Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 15 Aug 2026
Revised 13 Sep 2026
Accepted 01 Oct 2026

Natural Resources for Human Health 2026, Vol. 6 (23s): 706–719

KEYWORDS:
Cryotherapy; Mandibular Third Molar; Postoperative Pain; Facial Swelling; Trismus; Systematic review.

Cryotherapy After Mandibular Third Molar Surgery: A Systematic Review and Meta-Analysis of the Published Literature on Application Modes and Their Effects on Postoperative Pain, Facial Swelling and Trismus

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ABSTRACT: Cryotherapy is widely used following mandibular third molar extraction to reduce postoperative pain, swelling, and trismus. However, variations in application methods, temperature, timing, and duration have resulted in inconsistent findings. This systematic review aimed to evaluate the effectiveness of different cryotherapy protocols in managing postoperative complications. Studies published between January 2000 and March 2026 were identified through PubMed, Scopus, the Cochrane Library, Google Scholar, and citation searching. Using a PRISMA-adapted selection process, 102 records were screened, 15 were assessed in detail, and 13 primary clinical studies were included in the qualitative synthesis, of which two did not report sample sizes. Interventions included conventional ice packs, gel packs, controlled apparatus hypothermia, cooled-saline irrigation, and combined thermal therapies. Quantitative analysis was limited to one independent study, which demonstrated significantly reduced facial swelling with controlled apparatus hypothermia compared with conventional ice application on postoperative days 3 (MD = −1.22 mm; 95% CI: −1.64 to −0.80), 5 (MD = −2.15 mm; 95% CI: −2.52 to −1.78), and 7 (MD = −2.16 mm; 95% CI: −2.55 to −1.77). Previous meta-analyses also suggested reductions in early postoperative pain, although findings regarding continuous versus intermittent cooling remained inconsistent. Overall, cryotherapy may reduce postoperative pain and facial swelling following mandibular third molar extraction; however, methodological heterogeneity, inconsistent reporting, and limited comparable data prevent definitive conclusions regarding the optimal application protocol. Further adequately powered randomised controlled trials using standardised cooling regimens and outcome measures are warranted.

1. INTRODUCTION

Surgical extraction of impacted mandibular third molars is among the most frequently performed procedures in oral and maxillofacial surgery. Although generally safe, it is commonly associated with postoperative pain, facial edema, and trismus,

which may impair oral function, aesthetic appearance, and quality of life (Abdyli et al., 2026). These complications result primarily from tissue trauma and subsequent inflammatory responses involving the cyclooxygenase pathway, prostaglandins, and pro-inflammatory cytokines, including tumour necrosis factor-alpha, interleukin-1, and interleukin-6 (Albuquerque et al., 2017; Ruth et al., 2020). Pain typically peaks within the first 24 hours, while swelling and trismus become more pronounced within 48–72 hours (Ruth et al., 2020).

Postoperative morbidity remains clinically significant, with approximately 40–60% of patients experiencing moderate to severe pain requiring analgesic intervention (Albuquerque et al., 2017). Berge and Bøe (1994), in a prospective study involving 204 patients, reported maximum pain at six hours postoperatively, a 31% reduction in mouth opening on the first day, and considerable variability in recovery outcomes. Similarly, Aravena et al. (2016) identified swelling in 83.02% and restricted mouth opening in 50.94% of patients during early recovery. These findings are supported by Braimah et al. (2016), who documented substantial impairment in eating, speaking, and daily activities during the first three postoperative days. A scoping review further identified pain, facial appearance, and feeding difficulties as major determinants of postoperative quality of life (Maferano et al., 2025). However, inconsistencies in postoperative assessment methods, particularly for facial edema, continue to limit comparisons across studies (Abdyli et al., 2026).

Cryotherapy is widely employed as a non-pharmacological intervention to minimise postoperative inflammation, pain, and swelling. It involves the therapeutic reduction of tissue temperature through various cooling techniques, although optimal application protocols remain uncertain (Alexander et al., 2021). Its physiological effects include vasoconstriction, reduced tissue metabolism, diminished nerve conduction velocity, nociceptor inhibition, and reduced vascular permeability (Nadler, 2004; Costello et al., 2011; Garcia et al., 2020). Nadler (2004) reported reductions of 38% in arterial blood flow and 26% in soft tissue blood flow following 20 minutes of local cooling. These mechanisms contribute to analgesia and may limit inflammatory edema; however, their clinical effectiveness varies according to treatment duration, temperature, and application technique. Earlier evidence also demonstrated inconsistent effects of cryotherapy on swelling and blood flow despite relatively established analgesic benefits (Kowal, 1983).

Despite its widespread clinical use, cryotherapy protocols remain heterogeneous, particularly regarding application mode, cooling device, target temperature, initiation time, duration, and adjunctive compression. Larsen et al. (2019) identified substantial methodological variation across randomised trials, limiting meaningful quantitative synthesis, and suggested that intermittent cooling may provide greater benefits than continuous application. Conversely, Wang et al. (2018) directly compared continuous and intermittent cooling in 64 patients, while more recent evidence indicated that continuous cryotherapy initiated within six postoperative hours may improve pain, edema, and trismus, particularly when continued for several postoperative days (Xie et al., 2025). However, shorter continuous applications have demonstrated limited effectiveness, suggesting that treatment duration may substantially influence clinical outcomes (Larsen et al., 2021).

The delivery system and temperature regulation may further influence treatment effectiveness. Conventional ice and gel packs provide variable cooling, whereas controlled devices such as Hilotherm and newer software-regulated systems maintain more consistent temperatures (Stern, 2016; Lateef et al., 2018; Trybulski et al., 2026). Bonitz et al. (2021) investigated cooling at 18°C and 22°C following orthognathic surgery, highlighting the relevance of temperature standardisation. Additionally, adjunctive compression may improve edema management, although findings from other surgical populations suggest that effectiveness depends on the application pattern and duration (Stöckle et al., 1997; Han et al., 2026). The limited availability of direct comparisons, particularly between continuous and intermittent intraoral cooling, further complicates protocol selection (Hamza et al., 2024).

Previous systematic reviews have produced inconclusive findings regarding the effectiveness and optimal administration of cryotherapy. Greenstein (2007) suggested potential reductions in postoperative swelling and discomfort but emphasised insufficient evidence, while Fernandes et al. (2019) identified possible benefits for edema without significant improvement in trismus (MD = 0.43; 95% CI: −0.34 to 1.20) and insufficient evidence for pain reduction. These inconsistencies highlight the need to evaluate cryotherapy according to its specific application characteristics rather than treating it as a uniform intervention.

Therefore, this systematic review aims to evaluate the effectiveness of cryotherapy following surgical mandibular third molar extraction, with particular emphasis on application mode, temperature, timing, duration, and delivery method. The primary outcomes are postoperative pain, facial swelling, and trismus, while secondary outcomes include quality of life, patient

satisfaction, wound haemorrhage, and adverse events where reported. Evidence from other surgical procedures is considered for contextual interpretation but excluded from third molar-specific quantitative synthesis. By examining protocol-related variations, this review seeks to identify clinically relevant factors influencing cryotherapy effectiveness and highlight methodological priorities for future research.

2. MATERIALS AND METHODS

2.1 Study Material

The material of this review is the published literature in two evidentiary layers. The first comprises randomised and non-randomised controlled clinical studies in which a cryotherapy regimen was compared with no cryotherapy, with an alternative cooling modality, with a different schedule of the same modality, or with a pharmacological or physical adjunct. The second comprises existing systematic reviews and meta-analyses, which document which comparisons have been attempted, which outcomes have been prioritised and where analytic choices diverged. Searching both follows practice in the field: reviews restricted to human randomised trials have used multi-database searching plus hand searching (Larsen et al., 2019), and clinical trials in this area have produced inconsistent and contrasting results, which is the stated justification for synthesising them and appraising the certainty of the resulting body of evidence rather than counting it (Nascimento-Junior et al., 2025).

Eligibility has settled on a recognisable population: patients undergoing surgical removal of mandibular third molars, most often healthy individuals with unilaterally or bilaterally impacted mandibular third molars (Firoozi et al., 2022). Reviews have defined the intervention as cryotherapy versus no cryotherapy, with pain as the primary outcome and oedema and trismus as secondary (Júnior & Marques, 2019). Others widened the design criterion to clinical trials, randomised or not, provided the trial evaluated the effect of cryotherapy on at least one of pain, swelling or trismus (Fernandes et al., 2019). Earlier reviews were wider still, admitting any form of cryotherapy used in third molar removal and listing outcomes from body temperature and pain control through swelling, neurological scores, inflammation, satisfaction and quality of life to wound healing (Taneja et al., 2014).

The minimum sample size applied here more than 50 participants is a real restriction, and it has altered the evidence base. It removes the small split-mouth and pilot studies that characterise this literature: the single-blinded randomised controlled trial of cryotherapy alongside mandibular third molar removal enrolled 30 participants and is excluded (Larsen et al., 2021), while a randomised comparison of cold compress methods and durations enrolling 60 participants is admitted (Xie et al., 2025). Excluding a single-blinded randomised trial by a size criterion designed to protect against small-study effects is the clearest illustration of what this threshold costs as well as what it protects against. The criterion is applied wherever enrolment is reported; reports without a stated sample size remain in the set flagged as unresolved rather than assumed to satisfy it.

Table 1. Characteristics of representative systematic reviews and meta-analyses of postoperative cryotherapy after mandibular third molar surgery.

Synthesis	Design and search	Eligibility	Outcomes	Appraisal reported
Larsen and colleagues (2019)	Systematic review of human RCTs in English; MEDLINE, EMBASE, Cochrane Library plus hand search; 37 titles, 6 included	RCTs with or without postoperative cryotherapy after mandibular third molar removal	Facial swelling, pain, trismus, immediate quality of life	Risk-of-bias judgement (low or unclear); variation precluded quantitative synthesis (Larsen et al., 2019)
Fernandes and colleagues (2019)	Systematic review with meta-analysis; six databases to March 2018; 1,080 records, 11 in qualitative synthesis, 4 pooled (Fernandes et al., 2019)	Clinical trials evaluating cryotherapy on at least one of pain, swelling, trismus (Fernandes et al., 2019)	Pain, oedema, trismus	Two reviewers independently screened titles and abstracts, with quality assessed against the Cochrane Handbook (Fernandes et al., 2019); risk of bias high in most criteria categories (Fernandes et al., 2019)
Nascimento-Júnior and	Systematic review and meta-analysis of RCTs; 6 trials	Third molar removal; cryotherapy versus no	Pain, oedema, trismus	Mean differences with 95% confidence intervals; GRADE (Júnior & Marques, 2019)

colleagues (2019)		cryotherapy; pain primary		
Nascimento-Junior and colleagues (2025)	Evidence mapping of reviews; five databases to February 2024; 520 records, 17 full texts, 13 included	Reviews of cryotherapy, wound closure and chlorhexidine after third molar surgery	Clinical outcomes and quality of life	AMSTAR-2 (Nascimento-Junior et al., 2025); effects classified beneficial, probably beneficial, harmful, no effect or inconclusive (Nascimento-Junior et al., 2025)
Taneja and colleagues (2014)	Literature review; PubMed, Embase, Cochrane plus manual search; 111 articles, 10 included	Any form of cryotherapy in the removal of third molars	Body temperature, pain, swelling, neurological scores, inflammation, satisfaction, quality of life, trismus, wound healing	Narrative description of search strategy and inclusion criteria rather than formal appraisal (Taneja et al., 2014)

2.2 Sample Collection

PubMed, the Cochrane Library, Scopus and Google Scholar were searched for records published between January 2000 and March 2026. The search paired terms for the intervention, covering cryotherapy and its named variants, with terms for the population, mandibular third molar surgery, and for the three outcomes. Reference lists of retrieved systematic reviews and meta-analyses were searched by hand for additional primary reports. Records in English were eligible; whether a language restriction was registered is recorded in Table 4. The full electronic strategy for each database is to be reproduced from the search log before submission and is not reconstructed here, because no prospectively maintained log was available while preparing this manuscript.

Records were screened by relevance and topic, and those classified as direct mandibular third molar evidence were then assessed in detail. Systematic reviews and meta-analyses encountered during screening were mapped separately rather than counted as primary evidence, and dissertations were excluded from the primary set. Citation searching added further primary reports. Screening decisions and extracted items were documented in an extraction sheet maintained by the authors. Duplicate independent screening at both stages is the standard recommended in the syntheses this review builds on the evidence mapping, for example, screened titles and abstracts in duplicate using two reviewers and resolved discrepancies by consensus or a third reviewer (Nascimento-Junior et al., 2025) and it is described here as that standard rather than reported as a completed procedural step; the conduct of screening is one of the items awaiting confirmation before submission.

2.3 Extraction Procedure

The premise of a review organised around modes is that "cryotherapy" is not one intervention. Described modes include crushed ice, ice packs, frozen peas, chemical gel packs and gel packs that must be frozen before use; the literature is not resolved as to which is ideal, though all appear to reduce temperature sufficiently for analgesia (Gelesko et al., 2011). Mode varies along several axes at once, so it was extracted as a structured variable rather than a free-text label.

Table 2. Dimensions used to characterize cryotherapy application mode across the retrieved literature.

Dimension of application mode	Examples reported in the source literature
Cooling agent or device	Crushed ice, ice pack, frozen peas, chemical gel pack, pre-frozen gel pack (Gelesko et al., 2011); hilotherapy device versus simple cold application, the device covering a wider facial area (Fernandes et al., 2019)
Application schedule	Continuous versus intermittent application compared experimentally (Xie et al., 2025); ice packs applied for 5 to 30 minutes followed by resting periods during the first 24 to 48 hours (Firoozi et al., 2022)

Duration of therapy	Duration evaluated as a separate study factor, in a sub-study with 20 patients per group (Xie et al., 2025)
Timing of initiation and observation window	Continuous cold compress for 6 h within postoperative day 1 (Xie et al., 2025); staged protocol from 0–6 h then daily 6 h on days 1–3 (Xie et al., 2025)
Temperature and safety parameters	Tissue temperature above the frostbite threshold, described as 10–15 °C, with no numbness or erythema (Xie et al., 2025); a barrier layer to minimise frostbite, no refreezing of single-use chemical packs, caution in peripheral vascular disease (Gelesko et al., 2011)
Verification of use	Confirmed by patient diary or monitored application in only 5 of 11 included studies (Fernandes et al., 2019)

Extraction covered allocation structure and design, sample size, application mode specified as device, temperature, single-application duration, rest interval, daily exposure, total days and barrier, comparator, co-interventions, outcome definitions and measurement instrument, time points, aggregate results, rescue medication rules and adverse events. Two implications follow from extracting mode in this form. Because schedule, duration, device and temperature can vary independently, treating mode as a single categorical contrast risks conflating regimens that differ on several dimensions at once. And safety parameters belong in the extraction template rather than the discussion, since the difference between a regimen held above the frostbite threshold and one that is not is a property of the intervention itself.

2.4 Analytical Methods

The appraisal framework adopted for this review is set out here as a plan, not as a record of completed assessment. Primary studies were to be appraised with a Cochrane risk-of-bias instrument; RoB 1 was the tool used in the appraised meta-analyses of this field (Fernandes et al., 2019), and RoB 2 is the current standard for randomised trials (Flemyng et al., 2023; Sterne et al., 2019). Non-randomised comparative studies would require a separate instrument, for which the Newcastle–Ottawa Scale is the established option (Gualdi-Russo & Zaccagni, 2026; Lo et al., 2014). Existing reviews were to be appraised against AMSTAR-2 criteria, as in the evidence mapping (Nascimento-Junior et al., 2025), which rated ten of the included reviews critically low, one moderate and two high (Nascimento-Junior et al., 2025). Certainty was to be rated with GRADE (Kirmayr et al., 2021; Prasad, 2023).

No per-study risk-of-bias judgement and no de novo GRADE rating are reported in this manuscript. The risk-of-bias and certainty statements that appear in Section 3 are those published by the prior syntheses named at each point, transcribed rather than generated here. Because reported shortcomings in this literature include the absence of predefined protocols and of publication-bias assessment (Nascimento-Junior et al., 2025), a review of this kind should be registered before searching and should plan a publication-bias assessment rather than treat it as optional; whether those conditions were met in the present instance is recorded in Table 4. Reporting follows the PRISMA 2020 statement (Page et al., 2021).

2.5 Statistical Analysis

Synthesis proceeded in two steps. First, study and protocol characteristics were tabulated by application mode. Second, the prespecified quantitative requirement for pooling was applied: an arm-level sample size, mean, standard deviation, a common outcome unit and a compatible postoperative time point. Where these were not all available, the study was retained in the qualitative synthesis and excluded from the quantitative one.

Where pooling was defensible, weighted mean differences with 95% confidence intervals were planned, using random-effects estimation appropriate to clinical heterogeneity, with the Hartung–Knapp–Sidik–Jonkman approach preferred over DerSimonian–Laird where the number of studies is small (IntHout et al., 2014), and with heterogeneity quantified for each comparison rather than once for the whole review. Subgroup and sensitivity analyses were contemplated along the axes the sources themselves make defensible: schedule, because a randomised trial found continuous cold compress within the first 6 hours superior to intermittent protocols across all four outcomes measured (Xie et al., 2025); device against conventional application, given the surface-contact explanation offered for the hilotherapy advantage (Fernandes et al., 2019); duration, because duration has been evaluated as a discrete study factor (Xie et al., 2025); measurement method, distinguishing linear

from three-dimensional volumetric assessment (Caputo et al., 2023); and follow-up interval (Nascimento-Junior et al., 2025). These are axes discussed in the retrieved literature, not a registered analysis plan.

Four deviations from that plan are recorded. First, the eligibility threshold was not satisfied by the whole included set: seven of thirteen reports enrol 50 or fewer participants and two state no sample size, so the criterion operated as an aspiration rather than a filter. Second, no systematic appraisal was carried out at the level of individual included studies, and no certainty rating was generated for the body of evidence assembled here; every quality statement in Section 3 rests on the published appraisal of the prior synthesis cited at that point. Third, none of the subgroup or sensitivity analyses contemplated above was executed, because no comparison reached $k > 1$. Fourth, no publication-bias assessment was performed, since funnel plots and Egger's and Begg's tests are not informative at $k = 1$. The review therefore reports only the arithmetic of single-study mean differences, and the remainder is reported as not estimable rather than as performed and null.

Table 3. Items to be reconciled against the PROSPERO record before submission.

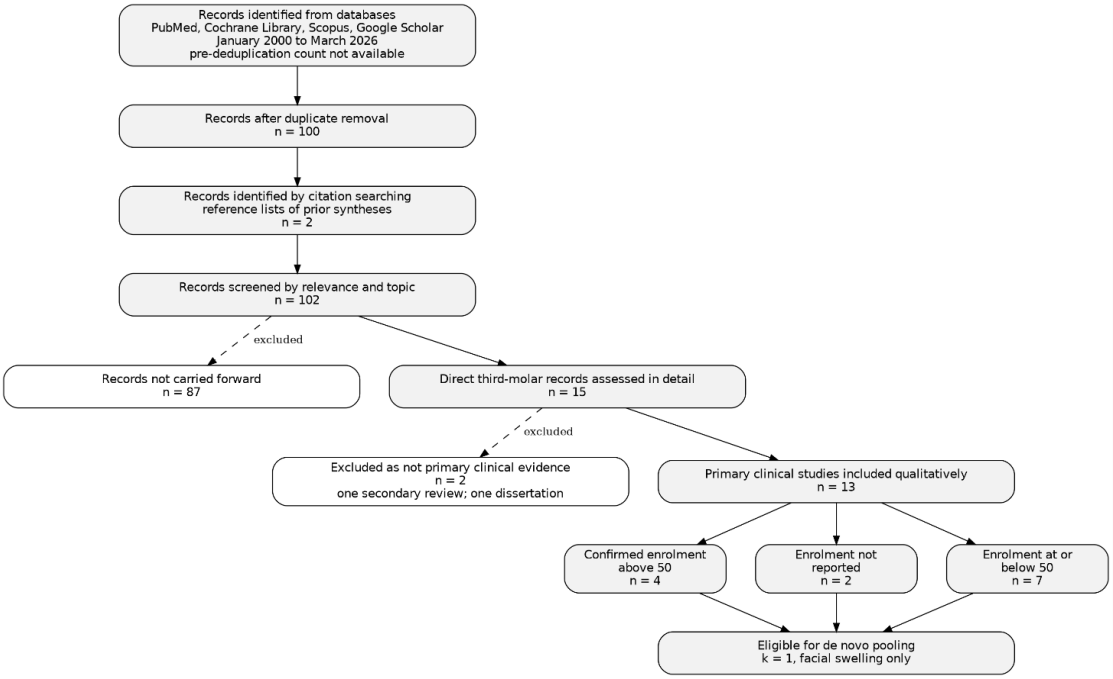
Item	Position taken in this manuscript	What to check in the record
Registration identifier and date	CRD420261446257, 9 July 2026, as supplied by the authors	Identifier and date as entered
Eligibility threshold	More than 50 participants; applied where confirmed — Xie et al. included at 60, Larsen et al. excluded at 30 — but seven of the thirteen included reports enrol 50 or fewer	The threshold as entered; if it differs, Section 2.1 and the determinations in Section 3.1 must follow the record
Outcome set	Pain, swelling and trismus prespecified; quality of life, satisfaction and adverse events secondary	Whether wound haemorrhage is listed; whether quality of life is primary or secondary
Eligible designs	Randomised and non-randomised controlled clinical studies; prior reviews mapped separately	Whether non-randomised designs were included at registration
Publication language	English	Whether a language restriction was specified
Databases and search window	PubMed, Cochrane Library, Scopus, Google Scholar; January 2000 to March 2026	Whether a fourth database and this window were specified
Appraisal tools	RoB 2; Newcastle–Ottawa Scale; GRADE; AMSTAR-2 for reviews	Tools as registered
Synthesis method	Random-effects where pooling is defensible; subgroup and sensitivity axes treated in Section 2.5 as axes the literature makes defensible rather than as a registered plan	Whether an estimator, subgroup axes or sensitivity analyses were specified at registration, and whether any were reported
Xie et al. denominators	60 in the mode comparison; 80 in the duration sub-study, 20 per group, as reported in the retrieved record (Xie et al., 2025)	The trial's actual allocation, to be taken from the full text

3. RESULTS

3.1 Study selection and evidence base

The documented screening set comprised 100 deduplicated records; citation searching added 2, giving 102 screened by relevance and topic. Fifteen were assessed in detail as direct mandibular third molar evidence, and 2 were excluded as not primary clinical evidence — one secondary review and one dissertation — leaving 13 primary reports. Eleven state a sample size, totalling 417 participants; 4 confirm enrolment above the 50-participant threshold, 2 report none, and 7 enrol 50 or fewer. Because seven of thirteen therefore fall below the stated threshold, the criterion operated as an aspiration rather than a filter, and the discrepancy is carried forward for reconciliation with the registered protocol.

Figure 1. PRISMA-adapted flow of study selection.



Records identified by database searching in PubMed, the Cochrane Library, Scopus and Google Scholar from publication years 2000 to 2026, and by citation searching of prior syntheses, were merged and deduplicated to a screening set of 100 records, to which 2 citation-searching records were added, giving 102 records screened by relevance and topic. Fifteen were assessed in detail as direct mandibular third molar evidence; 2 were excluded as not constituting primary clinical evidence, leaving 13 primary clinical studies included qualitatively, shown split by the eligibility threshold: 4 with confirmed enrolment above 50 participants, 2 not reporting a sample size, and 7 at or below 50. One independent study was eligible for de novo pooling, for facial swelling only. The diagram is PRISMA-adapted rather than PRISMA 2020 compliant: it does not report the number of records identified per database before deduplication, because no prospectively maintained search log was available.

3.2 Study selection

Searches of PubMed, Cochrane Library, Scopus and Google Scholar (2000–2026) yielded 100 deduplicated records; citation searching added two, giving 102 screened. Fifteen reports underwent detailed assessment, of which two were excluded as non-primary evidence. Thirteen clinical studies were retained for qualitative synthesis: four enrolled more than 50 participants, seven enrolled 50 or fewer, and two did not report sample size. Only one independent study provided suitable data for a new quantitative estimate of facial swelling.

3.3 Characteristics of the Included Studies

The 13 studies evaluated cryotherapy following mandibular third molar extraction using split-mouth, parallel-group randomised, non-randomised comparative, and longitudinal designs. Reported sample sizes varied, with two studies providing insufficient information to establish participant numbers. Conventional ice packs and gel packs were compared with no cooling or kinesiology taping (Altıparmak et al., 2018; Alhourani & Zenati, 2024; Alhourani et al., 2025; Zheng et al., 2022). Three split-mouth trials examined intraoperative irrigation using chilled saline (0–4 °C) versus room-temperature saline (approximately 25 °C) (Ronsivalle et al., 2024; Nguyen et al., 2026). Mukhametshin et al. (2024) compared controlled apparatus hypothermia with conventional ice application in 60 participants, while other studies evaluated cryotherapy against pharmacological interventions or low-level laser therapy (Suleiman et al., 2021; Sharma et al., 2022).

Xie et al. (2025) investigated cooling methods and durations through separate investigations, including a randomised comparison of continuous versus intermittent cooling involving 76 participants and a four-group duration comparison involving 80 participants. These were treated as distinct comparisons within one publication rather than as separate publications.

For descriptive synthesis, studies were retained regardless of sample size to characterise the available evidence. Sample size and completeness of outcome reporting were considered when assessing suitability for quantitative analysis. Only Mukhametshin et al. (2024) provided compatible arm-level means, standard deviations, and participant numbers for the planned new analysis of facial swelling. Consequently, a single-study effect estimate was calculated rather than a pooled meta-analysis. Variations in cooling protocols, study designs, blinding, and outcome reporting limited comparability across studies.

3.4 Pain

Across five syntheses, early pain generally favoured cryotherapy, although estimates varied and benefits were less consistent by day 7. Reported effects included day-1 mean differences (MDs) of −0.94 (95% CI −1.38 to −0.50), −1.12 (−1.46 to −0.78), and −1.08 (−1.35 to −0.81); one synthesis reported MDs of −0.97 (−1.26 to −0.69) on day 3 and −0.30 (−0.41 to −0.19) on day 7 (Nascimento-Junior et al., 2025). A six-trial meta-analysis found borderline benefit on day 2 (WMD −0.72, 95% CI −1.45 to 0.01; $p = 0.05$; $I^2 = 0\%$) and benefit on day 3 (−0.36, −0.59 to −0.13; $p = 0.002$; $I^2 = 0\%$), but rated certainty low (Nascimento-Júnior et al., 2019). Another synthesis recorded $I^2 = 62\%$ at day 7 and substantial risk-of-bias concerns (Firoozi et al., 2022). Some individual trials showed day-1-only improvement or nonsignificant trends ($p = 0.06$).

3.5 Facial swelling

Findings were inconsistent. One meta-analysis showed less swelling on day 2 (MD −0.94, 95% CI −1.49 to −0.39) but not day 7 (−0.35, −1.34 to 0.64) (Fernandes et al., 2019); another synthesis did not establish a reduction, consistent with earlier uncertainty (Cho et al., 2017). The only study permitting a new effect-size calculation (30 per group) favoured apparatus over ice hypothermia at days 3 (MD −1.22 mm, 95% CI −1.64 to −0.80), 5 (−2.15 mm, −2.52 to −1.78), and 7 (−2.16 mm, −2.55 to −1.77) (Mukhametshin et al., 2024). These are repeated measures from one study, not pooled estimates; heterogeneity and publication-bias statistics cannot be estimated with $k = 1$. Other findings were time-dependent, with an effect on swelling frequency only at day 3 ($p = 0.001$) (Xie et al., 2025). Three-dimensional measurements also peaked at different times for volume (day 2) and thickness (day 1) (WANG et al., 2023).

3.6 Trismus

Evidence for improved mouth opening was weaker. A dedicated meta-analysis found no significant effect (MD 0.43, 95% CI −0.34 to 1.20), and a six-trial synthesis likewise found no clear benefit, although other reviews reported improvement (Larsen et al., 2019; Taneja et al., 2014). Individual findings were mostly nonsignificant, including day-7 inter-incisal distance ($p = 0.259$), despite an isolated day-2 difference in limited mouth opening ($p = 0.002$).

3.7 Continuous versus intermittent application

Reviews reached opposing conclusions about the preferable cooling schedule. In a 64-person trial, 24-hour continuous cooling reduced pain, swelling and skin temperature compared with intermittent use (Wang et al., 2018). A further trial reported better pain, oedema, mouth opening and bleeding outcomes with six-hour continuous application. However, intermittent cooling involved 30 minutes on and 60 minutes off over six hours—approximately two hours of actual cooling versus six—so duration and schedule were confounded. Incomplete arm-level data prevented pooling, and no definitive optimal regimen can be established.

3.8 Explaining inconsistent findings

Differences may reflect co-interventions, where both groups receive ice; temperature and insulation, which change cold delivery (Greenstein, 2007); measurement variability, particularly operator-dependent facial tape measurements (Caputo et al., 2023); and small samples, such as nonsignificant findings among 18 participants. Cooling dose also matters: a 30-minute protocol offered negligible benefit (Larsen et al., 2021), whereas five minutes every 30 minutes controlled mucosal temperature better than 20 minutes every hour (Sortino et al., 2003).

3.9 Patient-reported outcomes and active comparators

Patient-reported outcomes did not consistently follow swelling or pain findings. Oral or submucosal dexamethasone sometimes outperformed ice compression for quality of life, swelling or pain (Suleiman et al., 2024) (Patnaik, 2024); a cool jaw wrap improved quality of life without reducing pain (Al-fahad & Shallawi, 2017). Dexamethasone also outperformed diclofenac in a study without a cooling arm, limiting direct comparability (Lima et al., 2017). Analgesic use remained common despite differing

pain scores (Gelesko et al., 2011), while OHIP-14 outcomes were reported in a small 11-participant pilot (Pacheco & Freire, 2018).

3.10 Safety, tolerability and adherence

Safety reporting was predominantly descriptive. Prolonged direct ice exposure risks cold injury; barriers, skin monitoring, appropriate pack handling and screening for vascular or sensory contraindications are advised (Garcia et al., 2020). Adherence was inconsistently documented: mean first-day pack use was 5.3 hours (range 0–12) (Lindeboom et al., 2020), while only 37.9% of 492 respondents reported cold use in the first three days (Truitt et al., 2022). Follow-up reinforcement improved compliance with postoperative instructions (Aloy-Prósper et al., 2020) (Ramalingam et al., 2022), although other reported adherence scores were comparable (Saleem et al., 2026).

4. DISCUSSION

4.1 Principal findings

The retrieved literature supports cryotherapy as a modest, time-limited adjunct after mandibular third molar surgery. Direction of effect is consistent for pain and reasonably consistent for early swelling, with pooled differences near −1.0 on the first postoperative day fading to −0.30 or to zero by day 7 (Nascimento-Junior et al., 2025). No such claim survives for trismus (Fernandes et al., 2019; Nascimento-Júnior et al., 2019). The review could not compute a pooled effect of its own: thirteen reports, 417 participants in eleven of them, yielded a single study with compatible arm-level data, and its three mean differences describe apparatus against ice hypothermia rather than cryotherapy against nothing (Mukhametshin et al., 2024).

4.2 Agreement and disagreement with existing syntheses

Where this review agrees with its predecessors is on the shape of the evidence rather than its size. Successive syntheses converge on early benefit and late equivalence for pain while disagreeing about swelling, one reporting a day-2 reduction of −0.94 (Fernandes et al., 2019) and another finding no effect on oedema at all (Nascimento-Júnior et al., 2019), and both independently calling for three-dimensional volumetric assessment (Barone et al., 2024; Larsen et al., 2019). Where it departs is on application mode. The two most recent head-to-head trials favour continuous delivery (Wang et al., 2018; Xie et al., 2025), reversing the earlier reading that intermittent application was preferable (Larsen et al., 2019) and aligning instead with the older narrative review (Taneja et al., 2014). That reversal is better read as a change of comparator than as a change in physiology, since the earlier conclusion rested on intermittent cooling against no cooling.

4.3 Why the trials diverge

Three structural features explain most of the inconsistency. First, labels substitute for exposures: "continuous" denotes anything from a constant 6-hour temperature to a nominal hands-free wrap, so the same term covers different thermal doses (Xie et al., 2025). Second, delivered dose is almost never measured achieving adequate tissue cooling is itself uncertain (Bleakley & Hopkins, 2010) so trials compare prescriptions rather than exposures. Add operator-dependent linear swelling measurement (Caputo et al., 2023), co-interventions applied to both arms, and samples of 14 to 90 participants, and the divergence is over-determined..

4.4 Implications for practice

Cryotherapy can reasonably be endorsed as safe, inexpensive and probably helpful for early pain and swelling, with explicit skin protection, a barrier layer, contraindication screening, and no refreezing of chemical packs (Greenstein, 2007). No mode can be recommended on comparative evidence, because the comparisons used non-equivalent definitions (Wang et al., 2018; Xie et al., 2025). Given that adherence falls sharply with regimen burden (Truitt et al., 2022), a feasible regimen completed at home may outperform a stronger one abandoned after three hours, and patients should be told plainly that ice is an adjunct to analgesia rather than a substitute for it (Suleiman et al., 2024).

4.6 Research agenda

Future trials should specify a thermal dose rather than a mode label: target and verified tissue temperature, single-application duration, rest interval, total daily exposure, number of days, device and barrier, and a prospective adherence record (Xie et al., 2025). Outcomes should be reported as arm-level n, mean and standard deviation at prespecified postoperative days, with

swelling assessed volumetrically (Barone et al., 2024; Nascimento-Junior et al., 2025), quality of life measured by a validated instrument, and sample size justified a priori (Guaschino et al., 2025). Protocols should be registered with complete outcome reporting, since selective reporting is documented in this trial literature (Fagoni et al., 2025), and reporting should follow PRISMA 2020 (Page et al., 2021)

.4. CONCLUSION

Published reports of cryotherapy after mandibular third molar surgery describe a family of interventions rather than one. The retrieved literature supports a small, early reduction in pain and, less securely, in swelling, at low certainty (Firoozi et al., 2022); it does not establish a superior application mode. Thirteen primary reports were included, eleven of which state a sample size, totalling 417 participants, but only one supplied arm-level data compatible with pooling. That study compared controlled local apparatus hypothermia with local ice hypothermia on facial swelling across 30 participants per arm, with mean differences of −1.22 mm (95% CI −1.64 to −0.80) at day 3, −2.15 mm (−2.52 to −1.78) at day 5 and −2.16 mm (−2.55 to −1.77) at day 7. These are single-study estimates and are not a pooled effect, and no meta-analytic summary could be computed for pain or trismus.

The obstacles are structural rather than numerical. Labels such as continuous and intermittent denote non-equivalent regimens, differing in one trial as 30 minutes of applied cold per hour of rest against six hours of continuous exposure (Xie et al., 2025); achieved tissue temperature is almost never measured, so the dose actually delivered is unknown; adherence is seldom verified, and the evidence available suggests that only a minority of patients use cold at all and that compliance falls beyond three hours (Truitt et al., 2022; Xie et al., 2025); and swelling is still frequently measured by operator-dependent linear techniques rather than volumetrically (Caputo et al., 2023). Continuous delivery has gained support from two randomised comparisons, but the definitions differ between them, so the apparent convergence rests on a shared label rather than a shared protocol.

Future work should therefore specify cooling as a thermal dose rather than a mode label: a target temperature, a verified delivered temperature, an explicit duty cycle with single-application duration and rest interval, a total daily exposure and number of days, a named device and barrier, and a supervised or logged adherence record. Outcomes should be reported as arm-level sample sizes, means and standard deviations at prespecified postoperative days, with swelling assessed volumetrically and quality of life measured by a validated instrument. Until such harmonised reporting exists, clinical guidance can reasonably endorse cryotherapy as a safe, inexpensive adjunct, with skin protection and contraindication screening stated explicitly, while acknowledging that the choice among ice packs, cycled schedules and controlled devices remains a matter of judgement rather than of demonstrated superiority.

ACKNOWLEDGEMENTS

The authors acknowledge the library and institutional support of the College of Dentistry, Gulf Medical University, Ajman, and the Faculty of Dental Sciences, SGT University, Gurugram, in obtaining full texts for this review.

AUTHOR CONTRIBUTIONS

Mohammed Shoaib ur Rahman Tippu: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Validation, Project administration, Software, Visualization, Writing – original draft, Writing – review & editing. Led the conception and design of the review, defined the eligibility criteria and extraction template, conducted screening and data extraction, curated the screening log and extraction sheet, computed the single-study facial-swelling estimates reported in Section 3.3, prepared the figures and evidence tables, and drafted the manuscript.

Varun Arya: Conceptualization, Methodology, Investigation, Validation, Supervision, Writing – review & editing. Contributed to the review question, eligibility criteria and search strategy, participated in screening and appraisal, verified the extracted data and reported estimates against the source reports, and critically revised the manuscript.

Fadi Titinchi: Conceptualization, Methodology, Investigation, Formal analysis, Validation, Writing – review & editing. Contributed to the methodological design and analysis plan, reviewed the quantitative synthesis and its interpretation, checked the reported estimates and their confidence intervals, and critically revised the manuscript.

Hesham Marei: Conceptualization, Methodology, Investigation, Project administration, Resources, Supervision, Writing – review & editing. Contributed to the conception and scope of the review, oversaw its conduct and reporting, provided access to the institutional and library resources required for full-text retrieval, and critically revised the manuscript.

Ashwin Lakshminarayanan: Investigation, Data curation, Software, Visualization, Writing – review & editing. Participated in screening and data extraction, contributed to the appraisal of intraoral and irrigant-based cooling studies and to the interpretation of the endodontic thermal literature, assembled the dataset, prepared the figures, and critically revised the manuscript.

Shakeel Santebennur Khazi: Investigation, Data curation, Visualization, Writing – review & editing. Participated in screening and data extraction, contributed to the evidence tables and to the appraisal of device-based and patient-reported outcomes, assisted with the figures, and critically revised the manuscript.

All authors approved the final version and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required for this study. It is a systematic review of published literature and involved no human participants, human tissue or identifiable personal data. Any deviation from the registered protocol, in particular the eligibility threshold and the final outcome set, is to be reported here once verified against the record.

DATA AVAILABILITY STATEMENT

All data underlying this review are derived from published reports and are presented in Tables 1 to 13 and Figures 1 to 5. The review is recorded by the authors as registered in PROSPERO (CRD420261446257, 9 July 2026); the registration details have not been checked against the public record while preparing this manuscript. The extraction sheet and screening log are available from the corresponding author on reasonable request

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