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Burns

Outcomes of Muscle versus Fasciocutaneous Free Flap Reconstruction in Acute Burns: A Systematic Review and Meta-analysis

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Background: Free flap reconstruction in acute burns is high risk but often required for limb salvage and coverage of vital structures. Prior studies have shown a flap loss rate up to 44%. This study aimed to compare the complications associated with muscle and fasciocutaneous free flaps in acute burn reconstruction.

Methods: A systematic review and meta-analysis was conducted according to PRISMA guidelines and registered on the PROSPERO database (CDR42023471088). The databases accessed were Embase, PubMed, Web of Science, and Cochrane Library. The primary outcome was free flap failure rate based on flap type. Secondary outcomes included venous congestion, arterial thrombosis, amputation, and need for reintervention.

Results: Twelve studies with 181 free flaps were included: 87 muscle flaps and 94 fasciocutaneous flaps. Muscle flaps had a higher risk ratio (RR) for total flap loss [RR: 2.32, 95% confidence interval (CI): 1.01–5.32, $P = 0.04$], arterial thrombosis (RR: 3.13, 95% CI: 1.17–8.42, $P = 0.02$), and amputations (RR: 8.89, 95% CI: 1.27–70.13, $P = 0.03$) compared with fasciocutaneous flaps. No significant differences were found in venous thrombosis (RR: 1.33, 95% CI: 0.37–4.78, $P = 0.65$) or need for reinterventions (RR: 1.34, 95% CI: 0.77–2.32, $P = 0.29$).

Conclusions: Muscle flaps in burn injuries are associated with higher risks of flap failure, arterial thrombosis, and amputations. Fasciocutaneous free flaps in acute burns seem to be safer with better outcomes, though further research is needed to confirm these findings. *(Plast Reconstr Surg Glob Open 2024; 12:e6027; doi: 10.1097/GOX.0000000000006027; Published online 9 August 2024.)*

INTRODUCTION

Burn injuries significantly contribute to accidental injuries and fatalities worldwide, affecting an estimated eight million people.[1] Full-thickness burns demand prompt excision and coverage for improved patient outcomes, often utilizing skin grafting as a prevalent reconstructive technique in burn surgery.[2] In cases involving extensive defects and exposure of critical structures such as bone, tendons, or neurovascular tissues, a robust and durable reconstruction through well-vascularized and healthy tissue transfer becomes the optimal choice.[3]

Although soft tissue defects resulting from a burn injury can be managed with local flaps, their application is sometimes limited by the wound size of involvement of local tissues in the zone of injury.[4,5] Free flap reconstruction offers a viable solution for early repair of complex, large defects, particularly when dealing with exposed bone, nerves, or tendons, and when local flaps are unsuitable or contraindicated.[6] However, free flap reconstruction is a challenging and time-consuming procedure, and eligibility for reconstruction depends not only on burn depth and size but also on the patient's clinical status. Prior studies have demonstrated an incidence of flap loss of 10%, with studies reporting a rate as high as 44%.[3,6,7] Operating after day 21 postinjury can reduce risks. Free flap selection for acute burn injuries depends on defect size, donor availability, pedicle length, and vessel diameter.[8–10] Criteria for selecting muscle or fasciocutaneous

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flaps lack standardization, often guided by institutional algorithms and surgeon preference. Muscle flaps, preferred for larger defects, have higher donor site morbidity, requiring simultaneous skin grafting. In contrast, fasciocutaneous flaps offer better contour, pliability, and reduced donor site morbidity.[11,12] This study compares complications of muscle and fasciocutaneous free flaps in acute burn reconstruction to identify strategies for mitigating high flap loss rates.

Takeaways

Question: What complications rates are associated with the use of muscle free flaps compared with fasciocutaneous free flaps in the context of acute burn reconstruction?

Findings: Muscle flaps in burn injuries show higher risks of flap failure, arterial thrombosis, and amputations. Conversely, fasciocutaneous flaps in acute burns seem safer with better outcomes. Muscle flaps were chosen for higher % TBSA cases. No significant differences in venous thrombosis or reinterventions were noted.

Meaning: In free flap reconstruction, selecting the appropriate flap emphasizes the importance of careful consideration in clinical decision-making and underscores the need for additional research.

MATERIALS AND METHODS

A systematic review and meta-analysis was performed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[13] Institutional review board approval and informed consents were not required for this study because all the reported data were obtained from the available published literature. The review protocol was registered on the PROSPERO database (CDR42023471088).

Inclusion and Exclusion Criteria

The PICOS framework[14] was used in developing the literature search strategy:

- Population (P): acute burn patients treated with free flap reconstruction within 6 weeks from the day of injury;
- Intervention (I): microsurgical reconstruction using muscle free flaps;
- Comparator (C): microsurgical reconstruction using fasciocutaneous free flaps;
- Outcome (O): rate of free flap loss;
- Study type (S): randomized controlled trials, prospective and retrospective cohort studies, and case series.

Studies were excluded if (1) they were not in English; (2) they were not available in full-text form; (3) data on free flap types were not extractable; (4) the study reported fewer than five patients; (5) the article type was a conference abstract, review, case report, book chapter, or letter to the editor; and (6) data presented were not specific to acute burn injuries. All articles had to be published in a peer-reviewed journal, and no restriction on publication date was applied.

Outcome Measures

The primary outcome was free flap loss. Secondary outcomes were rates of venous congestion, arterial thrombosis, amputation, and reintervention. Free flap loss was defined as total flap necrosis. Acute burns were defined as any burns presenting within 6 weeks from the day of injury that had not previously healed.

Data Source and Study Search

An electronic search was performed on PubMed, Embase, Web of Science and Cochrane Library using relevant keywords, phrases, and medical subject headings (MeSH) terms. The search strategy applied for PubMed was: ("Burns"[MeSH Terms] OR "burn"[All Fields]) AND ("Free Tissue Flaps"[MeSH Terms] OR "free tissue"[All Fields] OR "free flaps"[All Fields]) AND ("fail*"[All Fields] OR "issue*"[All Fields] OR "complic*"[All Fields]). The reference list of each selected article was checked to screen for potentially relevant studies (ie, snowballing method). The search was carried out on September 15, 2023.

Selection of Studies and Data Extraction

Two reviewers independently conducted the electronic literature search and data extraction (J.A. . and H.Y.L.). The reference lists from four databases (ie, PubMed, Embase, Web of Science, and Cochrane Library) were merged, and the duplicates were removed using the reference management software EndNote X9 (version X9.3.3). Titles and abstracts of unresolved articles were screened. Whenever appropriate, full texts of relevant articles underwent subsequent evaluation for eligibility. Discrepancies were resolved by a third author (M.A.-B.). Data extracted from selected articles were archived in a customized Excel (Microsoft Corp., Seattle, Wash.) spreadsheet. Variables collected included number and type of free flaps, number of free flap failures, and patients' demographics [age, percentage total body surface area (% TBSA), burn etiology, follow-up].

Risk of Bias and Study Quality Assessment

The methodological quality of included studies was assessed independently by two separate authors (J.A.A. and H.Y.L.). Because no randomized controlled trials were included, the Methodological Index for Nonrandomized Studies (MINORS) criteria, a validated instrument designed to assess the methodological quality of nonrandomized studies, was used to measure bias.[15] The maximum MINORS score for noncomparative studies is 16.[15]

Data Synthesis and Statistical Analysis

The analysis was performed using R software for statistical computing (R 4.0.1; "meta" package). Data were pooled using a fixed- or a random-effects model according to the identified level of heterogeneity, following the recommendation of the *Cochrane Handbook for Systematic Reviews of Interventions*.[16] The mean difference was calculated as a measure of effect size to compare continuous variables, whereas risk ratio (RR) was calculated for dichotomous variables. All results were expressed with 95% confidence interval (CI). A forest plot graph was created for each outcome. Statistical significance was defined as a *P* value of less than 0.05.

To assess heterogeneity among studies, the forest plots of study outcomes were examined to analyze the level of consistency considering the size and the direction of effects.[17] In addition, the I^2 statistic was calculated to quantify heterogeneity, assuming values less than 50% as indicative of substantial heterogeneity.[17] Cochrane *Q* test was also analyzed as the I^2 statistics underpowered in the presence of a low number of included studies.[18] Specifically, a *P* value of less than 0.05 was considered to indicate statistical significance of the *Q* test. Weights calculation was performed using the Mantel–Haenszel method. The maximum-likelihood estimator was used to estimate the between-study variance (τ^2).[19] Analysis of publication bias was performed by inspection of the funnel plot, and calculating the Peters linear regression test, which statistically examines the asymmetry of the funnel plot.[19] If I^2 statistics was less than 50% or Q statistics resulted a *P* value less than 0.05, a more conservative random effect model was used. If not, a fixed-effects model was used.

RESULTS

Electronic Database Search and Key Characteristics of Included Studies

From the initial search, a total of 1337 eligible papers were identified. After eliminating duplicate entries and screening titles and abstracts, 183 full-text articles were evaluated for eligibility. Upon applying inclusion and exclusion criteria, 12 articles were included in both qualitative and quantitative synthesis.[4,7–10,20–26] The PRISMA flow diagram is shown in Figure 1. Articles included in this study are shown in Table 1.

The included studies encompassed a total of 181 free flap procedures conducted for the reconstruction of complex acute burn injuries in 165 patients, with the groups consisting of 87 muscle flaps and 94 fasciocutaneous flaps.

In the muscle group, the mean age was 39.40 years (95% CI: 27.07–51.73), and the mean % TBSA affected by burns was 25.72 (95% CI: 16.19–35.2). The mean time interval between burn injury and surgery was 16.91 days (95% CI: 11.14–22.69). In the fasciocutaneous group, the mean age was 37.76 years (95% CI: 35.12–40.41), and the mean % TBSA affected by burns in the fasciocutaneous group was 16.45 (95% CI: 9.16–23.74). The mean interval between burn injury and surgery for the fasciocutaneous group was 15.07 days (95% CI: 10.11–20.03).

No differences between the muscle flap group and the fasciocutaneous flap group were found in terms of mean age ($P = 0.43$) or mean time between burn injury and reconstructive surgery ($P = 0.61$). The muscle group exhibited a greater mean % TBSA when compared with the fasciocutaneous group ($P < 0.01$).

Risk of Bias Assessment

Within the 12 studies included in the analysis, the scores fell within the range of 10–13, with a median score of 11. The primary shortcomings were the absence of study size calculations and a lack of prospective data collection. However, all the studies exhibited clear and well-defined objectives, utilized appropriate endpoints, experienced minimal loss to follow-up, and enrolled consecutive patients, as shown in Supplemental Digital Content 1. (**See figure, Supplemental Digital Content 1**, which displays MINORS scores. **http://links.lww.com/PRSGO/D391**.)

Total Flap Loss

The pooled RR of total flap loss for muscle flaps (24.1%) compared with fasciocutaneous flaps (7.4%) was 2.32 (95% CI: 1.01–5.32, $P = 0.04$), as shown in Figure 2. Small between-study heterogeneity ($Q = 4.04$, $P = 0.90$) was measured: $I^2 = 0\%$ (95% CI: 0.0%–62.4%), $\tau^2 = 0$. Therefore a fixed-effects model was used. The Peters linear regression test showed no obvious publication bias ($t = 0.48$, $P = 0.64$), and visual inspection of the funnel plot shows a symmetric distribution of the points, as shown in Supplemental Digital Content 2. (**See figure, Supplemental Digital Content 2**, which displays a total flap loss funnel plot. **http://links.lww.com/PRSGO/D392**.)

Venous Congestion

The pooled RR of venous thrombosis for muscle flaps (4.6%) compared with fasciocutaneous flaps (4.3%) was 1.33 (95% CI: 0.37–4.78, $P = 0.65$), as shown in Figure 3. Small between-study heterogeneity ($Q = 5.26$, $P = 0.38$) was measured: $I^2 = 4.9$ (95% CI: 0.0%–75.9%), $\tau^2 = 0.34$. Therefore, a fixed model was used. The Peters linear regression test showed no obvious publication bias ($t = 0.12$, $P = 0.91$), and visual inspection of the funnel plot shows a symmetric distribution of the points, as shown in Supplemental Digital Content 3. (**See figure, Supplemental Digital Content 3**, which displays a venous congestion funnel plot. **http://links.lww.com/PRSGO/D393**.)

Arterial Thrombosis

The pooled RR of arterial thrombosis for muscle flaps (21.8%) compared with fasciocutaneous flaps (6.4%) was 3.13 (95% CI: 1.17–8.42, $P = 0.02$), as shown in Figure 4. Small between-study heterogeneity ($Q = 3.6$, $P = 0.89$) was measured: $I^2 = 0\%$ (95% CI: 0.0%–64.8%), $\tau^2 = 0$. Therefore, a fixed-effects model was used. The Peters linear regression test showed no obvious publication bias ($t = -0.65$, $P = 0.54$), and visual inspection of the funnel plot shows a symmetric distribution of the points as shown in Supplemental Digital Content 4. (**See figure, Supplemental Digital Content 4**, which displays an arterial thrombosis funnel plot. **http://links.lww.com/PRSGO/D394**.)

Amputations

The pooled RR of amputations for muscle flaps (11.5%) compared with fasciocutaneous (2.1%) flaps was 8.89 (95% CI: 1.27–70.13, $P = 0.03$), as shown in Figure 5. Small between-study heterogeneity ($Q = 2.2$, $P = 0.69$) was

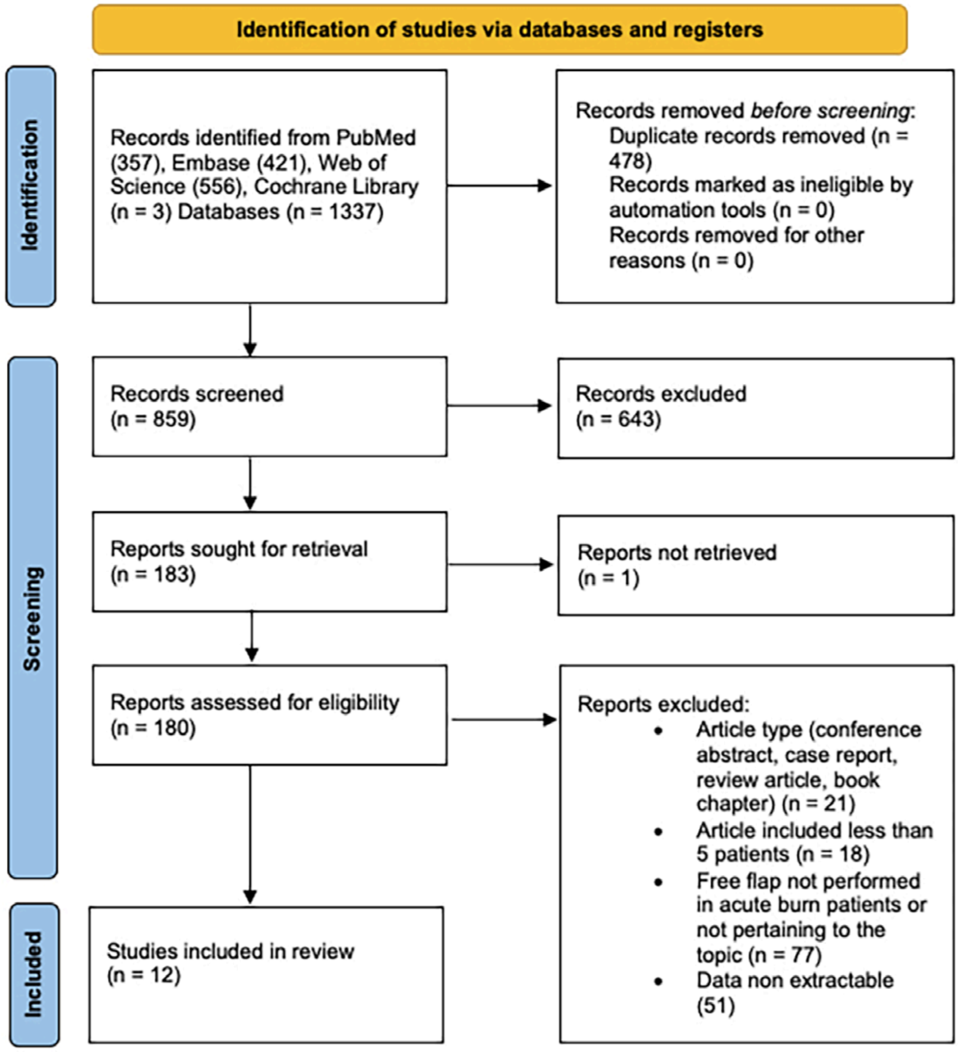

Fig. 1. PRISMA flow diagram.

measured: I^2 = 0% (0.0%–79.2%), τ^2 = 0. Therefore, a fixed-effects model was used.

The Peters linear regression test showed no obvious publication bias (t = −0.78, P = 0.49), and visual inspection of the funnel plot shows a symmetric distribution of the points, as shown in Supplemental Digital Content 5. (**See figure, Supplemental Digital Content 5**, which displays an amputations funnel plot. **http://links.lww.com/PRSGO/D395**.)

Reinterventions

The pooled RR of reinterventions for muscle flaps (31.0%) compared with fasciocutaneous flaps (23.4%) was 1.34 (95% CI: 0.77–2.32, P = 0.29), as shown in Figure 6. Small between-study heterogeneity (Q = 9.76, P = 0.46) was measured [I^2 = 0% (95% CI: 0.0%–60.2%), τ^2 = 0]; therefore, a fixed model was used.

The Peters linear regression test showed no obvious publication bias (t = −0.18, P = 0.85), and visual inspection of the funnel plot shows a symmetric distribution of the points, as shown in Supplemental Digital Content 6. (**See figure, Supplemental Digital Content 6**, which displays a reinterventions funnel plot. **http://links.lww.com/PRSGO/D396**.)

DISCUSSION

Complex reconstruction of acute buns may require free tissue transfer in cases of exposure of critical structures, such as bone, tendons, and neurovascular structures. Free flaps have the potential of saving patients from amputation in severe limb salvage situations.[27] Furthermore, free flaps have the potential to enable a single-stage reconstruction, resulting in reduced healing time, shorter hospital stays, and lower infection rates comparable to other reconstructive options.[3,6,25,27] However, free tissue transfer is typically reserved as a last resort when local options are not available or skin substitutes are not indicated. The reasons why free flaps are seldom used in the acute management of burn injuries include technological advancements in wound care; the often-unstable clinical status

Table 1. Complication Rates in Muscle and Fasciocutaneous Free Flaps

Authors	Year	Free Flaps, n	Muscle Flaps						Fasciocutaneous Flaps					
			Muscle Flaps, n	Flap Loss, n (%)	Venous Congestion, n (%)	Arterial Thrombosis, n (%)	Amputations, n (%)	Reinterventions, n (%)	Fasciocutaneous Flaps, n	Flap Loss, n (%)	Venous Congestion, n (%)	Arterial Thrombosis, n (%)	Amputations, n (%)	R-interventions, n (%)
Baumeister et al[8]	2005	32	23	7 (30)	0 (0)	6 (26)	3 (13)	7 (30)	9	2 (22)	1 (11)	1 (11)	0 (0)	2 (22)
Chick et al[20]	1992	7	3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Handschin et al[7]	2009	9	8	4 (44)	1 (13)	3 (38)	1 (13)	4 (50)	1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Jabir et al[9]	2015	22	6	0 (0)	1 (17)	0 (0)	0 (0)	1 (17)	16	0 (0)	0 (0)	1 (6)	0 (0)	5 (31)
Koul et al[21]	2008	17	7	1 (14)	0 (0)	1 (14)	0 (0)	1 (14)	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Parrett et al[22]	2006	7	4	0 (0)	NS	NS	NS	2 (50)	3	1 (33)	0 (0)	0 (0)	1 (33)	3 (100)
Pedrazzi et al[10]	2023	12	4	1 (25)	1 (25)	1 (25)	0 (0)	2 (50)	8	1 (13)	1 (13)	2 (25)	0 (0)	3 (38)
Pessoa Vaz et al[23]	2018	16	10	2 (20)	0 (0)	0 (0)	1 (10)	3 (30)	6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Saint-Cyr et al[24]	2008	15	5	2 (40)	1 (20)	1 (20)	2 (40)	3 (60)	10	1 (10)	0 (0)	0 (0)	0 (0)	3 (30)
Sauerbier et al[25]	2007	21	10	3 (30)	0 (0)	0 (0)	3 (30)	3 (30)	11	1 (9)	0 (0)	1 (9)	1 (9)	1 (9)
Stefanacci et al[26]	2003	9	3	1 (33)	NS	NS	NS	1 (33)	6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ziegler et al[4]	2020	14	4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10	1 (10)	2 (20)	1 (10)	0 (0)	5 (50)

of the patient; the complexity of the procedure, which requires a dedicated team; and the high free flap failure rate reported in the literature. Our group recently conducted a systematic review and meta-analysis of the literature and estimated the absolute risk for free flap failure in acute burns to be around 10%.[3] However, studies have shown flap loss rates as high as 44%.[7] Therefore, further research efforts are necessary to identify factors and solutions that can minimize the risk of flap failure and optimize outcomes for these patients.

Type of flap has been compared in other reconstructive etiologies such as trauma or oncology. Cho et al[28] compared outcomes between muscle and fasciocutaneous free tissue transfer for lower extremity traumatic reconstruction in 518 trauma patients. The flap choice did not significantly affect flap outcomes, reinterventions, or limb salvage rates.[28] In another study specifically focusing on heel reconstruction, patients with fasciocutaneous flaps had improved sensory perception, facilitating quicker return to daily activities compared with muscle flaps.[29] However, flap survival, reinterventions, and limb salvage rates between muscle and fasciocutaneous flaps did not show significant differences.[29] Other studies presented similar findings, with no significant differences between the two flap types.[30,31] Despite a slightly higher trend of complications in muscle flaps, including donor site morbidity, there were no significant disparities in total flap loss, reinterventions, or amputations compared with fasciocutaneous flaps.[30,31] A systematic review by Shimbo et al[32] found no substantial differences in total flap loss and vascular thrombosis rates between muscle and fasciocutaneous free flaps.

Thus, recent literature suggests that there is little difference between the use of muscle free flaps and fasciocutaneous flaps in patients with no burn. Muscle flaps exhibit higher rates of wound complications, indicating a preference for fasciocutaneous flaps, particularly in foot and ankle reconstruction. However, previous studies focus primarily on trauma or infection-related free flap reconstructions rather than acute burns.

In an attempt to identify ways to improve free flap outcomes in acute burns, the authors conducted a systematic review and meta-analysis with the primary focus to assess whether the type of free flap used could have a discernible impact on the overall outcome. This study demonstrated that the utilization of muscle flaps was associated with an elevated risk of complications, particularly in terms of total flap loss, arterial thrombosis, and amputations.

The mean interval between burn injury and free flap surgery was consistent across the muscle and fasciocutaneous flap groups, highlighting similar timeframes for surgical intervention. In a separate meta-analysis conducted by our group, we delved into the timing of surgery after burn injuries and its impact on surgical outcomes. Interestingly, our findings revealed that free flap surgery performed between 5 and 21 days after the injury correlated with a nearly three-fold higher risk of flap failure. The comparable surgical timing between the muscle and fasciocutaneous free flap groups suggests that our results are not biased by reconstructive timing.

Study	M Events	M Total	FC Events	FC Total	Weight (common)	Weight (random)	Risk Ratio MH, Fixed + Random, 95% CI
Baumeister et al	7	23	2	9	41.8%	28.1%	1.37 [0.35; 5.39]
Chick et al	0	3	0	4	0.0%	0.0%	
Handschin et al	4	8	0	1	0.0%	9.6%	1.59 [0.15; 16.66]
Jabir et al	0	6	0	16	0.0%	0.0%	
Koul et al	1	7	0	10	0.0%	5.6%	4.20 [0.20; 89.61]
Parrett et al	0	4	1	3	16.6%	6.4%	0.26 [0.01; 4.62]
Pedrazzi et al	1	4	1	8	9.7%	8.5%	2.00 [0.16; 24.33]
Pessoa Vaz et al	2	10	0	6	0.0%	6.4%	3.10 [0.17; 54.84]
Saint-Cyr et al	2	5	1	10	9.7%	11.4%	4.00 [0.47; 34.24]
Sauerbier et al	3	10	1	11	13.9%	12.0%	3.30 [0.41; 26.81]
Stefanacci et al	1	3	0	6	0.0%	6.2%	5.57 [0.30; 103.81]
Ziegler et al	0	4	1	10	8.3%	5.8%	0.78 [0.04; 15.69]
Total (common effect, 95% CI)		**87**		**94**	**100.0%**	**--**	**2.32 [1.01; 5.32]**
Total (random effect, 95% CI)					**--**	**100.0%**	**1.92 [1.09; 3.36]**
Prediction interval							**[0.82; 4.51]**

Heterogeneity: $Tau^2 = 0$; $Chi^2 = 4.04$, df = 9 ($P = 0.91$); $I^2 = 0\%$

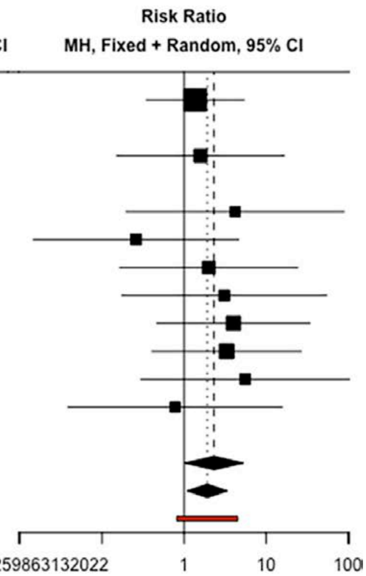

Fig. 2. Forest plot comparing total free flap loss in muscle and fasciocutaneous flaps. FC, fasciocutaneous; M, muscle.

Study	M Events	M Total	FC Events	FC Total	Weight (common)	Weight (random)	Risk Ratio MH, Fixed + Random, 95% CI
Baumeister et al	0	23	1	9	44.3%	14.1%	0.13 [0.01; 3.02]
Chick et al	0	3	0	4	0.0%	0.0%	
Handschin et al	1	8	0	1	0.0%	18.5%	0.53 [0.04; 7.79]
Jabir et al	1	6	0	16	0.0%	14.4%	7.62 [0.35; 163.92]
Koul et al	0	7	0	10	0.0%	0.0%	
Parrett et al	.	4	.	3	0.0%	0.0%	
Pedrazzi et al	1	4	1	8	20.5%	21.3%	2.00 [0.16; 24.33]
Pessoa Vaz et al	.	10	.	6	0.0%	0.0%	
Saint-Cyr et al	1	5	0	10	0.0%	14.8%	5.73 [0.28; 118.51]
Sauerbier et al	.	10	.	11	0.0%	0.0%	
Stefanacci et al	.	3	.	6	0.0%	0.0%	
Ziegler et al	0	4	2	10	35.2%	16.9%	0.47 [0.03; 7.90]
Total (common effect, 95% CI)		**87**		**94**	**100.0%**	**--**	**1.34 [0.37; 4.78]**
Total (random effect, 95% CI)					**--**	**100.0%**	**1.19 [0.25; 5.68]**
Prediction interval							**[0.17; 8.32]**

Heterogeneity: $Tau^2 = 0.1206$; $Chi^2 = 5.26$, df = 5 ($P = 0.39$); $I^2 = 5\%$

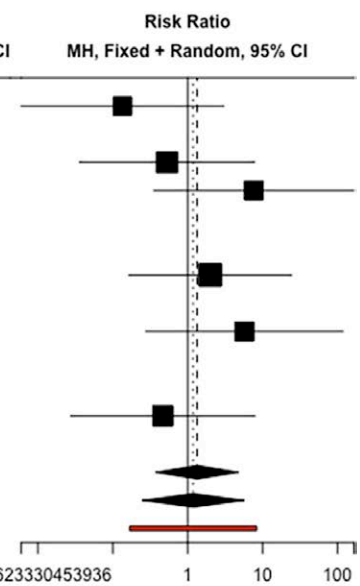

Fig. 3. Forest plot comparing venous congestion in muscle and fasciocutaneous flaps. FC, fasciocutaneous; M, muscle.

Another aspect to consider, which may contribute to the higher flap loss rate within the muscle flap group, is the larger % TBSA when compared with the fasciocutaneous flap group. A larger % TBSA may correlate with an enhanced inflammatory response; an amplified hypercoagulable state; and possibly, a more unstable patient condition.[33] Additionally, a larger % TBSA involvement may suggest that muscle flaps were chosen to cover more extensive defects than fasciocutaneous flaps.[3] As a result, there is a higher likelihood that the microvascular anastomosis had to be performed within the zone of injury.[6] This area may be more vulnerable to the local edema and inflammation associated with the burn injury.[34] These aspects may also account for the observed increased arterial thrombosis rates in the muscle group compared with the fasciocutaneous flap group.

A potential explanation for the increased complication rate associated with muscle free flaps is that muscular tissue is more vulnerable to the systemic inflammatory response triggered by severe burns.[35] This heightened response may lead to increased vascular permeability and reduced vascular integrity, resulting in elevated interstitial pressure and edema.[33] The simultaneous local and systemic hyperinflammatory response caused by larger burn injuries may contribute to the increased risk of flap failure.[3,4,33]

Study	M Events	M Total	FC Events	FC Total	Weight (common)	Weight (random)	Risk Ratio MH, Fixed + Random, 95% CI
Baumeister et al	6	23	1	9	29.7%	17.6%	2.35 [0.33; 16.87]
Chick et al	0	3	0	4	0.0%	0.0%	
Handschin et al	3	8	0	1	0.0%	11.8%	1.24 [0.11; 13.64]
Jabir et al	0	6	1	16	11.3%	7.3%	0.85 [0.04; 18.21]
Koul et al	1	7	0	10	0.0%	7.3%	4.20 [0.20; 89.61]
Parrett et al	.	4	.	3	0.0%	0.0%	
Pedrazzi et al	1	4	2	8	27.5%	15.8%	1.00 [0.13; 8.00]
Pessoa Vaz et al	2	10	0	6	0.0%	8.3%	3.10 [0.17; 54.84]
Saint-Cyr et al	3	5	0	10	0.0%	8.9%	13.36 [0.83; 214.94]
Sauerbier et al	3	10	1	11	19.7%	15.6%	3.30 [0.41; 26.81]
Stefanacci et al	.	3	.	6	0.0%	0.0%	
Ziegler et al	0	4	1	10	11.8%	7.6%	0.78 [0.04; 15.69]
Total (common effect, 95% CI)		**87**		**94**	**100.0%**	**--**	**3.14 [1.17; 8.42]**
Total (random effect, 95% CI)					**--**	**100.0%**	**2.13 [1.11; 4.09]**
Prediction interval							**[0.79; 5.78]**

Heterogeneity: $Tau^2 = 0$; $Chi^2 = 3.60$, df = 8 (P = 0.89); $I^2 = 0\%$

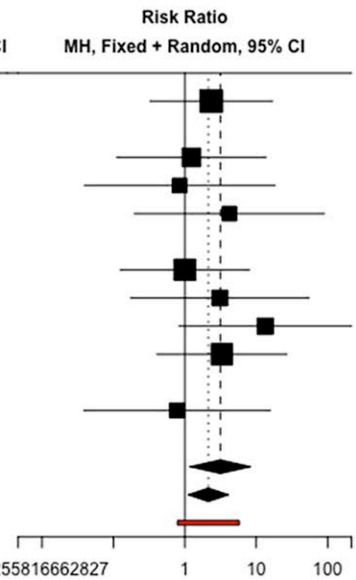

Fig. 4. Forest plot comparing arterial thrombosis in muscle and fasciocutaneous flaps. FC, fasciocutaneous; M, muscle.

Study	M Events	M Total	FC Events	FC Total	Weight (common)	Weight (random)	Risk Ratio MH, Fixed + Random, 95% CI
Baumeister et al	3	23	0	9	0.0%	17.0%	2.83 [0.16; 49.70]
Chick et al	0	3	0	4	0.0%	0.0%	
Handschin et al	1	8	0	1	0.0%	19.3%	0.53 [0.04; 7.79]
Jabir et al	0	6	0	16	0.0%	0.0%	
Koul et al	0	7	0	10	0.0%	0.0%	
Parrett et al	.	4	1	3	0.0%	0.0%	
Pedrazzi et al	.	4	.	8	0.0%	0.0%	
Pessoa Vaz et al	1	10	0	6	0.0%	15.0%	1.86 [0.09; 39.11]
Saint-Cyr et al	2	5	0	10	0.0%	17.1%	9.55 [0.55; 165.97]
Sauerbier et al	3	10	1	11	100.0%	31.7%	3.30 [0.41; 26.81]
Stefanacci et al	.	3	.	6	0.0%	0.0%	
Ziegler et al	.	4	.	10	0.0%	0.0%	
Total (common effect, 95% CI)		**87**		**94**	**100.0%**	**--**	**8.89 [1.13; 70.14]**
Total (random effect, 95% CI)					**--**	**100.0%**	**2.49 [0.71; 8.68]**
Prediction interval							**[0.37; 16.89]**

Heterogeneity: $Tau^2 = 0$; $Chi^2 = 2.24$, df = 4 (P = 0.69); $I^2 = 0\%$

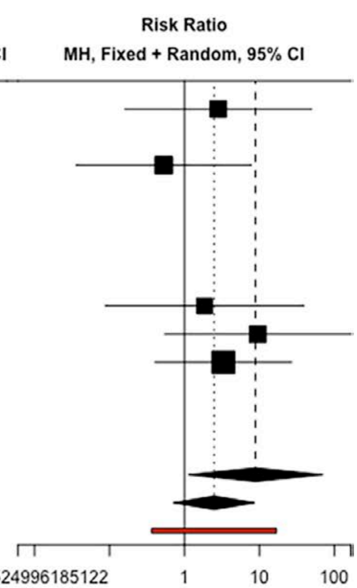

Fig. 5. Forest plot comparing amputations in muscle and fasciocutaneous flaps. FC, fasciocutaneous; M, muscle.

It has been postulated that electrical injuries may be associated with a higher risk of flap loss, but significant differences have not been identified in various studies.[24–26] However, conclusions on flap loss differences due to burn etiology are limited due to the low level of evidence and lack of comparative analysis in the available literature.

Our study has some important limitations. These include the relatively small sample size and the retrospective nature of the included studies, which may affect the generalizability and introduce potential biases. Moreover, the lack of data regarding the patients' comorbidities, burn injury type, and burn severity represent notable shortcomings.

The primary objective of this study was to gain a comprehensive understanding of the factors contributing to free flap loss in acute burn cases, specifically, free flap loss in muscle and fasciocutaneous free flaps. The results of this study, particularly the higher risk of complications in the muscle flap group, underscore the relevance of this research in addressing the challenges of acute burn management and, ultimately, improving patient care.

By achieving a better understanding of the factors at play, the researchers aim to improve patient outcome and make free flaps a more reliable and safer reconstructive option in this challenging population. It is important to keep in mind that free flaps are generally used as the last

Study	M Events	M Total	FC Events	FC Total	Weight (common)	Weight (random)	Risk Ratio MH, Fixed + Random, 95% CI
Baumeister et al	7	23	2	9	17.1%	12.0%	1.37 [0.35; 5.39]
Chick et al	0	3	0	4	0.0%	0.0%	
Handschin et al	4	8	0	1	0.0%	4.1%	1.59 [0.15; 16.66]
Jabir et al	1	6	5	16	16.2%	6.0%	0.53 [0.08; 3.68]
Koul et al	1	7	0	10	0.0%	2.4%	4.20 [0.20; 89.61]
Parrett et al	2	4	3	3	20.4%	33.0%	0.56 [0.24; 1.27]
Pedrazzi et al	2	4	3	8	11.9%	12.8%	1.33 [0.35; 5.03]
Pessoa Vaz et al	3	10	0	6	0.0%	2.9%	4.33 [0.26; 71.05]
Saint-Cyr et al	3	5	3	10	11.9%	16.0%	2.00 [0.61; 6.55]
Sauerbier et al	3	10	1	11	5.7%	5.1%	3.30 [0.41; 26.81]
Stefanacci et al	1	3	0	6	0.0%	2.6%	5.57 [0.30; 103.81]
Ziegler et al	0	4	5	10	17.0%	3.1%	0.21 [0.01; 3.08]
Total (common effect, 95% CI)		**87**		**94**	**100.0%**	**--**	**1.34 [0.77; 2.32]**
Total (random effect, 95% CI)					**--**	**100.0%**	**1.11 [0.65; 1.90]**
Prediction interval							**[0.64; 1.92]**

Heterogeneity: $Tau^2 = 0$; $Chi^2 = 9.76$, df = 10 ($P = 0.46$); $I^2 = 0\%$

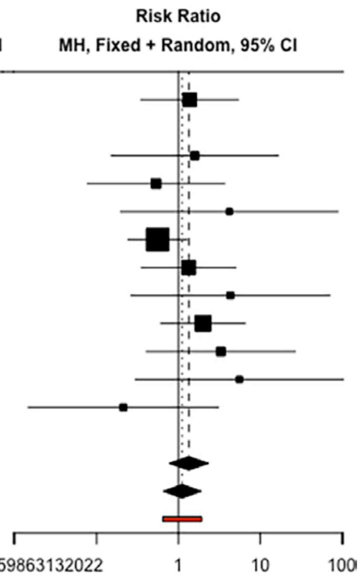

Fig. 6. Forest plot comparing reintervention in muscle and fasciocutaneous flaps. FC, fasciocutaneous; M, muscle.

reconstructive resort in limb salvage situations and have the potential of saving patients from amputation. For this reason, it is important that further high-quality and robust research is conducted on this topic to enhance our understanding and decision-making processes.

CONCLUSIONS

The use of muscle flaps in burn injuries is associated with a higher risk of flap failure, arterial thrombosis, and amputations. The use of fasciocutanoues free flaps in acute burns seems to be safer and lead to better outcomes. However, muscles flaps were used in cases of higher % TBSA, which may influence the results of this study. Notably, there were no discernible differences in the risk of venous thrombosis or reinterventions when comparing muscle and fasciocutaneous flaps. It is important to acknowledge that these findings are constrained by the limited sample size and the relatively low level of evidence of the studies included. Thus, further research is needed to confirm these findings.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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