.

To facilitate interpretation, some percentages were rounded up to the nearest whole number on the pie chart.

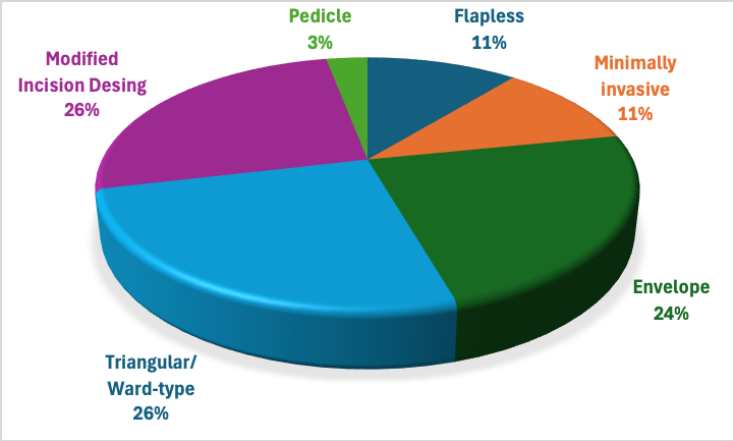


Figure 2. Distribution of flap designs across included studies (n=19).

4.2.2.2. Inflammatory outcomes according to flap type

Flapless and minimally invasive techniques demonstrated the highest reduction in postoperative pain and edema (respectively, up to 75% and 100%), closely followed by modified incision design (70%-75%). In contrast, envelope and triangular/Ward-type flaps showed substantially lower pain reduction and limited edema improvement. A similar pattern was observed regarding trismus; flapless approaches demonstrated the highest benefit (50%), with minimally invasive and modified designs showing moderate reductions. Envelope flaps presented relatively modest effect, whereas triangular/Ward-type presented minimal effect or no improvement, depending on the variable. Pedicle flap was not associated with any improvement in postoperative inflammatory manifestations. Overall, these findings indicate that flapless and minimally invasive approaches are associated with the most consistent reduction of postoperative inflammatory triad.

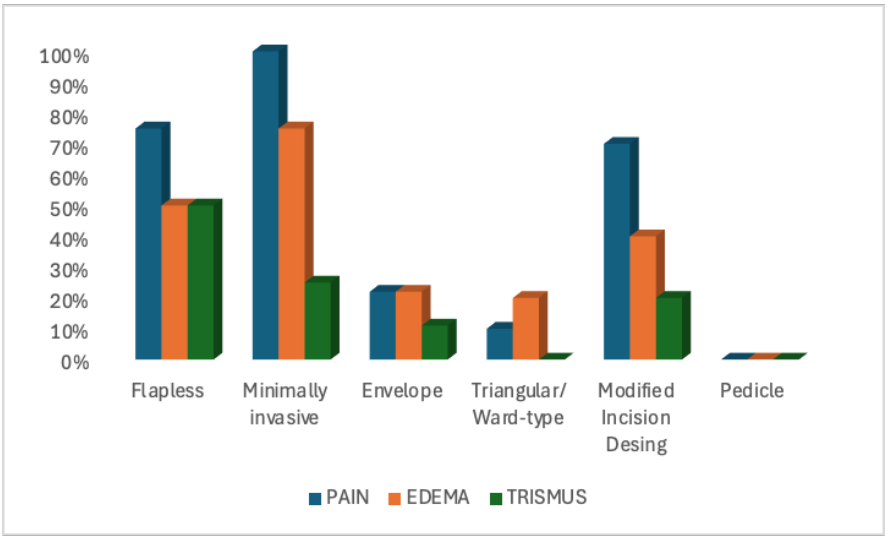


Figure 3. Inflammatory outcomes according to flap type.

4.2.2.3. Outcomes related to surgical performance by flap category

Flapless technique demonstrated the most consistent reduction in surgical time and was associated with improved distal periodontal outcomes. Minimally invasive approaches showed moderate benefits in reducing operative time, although reporting was limited for certain parameters. Modified incision design presented uniform but relatively modest improvements concerning all the studied variables. Conversely, envelope and triangular/Ward-type flaps exhibited minimal functional and periodontal improvement overall. Although pedicle flaps showed complete resolution of dehiscence in the available data, this finding was based on a single study and therefore remains limited in interpretative strength.

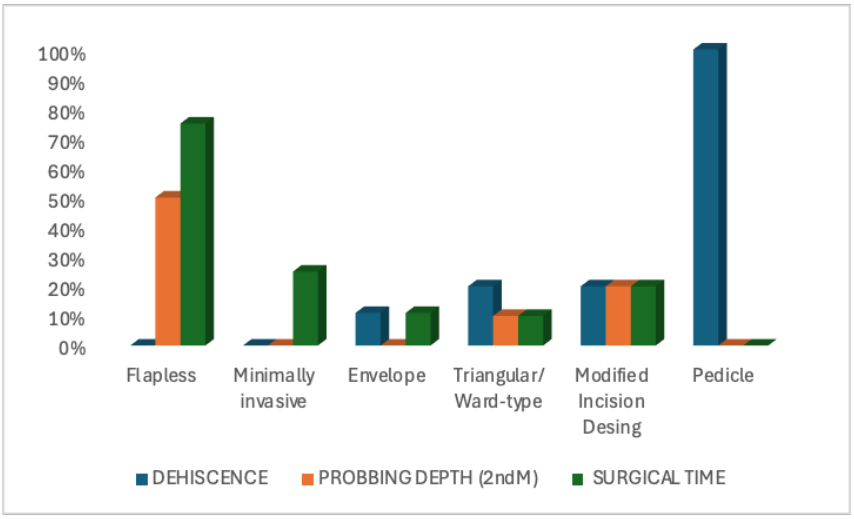


Figure 4. Outcomes related to surgical performance by flap category.

4.2.2.4. Patient-centered outcomes

The highest improvement in quality of life was associated with flapless and pedicle techniques, with all corresponding study arms indicating positive results. Importantly, a reported value of 100% reflects that all included intervention groups reported improvement within that specific category, however this does not imply absolute clinical superiority and particularly when derived from a limited number of studies. Although pedicle flap design demonstrated 100% improvement in postoperative quality of life, this observation was derived from a single study (1/19), therefore limiting robustness within overall dataset. Excluding this isolated finding, modified incision showed the next highest score of 60%, followed by minimally invasive approaches which also exhibited meaningful benefit. In contrast, conventional envelope and triangular/Ward-type flaps demonstrated limited impact on patient reported quality of life.

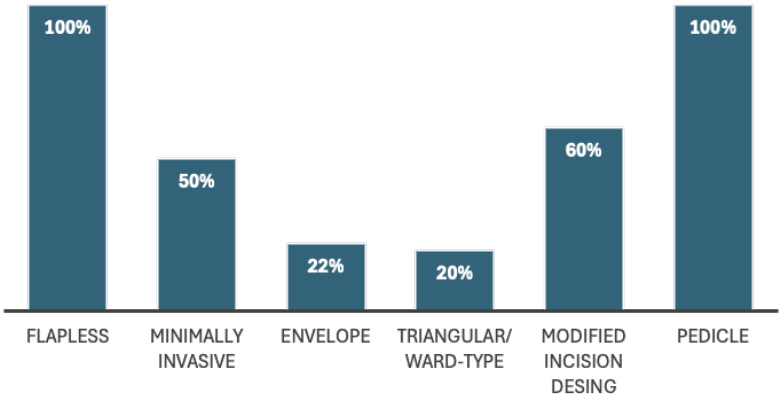


Figure 5. Patient-centered outcomes : quality of life (%).

Note: Percentages were calculated relative to the number of studies evaluating each specific flap type.

4.2.3. Most commonly reported postoperative adverse event after TME

To contextualize the comparative findings related to flap design, the overall reporting frequency of postoperative complications across included studies is presented in the table below.

Table 5. Frequency of postoperative complications report.

AUTOR/ YEAR	SAMPLE SIZE	PAIN	EDEMA	TRISMUS	ALVEOLAR OSTEITIS	INFECTION	NERVE INJURY	WOUND DEHISCENCE
Sen (2024)	101	✓	✓	✓	0/N	0/N	✓	NE
Khiabani (2021)	34	✓	✓	✓	NE	NE	NE	0/N
Costa (2022)	60	✓	✓	✓	0/N	0/N	0/N	0/N
Materni (2023)	42	✓	✓	NE	0/N	0/N	0/N	0/N
Karpe (2024)	120	✓	✓	✓	NE	NE	NE	NE
Shahi (2024)	88	✓	✓	✓	NE	NE	O/N	NE
Daftary (2025)	40	✓	✓	✓	NE	NE	NE	NE
Materni (2024)	30	✓	✓	NE	NE	NE	NE	0/N
Pippi (2025)	56	✓	✓	NE	0/N	0/N	NE	✓
Materni (2021)	12	✓	✓	NE	NE	NE	NE	NE
Choudhury (2022)	50	✓	✓	✓	NE	NE	0/N	✓

Zhao (2023)	80	NE	NE	NE	NE	0/N	NE	✓
Naruse (2025)	188	✓	NE	NE	✓	✓	0/N	NE
Ahmad (2021)	60	✓	✓	✓	✓	NE	NE	NE
Gumrukcu (2024)	38	✓	✓	✓	NE	0/N	NE	NE
Lohana (2024)	126	✓	✓	✓	NE	NE	NE	NE
Kukreja (2023)	40	✓	✓	✓	NE	NE	NE	NE
Ku (2023)	2	✓	✓	NE	NE	NE	NE	NE
Albanese (2023)	300	NE	NE	NE	✓	✓	✓	NE

Legend:
✓ - Outcome evaluated, ≥ 1 case reported in results
O/N – Outcome evaluated, zero cases observed
NE – Outcome not evaluated in the study

Within the corpus of 19 included studies, pain emerged as the most consistently reported postoperative adverse event, documented in 17 studies (≈ 89%). Facial edema followed closely, appearing in 16 studies (≈ 84%), indicating similarly high reporting prevalence across the analyzed literature. Trismus was identified in 11 studies (≈ 58%), which represents intermediate representation. In contrast alveolar osteitis and wound dehiscence were reported in 3 studies each (16%), indicating limited documentation. Infection and nerve injury exhibited the lowest representation, each appearing in only 2 studies (11%), suggesting sporadic reporting within the current evidence base.

This distribution highlights a disproportionate emphasis on certain postoperative outcomes within the literature. The predominance of specific complications may reflect their clinical relevance, higher incidence, or routine inclusion as predefined outcome measures in surgical trials. Importantly, these proportions quantify the frequency of reporting across studies and not the absolute clinical incidence among patients. The observed variability may be attributed to heterogeneity among included studies, including variation in study design, selective outcome reporting, methodological rigor, differences in outcome definitions, different prioritization of endpoints and finally postoperative follow-up duration.

Table 6. Synthesis of results of most commonly reported postoperative complication.

ADVERSE EVENT	TOTAL NUMBER OF INCLUDED STUDIES	STUDIES REPORTING IT	OUTCOME EVALUATED 0/N	OUTCOME NOT EVALUATED	% OF INCLUDED STUDIES
Pain	19	17	0	2	≈ 89%
Edema	19	16	0	3	≈ 84%
Trismus	19	11	0	8	≈ 58%
Alveolar Osteitis	19	3	4	12	≈ 16%
Infection	19	2	6	11	≈ 11%
Nerve injury	19	2	5	12	≈ 11%
Wound dehiscence	19	3	4	12	≈ 16%

4.2.4. Management strategy of the most commonly reported postoperative adverse event

Considerable variability was observed in postoperative management protocols aiming to minimize morbidity, as summarized in the following table.

Table 7. Synthesis of management strategy.

AUTOR/ YEAR	ANTIBIOTICS	ANALGESISC/ NSAIDS	CORTICOSTEROIDS	OTHER MESURES	FOLLOW UP
Sen (2024)	"administered as prescribed" ND	"administered as prescribed" ND	NR	1. sutures group A (3-0 silk) group B (suture-less) 2. mouthwash: warm salt water 3. OHT	PO: D1, D3, D7 & 1M
Khiabani (2021)	ND	ND	ND	ND	PO: D2, D7
Costa (2022)	**Pre-op:** 1g Amoxicillin (1h prior)	Acetaminophen 500mg (3x/day, 5d)	**Pre-op:** Dexamethasone 8mg PO: Dexamethasone 4mg (3x/day, 3d)	1. sutures 4-0 nylon 2. CHX 0.12% (4x/day, 4d)	PreO: DO PO: D3, D7
Materni (2023)	NA	Ibuprofen 600mg (1 every 12h/3d)	**Pre-op:** Dexamethasone 8mg IM (4mg per side)	1. ice 5min alternating 2. cold meal 3. CHX 0.12% (W1)	every week PO
Karpe (2024)	PO: Amoxicillin 500mg + Metronidazole 400mg (3x/day, 5d)	Ibuprofen 400mg (3x/day, 3d)	NR	sutures group I 3-0 Mesilk group II None	PO: 2D, 7D, 1M, 2M
Shahi (2024)	standard regimen + PPI 5d ND	analgesics 5d ND	NR	sutures 3-0 silk	PO: D3, D5, D7, D28
Daftary (2025)	PO: Amoxicillin 500mg + Metronidazole 400mg (3x/day, 5d)	Ibuprofen 400mg "as needed"	NR	1. sutures 3-0 silk (removed D7) 2. intraoperative irrigation saline	PO: D1, D3, D7 & 3M

Materni (2024)	NA	NA "pain recorded as bearable"	NR	1. sutures TA 4-0 PGCL NT cyanoacrylate glue 2. bovine collagen sponge	PreO: D0 PO: W1, W4, W8
Pippi (2025)	**Pre-op:** 2g Amoxicillin + Clavulanic acid (1h prior)	analgesics ND	NR	sutures 4-0 silk (removed D7)	PO: D2, D7, D14
Materni (2021)	NA	Ibuprofen 600mg (1/12h, 3d)	**Pre-op:** Dexamethasone 8mg IM (4mg per side)	1. ice 5min alternating 2. CHX 0.12% (W1) 3. sutures: TA (4-0 PGCL), FSA (none)	PreO: D0 PO: D1, D2, D3, W8
Choudhury (2022)	PO: Amoxicillin 500mg + Metronidazole 400mg (3x/day, 3d)	Ibuprofen 400mg + Paracetamol 325mg (3x/day, 3d)	NR	sutures 3-0 silk (removed D7)	PO: 2D, 7D, 30D
Zhao (2023)	NA	Loxoprofen sodium 60mg (3x/day, 3d) "if necessary"	NR	1. sutures 4-0 silk 2. OHT	PO: 1W, 4W, 8W
Naruse (2025)	PO: Amoxicillin 250mg (3x/day, 2d)	Loxoprofen 60mg (3x/day, 7d)	NR	1. (local) oxytetracycline hydrochloride + gelatine sponge 2. sutures 5-0 nylon	PO: 7D +/-1D
Ahmad (2021)	PO: Amoxicillin 500mg (3x/day)	NSAID ND	NR	1. sutures 4-0 silk 2. irrigation saline	PO: 3M, 6M
Gumrukcu (2024)	PO: Amoxicillin 1000mg (2x/day)	Flurbiprofen 100mg (2x/day)	NR	1. CHX + Benzydamine HCl antiseptic mouthwash 2. sutures (removed D7)	PO: D3, D7 & 3M, 6M
Lohana (2024)	PO: Amoxicillin + Metronidazole (3x/day, 5-7d)	NSAIDs (3x/day, 5-7d) ND	NR	1. sutures 3-0 Vicryl 2. bite on gauze 30 min	PO: D1, D3, D7
Kukreja (2023)	PO: Amoxicillin 500mg + Metronidazole 400mg (5d)	Diclofenac potassium 50mg (5d)	NR	sutures 3-0 silk	PO: 3H, D1,D3,D7
Ku (2023)	PO: Amoxicillin 625mg (3x/day, 7d)	Dexibuprofen 500mg (3x/day, 7d)	NR	Pre-op: 1. general anesthesia PO: 1. bilateral ice packs 2. cold food 3. CHX daily 4. collagen plug in socket	PO: D1—D4

Albanese (2023)	**Pre- op:** Amoxicillin 2 tablets of 875mg + Clavulanic acid 125mg (1h prior) + CHX 0.20% 1min PO: Amoxicillin 875mg + Clavulanic acid 125mg (3x/day, 5d)	Physiological pain relief	NR	Pe-op: 1. CHX PO: 1. sutures 4-0 Vicryl (removed D7) 2. irrigation 0.9% saline	PO: 60 days

Legend:
NA – not administered
NR – not recorded
CHX – chlorhexidine
D – days
W – weeks
M – months

5. DISCUSSION

Contemporary clinical literature provides a multifaced evaluation of surgical methodologies for third molar (TM) odontectomy, focusing on the reduction of inflammatory cascade and optimal periodontal healing dynamics (33,40).

5.1. Synthesis of main findings

5.1.1. Mechanisms of inflammatory morbidity and incision design

Surgical trauma during extraction of impacted TM triggers a significant release of proinflammatory mediators, such as prostaglandins, histamine and cytokines, leading to the common postoperative triad of pain, edema and trismus, that often disrupt patient's functional capacity and amplify nociceptive signalling, collectively contributing to diminished quality of life (32,34,41). Optimal management of these adverse events is multifaced, with a flap design as one of the primary determinants of severity (34,44). Notably, several included studies classified postoperative inflammatory manifestations as expected physiological response of the organism rather than true complication (27,36,40,44).

Evidence indicates that flapless (FSA) and single incision access (SIA) significantly attenuate this set of three interrelated inflammatory elements by minimizing mucoperiosteal elevation and vascular disruption (35).

Regarding postoperative pain, individual trials, such as those for the minimally invasive envelope flap (MIE) report a significantly less painful experience for patients during the first 3 days when compared to conventional 20mm incisions (29). Comma-shaped innovative geometric approaches have also been shown to consistently outperform standard Ward's

incisions at this point (41,42). Traditional techniques like the envelope flap and triangular flap remain the most widely employed, yet they are frequently associated with postoperative discomfort (35,44).

These specific successes contrast with the meta-analysis (45) results, which found no statistically significant difference in pain levels between envelope and triangular modalities over time, with exception of 6th postoperative day when envelope was found more painful. De Marco et all. (2021) scoping review even notes that in some studies, triangular and modified triangular flaps actually reported better pain results, highlighting the probable variability in patient perception (46).

Trismus, or limited mouth opening, is another common manifestation of inflammatory morbidity where results vary between specific studies and systematic overviews. Clinical research indicates that sutureless techniques and flapless approaches result in markedly attenuated trismus and fewer cases of delayed wound healing compared to multiple-suture closure (27,31). From another perspective, Karpe et al. (2024) demonstrated that a flapless approach leads to significantly reduced postoperative edema, discomfort and trismus, while also improving procedural efficiency through shorter operative times (31). These observations broadly reflect the conclusions of the scoping review conducted by De Marco et al. indicating that trismus is more closely related to the duration of the surgical procedure that the specific flap design chosen. Similarly, comparative clinical data provided by Materni et al. (2021) highlighted that a flapless surgical approach (FSA) undoubtedly supports significant reduction in postoperative edema and pain relative to traditional flap elevation method (35). Albanese et al. (2023) observed that while the conventional envelope flap may be associated with a higher incidence of transient neurosensory alterations, it frequently correlates with a lower overall percentage of healing complications when compared to triangular flap (44). In comparative analysis, Daftary et al. (2025) established that envelope flap design demonstrates enhanced control of facial tumefaction and promotes more reestablishment of physiological mandibular mobility compared to triangular design. This clinical advantage is potentially attributed to the preservation of mucoperiosteal integrity, which facilitates enhanced lymphatic drainage and limits interstitial fluid accumulation (33). Conversely, qualitative and quantitative analysis using magnetic resonance imaging (MRI) by Ku et al. (2023) provides evidence that vertical releasing incisions are biophysically linked to more extensive edema propagation, specifically spreading into the buccal space beyond the buccinator muscle (43). However, the scoping systematic review by De Marco at al. introduces a broader perspective, noting that while there is a general trend favouring the envelope flap for reducing swelling, the existing literature remains divided and lack a consensus on an “ideal” design (46). This ambiguity is further supported by the meta-

analysis of Glera-Suárez et al., which found no clear, statistically significant differences in swelling among various major flap designs across a cumulative literature (45).

Comparable observations have been reported in systematic review evidence (47), which suggest that minimally invasive techniques are associated with greater patient satisfaction, which is consistently liked to reduced postoperative pain. Importantly, while flapless or minimally invasive approaches were associated with improved results in inflammatory outcomes in some individual studies, the overall findings related to postoperative morbidity appear to be much more complex (46). Ultimately, while specific modifications like the pedicle flap or modified triangular flap show promise in reducing localized complications, as alveolar osteitis and dehiscence (36,37), systematic reviews suggest that surgical difficulty, surgeon experience, and minimization of operative time are the most critical factors in managing inflammatory morbidity (44,46).

5.1.2. Innovation in incision design

The progressive shift to minimally invasive surgery aims to reduce surgical invasiveness and shorten recovery periods by limiting tissue dissection while maintaining adequate surgical access (29). In that context, single-incision access, comma or bayonet type modifications can be interpreted as attempt to maximize operative control. Specific modifications have been proven superior to classical designs in reducing postoperative sequelae (19,34,39,41,42). Lohana et al. (2024) suggest that comma-shaped incision may confer clinical advantages over modified Ward's incision, including diminished pain and edema, improved mouth opening and faster tissue recovery. The technique was also described less traumatic and no particular disadvantages were explicitly documented in the study (41). This was corroborated by Kukreja et al. (2023), who found that the comma incision resulted in lower pain scores and enhanced wound healing compared with standard Ward's incision, accompanied by reduced trismus and improved patient-reported quality of life (42). The 2020 Glera at al. meta-analysis did also show that comma flap subtype was associated with overall reduced postoperative morbidity in some subgroup analyses. Numerous authors suggest that innovative flaps may depend on specific clinical contexts and can be easily influenced by confounding variables, such as patient sex, surgeons experience (29,34,40,44,46), operating time or impaction depth (29,34,38,44,46).

Another aspect of innovation relates to the modification of flap geometry and involves repositioning of incision away from the vulnerable tissue. For maxillary TM, Materni et al. (2024) introduced a new technique involving an oblique incision and cyanoacrylate glue closure, which significantly reduced postsurgical pain and duration of the procedure compared to traditional sutured access (19). Additionally, the use of minimally invasive envelope flaps, utilizing a 5mm incision and tissue tunnelization, has been shown by Costa et al. (2022) to lead to a less painful

experience and volumetric swelling during acute phase compared to conventional 20mm incisions, through limited incision length and minimized periosteal and mucosal reflection (29). Flapless technique (FSA) refine this surgical concept by omitting mucoperiosteal elevation completely, consequently attenuating soft-tissue inflammatory stress (31,35). Advanced variants, such as the single incision access (SIA) evaluated by Materni et al. (2023), have been shown to accelerate wound closure and overall tissue recovery by approximately one week when contrasted with the standard FSA protocol (30). This conceptual evolution is consistent with broader recent available analyses, even though the certainty and comparability of evidence remain relatively limited. Authors adopt a cautious stance and do not support the routine adoption of novel techniques without critical evaluation of each singular case (45).

5.1.3. Periodontal homeostasis of second molar (SM)

Preserving periodontal health of the adjacent SM rest one of the primary concerns when extracting third molar. Impact of flap design (FD) on periodontal healing remains significantly controversial within the clinical literature (35,37,39,41). Given the risk of distal attachment loss and increased probing depth, proper selection of FD seems to be fundamental (37), yet, recent research suggests that while flap is a factor, it is unlikely to represent the sole or principal determinant of the healing course (40,44,46). Flap influence remains not fully clear, many authors indicate that periodontal recovery seems to result from complex interaction of tissue trauma with patients age, preoperative impaction pattern, plaque control and overall surgical burden (33,34,37,46). Many of the recent key studies comparing different flaps, including studies by Daftary et al. and Materni et al., show that while significant changes in probing depth and clinical attachment level occur at distal site of the SM immediately after surgery, this intergroup difference becomes non-significant at 6 months follow-up. Importantly, this perspective was supported by clinical findings indicating that younger patients experience more favourable healing pathways, which reinforce idea that individual host characteristics and site-related factors outweigh specific FD (33,37). The precedent statement, in turn, strengthen the view that conventional envelope and triangular flaps may produce comparable periodontal regeneration when surgery is properly executed and patient exhibits favourable characteristics that promote optimal healing (33).

Not all flaps appear biologically equivalent, Ahmad et al. (2021) concluded that Szmyd FD showed better soft tissue attachment and bone stability around SM compared to conventional envelope flap (39). De Marco at al. systematic review also support the use of paramarginal incision to better preserve periodontal health by leaving a band of keratinized tissue around SM (46). Similarly, Zhao et al. (2023) revealed that modified triangular flap significantly attenuated distal attachment loss and limited pathogenic bacterial proliferation relative to standard

triangular design (37). To provide further clarity on these observations, meta-analytic evidence suggest that the triangular flap may be associated with less clinical attachment loss distal to the SM compared with envelop design (45). To further expand on this finding, Pippi et al. (2025) noted that while the type of flap do not appear to meaningfully affect patient's postoperative quality of life, the envelope flap was associated with larger mean dehiscence diameters than bayonet flap (34). Choudhury et al. (2022), in turn, evaluated a pedicle FD and found that wound dehiscence and alveolar osteitis occurred less frequently, procuring for the patient a beneficial impact on quality of life compared to the conventional triangular flap (36). All of those various findings were confronted in a study evaluating bone healing radiographically, which states that difference in between flaps was not statistically significant (40).

Overall, findings suggest that the preservation of periodontal ligament and gingival fibres, usually closely related to surgeons' technical abilities, is the most critical factor for SM homeostasis. Nevertheless, consulted systematic review points out that variations in probing depth are often limited to the first three post-surgery months, with most parameters returning to baseline thereafter (46). Therefore, while specialized flaps offer short-term protection, long-term periodontal outcomes may be less dependent on the initial incision (34). Although modified designs appear promising, when the risk of distal periodontal breakdown is high, clinicians may obtain greater benefit from combining careful flap selection with adjunctive regenerative strategies. Furthermore, evidence from different investigations suggest that flapless approach or minimally invasive surgical techniques may contribute to slightly improved periodontal health score by avoiding the detachment of soft tissue from the underlying bone, while simultaneously supporting all the evoked previously principles, reflected in higher patient satisfaction (31).

Ultimately, current evidence does not support universal superiority of one flap over another, as such a conclusion would constitute an oversimplification. This statement is consistent with overall recent study results, that conclude that an atraumatic flap execution, particularly avoiding disruption of junctional tissue, is likely more important than rigid adherence to a single design (31).

5.1.4. Surgical time and closure strategies

The total duration of the surgery is a well-known predictor of postoperative morbidity (19,29–32,35,37,38,42,43). Concerning closure protocols, sutureless approaches or healing by secondary intention have demonstrated a statistically significant reduction in postoperative trismus when compared with multiple suture primary closure. This improved functional outcome likely results from enhanced drainage of inflammatory fluids, reducing local pressure and subsequent muscle spasm (27,35). Karpe et al., in split mouth research, further emphasized

that the flapless method significantly reduces surgical time by omitting the flap-raising and suturing steps, leading to milder inflammatory response (31). This finding was supported by Materni et al. (2023) which compared two flapless methods and found that the single incision access (SIA) allowed for even faster recovery time, directly improving patients' well-being by decreasing activation of inflammatory pathways (19,29). Consistent outcomes were observed in a study using cyanoacrylate tissue adhesive as an alternative to suture for wound closure, which demonstrated significantly shorter operative times together with reduced postoperative pain (19). Conversely, findings from parallel investigation indicated that although surgical time did not differ significantly between the comma and Ward's incisions, the comma incision resulted in significantly improved patient experience. This observation implies that operative duration may not be the sole determinant of postoperative morbidity but instead represents only one factor within a multifactorial process influencing recovery (41). In this context, tissue tension during wound closure may represent an additional determinant, as the Szmyd flap has been shown to promote healing primarily by reducing closure tensile stress (39). Most observations reported in the included individual studies were corroborated by high-level evidence synthetized in recent literature, particularly by the systematic review by De Marco et al. suggesting that edema and trismus appear to be more strongly associated with intraoperative time than with the flap design itself (46).

5.1.5. Management of most common adverse effect after surgical third molar extraction

Across the included studies, no major postoperative complications were reported. The management of postsurgical morbidity following third molar surgery (TMS) primarily targets pain, swelling, and trismus, which reflects immune-mediated response inherently associated to the procedure. Consequently, recovery care mainly focuses on controlling this inflammatory driven morbidity rather than addressing severe pathological sequelae (19,27–44).

While certain flap designs have been proposed to minimize tissue trauma, the evidence from reviewed articles generally indicates that its configuration alone does not determine postoperative symptoms severity (30,36–38).

It cannot be overlooked that pharmacological therapy constitutes a fundamental component of a large proportion of postoperative care protocols. In terms of antibiotics, TMS is characterized by significant diversity in clinical protocols. While most protocols utilized a combination of systemic antibiotics (ATB) and NSAIDs, a fraction of contemporary studies evaluating flapless or minimally invasive techniques explicitly omitted postoperative ATB (30,35,37). Despite the fact that contemporary evidence does not support the routine ATB

administration in healthy individuals undergoing TMS (48), several clinical protocols mention its prescription either preoperatively, for prophylaxis (29,34,44) or postoperatively, with the most common regimen being a combination of amoxicillin and metronidazole for 3 to 7 days (31,33,36,41,42). Importantly, selected studies were conducted in healthy individuals, suggesting that ATB use were often implemented as a precaution rather than in response to clear clinical indications (27,29,31–34,36,38–44). In contrast, symptoms control was mainly achieved through analgesics, with paracetamol frequently used, either alone or in combination. In addition, attenuation of the nociceptive response and limitation of the early inflammatory phase relied on non-steroidal anti-inflammatory drugs, such as ibuprofen, loxoprofen or diclofenac. Overall, both pharmacological strategies show consistent effectiveness (27,29,35–38,42). In selected situations, especially in scenarios associated with increased surgical trauma, perioperative administration of corticosteroids, most commonly dexamethasone, has demonstrated efficacy (29,30,35). Additional supportive measures included proper wound suturing and intermittent local cryotherapy with application of ice pack within first 24 hours, contributing to vasoconstriction-mediated reduction of edema. Ultimately, antimicrobial mouth rinses, particularly chlorhexidine, were frequently recommended to reduce bacterial load (29,35,40,43,44).

Alongside drug therapy, follow-up visits were structured to assess three main stages of recovery. Most studies primarily concentrated their appraisal on short-term evaluation and implemented a 1 to 7 days window to assess inflammatory triad (30,34,35,42,43), while others added intermediate time points, 14 to 30 days, to monitor recovery time and quality of life (27,32,34,36). Only few of included trials focused mainly on long-term monitoring period to assess alveolar bone density and clinical attachment level distal to the adjacent second molar (33,39,44). Although most of the parameter evaluations were performed during early stage of healing, marked variability was observed in the duration and frequency of patient assessment, reflecting different objectives of each investigation, therefore complicating direct comparison (41–43).

5.2. Clinical interpretation of findings in relation to the PICO question and hypothesis evaluation

The PICO question targeted whether less invasive flap surgical access could mitigate postoperative (PO) morbidity following impacted wisdom tooth extraction and, in this context, the null hypothesis stated that no significant difference exists in the severity of PO adverse events between techniques. Nevertheless, the overall pattern emerging from the reviewed literature indicates that this assumption may not fully reflect the clinical reality. In fact, a

substantial proportion of the included randomized trials reported reduction in early PO morbidity when minimally invasive approaches were employed. They confer certain clinical advantage, specifically regarding pain intensity, facial swelling, and the degree of trismus; parameters that collectively represent inflammatory response. Conversely, for less frequently occurring complications, such as infection or nerve injury, the evidence remains scarce and unconclusive, preventing definitive conclusion. Overall, it appears that the influence of flap design differs depending on the PO outcome considered and is concurrently modulated by additional surgical and patient-related factors. Consequently, in the light of these findings, the null hypothesis can be considered only partially valid and point to the necessity for additional investigation.

5.3. Study limitations

One of the main limitations of this review relates to the applied research strategy, as the analysis was restricted to the PubMed, ResearchGate, ScienceDirect and defined publication period. As a result, relevant studies published outside of these parameters may have been unintentionally excluded. Additionally, a considerable methodological heterogeneity was observed among the included trials, particularly regarding flap design classification, surgical difficulty and outcome assessment timing. Accurate interpretation of surgical outcomes requires a clear understanding of the initial anatomical condition. Unfortunately, although 13 of 19 studies utilized the Pell and Gregory classification to define impaction depth and relationship to the mandibular ramus, their results are not directly comparable because the information was reported in inconsistent way, such as using it as a screening tool to only include or exclude specific teeth, a method to group patients into different difficulty levels or simply as a way to describe the trait of specific patient group (29,30,32–39,42–44). The remaining trials relied on Winter classification, Pederson's Difficulty index (27,31) or various descriptive methodologies (19,28,40,41), resulting in lack of baseline homogeneity. Furthermore, the clinical evidence derives from studies with widely different sample size, extending from specialized case report with only two subjects (43) to larger retrospective analysis of 300 patients (44). Despite this variation, the vast majority of the research explicitly categorizes theirs sample sizes as small, limited, or modest, identifying the restricted number of participants as a primary methodological weakness that necessitates further large-scale validation, because, potentially reducing statistical power and at the same time increasing the risk of underestimating true differences between surgical approaches (19,33–38,41,42,44). A further limitation concerns the experience of surgeons, that was reported explicitly in 14 studies, illustrating a very diverse spectrum of expertise that ranges from broad-certified specialist in research by Naruse et al. (2025) and Ahmad et al. (2021) to post-graduate students operating under supervision (34). In

addition only 9 of included studies were performed by a single operator, which permits to avoid intraoperator bias (19,27,29,30,35–37,40,43). Taken together these observations suggest that outcomes may differ significantly based on individual skill level rather than efficacy of the surgical technique itself. It is also worth noting that 11 of 19 studies focused primarily on short-term inflammatory triad of pain, edema and trismus, with follow-up periods typically ranging from one to seven days (19,27,29,31,33,38,41,42), which limited evaluation of long-term periodontal sequelae. It should also be acknowledged that, regardless of the age of participants, the clinical protocols were consistent in including only participants that were systematically healthy and with exclusion of smokers, pregnant women or with autoimmune disease (27,29,34,35,39), which makes results being uncertain to medically compromised patients. Additionally, the data regarding postoperative prescription pattern were of considerable heterogeneity, limiting conclusions (27). Lastly, during the process of contextualizing the results of the present analysis proved to be challenging due to the relatively small number of recent systematic reviews and meta-analyses focusing on this specific topic. The available reviews did not consistently evaluate all investigated postoperative variables, which restricted the extent of direct comparison, and consequently providing complementary perspectives rather than definitive conclusions.

5.4. Research gaps and future directions

Advancement in the present field requires methodologically standardized randomized clinical trials with expanded sample size and calibrated surgical protocols; among others, uniform application of diagnostic classification, standardized results reporting and single-operator intervention. Beyond this, the implementation of longer follow-up is essential to assess periodontal impact.

6. CONCLUSIONS

Systematic assessment of surgical modalities in third molar odontectomy demonstrates a progressive transition towards minimally invasive, tissue-preserving strategies. Based on the synthesis of recent available clinical evidence, the degree of surgical invasiveness, particularly flap design, plays a decisive role in modulating postoperative inflammatory morbidity. Variations in incision configuration can substantially affect short-term healing parameters, such as swelling, overall discomfort and interincisal limitation. Despite differences in healing trajectories, long-term patient-centred outcomes and periodontal parameters tend to converge across traditional flap approaches (34,44). Evidence suggests that the conventional envelope flap may offer advantage over triangular in reducing facial edema and promoting earlier recovery of interincisal distance. These benefits are plausibly attributable to more conservative

soft-tissue handling (33). Flapless surgical approaches (FSA) and advanced single incision access (SIA) demonstrate a clear clinical advantage by significantly reducing postoperative pain, edema and trismus through elimination of mucoperiosteal elevation and reduction of surgical duration (30,31,35). Incorporation of vertical releasing incision, characteristic of triangular and Ward-type designs, appears to be associated with more extensive edema, likely due to altered microvascular perfusion and compromise lymphatic drainage pathways (43). Available comparative data indicates that preservation of periodontal integrity is optimized with Szmyd or sulcus-conserving modified triangular flaps. (37,41,42). Specialised design, specifically the comma-shaped incision, emerges as a particularly effective curvilinear modification, demonstrating that by optimizing incision curvature and reducing localized tissue tension, favourable primary healing and greater patient comfort relative to modified Ward's or linear configurations can be achieved (41,42). Collectively, the integrated clinical data indicates that the biological impact of third molar extraction is closely linked to operative duration and extend of tissue manipulation. Shorter operative times, commonly achieved with flapless and minimally invasive techniques, tend to be associated with reduced inflammatory morbidity (19,29,35). Furthermore, approaches promoting secondary intention healing, including sutureless protocols, appear to mitigate trismus by facilitating drainage of inflammatory exudate and reducing facial tension within masticatory musculature (27). Importantly, postoperative complications are not solely dependent on flap design selection but remains multifactorial: anatomical complexity, impaction depth, smoking status, oral contraceptive use, significantly predispose to dehiscence and alveolar osteitis irrespective of flap configuration (19,31,44). It would be an oversimplification to conclude that one flap is universally superior and consequently, should be individualized, guided by case complexity. Clinical decision-making must balance surgical visibility requirements with tissue preservation principles, reserving traditional triangular flaps for deep, complex impactions or anatomically challenging cases requiring enhanced exposure, whereas flapless, minimally invasive options or envelope are preferable for routine extractions to optimize recovery dynamics (19,29,31). Nevertheless, although minimally invasive approaches demonstrate promising advantages, no single flap design can yet be unequivocally identified as the superior standard. Despite considerable efforts and advancements, definitive consensus on the optimal extraction protocol for impacted lower third molar remains elusive. Additional robust randomized clinical trials remain necessary to resolve ongoing uncertainties, strengthen reliability before evidence-based and universally applicable surgical guidelines can be proposed across diverse clinical settings.

7. SUSTAINABILITY

The promotion of minimally invasive surgical approaches in third molar extraction contributes not only to improved clinical outcomes but also to the sustainability of oral healthcare delivery. Reduced operative time, limited material use, and decreased postoperative complication may lower environmental burden, biomedical waste production and decrease healthcare costs. Reduction of surgical morbidity through conservative, tissue-preserving approaches decreases the likelihood of secondary infections and the need for emergency consultations and subsequent adjunctive prescription of antibiotics. Given the critical global treat posed by antimicrobial resistance, this consideration is of outmost importance. Optimized surgical protocols inherently decrease the need for excessive analgesics use and reduce emergency unplanned visits, reinforcing a responsible and resource-efficient model care (48).

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