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Breast

Unilateral Versus Bilateral Deep Inferior Epigastric Perforator Flap Breast Reconstruction: A Systematic Review and Meta-analysis

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Background: Previous studies have shown a higher complication rate in bilateral (BL) compared to unilateral (UL) deep inferior epigastric perforator (DIEP) flap breast reconstructions. This systematic review and meta-analysis aimed to offer an update by including recent studies to thoroughly assess the complication rates in UL versus BL DIEP flap reconstructions and provide clear guidance for clinicians and their patients.

Methods: A systematic review of the literature and comparative meta-analysis were performed to assess the differences in complication rates between UL and BL procedures. Only comparative studies that reported on postoperative complications after UL and BL DIEP flap breast reconstructions were included. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using a random-effects model.

Results: Five studies representing 5120 patients who underwent either UL or BL DIEP flap breast reconstructions were included. BL DIEP flap reconstructions were associated with a higher risk of total flap loss, with an OR of 1.48 (95% CI, 1.02–2.14) and a *P* value of 0.04. Conversely, the risk of reexploration surgery was reduced, with an OR of 0.68 (95% CI, 0.55– 0.84) and a *P* value of 0.0002.

Conclusions: BL DIEP flap breast reconstruction carries a higher risk of complete flap loss compared with UL reconstructions, with a moderate risk increase. Despite this increased risk, the significant benefits of BL reconstruction make it a viable and recommended option for women requiring this type of surgery. *(Plast Reconstr Surg Glob Open 2024; 12:e6359; doi: 10.1097/GOX.0000000000006359; Published online 5 December 2024.)*

INTRODUCTION

Over the past few decades, the increase in prophylactic mastectomies has been largely driven by advancements in genetic testing, particularly BRCA genotyping, which has improved the identification of high-risk women, thereby encouraging more patients to opt for preventative interventions.[1–3] Consequently, the increase in prophylactic mastectomies logically led to a rise in bilateral (BL) breast reconstructions, as patients seek to restore their physical integrity after surgery. This trend reflects the growing demand for reconstruction solutions that combine both functionality and aesthetics.

Previous research indicates that, compared with implant-based reconstructions, autologous flap breast reconstructions provide better long-term aesthetic results, higher patient satisfaction, and improved quality of life.[4–9] Among the autologous tissue options for breast reconstruction, the deep inferior epigastric perforator (DIEP) flap is the gold standard approach due to its numerous benefits: reduced donor site morbidity, shorter hospital stays, less postoperative pain, and superior cosmetic outcomes.[10–18]

To date, comparisons between postoperative complications after unilateral (UL) and BL DIEP breast reconstructions have been sparingly addressed in the literature. A significant meta-analysis by Wormald et al,[19] published in 2014, indicated that BL reconstructions were associated with an increased risk of complications compared with UL reconstructions. However, this analysis was based on a limited number of studies. Since its publication, new comparative

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research has been conducted, thus enriching the existing data. Our meta-analysis aimed to include these recent comparative studies to provide a more comprehensive evaluation that could better guide physicians and their patients in selecting the most appropriate reconstruction technique.

Takeaways

Question: Are the outcomes following unilateral (UL) and bilateral (BL) deep inferior epigastric perforator (DIEP) flap breast reconstructions comparable?

Findings: A systematic review and meta-analysis of recent comparative studies on postoperative complications following UL and BL DIEP flap showed that BL DIEP flap reconstructions were associated with a moderately higher risk of total flap loss. Conversely, the risk of requiring reexploration surgery was lower in BL reconstructions.

Meaning: Despite this moderately increased risk, the significant benefits of BL reconstruction make it a viable and recommended option for women requiring this type of surgery.

METHODS

A systematic review of PubMed, Embase, Cochrane Library, and Web of Science was conducted on May 15, 2024, in accordance with PRISMA guidelines.[20] The study protocol was prospectively registered on PROSPERO (registration ID: 536191). A combination of keywords and synonyms of "deep inferior epigastric perforator flap," "unilateral," and "bilateral," linked with Boolean operators was used to develop a search strategy (Table 1).

Article Selection

Inclusion and exclusion criteria were defined based on the population, intervention, comparator, outcome, and study design (PICOS) principles before starting the review process (Table 2). This systematic review and meta-analysis included retrospective and prospective comparative studies published between 2014 and 2024, focusing on adult female patients who underwent UL or BL DIEP flap reconstructions after mastectomy. Studies evaluating other types of breast reconstructions, such as transverse rectus abdominis myocutaneous (TRAM) flap reconstructions, latissimus dorsi flaps, or implant-based reconstructions, were excluded. The primary outcome was the complete flap loss rate, a key indicator for assessing the safety of the procedures. Studies that did not report the primary outcome were excluded. Case reports, systematic reviews, meta-analyses, letters, and conference abstracts were excluded. No language restrictions were applied.

Articles obtained from the search query were processed using Rayyan (https://www.rayyan.ai/, accessed in May 2024) to enable independent and blind screening by 2 authors (B.T. and J.M.).[21] Initially, articles were screened by title and abstract, and in cases of divergent opinions, the senior author (C.M.O.) was consulted to resolve the discrepancies. Selected articles were then fully read, and those that met the inclusion criteria were added to a standardized spreadsheet file.

Data Extraction and Outcomes Definition

Data on study characteristics and clinical outcomes were gathered independently by 2 authors (B.T. and J.M.) and compiled into an Excel spreadsheet (version 16.30; Microsoft Corp, Redmond, WA). The results were subsequently cross-referenced to detect any discrepancies in reporting. Data compilation included demographic information, primary outcomes, and secondary outcomes—the main outcome being the complete flap loss rate, whereas secondary outcomes were overall complications, partial flap loss, infection, hematoma, seroma, fat necrosis, donor

Table 1. Search Strategy

Database	Search Strategy	No. Articles
PubMed	((“DIEP flap”[All Fields] OR “deep inferior epigastric perforator flap”[All Fields] OR “DIEP”[All Fields]) AND (“unilateral”[All Fields] OR “single”[All Fields]) AND (“bilateral”[All Fields] OR “double”[All Fields])) AND ((“2014/01/01”[Date - Publication]: “3000”[Date - Publication]))	144
Embase/Medline/Preprints	(“deep inferior epigastric perforator flap”:ab,ti OR “diep”:ab,ti) AND (“unilateral”:ab,ti OR “single”:ab,ti) AND (“bilateral”:ab,ti OR “double”:ab,ti) AND [2014-2024]/py	155
Cochrane Library	(“DIEP flap” OR “deep inferior epigastric perforator flap” OR DIEP):ti,ab,kw AND (unilateral OR single):ti,ab,kw AND (bilateral OR double):ti,ab,kw Search limits: Publication Year from 2014 to present	12
Web of Science	(AB=(“DIEP flap” OR “deep inferior epigastric perforator flap” OR DIEP)) AND (AB=(unilateral OR single)) AND (AB=(bilateral OR double)) AND DOP=(2014-01-01/2024-12-31)	108

Table 2. Selection Criterion

PICOS	Inclusion	Exclusion
Population	Adult female patients with unilateral or bilateral mastectomy	Cadaver, animal
Intervention	Unilateral and bilateral DIEP flap	Other types of flap reconstructions such as TRAM flaps, latissimus dorsi flaps, or implant-based reconstructions
Comparator	Unilateral DIEP flap compared with bilateral DIEP flap	
Outcomes	Primary outcome is a complete flap loss rate	Studies that do not report the primary outcome
Studies	Prospective, retrospective, comparative studies	Case reports, case series, abstracts only, letters, reviews, comments

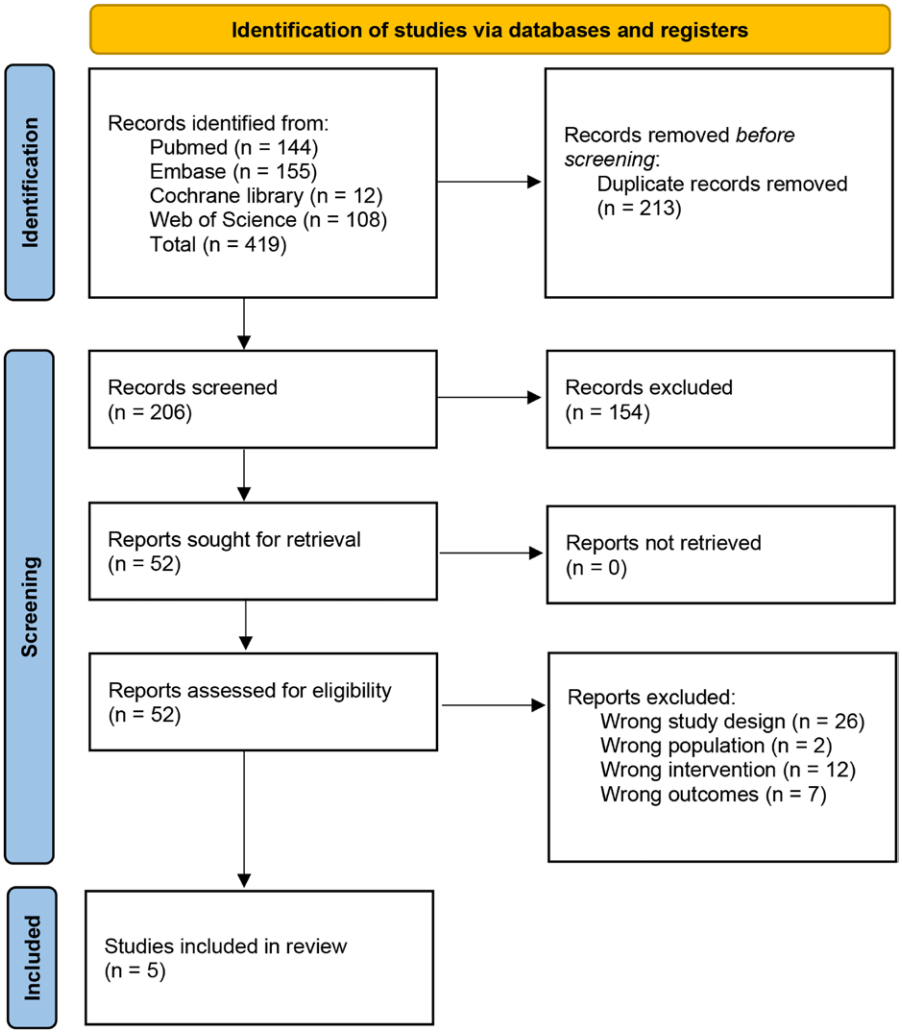

Fig. 1. PRISMA flowchart.

site morbidity, dehiscence, and reoperation rate. To be eligible for inclusion in the meta-analysis, a complication had to be reported in at least 3 articles. Complications associated with the flap and recipient site were recorded on a per-breast basis, whereas abdominal complications were recorded per patient.

Statistical Analysis

Data were analyzed for a comparative meta-analysis using Review Manager 5.4.1 software (The Cochrane Collaboration, The Nordic Cochrane Center, Copenhagen, Denmark). The Mantel–Haenszel method, a random-effects model, was used to calculate the pooled odds ratios (ORs) between UL and BL DIEP flap reconstructions. Heterogeneity among studies was assessed using the I^2 statistic and the Q statistic P value. An I^2 value below 30% was considered indicative of low heterogeneity, whereas values above 70% were deemed to represent significant heterogeneity.[22] Comparative outcomes are presented in forest plots illustrating the ORs and their respective 95% confidence intervals (CIs). All statistical tests were 2-sided, and statistical significance was defined as a P value less than 0.05.

RESULTS

A total of 419 studies were identified through the initial database search (Fig. 1). After removing duplicates and screening titles and abstracts, 52 articles were thoroughly read, resulting in 5 studies that met all inclusion criteria.[23–27]

A total of 5120 patients were included in the analyzed studies, with 4172 undergoing UL DIEP flap procedures and 947 undergoing BL procedures. The mean age of patients ranged from 49.7 to 56.7 years for those undergoing UL procedures, and from 48.1 to 51.7 years for BL procedures. The average body mass index was spanned from 25.8 to 27.8 kg/m^2 for UL procedures and 26.0 to 27.4 kg/m^2 for BL procedures (Table 3). All included studies were monocentric and retrospective in nature, with the exception of those conducted by Moellhoff et al[26] and Wade et al.[27] Furthermore, the studies by Beugels et al[23] and Moellhoff et al[26] were multicentric.

The average operative times for UL reconstructions ranged from 285 to 503 minutes, whereas those for BL reconstructions were from 399 to 715 minutes. The

Table 3. Clinical Characteristics of the Included Studies

Author	Year	Study Period	Study Design	Patients (n)	Unilateral Reconstruction (n)	Bilateral Reconstruction (n)	Mean Age Unilateral Reconstruction (SD/Range)	Mean Age Bilateral Reconstruction (SD/Range)	Mean BMI Unilateral Reconstruction (SD/Range)	Mean BMI Bilateral Reconstruction (SD/Range)	Median Follow-up, Month (IQR)
Beugels et al[23]	2016	2010–2014	Retrospective multicentric	426	322	104	51.0 (8.0)	47.5 (9.0)	26.8 (3.8)	27.4 (3.8)	11 (5–18)
Bodin et al[24]	2015	2008–2013	Retrospective monocentric	122	110	11	49.7 (27–67)	48.1 (41–60)	25.8 (19.5–33.6)	26.01 (22.8–28.6)	***
Laurent et al[25]	2023	2010–2013	Retrospective monocentric	178	157	21	53.9 (36–73)	50.5 (45–59)	27.80	27.30	***
Moellhoff et al[26]	2021	***	Prospective multicentric	3926	3212	714	53.0 (36.8)	47.3 (11.2)	25.9 (4.3)	27.2 (4.6)	3
Wade et al[27]	2017	2009–2014	Prospective monocentric	468	371	97	56.7 (9.3)	51.7 (9.1)	26.4 (3.0)	27.1 (3.46)	***

***Data not reported in the study.
BMI, body mass index; IQR, interquartile range.

average ischemic times for UL procedures varied from 31.0 to 76.1 minutes, compared with 30.0 to 67.6 minutes in BL procedures. The average duration of hospital stay fluctuated between 6 and 8.8 days for UL procedures and from 6.6 to 7.6 days for BL procedures (Table 4).

The results from the random-effects model indicated that BL DIEP flap reconstructions were associated with a higher risk of total flap loss, with an OR of 1.48 [95% CI, 1.02–2.14] and a *P* value of 0.04 (Fig. 2). Conversely, reexploration rates were lower in BL reconstructions, with an OR of 0.68 [95% CI, 0.55–0.84] and a *P* value of 0.0002, suggesting a reduced likelihood of needing revision surgery after initial procedure (Fig. 3).

Our meta-analysis showed no statistical difference across groups in terms of partial flap loss (OR, 0.68 [95% CI, 0.42–1.10]; $P = 0.11$), venous congestion (OR, 0.94 [95% CI, 0.67–1.34]; $P = 0.74$), recipient site infections (OR, 0.89 [95% CI, 0.24–3.30]; $P = 0.86$), recipient site hematomas (OR, 0.69 [95% CI, 0.42–1.14]; $P = 0.15$), donor site herniation (OR, 1.98 [95% CI, 0.56–7.02]; $P = 0.29$), and donor site infections (OR, 1.60 [95% CI, 0.65–3.97]; $P = 0.31$).

DISCUSSION

Breast reconstruction using the DIEP flap is widely recognized today as the method of choice for postmastectomy reconstructive surgery. This approach is highly valued for its high patient satisfaction rates and safety. Although the complications associated with this method are well documented, knowledge of differences in complications after UL or BL reconstructions remains insufficient.

To our knowledge, until the completion of this study, no meta-analysis had exclusively grouped and analyzed comparative studies between UL and BL DIEP breast reconstructions. The meta-analysis conducted by Wormald et al[19] partially addressed this issue. Their analysis, which included 17 studies representing a total of 2398 patients, revealed that BL reconstructions were associated with a significantly higher risk of total flap loss (relative risk [RR], 3.31 [95% CI, 1.50–7.28]; $P = 0.003$), indicating a 3-fold increase in risk of this adverse outcome after BL DIEP flap breast reconstruction.[19] However, the authors point out that total flap loss is relatively rare, occurring in 2.2%–3.4% of cases, and was considered in only 4 heterogeneous studies of 762 patients. Therefore, a cautious interpretation of their results is essential. Moreover, the pooled analysis included studies with relatively small sample sizes that were likely insufficient to reliably detect rare events such as total flap loss. Among the studies included, some were not comparative and only comprised cases of UL or BL DIEP reconstruction.

Our meta-analysis demonstrates, similar to the findings of Wormald et al,[19] that BL reconstructions are associated with more total flap loss than UL reconstructions. However, our study shows a less significant increase in risk. The results from our random-effects model analysis show that BL reconstructions were associated with a higher risk of total flap loss, with an OR of 1.48 (95% CI, 1.02–2.14) and a *P* value of 0.04. This indicates an increased but relatively moderate risk compared with the 3-fold increase

Table 4. Operative and Postoperative Characteristics of the Included Studies

Author	Variable	Unilateral	Bilateral
Beugels et al[23]	Operation time (min, median [IQR])	371 [313–417]	496 [439–583]
(322 unilateral, 104 bilateral)	Ischemia time (min, median [IQR])	60 [45–79]	45 [40–55]
	Hospital stay (d, median [IQR])	7 [7–8]	7 [7–8]
Bodin et al[24]	Operation duration (min, mean [range])	291 [185–645]	513 [400–790]
(110 unilateral, 11 bilateral)	Ischemia duration (min, mean [range])	31 [18–63]	35 [24–54]
	Hospital stay (d, mean [range])	6.55 [4–17]	6.63 [6–8]
Laurent et al[25]	Operative time (min, mean)	502.6	715.2
(157 unilateral, 21 bilateral)	Ischemia time (min, mean)	76.1	67.6
	Hospital stay (d, mean)	***	***
Moellhoff et al[26]	Operation time (min, mean [SD])	285.2 [107.7]	399.1 [136.8]
(3212 unilateral, 714 bilateral)	Ischemia time (min, mean [SD])	50.9 [26.7]	50.6 [23.8]
	Hospital stay (d, mean [SD])	8.8 [13.2]	7.6 [5.1]
Wade et al[27]	Operative time (min, mean [SD])	362 [86]	486 [109]
(371 unilateral, 97 bilateral)	Ischemia time (min, median [IQR])	31.5 [25.0–41.0]	30.0 [24.5–37.5]
	Hospital stay (d, median [IQR])	6 [5–7]	7 [5–9]

***Data not reported in the study.
IQR, interquartile range.

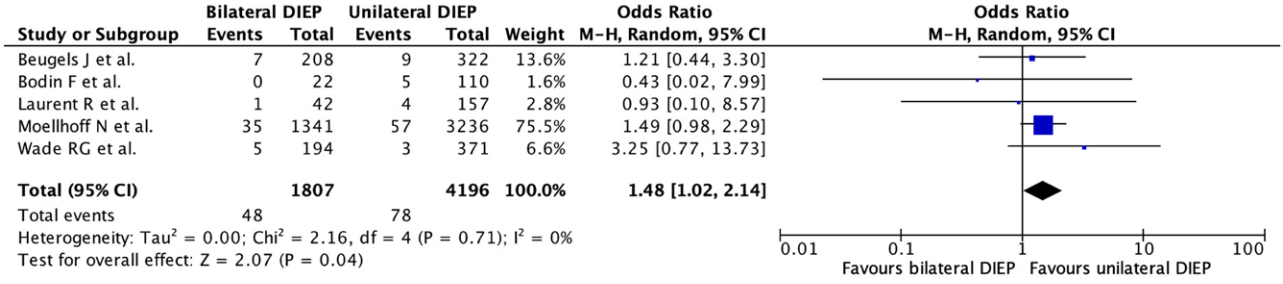

Fig. 2. Pooled total flap loss rate.

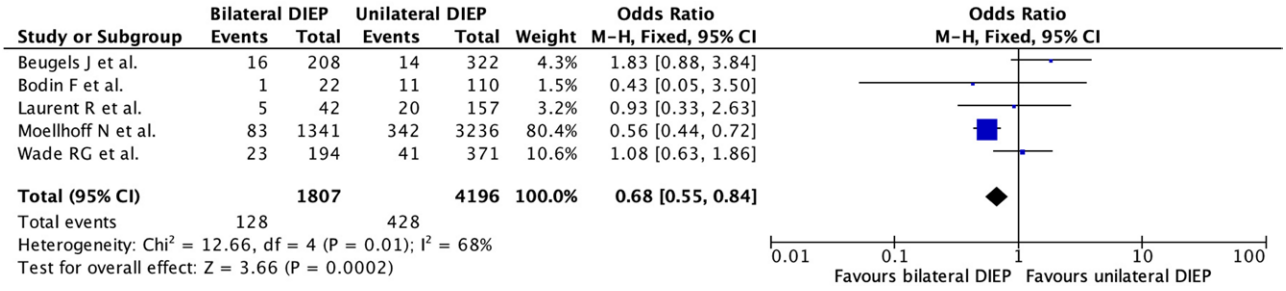

Fig. 3. Pooled reexploration rate.

reported by Wormald et al.[19] The increased risk of total flap loss in BL reconstructions may be attributed to factors such as prolonged operative times and surgeon fatigue, which are exacerbated in BL procedures.[28,29] In addition, UL reconstructions allow for the selection of the more favorable side of the abdomen for the pedicle based on preoperative anatomical assessments, providing an advantage that is not present in BL reconstructions.

Contrary to our results and meta-analysis conducted by Wormald, which suggested an increased risk of complications with BL reconstructions, a more recent meta-analysis conducted by Cao et al,[30] published in 2020, examined various types of abdominal flaps. This study found that, compared with BL reconstructions, UL reconstructions were associated with a significantly higher risk of flap loss (RR, 1.56 [95% CI, 1.21–2.00]; $P < 0.05$) and fat necrosis (RR, 1.60 [95% CI, 1.23–2.09]; $P < 0.05$). However, meta-analysis conducted by Cao et al[30] encompassed various abdominal flap reconstruction techniques, including DIEP, free TRAM, pedicled TRAM, unipedicled TRAM, and "others." This broad inclusion of different flap types may have influenced the overall risk profile for flap loss. Moreover, their subgroup analysis specifically for DIEP flaps indicated that there was no significant difference in flap loss between UL and BL DIEP reconstructions. In addition, their analysis did not differentiate between partial and total flap loss, potentially overestimating the incidence of flap loss across studies. In contrast, our meta-analysis specifically addresses this aspect and found that BL reconstructions have a trend toward lower risk of partial flap loss (OR, 0.68

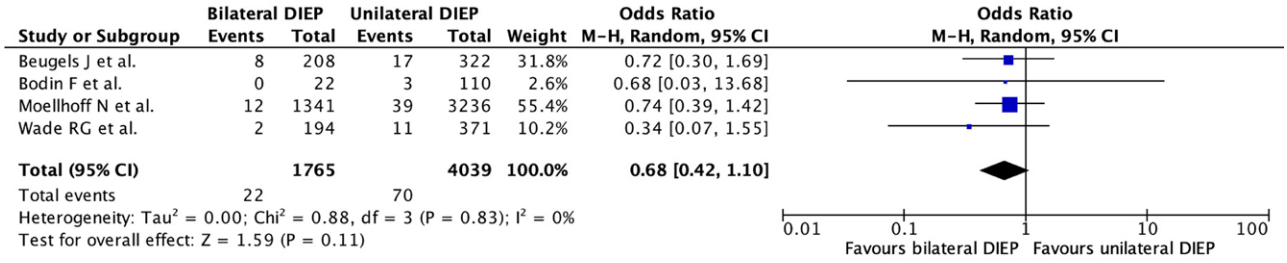

Fig. 4. Pooled partial flap loss rate.

[95% CI, 0.42–1.10]; $P = 0.11$), although these results were not statistically significant. This trend is observed across the 4 studies that mention partial flap loss included in our analysis (Fig. 4). The reduced incidence of partial flap loss in BL reconstructions could be explained by the surgical strategy in UL DIEP reconstructions, where a larger flap is often required to achieve symmetry with the contralateral breast. This larger flap size may increase the risk of poor perfusion in the periphery of the flap, potentially leading to higher rates of partial flap loss.

Demographic data in the included studies show that the average age of patients undergoing BL reconstructions is slightly lower than that of patients with UL reconstructions. For UL procedures, the average age ranged from 49.7 to 56.7 years, whereas for BL procedures, it was from 48.1 to 51.7 years. This age difference was statistically significant in 3 of the 5 studies included.[23,26,27] This tendency for younger patients to undergo BL reconstructions is often linked to those needing prophylactic contralateral mastectomy due to genetic or familial predispositions. In addition, other factors such as the desire for symmetrical reconstruction also play a role.[2]

Our findings indicate that BL DIEP flap reconstructions are associated with lower reexploration rates, with an OR of 0.68 (95% CI, 0.55–0.84) and a P value of 0.0002, suggesting a reduced likelihood of requiring additional procedures due to complications after the initial procedure. One plausible explanation for this could be a higher incidence of nonvascular complications in UL reconstructions. For instance, the study by Moellhoff et al[26] reported that a significantly higher number of patients in the UL group required emergent or unexpected revision surgery compared with the BL group (UL, 10.6% versus BL, 6.2%; $P < 0.001$). The authors report that even after adjusting for confounding factors, the hematoma rate was higher in the UL group. They also found a higher rate of medical complications in patients undergoing UL DIEP reconstruction—hypothesizing that these results may be explained by the fact that patients in their BL DIEP group were significantly younger.[26] Interestingly, Beugels et al[23] observed a statistically significant higher rate of nonvascular complications in their UL DIEP reconstruction patients, who were significantly older compared with the BL reconstruction patients, further supporting this hypothesis. Further analysis revealed comparable rates of microvascular venous or arterial thrombosis between both groups, yet significantly higher rates of hematoma at both the donor and recipient sites were observed in the UL group (donor site: UL 1.1% versus BL 0.1%; $P = 0.001$; recipient site: UL 3.9% versus BL 1.7%; $P < 0.001$). In addition, our meta-analysis found a trend toward more recipient site hematomas in UL reconstructions (OR, 0.69 [95% CI, 0.42–1.14]; $P = 0.15$), although not statistically significant. Regarding donor site hematoma, only 3 studies reported this outcome, and the results were highly heterogeneous (OR, 0.93 [95% CI, 0.03–26.51]; $P = 0.97$).

CONCLUSIONS

This study demonstrates that performing a BL DIEP breast reconstruction is associated with a significantly higher risk of complete flap loss on a per-flap basis compared with UL DIEP reconstructions. However, the increased risk is moderate and given the substantial benefits that BL reconstruction can provide, this procedure remains a viable and advisable option for women who require BL breast reconstruction.

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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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