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Burns

Free Flap Failure and Contracture Recurrence in Delayed Burn Reconstruction: A Systematic Review and Meta-analysis

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Background: Free tissue transfer is often considered a last resort in burn reconstruction due to its complexity and associated risks. A comprehensive review on free flap outcomes in delayed burn reconstruction is currently lacking. The study aimed to evaluate the available evidence on the failure and contracture recurrence rates in free flap delayed burn reconstruction.

Methods: A systematic review and meta-analysis was conducted and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. The protocol was registered on PROSPERO (CRD42023404478). The following databases were accessed: Embase, PubMed, Web of Science, and Cochrane Library. The measured outcomes were free flap loss and contracture recurrence rate.

Results: Of the 1262 retrieved articles, 40 qualified for inclusion, reporting on 1026 free flaps performed in 928 patients. The mean age was 29.25 years [95% confidence interval (CI), 24.63–33.88]. Delayed burn reconstruction was performed at an average of 94.68 months [95% CI, − 9.34 to 198.70] after initial injury, with a follow-up period of 23.02 months [95% CI, 4.46–41.58]. Total flap loss rate was 3.80% [95% CI, 2.79–5.16] and partial flap loss rate was 5.95% [95% CI, 4.65–7.57]. Interestingly, burn contracture recurrence rate was 0.62% [95% CI, 0.20–1.90].

Conclusions: This systematic review provides a comprehensive evaluation of the free flap outcomes in delayed burn reconstruction. The flap loss rate was relatively low, given the complexity of the procedure and potential risks. Furthermore, burn contracture rate was found to be extremely low. This study demonstrates that free flaps are a safe and effective option for delayed burn reconstruction. *(Plast Reconstr Surg Glob Open 2024; 12:e6026; doi: 10.1097/GOX.0000000000006026; Published online 9 August 2024.)*

INTRODUCTION

Burn injuries are a significant global health issue, causing substantial morbidity and mortality.[1,2] An estimated 180,000 deaths occur annually due to burns worldwide, with millions more experiencing nonfatal burn injuries that require medical attention and often result in long-term disabilities.[3]

The primary goal of burn management is to promote wound healing and restore function while minimizing complications.[2,4–6] However, despite advancements in burn care, these interventions often result in problematic scars and contractures.[7] Especially when located in critical areas such as the face and neck, upper extremity, or lower extremity, these burn complications can not only cause disfigurement and profound psychological distress, but also significantly limit mobility and function,[8,9] often jeopardizing normal daily activities.

Delayed reconstruction using flaps has emerged as a valuable technique to release severe scar contractures and allow for large scars resurfacing in burn patients.[10–15]

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However, the success rates and complications associated with free flaps in delayed burn reconstruction vary in the existing literature. This poses a challenge to the reconstructive surgeon not only in preoperative planning and surgical decision-making but also in counseling patients and providing them with evidence-based data on different reconstructive options. Providing a comprehensive analysis of the success rates and complications associated with this complex procedure will help guide clinical decision-making and optimize patient outcomes.

Thus, the aim of this systematic review and meta-analysis is to evaluate the available evidence on the free flap loss and contracture recurrence rates in delayed burn reconstruction.

Takeaways

Question: What are the failure and contracture recurrence rates of free flaps in delayed burn reconstruction?

Findings: This systematic review provides a comprehensive evaluation of the free flap outcomes in delayed burn reconstruction. The flap loss rate was relatively low, given the complexity of the procedure and potential risks. Furthermore, burn contracture rate was found to be extremely low.

Meaning: Free flaps are a safe and effective option for delayed burn reconstruction.

MATERIALS AND METHODS

A systematic review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[16] Institutional review board approval and informed consent 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 (CRD42023404478).

Inclusion and Exclusion Criteria

The population, intervention, comparison, outcomes and study framework[17] was used to develop the literature search strategy: *population* (P), patients undergone microsurgical delayed burn reconstruction, which was defined as burn reconstruction by means of free tissue transfer performed 6 weeks or more from the day of injury and patients had already received definitive acute burn surgical care; *intervention* (I), free flap reconstruction; *comparator* (C), none; *outcomes* (O), free flap loss and contracture recurrence; *study type* (S), randomized controlled trials, prospective and retrospective cohort studies, and case series. Studies were excluded if (a) they were not in English, (b) they were not available in full-text form, (c) data on free flap loss were not extractable, (d) the study reported fewer than five patients, (e) the article type was a conference abstract, review, case report, book chapter or letter to the editor, or (f) data presented was not specific to delayed burn reconstruction. No restriction on publication date was applied, but articles had to be published in a peer-reviewed journal.

Outcome Measures

The primary outcomes measured by this systematic review were the rate of total flap loss (TFL, total necrosis or failure of the flap), and partial flap loss (PFL, partial flap failure or marginal/tip necrosis) in delayed burn reconstruction. Rate of contracture recurrence after delayed free flap reconstruction was measured as a secondary outcome. The TFL and PFL rates in different anatomical areas (head and neck, upper extremity, and lower extremity) were also reported.

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 lists of review articles and included articles were checked to screen for potentially relevant studies (ie, snowballing method). The search was carried out on February 8, 2023.

Selection of Studies and Data Extraction

Two reviewers independently conducted the electronic literature search. The reference lists from four databases (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 were screened for relevance. Whenever appropriate, full texts of relevant articles underwent subsequent evaluation for eligibility. Discrepancies were resolved by the senior author. Data were extracted from selected articles by two independent authors and verified by the senior author. Data were archived in an Excel (Microsoft Corp, Seattle, Wash.) spreadsheet. Variables collected included patient demographics (age, sex), percentage total body surface area, reconstructive timing, follow-up, number of free flaps, complications (total and partial flap loss, contracture recurrence), and area of the body requiring a free flap reconstruction.

Risk of Bias and Study Quality Assessment

The methodological quality of included studies was assessed independently by two separate authors. Because no randomized controlled trials were included, the Methodological Index for Nonrandomized Studies (MINORS) criteria were used to measure study quality.[18] Funnel plots were created using the effect size for the reported outcomes to identify potential publication bias.

Data Synthesis and Statistical Analysis

Data from the included studies were summarized using descriptive statistics. Dichotomous variables were reported as frequencies and percentages, whereas continuous variables were reported as a mean with a 95% confidence interval (CI) calculated using the method described by McGrath et al.[19]

A single-arm meta-analysis of proportions was performed for all outcomes on the entire cohort using a logistic regression model. The maximum-likelihood estimator was used to estimate the between-study variance (τ^2). Results are presented as pooled estimates with a 95% CI. A forest plot graph was created for each outcome. Cochran's Q method was used to assess between-study heterogeneity.[20] I^2 was calculated as a measure of heterogeneity.[21] An I^2 value represents the percentage of total variation across studies caused by heterogeneity rather than by chance. If the I^2 was greater than 50% or if the heterogeneity test produced a low probability value (Q-statistic, $P < 0.05$), a more conservative random effects model was used. If not, a fixed effects model was used.

Analysis of publication bias was performed by inspection of the funnel plot[22] and calculating the Peters linear regression test, which statistically examines the asymmetry of the funnel plot.

All the analyses were performed using the R software for statistical computing (R version 4.0.1; "meta" package).

RESULTS

Electronic Database Search Results

A total of 1262 eligible articles were retrieved from the preliminary search. After the removal of duplicates and screening of both titles and abstracts, 199 full-text articles were assessed for eligibility. After applying inclusion and exclusion criteria, 40 articles were included in the qualitative and quantitative synthesis.[23–62] A flow chart of the study inclusion process and the reasons justifying the exclusion of the studies are shown in Figure 1.

General Features of the Included Studies

The included studies comprised a total of 1026 free flaps performed for delayed burn reconstruction in 928 patients (50.3% men, 49.7% women). The patients' mean age was 29.3 years [95% CI, 24.63–33.88]. The median percentage total body surface area was 30.1%. The mean follow-up period was 23.02 months [95% CI, 4.46–41.58]. Mean time from initial acute burn injury was 94.7 months [95% CI, − 9.34 to 198.70]. The studies' general characteristics are presented in Table 1.

Risk of Bias Assessment

In the 40 included studies, scores ranged from 7 to 14, with a median of 11. The major deficiencies were lack of prospective collection of data and study size, and lack of clearly stated follow-up. All studies showed a clearly stated aim, appropriate endpoints, and unbiased assessment of endpoints. MINORS scores for the included studies are listed in Supplemental Digital Content 1. **(See figure, Supplemental Digital Content 1,** which displays MINORS scores of the included studies. **http://links.lww.com/PRSGO/D397**.)

Overall Free Flap Loss

The meta-analysis of proportions including all delayed free flap burn reconstructions showed a pooled prevalence of 3.80% [95% CI, 2.79–5.16] for TFL, as shown in the forest plot in Figure 2. Small between-study heterogeneity ($Q = 5.10$, $P = 1.00$) was measured ($I^2 = 0\%$ and $\tau^2 = 0.44$); hence, a fixed-effect model was used. Peters linear regression test and visual inspection of the funnel plot showed a symmetric distribution of the points for TFL ($t = 1.44$, $P = 0.16$), suggesting no obvious publication bias. (**See figure, Supplemental Digital Content 2,** which displays a funnel plot of overall TFL following delayed free flap burn reconstruction. **http://links.lww.com/PRSGO/D398**.)

The pooled prevalence for PFL in delayed free flap burn reconstruction was 5.95% [95% CI, 4.65–7.57], as shown in the forest plot in Figure 3. Small between-study heterogeneity ($Q = 18.27$, $P = 1.00$) was measured ($I^2 = 0\%$ and $\tau^2 = 2.04$); hence, a fixed-effect model was used. Peters linear regression test and visual inspection of the funnel plot showed a symmetric distribution of the points for PFL ($t = 0.28$, $P = 0.7843$), suggesting no obvious publication bias. (**See figure, Supplemental Digital Content 3**, which displays a funnel plot of overall PFL following delayed free flap burn reconstruction. **http://links.lww.com/PRSGO/D399**.)

Free Flap Loss by Anatomical Region

Among the 1026 free flaps included, the body area involved was extractable for 903 flaps. Of these, 727 (80.5%) were performed on the head and neck, 107 (11.8%) on the upper extremity, and 69 (7.6%) on the lower extremity. The number of free flaps and flap losses by anatomical region are presented in Table 2. There were not enough studies comparing the free flap loss rate among different body areas to perform a meta-analysis and evaluate potential differences in terms of free flap failure rates.

Contracture Recurrence

Of the 40 articles that qualified for inclusion in analysis of TFL and PFL, 18 articles included data on contracture recurrence following a total of 484 delayed free flap reconstructions. The meta-analysis of proportions including delayed free flap burn reconstructions showed a pooled prevalence of 0.62% [95% CI, 0.20–1.90] for contracture recurrence, as shown in the forest plot in Figure 4. Small between-study heterogeneity ($Q = 0.19$, $P = 1.00$) was measured ($I^2 = 0\%$ and $\tau 2 = 6.54$); hence, a fixed-effect model was used. Peters linear regression test was unable to calculate any publication bias (t = NA, p = NA). (**See figure, Supplemental Digital Content 4,** which displays a funnel plot of contracture recurrence following delayed free flap burn reconstruction. **http://links.lww.com/PRSGO/D400**.)

DISCUSSION

Scar contractures result from excessive scarring and evolving contraction, which is a commonly observed complication following burns.[63,64] These contractures can limit the range of motion of joints, thus affecting the ability to perform everyday activities, impacting patients' physical well-being and overall quality of life.[65]

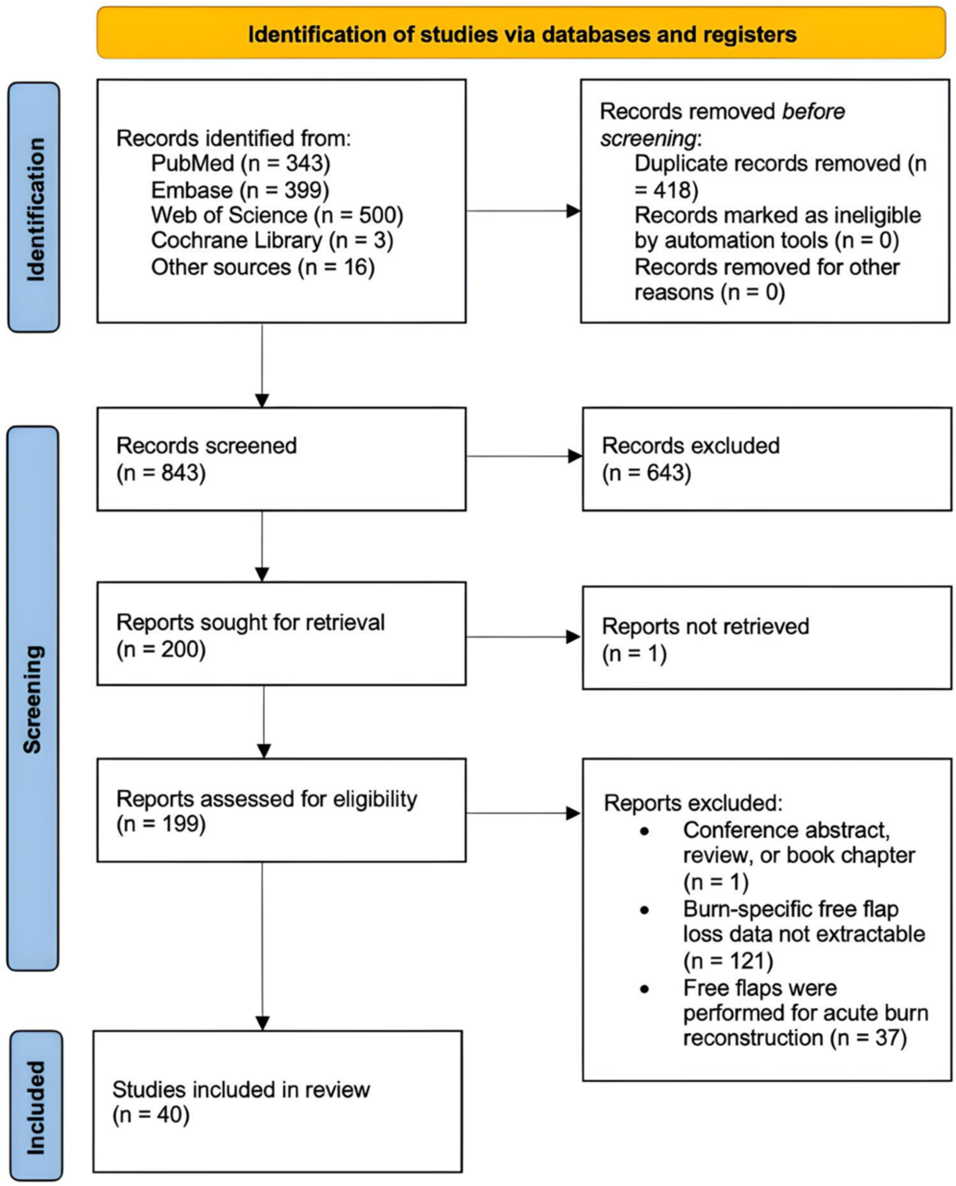

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram.

Additionally, there is a potential risk of developing secondary conditions, as adjacent or unaffected joints may be overused to compensate for the restricted movement. In this context, free tissue transfer is typically reserved for severe cases where more simple reconstructive techniques such as skin grafting or two-stage reconstructions using skin substitutes are not indicated. One reason for the limited utilization of free flaps in burn patients is the relatively limited evidence on outcomes, safety, and failure rate, which has been reported to vary between 0% and 14% across studies. Thus, the purpose of this systematic review was to summarize the existing literature and determine the rate of free flap loss following delayed burn reconstruction. Additionally, we investigated contracture recurrence as a secondary outcome, considering it to be one of the most important complications in delayed burn reconstruction.

The overall rate of TFL was found to be 3.80%, whereas the rate of PFL was 5.95%. These are relatively low rates, comparable to free flap loss rates in other populations such as oncological patients, and lower than the rate of flap loss in acute burn patients.[66–68] Furthermore, we assessed the rate of contracture recurrence after delayed free flap burn reconstruction and found it to be only 0.62%, which was extremely low. All three contracture recurrences after free flap reconstruction reported in literature occurred in the hand. A possible explanation is the incomplete release of the underlying ligamentous and tendinous structures under the skin contractures leading to a persistent contracture and functional limitation.

Table 1. General Characteristics of the Included Studies

Authors	Year of Publication	No. of Patients	Males	Females	Mean Age (y)	Mean TBSA (%)	Mean Time from Injury (Mo)	Mean Follow-up (Mo)	No. Free Flaps	No. TFL	No. PFL	No. Contracture Recurrences
Adant et al[23]	1998	5	2	3	35.4	33.0	NS	72.0	5	0	0	0
Angrigiani[24]	1994	86	24	62	28.3	NS	NS	NS	74	4	0	0
Angrigiani et al[26]	2017	150	56	94	27.3	NS	14.2	NS	150	9	22	NS
Angrigiani et al[25]	2022	25	10	15	33.0	NS	79.0	84.0	31	2	1	NS
Bali et al[27]	2021	14	12	2	36.6	NS	NS	22.0	15	0	1	1
Baumeister et al[28]	2005	NS	NS	NS	NS	NS	NS	NS	32	0	0	NS
Brewin et al[29]	2020	32	14	18	34.8	19.8	254	NS	39	1	0	NS
Burd et al[30]	2006	19	10	9	7.8	NS	NS	NS	27	2	1	ON
Chang et al[31]	2021	25	12	13	38.1	NS	18.0	17.2	29	0	4	0
NSChen et al[32]	2017	10	8	2	46.2	48.1	7.7	27.1	10	0	0	NS
De Lorenzi et al[33]	2001	39	28	11	30.4	NS	NS	NS	53	3	4	0
Feng et al[34]	2010	8	6	2	34.9	30.1	4.5	16.5	9	0	1	0
Ghosh et al[35]	2010	5	NS	NS	7.4	NS	NS	29.0	5	0	0	0
Heidekrueger et al[36]	2016	13	4	9	28.3	NS	NS	36.0	14	1	3	NS
Hur et al[37]	2013	15	14	1	34.5	46.6	54.0	45.0	15	0	1	0
Kalra et al[39]	2017	15	NS	NS	NS	NS	NS	12.0	15	0	0	ON
Kalra et al[38]	2022	52	20	32	NS	NS	NS	NS	52	0	2	ON
Karami et al[40]	2020	6	5	1	11.0	NS	NS	NS	6	0	0	NS
Lee et al[41]	2006	7	6	1	35.0	NS	NS	26.8	7	0	0	NS
Lee et al[42]	2016	8	3	5	47.1	NS	343.2	10.0	7	0	0	NS
Mardini et al[43]	2004	7	NS	NS	NS	NS	NS	NS	14	0	3	0
Monga et al[44]	2021	14	NS	NS	NS	NS	NS	NS	14	2	0	NS
Moroz et al[45]	2001	63	45	18	NS	NS	NS	NS	63	7	0	0
Mun et al[46]	2007	12	4	8	32.8	NS	NS	18.1	12	0	2	0
Ninkovic et al[47]	2004	8	3	5	29.3	NS	NS	48.0	8	0	0	0
Ohkubo et al[48]	1991	99	43	56	24.0	NS	NS	104.4	99	5	0	0
Parrett et al[49]	2007	32	21	11	31.0	NS	NS	12.0	36	2	6	ON
Sarkar et al[50]	2014	11	4	7	31.5	NS	12.3	66	11	0	2	NS
Sauerbier et al[51]	2007	NS	NS	NS	NS	NS	NS	NS	21	0	0	NS
Song et al[52]	2015	12	5	7	20.4	NS	NS	12	12	0	0	NS
Tsai et al[53]	2004	7	6	1	34.9	NS	NS	9.0	7	0	0	NS
Tsai et al[54]	2006	40	33	7	41.1	29.8	19.2	11.0	40	0	0	0
Ulkur et al[55]	2006	7	NS	NS	21.6	NS	159.4	7.4	7	0	0	0
Vinh et al[56]	2015	17	12	5	26.9	NS	NS	NS	17	0	2	0
Woo et al[57]	2001	15	12	3	24.5	NS	NS	16.0	18	0	0	2
Xu et al[58]	1995	11	3	8	21.9	NS	NS	NS	11	0	0	NS
Yang et al[59]	2002	7	3	4	32.7	NS	NS	7.7	7	0	1	NS
Yen et al[60]	2018	6	2	4	25.2	25.5	100.0	59.0	7	0	1	ON
Yucel et al[61]	2000	6	3	3	19.0	NS	NS	37.2	7	0	0	ON
Zhang et al[62]	2010	20	NS	NS	25.0	NS	96.0	NS	20	0	0	0

TBSA, total body surface area; NS, not specified; NA, not applicable.

Study	Events	Total	Events per 100 observations GLMM, Fixed, 95% CI
Adant et al.	0	5	0.00 [0.00; 52.18]
Angrigiani	4	74	5.41 [1.49; 13.27]
Angrigiani et al.	9	150	6.00 [2.78; 11.08]
Angrigiani et al.	2	31	6.45 [0.79; 21.42]
Bali et al.	0	15	0.00 [0.00; 21.80]
Baumeister et al.	0	32	0.00 [0.00; 10.89]
Brewin et al.	1	39	2.56 [0.06; 13.48]
Burd et al.	2	27	7.41 [0.91; 24.29]
Chang et al.	0	29	0.00 [0.00; 11.94]
Chen et al.	0	10	0.00 [0.00; 30.85]
De Lorenzi et al.	3	53	5.66 [1.18; 15.66]
Feng et al.	0	9	0.00 [0.00; 33.63]
Ghosh et al.	0	5	0.00 [0.00; 52.18]
Heidekrueger et al.	1	14	7.14 [0.18; 33.87]
Hur et al.	0	15	0.00 [0.00; 21.80]
Kalra et al.	0	15	0.00 [0.00; 21.80]
Kalra et al.	0	52	0.00 [0.00; 6.85]
Karami et al.	0	6	0.00 [0.00; 45.93]
Lee et al.	0	7	0.00 [0.00; 40.96]
Lee et al.	0	7	0.00 [0.00; 40.96]
Mardini et al.	0	14	0.00 [0.00; 23.16]
Monga et al.	2	14	14.29 [1.78; 42.81]
Moroz et al.	7	63	11.11 [4.59; 21.56]
Mun et al.	0	12	0.00 [0.00; 26.46]
Ninkovic et al.	0	8	0.00 [0.00; 36.94]
Ohkubo et al.	5	99	5.05 [1.66; 11.39]
Parrett et al.	3	36	8.33 [1.75; 22.47]
Sarkar et al.	0	11	0.00 [0.00; 28.49]
Sauerbier et la.	0	21	0.00 [0.00; 16.11]
Song et al.	0	12	0.00 [0.00; 26.46]
Tsai et al.	0	7	0.00 [0.00; 40.96]
Tsai et al.	0	40	0.00 [0.00; 8.81]
Ulkur et al.	0	7	0.00 [0.00; 40.96]
Vinh et al.	0	17	0.00 [0.00; 19.51]
Woo et al.	0	18	0.00 [0.00; 18.53]
Xu et al.	0	11	0.00 [0.00; 28.49]
Yang et al.	0	7	0.00 [0.00; 40.96]
Yen et al.	0	7	0.00 [0.00; 40.96]
Yucel et al.	0	7	0.00 [0.00; 40.96]
Zhang et al.	0	20	0.00 [0.00; 16.84]
Total (95% CI)		**1026**	**3.80 [2.79; 5.16]**
Prediction interval			**[0.58; 11.24]**

Heterogeneity: $Tau^2 = 0.4393$; $Chi^2 = 5.10$, df = 39 (P = 1.00); $I^2 = 0\%$

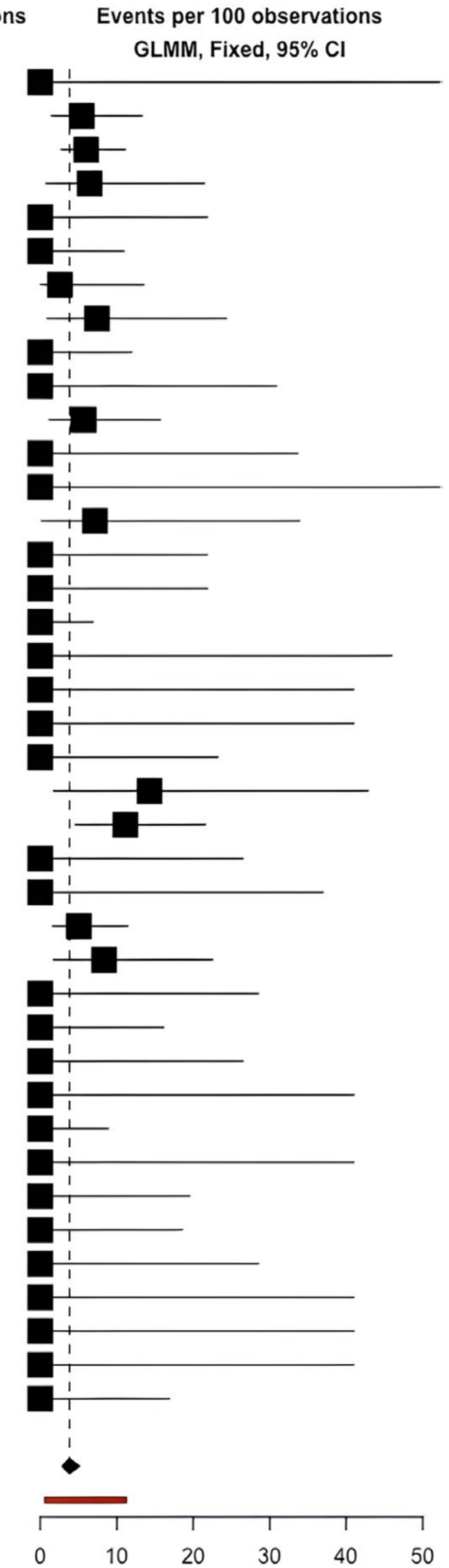

Fig. 2. Forest plot of TFL following delayed burn reconstruction.

In the senior authors' experience, to treat scar contractures effectively, the entire scar needs to be released and often excised, the contracted tissue including the margins of the scar removed, and all tension in the tissue completely released. Free flaps allow for coverage of extensive resections, especially when large areas are involved in the

Study	Events	Total	Events per 100 observations GLMM, Fixed, 95% CI
Adant et al.	0	5	0.00 [0.00; 52.18]
Angrigiani	0	74	0.00 [0.00; 4.86]
Angrigiani et al.	22	150	14.67 [9.43; 21.36]
Angrigiani et al.	1	31	3.23 [0.08; 16.70]
Bali et al.	1	15	6.67 [0.17; 31.95]
Baumeister et al.	0	32	0.00 [0.00; 10.89]
Brewin et al.	0	39	0.00 [0.00; 9.03]
Burd et al.	1	27	3.70 [0.09; 18.97]
Chang et al.	4	29	13.79 [3.89; 31.66]
Chen et al.	0	10	0.00 [0.00; 30.85]
De Lorenzi et al.	4	53	7.55 [2.09; 18.21]
Feng et al.	1	9	11.11 [0.28; 48.25]
Ghosh et al.	0	5	0.00 [0.00; 52.18]
Heidekrueger et al.	3	14	21.43 [4.66; 50.80]
Hur et al.	1	15	6.67 [0.17; 31.95]
Kalra et al.	0	15	0.00 [0.00; 21.80]
Kalra et al.	2	52	3.85 [0.47; 13.21]
Karami et al.	0	6	0.00 [0.00; 45.93]
Lee et al.	0	7	0.00 [0.00; 40.96]
Lee et al.	0	7	0.00 [0.00; 40.96]
Mardini et al.	3	14	21.43 [4.66; 50.80]
Monga et al.	0	14	0.00 [0.00; 23.16]
Moroz et al.	0	63	0.00 [0.00; 5.69]
Mun et al.	2	12	16.67 [2.09; 48.41]
Ninkovic et al.	0	8	0.00 [0.00; 36.94]
Ohkubo et al.	0	99	0.00 [0.00; 3.66]
Parrett et al.	10	36	27.78 [14.20; 45.19]
Sarkar et al.	2	11	18.18 [2.28; 51.78]
Sauerbier et la.	0	21	0.00 [0.00; 16.11]
Song et al.	0	12	0.00 [0.00; 26.46]
Tsai et al.	0	7	0.00 [0.00; 40.96]
Tsai et al.	0	40	0.00 [0.00; 8.81]
Ulkur et al.	0	7	0.00 [0.00; 40.96]
Vinh et al.	2	17	11.76 [1.46; 36.44]
Woo et al.	0	18	0.00 [0.00; 18.53]
Xu et al.	0	11	0.00 [0.00; 28.49]
Yang et al.	1	7	14.29 [0.36; 57.87]
Yen et al.	1	7	14.29 [0.36; 57.87]
Yucel et al.	0	7	0.00 [0.00; 40.96]
Zhang et al.	0	20	0.00 [0.00; 16.84]
Total (95% CI)		**1026**	**5.95 [4.65; 7.57]**
Prediction interval			**[0.13; 35.24]**

Heterogeneity: $Tau^2 = 2.0370$; $Chi^2 = 18.27$, df = 39 (P = 1.00); $I^2 = 0\%$

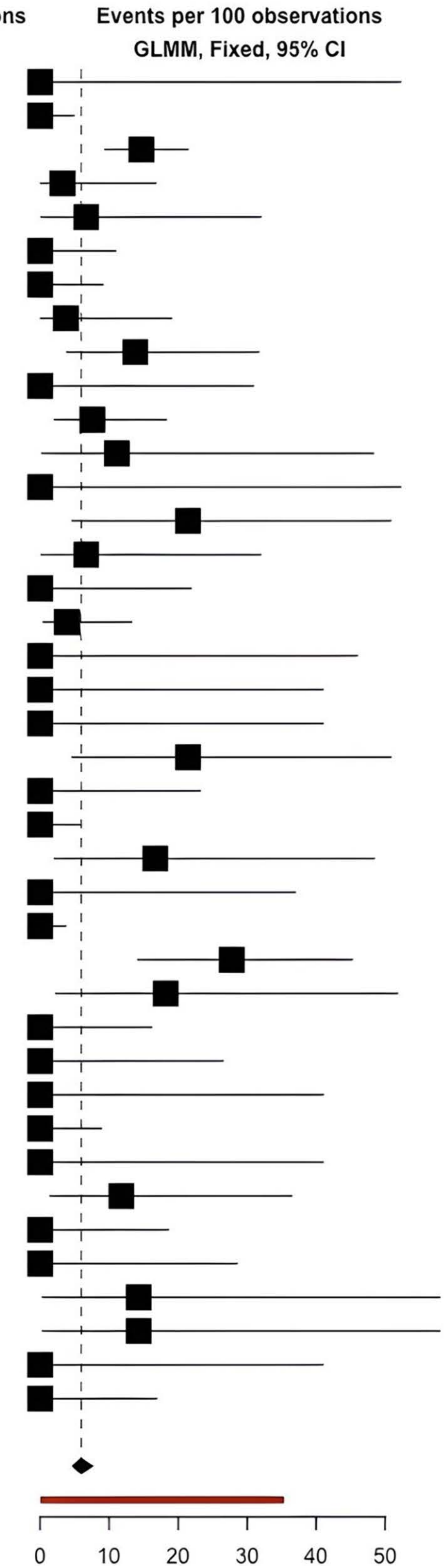

Fig. 3. Forest plot of PFL following delayed burn reconstruction.

Table 2. Total No. Free Flaps and Flap Losses by Anatomical Region

Anatomical Region	No. Free Flaps	No. TFL (TFL %)	No. PFL (PFL %)
Head and neck	727	30 (4.1)	40 (5.5)
Upper extremity	107	0 (0)	7 (6.5)
Lower extremity	69	2 (2.9)	3 (4.3)

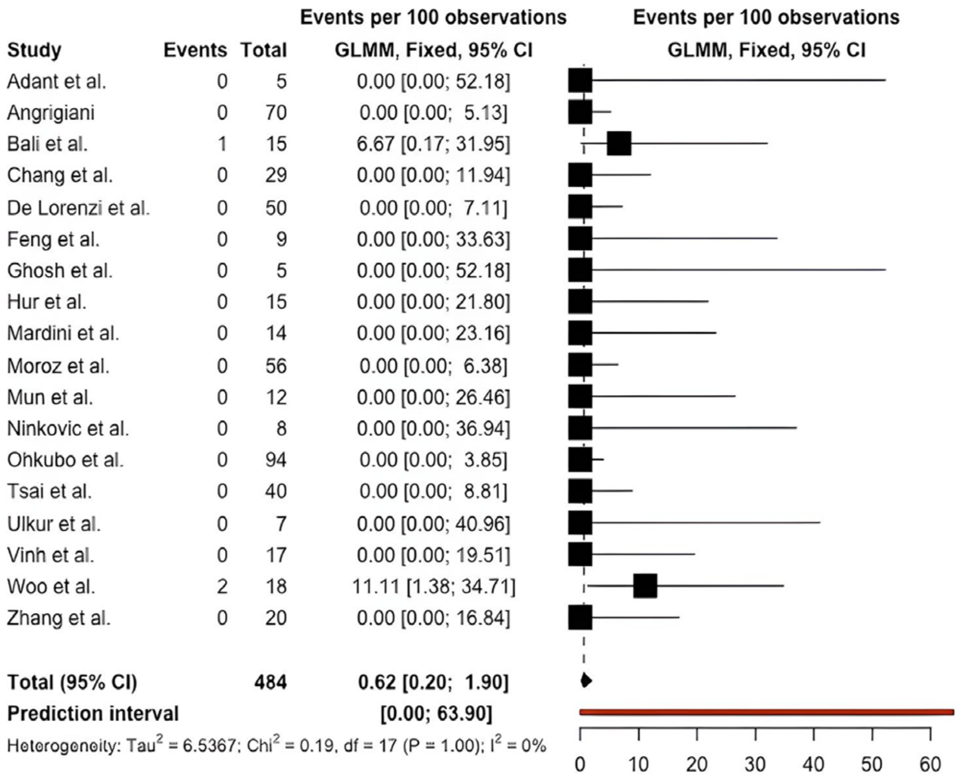

Fig. 4. Forest plot of contracture recurrence following delayed burn reconstruction.

contracture. Thus, free flaps are an appropriate reconstructive option.[14]

Because this review exclusively focused on free flaps without comparing them with alternative reconstructive approaches, we cannot assert their inherent superiority. However, this result should instigate further research to determine whether free tissue transfer should be considered as a first line option for severe contractures given the reported optimal outcomes. Stekelenburg et al previously attempted to make comparisons by conducting a systematic review on different burn scar contracture treatments.[64] However, their study was limited by the scarcity and low quality of the included studies, preventing definitive conclusions about treatment effectiveness and practical implications. Several factors contributed to these limitations, such as the use of subjective outcome measures whose heterogeneity hindered the possibility of performing a meta-analysis. Additionally, the exclusion of studies focusing on postoperative complications significantly restricted the number of articles on free flap burn reconstruction that could be included. Notably, our study incorporated two articles[54,57] that were part of Stekelenburg et al's review, although several studies published in the past 8 years were not covered by Stekelenburg et al.

This study has several limitations, such as the inclusion of mostly retrospective and underpowered studies; unfortunately, free tissue transfer is not commonly used, and thus, the sample size in each study reflects this limitation. Moreover, the lack of standardized criteria and indications for free flap reconstruction introduces variation in case severity, which may contribute to the wide range of reported flap loss rates in individual studies. Furthermore, the literature currently lacks sufficient evidence on predictive factors associated with unfavorable outcomes in free flap reconstruction in burns, due to limited data availability of variables such as burn etiology, pathophysiology, area of injury, and type of microanastamosis. Although electrical injuries have been linked to worse outcomes in acute burns compared with nonelectrical injuries, it remains unclear if this association extends to delayed burn reconstruction due to the limited extractability of burn etiology data from the included studies. Similarly, the lack of comparative studies on anatomical areas affected by burns prevents drawing conclusions about the influence of injury location on outcomes. Also, we observed a lack of a standardized way to evaluate outcomes of scar contracture release and recurrence.

We urge researchers to utilize the findings of this review and consider its implications for future investigations. It is crucial to design comparative studies with adequate sample size to differentiate treatment effects from the natural clinical course and other surgical techniques. Reliable and valid measurement techniques should be used to ensure comparability across studies. The incidence of burn scar contracture recurrence is often underestimated by reconstructive surgeons, but research initiatives focusing on this challenging, yet meaningful problem, should be encouraged.

CONCLUSIONS

Free flaps represent a viable option for releasing contractures and improving scar resurfacing in burn patients. The pooled estimates for complete flap loss and partial flap loss were found to be low, and the rate of contracture recurrence was extremely low. However, due to heterogeneity among studies and potential publication bias, caution should be exercised when interpreting the findings. Further research and well-designed studies are warranted to enhance the current understanding of outcomes and optimize patient care in this complex procedure.

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DISCLOSURE

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