

Clinical Outcomes and Flap Survival of Freestyle Perforator Flaps for Lower-Limb Traumatic Reconstruction: A Systematic Review and Mapping of the Available Evidence

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ABSTRACT

Freestyle perforator flaps—propeller and perforator-based V-Y advancement flaps raised on an intraoperatively or radiologically identified perforator—are increasingly used for post-traumatic lower-limb reconstruction, but their consolidated outcome profile is unmapped. Following PRISMA 2020 and prospective PROSPERO registration CRD420261422030, Data Search was conducted in PubMed, the Cochrane Library, Embase, Web of Science, MEDLINE, and Scopus abases using a predefined PICOS framework. Human studies (≥ 5 patients) of freestyle/pedicled perforator flaps for traumatic lower-limb defects reporting flap survival or complications were eligible; synthesis was narrative.

Of 1,000 records, 40 underwent full-text review and 7 were included. None studied freestyle perforator flaps in lower-limb trauma directly; all were secondary syntheses of adjacent techniques. Reported survival/success ranged from 78.8% (reverse sural flap) to 98% with 0% total loss (Color-Doppler-guided pedicled perforator flaps); free flaps achieved 92–94% versus 86–90% for local flaps. Overall complications were 14.8–21.2%; venous congestion predominated, and coverage within 72 hours reduced osteomyelitis (RR 0.28, 95% CI 0.16–0.49). This systematic review provides the first consolidated map of perforator-based flap survival relevant to traumatic lower-limb reconstruction and delivers clinically actionable findings. Across the closest available evidence, perforator-based and comparator flaps achieved consistently high survival—up to 98% reconstructive success with 0% total flap loss for preoperatively mapped (Color-Doppler-guided)

KEYWORDS: freestyle perforator flap; propeller flap; lower-extremity trauma; flap survival; soft-tissue reconstruction; systematic review.

ARTICLE DETAILS

Published On:
02 July 2026

Available on:
<https://ijmscrs.com>

INTRODUCTION

Soft-tissue defects of the lower limb after high-energy trauma are among the most demanding reconstructive problems,

particularly in the unforgiving distal third of the leg, ankle, and foot. Perforator-based reconstruction permits like-with-like cutaneous cover while sparing the underlying muscle (1).

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The freestyle concept generalises this principle by designing a flap around any suitable perforator localised by color-Doppler ultrasound, CT angiography, or intraoperative exploration—most often a propeller or perforator-based V-Y advancement flap in the limb (2).

Because lower-limb outcomes are reported mostly for named pedicled flaps, free flaps, and mixed series, results specific to the freestyle strategy—especially venous congestion and partial necrosis after pedicle rotation—are difficult to isolate. We therefore systematically mapped the evidence on complete flap survival and the clinical outcome profile of freestyle perforator flaps for traumatic lower-limb reconstruction.

MATERIALS AND METHODS

Protocol and search. The review followed the PRISMA 2020 statement (3,4) and was prospectively registered in PROSPERO CRD420261422030; as it synthesises published aggregate data, ethical approval was not required. Primary retrieval used a research platform, Data Search was conducted in PubMed, the Cochrane Library, Embase, Web of Science, MEDLINE, and Scopus abasesusing a predefined PICOS framework.. Reproducible concept-level strings are shown in Table 1; English full text was required, and the search was run in 2026.

Table 1. Information sources and concept-level search strategy. Database strings are provided for transparent replication.

Source / databaase	Concept-level search string (Boolean)	Filters	Records (n)
Elicit semantic index (Semantic Scholar + OpenAlex)	(“freestyle perforator flap” OR “propeller flap” OR “perforator-based V-Y” OR “pedicled perforator flap”) AND (“lower limb” OR “lower extremity” OR leg OR ankle OR foot OR tibia) AND (trauma* OR “soft-tissue defect”) AND (survival OR necrosis OR “venous congestion” OR complication*)	Human; English	1,000
PubMed/MEDLINE (replication)	“Perforator Flap”[Mesh] AND “Leg Injuries”[Mesh] AND (survival OR necrosis)	Humans; English	—
Scopus / WoS / Embase (replication)	TITLE-ABS-KEY equivalents of the above concept blocks	English	—
Total screened	—	—	1,000

Eligibility, selection, and appraisal. Eligibility followed a predefined PICOS framework (Table 2). Records were screened in two stages (title/abstract, then full text) against the a priori criteria (Figure 1). A structured form captured study identifiers, design, sample, defect and flap characteristics, survival, complications, functional/aesthetic outcomes, and follow-up, recording the source of each datum

so indirect data could be flagged. Methodological quality of the secondary studies was appraised with AMSTAR-2 (5) and certainty with GRADE, downgraded principally for indirectness (6). Synthesis was narrative; heterogeneity and the absence of direct studies precluded pooling, so comparative estimates are presented as originally reported.

Table 2. Predefined eligibility criteria (PICOS).

Domain	Criterion
Population	Adult and paediatric patients with acute or delayed traumatic soft-tissue defects of the lower extremity (thigh, knee, leg, ankle, foot); non-traumatic aetiologies excluded unless a comparative arm.
Intervention	Freestyle/pedicled perforator flap (propeller or perforator-based V-Y), perforator identified intraoperatively or by imaging (color-Doppler, CTA, ICG angiography).
Comparator	Optional: free, pedicled muscle, random local flaps, or skin grafts.
Outcomes	Complete flap survival and/or perioperative complications (venous congestion, partial necrosis, total loss, infection, revision).
Study design	Case series ≥ 5 patients, cohort, case-control, RCT, systematic review, or meta-analysis with defined follow-up; abstracts, editorials, animal/cadaveric, and design-only reports excluded.

RESULTS

Selection and principal finding. Of 1,000 records, 960 were excluded and 40 sought in full text; 29 could not be retrieved and 4 were excluded, leaving 7 studies (Figure 1). The

principal finding is that none of the seven (7-13) studied freestyle perforator flaps for traumatic lower-limb defects directly; freestyle-specific survival data were absent, so no pooled survival rate could be derived.

Figure 1. PRISMA 2020 flow diagram of study identification and selection

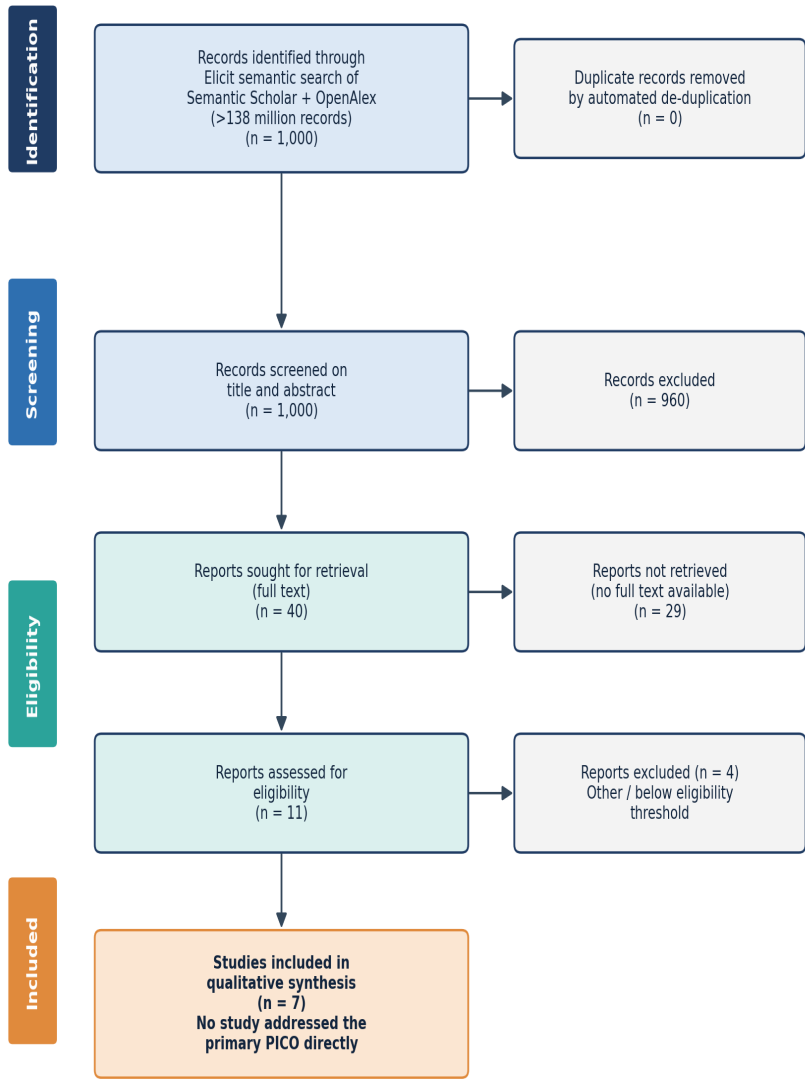


Figure 1. PRISMA 2020 flow diagram. 1,000 records screened; 960 excluded; 40 full texts sought (29 not retrieved, 4 excluded); 7 included. No study addressed the primary question directly.

Included sources and outcomes. The seven sources (2018–2026) were all secondary syntheses—six systematic reviews/meta-analyses, one also contributing an original 33-patient military series (7)—covering adjacent topics: timing of coverage (9), free vs pedicled flaps (10), free vs local flaps

(11), the reverse sural flap (7), Color-Doppler-guided pedicled perforator flaps (8), perforator flaps for hidradenitis suppurativa (12), and risk-prediction models (13). Their sizes are shown in Figure 2 and their characteristics and outcomes in Table 3.

Clinical Outcomes and Flap Survival of Freestyle Perforator Flaps for Lower-Limb Traumatic Reconstruction: A Systematic Review and Mapping of the Available Evidence

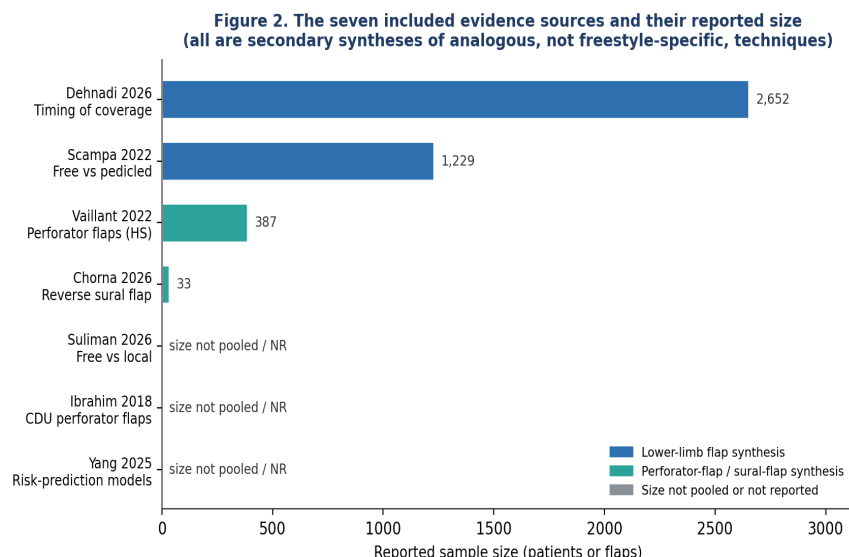


Figure 2. The seven included sources by reported sample size; all are syntheses of techniques analogous to—not identical with—freestyle perforator flaps. NR = not reported/not pooled.

Table 3. Characteristics and reported outcomes of the seven included sources (values as reported, not pooled). * Only statistically significant flap-versus-flap comparison. NR = not reported; CDU = color-Doppler ultrasonography; SR/MA = systematic review/meta-analysis.

Study (year)	Design / sample	Primary focus	Survival / success	Key complications
Chorna et al. (2026) (7)	Meta-analysis + 33-pt series	Reverse sural flap (blast injuries)	78.8% complication-free	Overall 21.2%; venous stasis/thrombosis main cause
Ibrahim et al. (2018) (8)	SR/MA; mixed sites	CDU-guided pedicled perforator flaps	Goal 98%; 0% total loss	Venous congestion 7% (11% limb); revision 8%
Dehnadi et al. (2026) (9)	SR/MA; 2,652 patients	Timing of coverage (≤ 72 h)	NR	≤ 72 h: osteomyelitis RR 0.28 (0.16–0.49); infection RR 0.69
Scampa et al. (2022) (10)	Meta-analysis; 1,229 procedures	Free vs pedicled flaps	Not pooled	Partial necrosis RR 0.45 (0.22–0.91)*; overall RR 0.83 (NS)
Suliman et al. (2026) (11)	Meta-analysis; 27 studies	Free vs local flaps	Free 92–94%; local 86–90%	Partial necrosis 9% vs 13%; venous congestion 6–7% vs 12–14%
Vaillant et al. (2022) (12)	SR/MA; 286 pt / 387 flaps	Perforator flaps (hidradenitis)	Total necrosis 0.5%	Overall 15.1%; revision 3.6%
Yang et al. (2025) (13)	SR; 16 studies / 28 models	Risk-prediction models	NR	Pooled complications 14.8% (10.7–19.0%)

Survival, complications, and timing. Within this analogous evidence (Figure 3), the reverse sural flap healed without complications in 78.8% (overall complications 21.2%; venous stasis/thrombosis the leading failure) (7); Color-Doppler-guided pedicled perforator flaps achieved the reconstructive goal in 98% with 0% total loss but 11% venous congestion in the extremities (8); free versus local flaps showed survival 92–94% vs 86–90%, partial necrosis 9% vs

13%, and venous congestion 6–7% vs 12–14% (11). Free flaps significantly outperformed pedicled flaps for partial necrosis (RR 0.45, 0.22–0.91), with no difference for total necrosis, overall complications, infection, or revision (10). Soft-tissue coverage within 72 hours reduced infection (RR 0.69), osteomyelitis (RR 0.28, 0.16–0.49; significant), and amputation (RR 0.55) across 2,652 patients (9).

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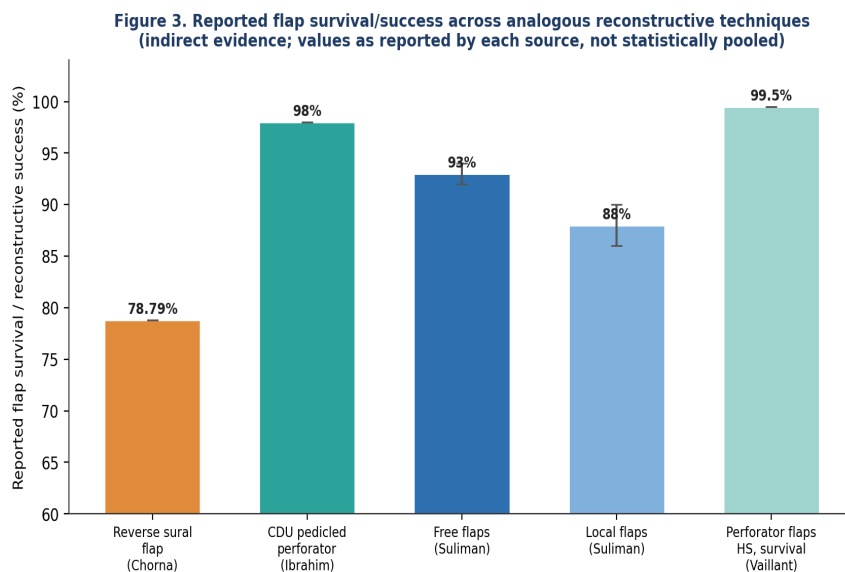


Figure 3. Reported flap survival/success across analogous techniques (values as reported, not statistically pooled). HS = hidradenitis suppurativa; CDU = color-Doppler ultrasonography.

Functional outcomes and certainty. Only Suliman et al. quantified function—earlier weight-bearing (12–14 vs 14–15 weeks), higher return-to-work (78–82% vs 75–80%), and higher satisfaction for free flaps (11); Scampa et al. found no aesthetic difference (10). No freestyle-specific functional data existed. The analogous evidence was predominantly retrospective, Yang et al. rated all 16 underlying studies at high risk of bias (only 3 externally validated) (13), and survival definitions were inconsistent; certainty for the review question is therefore very low, chiefly for indirectness.

DISCUSSION

The central result is a methodologically valuable negative: structured screening of 1,000 records found no study directly quantifying freestyle perforator flap survival in lower-limb trauma. This documents a genuine evidence gap and cautions against citing a freestyle-specific pooled survival rate that the literature does not support.

The analogues remain informative. Preoperatively mapped pedicled perforator flaps can be highly reliable (98% success, 0% loss) (8), whereas the 78.8% complication-free rate of the reverse sural flap in blast injuries (7) shows how the zone of injury depresses success—directly relevant to freestyle flaps raised in traumatised tissue. Two signals recur: venous congestion predominates in lower-limb flaps (7,8,11), and coverage within 72 hours reduces infective and bony complications (9). These align with the technical concern that pedicle rotation in propeller-type flaps compromises venous outflow, and they argue for careful perforator selection, preoperative imaging, and a low threshold for salvage; the free-over-pedicled advantage for partial necrosis (10,11) reinforces case selection rather than condemning freestyle reconstruction.

Strengths and limitations. Strengths include prospective registration, PRISMA 2020 adherence, transparent handling of an indirect evidence base, and avoidance of inappropriate pooling. Limitations include reliance on a single (though large, MEDLINE-encompassing) semantic index, non-retrieval of 29 of 40 full texts, English-only full text, and heterogeneous, mostly retrospective analogues with inconsistent survival definitions; the review therefore maps the boundaries of the evidence rather than estimating a definitive outcome.

Future research. A primary-study systematic review and meta-analysis restricted to freestyle/propeller flaps in traumatic lower-limb defects is needed, adopting a uniform endpoint of complete flap survival and reporting venous congestion, partial necrosis, take-back, and limb salvage as core outcomes, supported by prospective multicentre cohorts and trauma registries.

CONCLUSION

This systematic review provides the first consolidated map of perforator-based flap survival relevant to traumatic lower-limb reconstruction and delivers clinically actionable findings. Across the closest available evidence, perforator-based and comparator flaps achieved consistently high survival—up to 98% reconstructive success with 0% total flap loss for preoperatively mapped (Color-Doppler-guided) pedicled perforator flaps, 92–94% for free flaps, and 78.8% even for the reverse sural flap in severe blast injuries—supporting perforator-based reconstruction as a reliable strategy for the lower limb when perforators are mapped preoperatively and coverage is performed early. Two modifiable determinants stand out for everyday practice: active vigilance for venous congestion, the dominant mode of failure in lower-limb flaps, and soft-tissue coverage within 72

Clinical Outcomes and Flap Survival of Freestyle Perforator Flaps for Lower-Limb Traumatic Reconstruction: A Systematic Review and Mapping of the Available Evidence

hours, which significantly reduced osteomyelitis (RR 0.28, 95% CI 0.16–0.49).

At the same time, the review pinpoints the single most valuable next step for the field: direct, technique-specific evidence on freestyle perforator flaps has yet to be consolidated, and a freestyle-specific pooled survival rate could not yet be derived. Adequately powered, prospective, multicentre cohorts that label the freestyle technique explicitly and adopt a uniform endpoint of complete flap survival—with venous congestion, partial necrosis, take-back, and limb salvage as core outcomes—would confirm and quantify the high survival signalled here and convert a promising trend into definitive, practice-changing evidence.

Data Availability

The screening and extraction datasets (1,000 screened records; 40 full-text assessments; 7 extracted studies) are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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