Damage-Control Surgery in Severe Maxillofacial Trauma: A Pragmatic Scoping Review of Indications, Hemorrhage Control, Temporary Stabilization, and Transition to Definitive Reconstruction

Abstract:

Background: Damage-control surgery (DCS) is established in major trauma, but its application to severe maxillofacial injury remains poorly standardized. Life-threatening facial hemorrhage, physiologic instability, major contamination, and complex skeletal disruption may require abbreviated treatment before definitive reconstruction.

Objective: To map the clinical evidence on indications for maxillofacial damage-control management, emergency hemorrhage control, temporary stabilization, and transition to definitive reconstruction.

Methods: A pragmatic scoping review informed by JBI guidance and reported with reference to PRISMA-ScR was performed. MEDLINE/PubMed and Scopus were searched from inception to 9 September 2026 without date restriction using complementary routes for explicit damage-control terminology, major hemorrhage, temporary or staged fixation, and ballistic or high-energy trauma. The searches yielded 2,191 records; 1,601 remained after deduplication. Structured text prioritization supported screening against predefined clinical criteria. Sixty-seven reports underwent detailed eligibility assessment, and 35 primary clinical reports with sufficiently extractable, nonredundant data formed the core evidence map. No meta-analysis or formal risk-of-bias scoring was planned.

Results: The 35 core reports spanned 1984-2026. Dominant themes were hemorrhage or immediate life-saving care (13 reports), temporary stabilization (7), transition or timing of definitive reconstruction (13), and explicit damage-control selection (2). Hemodynamic instability was the clearest direct trigger for abbreviated management. Severe oronasal bleeding was generally managed by escalation from local measures and packing to angiography and transarterial embolization when bleeding persisted. External fixation remained useful in selected comminuted, contaminated, ballistic, and war-related mandibular injuries. No validated maxillofacial-specific readiness criteria for definitive reconstruction were identified.

Conclusion: Damage-control management in severe maxillofacial trauma is best understood as a selective staged strategy rather than a single procedure. Current evidence supports physiologic instability and uncontrolled hemorrhage as major reasons to abbreviate initial treatment. The principal unresolved issue is readiness for definitive reconstruction: available studies support a physiology- and tissue-based transition rather than an arbitrary elapsed-time threshold.

Keywords: damage control surgery; maxillofacial trauma; facial injuries; hemorrhage; external fixation; ballistic trauma; staged reconstruction.

Introduction

Severe maxillofacial trauma is unusual within major trauma because most facial fractures are not themselves life threatening, yet a small subset threatens the airway or circulation and occurs alongside traumatic brain injury or multisystem injury. In these patients, the immediate surgical problem is not simply how to reconstruct the face, but whether definitive repair can be completed without worsening physiologic derangement or compromising already injured tissues.

Damage-control surgery (DCS) addresses that problem by separating urgent life-saving and temporizing interventions from definitive reconstruction. The approach is well established in general trauma, but its maxillofacial application remains inconsistently defined [1-4]. Military and ballistic series often describe staged debridement and stabilization, whereas contemporary reconstructive literature increasingly favors earlier definitive repair once physiology and local tissues permit [5,6]. These positions are not necessarily contradictory because they refer to different phases of care and use different definitions of what constitutes early surgery.

The distinction is clinically important. Emergency packing, embolization, temporary fracture reduction, external fixation, and limited debridement are fundamentally different from complete rigid fixation or microsurgical reconstruction, even when all occur during the same admission. Recent systematic reviews of early versus delayed facial fracture fixation confirm substantial heterogeneity in timing definitions and low-quality comparative evidence [7,8], but they do not map the entire pathway from patient selection and temporary intervention to readiness for definitive reconstruction.

This review therefore maps the available clinical evidence across that pathway. The objective was not to identify a single superior timing strategy, but to determine how DCS has been applied in severe maxillofacial trauma, which physiologic or anatomic triggers have been reported, how life-threatening hemorrhage and unstable facial injuries have been temporized, and what factors have guided transition to definitive reconstruction.

Materials and Methods

Design and review question

A pragmatic scoping review was undertaken, informed by JBI methodological guidance and reported with reference to PRISMA-ScR items applicable to evidence mapping [9,10]. An internal a priori protocol was developed before screening but was not prospectively registered. The review question was: What evidence is available regarding the indications, hemorrhage-control strategies, temporary stabilization techniques, and transition to definitive reconstruction in patients undergoing damage-control management for severe maxillofacial trauma?

Eligibility criteria

Human clinical reports were eligible when they addressed severe maxillofacial trauma and provided extractable information on at least one component of the damage-control pathway: patient selection or physiologic instability; emergency hemorrhage control; abbreviated or staged surgery; temporary skeletal or soft-tissue stabilization; or timing and criteria for definitive reconstruction. Civilian and military injuries, isolated severe facial trauma, polytrauma, and blunt, penetrating, ballistic, blast, or avulsive mechanisms were eligible. Routine ORIF without a staged or damage-control component, minor dentoalveolar trauma, elective secondary reconstruction unrelated to acute trauma management, nonclinical studies, and review articles were excluded from the primary clinical evidence set. Case and technical reports were considered when they contributed distinct clinical information; reports that duplicated a technique already represented in higher-information series without adding a new selection criterion, intervention, or transition variable were not retained in the core evidence map. Secondary reviews were retained for context and reference checking.

Information sources and search

MEDLINE/PubMed and Scopus were searched from database inception to 9 September 2026. The strategy combined maxillofacial-trauma terminology with four complementary routes: explicit damage-control terminology; life-threatening hemorrhage and hemostatic intervention; temporary or staged fixation; and transition to definitive reconstruction. A supplementary ballistic/high-energy route was added because relevant surgical series often do not use the phrase "damage control." PubMed yielded 984 records and Scopus 1,207. After removal of 70 internal PubMed duplicates, 69 internal Scopus duplicates, and 451 cross-database duplicates, 1,601 unique records remained. No date or language filter was applied at the search stage. Reference lists of key reviews and sentinel clinical papers were checked during verification. Complete database strategies and yields are provided in Supplementary File S1.

Selection and synthesis

The 1,601 unique records underwent structured title/abstract screening against predefined clinical eligibility criteria. Text-based prioritization was used to order screening and identify low-relevance records, while potentially relevant and borderline records were re-evaluated against the same eligibility framework. Sixty-seven reports underwent detailed eligibility assessment using titles, abstracts, indexed metadata, and full text when retrievable. Thirty-five primary reports with sufficiently extractable and nonredundant clinical information were retained for the core evidence map. Thirty-two reports were not retained at detailed assessment because they were isolated or technical reports that added no distinct pathway information beyond larger series (n=22), did not provide sufficiently specific damage-control or staged-management information (n=9), or contained a mixed population without separately extractable maxillofacial-trauma data (n=1). For older reports without retrievable full text, indexed abstracts and source records were used only when the relevant clinical variables were explicit. Data were charted for study design, sample size, setting, injury mechanism, DCS indication, hemorrhage-control strategy, temporary stabilization, timing or transition to definitive surgery, and reported outcomes. Because the objective was evidence mapping across heterogeneous observational literature, no meta-analysis or formal risk-of-bias score was performed; study design and sample size were retained to contextualize evidentiary strength.

Results

Study selection and characteristics

The combined searches identified 2,191 records before deduplication and 1,601 unique records after deduplication. Sixty-seven reports underwent detailed eligibility assessment, and 35 primary clinical reports were retained for the core evidence map. The retained core studies were published between 1984 and 2026; 19 were published from 2018 onward, 15 from 2021 onward, and 9 from 2023 onward. The evidence base was dominated by retrospective cohorts, institutional case series, trauma-center experiences, and ballistic or war-related series. No prospective study validated a maxillofacial-specific DCS selection algorithm.

For synthesis, each of the 35 core reports was assigned a dominant theme while acknowledging substantial overlap: 2 focused primarily on explicit DCS selection, 13 on hemorrhage or immediate life-saving management, 7 on temporary stabilization, and 13 on transition or timing of definitive reconstruction. Table 1 summarizes the core primary evidence.

Patient selection and indications for damage-control management

The most direct clinical evidence for selecting a maxillofacial DCS strategy came from Daniels et al. [11]. Among 173 war-related maxillofacial gunshot injuries, 78 hemodynamically unstable patients were managed using DCS, whereas 47 hemodynamically stable patients underwent early definitive surgery. A large emergency cohort from Shanghai also reported DCS in 65 of 326 hospitalized oral and craniomaxillofacial trauma patients within a broader triage and life-support pathway [12]. These studies support physiologic instability, rather than fracture morphology alone, as the most defensible primary trigger for DCS.

Across the hemorrhage literature, additional selection variables emerged indirectly. Shock, hypotension, transfusion requirement, Glasgow Coma Scale, Injury Severity Score, and failure of local hemostatic measures were repeatedly associated with escalation of care [13-24]. One embolization series defined hemodynamic instability as systolic blood pressure ≤90 mmHg [15]. In a later cohort of life-threatening traumatic oronasal bleeding, a Shock Index >0.95 identified patients more likely to require transarterial embolization after preliminary hemostatic measures failed [17]. These thresholds are clinically useful signals, but none has been validated as a universal maxillofacial DCS trigger.

Hemorrhage control and immediate life-saving interventions

The hemorrhage literature showed the most consistent treatment pathway. Initial management generally included airway protection, direct pressure, wound or nasal packing, correction of coagulopathy, and resuscitation. When bleeding persisted, angiography with transarterial embolization (TAE) was the dominant escalation strategy [13-21]. In the multicenter series by Cogbill et al. [13], packing alone controlled bleeding in 29% of patients in whom it was used, whereas TAE achieved definitive control in 87.5%. Other cohorts similarly reported high technical hemostasis rates with TAE, while mortality was driven mainly by severe traumatic brain injury, refractory shock, or overall injury burden rather than failure of embolization [14-21].

Not all severe facial bleeding requires endovascular treatment. Temporary fracture reduction combined with nasal packing controlled massive bleeding in a small midfacial-fracture series [23], while broader emergency series emphasized prompt recognition that the face itself may be the dominant hemorrhage source [13,22,25]. These findings support a stepwise escalation model rather than routine immediate embolization for every bleeding facial fracture.

Temporary skeletal stabilization

Temporary stabilization was most clearly represented by external fixation. Contemporary mandibular series describe its use in comminuted, contaminated, infected, ballistic, or tissue-deficient injuries where extensive open dissection or immediate definitive reconstruction may be undesirable [26-30]. Rogol [26] reported 23 patients in whom external fixation preserved tissue and temporarily stabilized selected gap defects. A 25-year institutional series documented 29 external-fixation episodes, including 14 gunshot injuries, and showed that secondary reconstruction was common after complex injuries [27]. In 2026, a direct comparison of initial external versus internal fixation for ballistic mandibular fractures demonstrated a shorter median initial operative time with external fixation (118.5 versus 194.5 minutes) and supported its use as a staged strategy that permits soft-tissue recovery before definitive reconstruction [28].

War-related data reinforce the continuing role of external fixation. In a 91-patient series, 94.5% of injuries were high-velocity gunshot wounds; external fixation was used as the principal stabilization method in the setting of severe comminution, bone loss, infection, and delayed presentation. Seventy-eight percent healed without a secondary bone procedure, while 22% required delayed grafting [29]. Historical cranial external-fixation experience and longer-term mandibular series show that the principle predates modern DCS terminology [30,31]. More recent submental gunshot data confirm that external fixation remains one of several early skeletal options before definitive ORIF, grafting, or free-flap reconstruction [32].

Transition to definitive reconstruction

The transition from damage control to definitive reconstruction was the least standardized domain. Ballistic series ranged from aggressive early reconstruction to deliberately staged microsurgical repair [33-45]. The FACES protocol explicitly begins with damage control and selective debridement before computer-assisted staged reconstruction during the index hospitalization [34]. Knudson et al. [45] reported same-admission microsurgical mandibular reconstruction at a mean of 16.4 ± 9.1 days after presentation, after an average of 6.2 ± 2.8 operations per patient. Other contemporary series likewise show that definitive treatment may occur during the index admission but can require repeated procedures before reconstruction is complete [33,35,36].

In polytrauma, the dominant reason to delay facial fracture repair was not a predetermined number of days but concern that associated injuries or physiology made a non-life-threatening operation unsafe. Rothweiler et al. [38] found no increase in complications when fixation occurred after 72 hours and argued for individualized timing at the earliest point at which adverse effects from comorbidities were no longer expected. An earlier multitrauma series identified soft-tissue swelling, intracranial injury, unstable medical condition, and coordination with other surgical services as explicit reasons for delay [39].

Ballistic literature demonstrates an important evolution. Earlier protocols often favored delayed reconstruction, whereas later series increasingly supported early skeletal alignment, primary closure of viable tissues, serial conservative debridement, and earlier definitive reconstruction [40-44]. A 2026 panfacial cohort further showed that planned multistage repair remains useful in selected highly complex fracture patterns and polytrauma, although staged patients had greater baseline injury severity and therefore cannot be directly compared with uncomplicated single-stage cases [37]. Taken together, the literature does not support a universal clock-based transition threshold.

Discussion

This review maps a clinically recognizable but poorly standardized field. Only a small proportion of primary studies explicitly label their strategy as DCS; most describe individual components such as control of catastrophic hemorrhage, temporary stabilization of a disrupted facial skeleton, staged debridement, or delayed reconstruction in physiologically compromised patients. This fragmented terminology helps explain why earlier reviews found conceptual support for maxillofacial DCS but little direct outcome evidence [1-4].

The clearest indication for a damage-control strategy is physiologic instability. This is consistent with general trauma DCS, in which physiology, injury burden, resuscitation requirement, and inability to safely complete definitive surgery are central considerations [2,4]. Maxillofacial thresholds are less mature. Daniels et al. [11] used hemodynamic stability as the principal branch point, while hemorrhage cohorts identified systolic pressure, Shock Index, transfusion burden, GCS, and ISS as severity markers [13-18]. These variables should be interpreted as decision-support signals rather than validated maxillofacial cutoffs.

Hemorrhage control is the strongest evidence domain. The available studies support a pragmatic escalation sequence: secure the airway when required; apply direct/local measures and packing; reduce unstable fractures when this contributes to tamponade; correct coagulopathy and resuscitate; and proceed to angiography/TAE when clinically important bleeding persists. TAE is consistently effective across observational series, but the mortality of these cohorts is driven by severe associated brain injury and shock. Successful arterial hemostasis therefore should not be equated with global physiologic recovery.

Temporary skeletal stabilization should be viewed as a means rather than an endpoint. External fixation is most useful when definitive internal fixation would require excessive operative time, devascularizing exposure, placement of hardware into contaminated or deficient tissue, or when serial access to wounds is required. The recent comparative ballistic mandibular study [28] is particularly relevant because it moves the discussion beyond historical experience: a shorter initial operation and preservation of soft-tissue conditions for later reconstruction align directly with the logic of damage control.

The major unresolved issue is transition. The evidence does not define a validated maxillofacial “ready for definitive reconstruction” score. Readiness appears multidimensional: hemodynamic normalization, control of bleeding, correction of coagulopathy/acidosis/hypothermia, neurologic stability, treatment of competing injuries, acceptable soft-tissue conditions, contamination control, and reconstructive feasibility. Timing should therefore be reported as a consequence of readiness rather than used as a surrogate for readiness itself. This distinction also reconciles much of the apparent conflict between advocates of early reconstruction and staged treatment: definitive surgery can be performed early once stabilization is achieved, whereas DCS is appropriate when definitive surgery would add unsafe physiologic or local-tissue burden.

Based on the mapped evidence, a four-phase conceptual framework is proposed. Phase 1 is immediate life-saving care: airway management, hemorrhage control, resuscitation, and exclusion of competing bleeding sources. Phase 2 is abbreviated maxillofacial stabilization: temporary skeletal alignment or fixation, conservative debridement, contamination control, and temporary soft-tissue management. Phase 3 is readiness assessment based on physiology, associated injuries, and local tissues. Phase 4 is definitive reconstruction. The framework is intentionally descriptive; the current literature does not justify an evidence-graded prescriptive algorithm.

Two features improve the interpretability of this evidence map despite its pragmatic design. First, the search was concept-based rather than limited to the phrase "damage control," allowing capture of hemorrhage-control, temporary-fixation, and ballistic-treatment studies that operationalized the same principles without using that label. Second, the synthesis explicitly separates life-saving intervention, temporary damage-control stabilization, readiness assessment, and definitive reconstruction. This distinction addresses a recurrent problem in the timing literature, where early temporizing procedures and early definitive fixation are often conflated [7,8].

Clinical Implications and Research Priorities

For the maxillofacial surgeon, the practical decision is not simply early versus delayed fixation. The more useful question is whether the patient can safely tolerate definitive reconstruction now. Hemodynamic instability, uncontrolled hemorrhage, severe associated injury, prolonged anticipated operative burden, major contamination, or compromised soft tissue favor an abbreviated strategy. Once those constraints have resolved, prolonged delay is not inherently beneficial, and contemporary ballistic literature generally supports earlier restoration of skeletal relationships and vascularized tissue when feasible.

Future research should move beyond clock-based definitions of early and delayed surgery. Prospective multicenter studies should report the physiologic trigger for damage-control management, the temporary intervention performed, time to correction of shock and coagulopathy, reasons for deferring definitive repair, and the objective findings used to declare reconstructive readiness. A multicenter maxillofacial-trauma registry would be a practical route toward deriving and validating a readiness framework rather than relying on institution-specific timing conventions.

Limitations

This review used a pragmatic methodology tailored to broad clinical evidence mapping. Searches were limited to PubMed/MEDLINE and Scopus, although complementary search routes were deliberately used to capture literature that does not explicitly use the term "damage control." Screening used structured text prioritization rather than duplicate independent review. Detailed eligibility assessment used full text when retrievable; for older reports without accessible full text, explicit abstract and indexed source data were used. Lower-level reports that did not add distinct pathway information beyond larger series were not retained in the core evidence map, so the synthesis is intentionally clinically focused rather than exhaustive at the case-report level. The literature was highly heterogeneous and predominantly retrospective, and definitions of severe trauma, early surgery, delayed surgery, and staged reconstruction varied substantially. No formal risk-of-bias appraisal or meta-analysis was performed. These limitations preclude causal treatment comparisons and are the reason the conclusions are presented as an evidence map rather than as graded clinical recommendations.

Conclusion

Damage-control surgery in severe maxillofacial trauma is best understood as a selective staged strategy rather than a single technique. Physiologic instability and uncontrolled hemorrhage are the most defensible reasons to abbreviate initial treatment. Packing, local control, temporary fracture reduction, and transarterial embolization form a practical hemorrhage-control escalation, while external fixation remains useful for selected complex and ballistic mandibular injuries. Definitive reconstruction should follow resolution of the physiologic, competing-injury, and local-tissue constraints that prompted abbreviation rather than an arbitrary time interval. The principal evidence gap is the absence of validated maxillofacial-specific criteria for selecting DCS and determining readiness for definitive reconstruction.

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Conflicts of Interest

The authors declare no competing interests.

Ethical Approval

Not applicable; this study synthesizes previously published literature and involved no new human or animal participants.

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Tables

Table 1. Core primary clinical evidence retained in the pragmatic scoping review.

Ref.	Study / year	n	Dominant domain
11	Daniels et al., 2022	173	Patient selection / explicit DCS
12	Ge et al., 2023	326	Patient selection / explicit DCS
13	Cogbill et al., 2008	90	Hemorrhage / immediate life-saving care
14	Bynoe et al., 2003	11	Hemorrhage / immediate life-saving care
15	Chen et al., 2009	8	Hemorrhage / immediate life-saving care
16	Liao et al., 2007	34	Hemorrhage / immediate life-saving care
17	Hsu et al., 2021	72	Hemorrhage / immediate life-saving care
18	Dar et al., 2021	39	Hemorrhage / immediate life-saving care
19	Wu et al., 2022	49	Hemorrhage / immediate life-saving care
20	Gamanagatti et al., 2016	21	Hemorrhage / immediate life-saving care
21	Dean et al., 2009	19	Hemorrhage / immediate life-saving care
22	Patricio Andrades et al., 2012	21	Hemorrhage / immediate life-saving care
23	Shimoyama et al., 2003	5	Hemorrhage / immediate life-saving care
24	Orthopoulos et al., 2013	155	Hemorrhage / immediate life-saving care

25	Dolin et al., 1992	100	Hemorrhage / immediate life-saving care
26	Rogol et al., 2025	23	Temporary stabilization
27	Rose et al., 2025	29	Temporary stabilization
28	Asserson et al., 2026	40	Temporary stabilization
29	Mukamba et al., 2026	91	Temporary stabilization
30	Marti-Flich et al., 2020	65	Temporary stabilization
31	Gratz et al., 1984	61	Temporary stabilization
32	Wenzel et al., 2024	27	Temporary stabilization
33	Chaiyasate et al., 2022	13	Transition / timing of definitive reconstruction
34	Khatib et al., 2018	10	Transition / timing of definitive reconstruction
35	Lee et al., 2023	331	Transition / timing of definitive reconstruction
36	Stein et al., 2026	17	Transition / timing of definitive reconstruction
37	Resnick et al., 2026	50	Transition / timing of definitive reconstruction
38	Rothweiler et al., 2018	168	Transition / timing of definitive reconstruction
39	Weider et al., 1999	49	Transition / timing of definitive reconstruction
40	Murphy et al., 2018	76	Transition / timing of definitive reconstruction
41	Glapa et al., 2007	55	Transition / timing of definitive reconstruction
42	Clark et al., 1996	318	Transition / timing of definitive reconstruction
43	Siberchicot et al., 1998	165	Transition / timing of definitive reconstruction
44	Vásconez et al., 1996	33	Transition / timing of definitive reconstruction
45	Knudson et al., 2022	5	Transition / timing of definitive reconstruction

Table 2. Proposed clinical evidence map.

Phase	Main decision	Evidence-mapped actions
1. Life-saving care	Is there an immediate threat to life?	Airway protection; direct/local hemostasis; packing/tamponade; resuscitation; identify other bleeding sources; angiography/TAE when bleeding persists.
2. Damage-control stabilization	Would definitive repair add unsafe physiologic or local-tissue burden?	Temporary fracture reduction; external/limited fixation; conservative serial debridement; contamination control; temporary soft-tissue closure.
3. Readiness assessment	Has the reason for abbreviation resolved?	Hemodynamic stability; correction of coagulopathy/acidosis/hypothermia; neurologic and multisystem stability; acceptable soft tissue and contamination status.
4. Definitive reconstruction	Can anatomy and function now be restored safely?	Definitive fixation, bone grafting, orbital/midface reconstruction, local/regional or free tissue transfer as indicated.

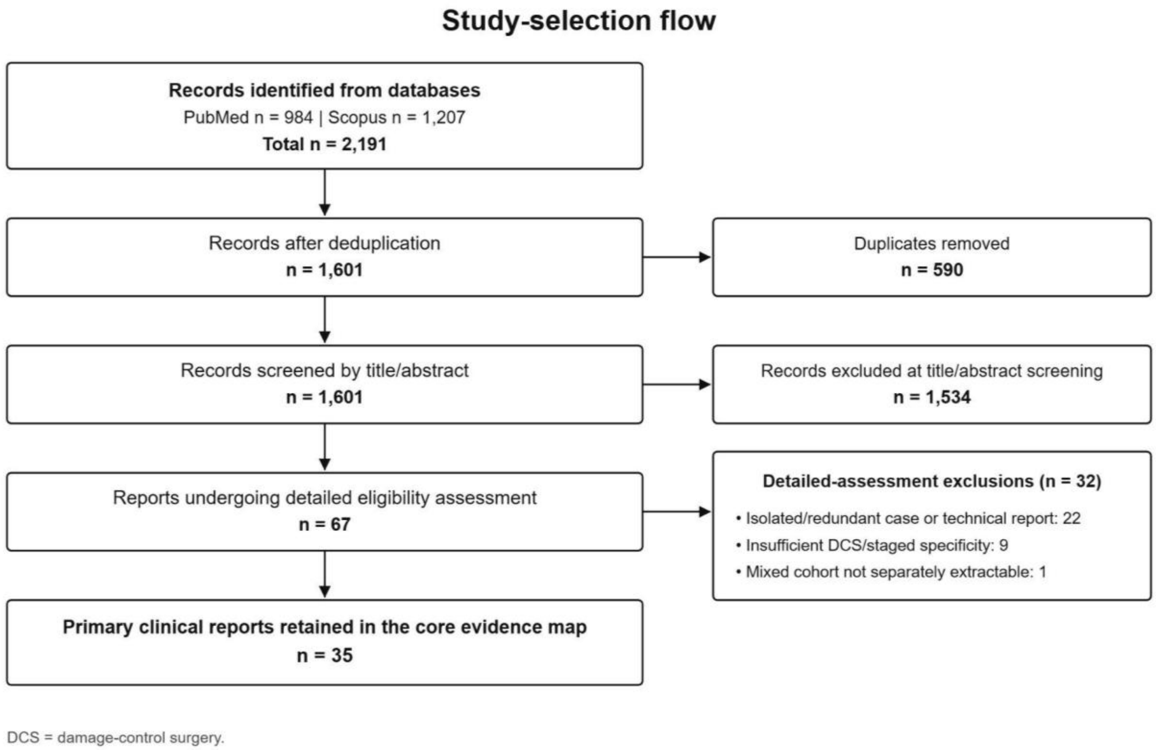

Figure 1. Study-selection flow for the pragmatic scoping review. The diagram shows database identification, deduplication, title/abstract screening, detailed eligibility assessment, reasons for detailed-assessment exclusions, and the final core clinical evidence set.