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Review

Fat-augmented latissimus dorsi flap and implant-based latissimus dorsi flap: A systematic review

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Autologous reconstruction

Summary *Background:* Implant-related concerns have increased the interest in the use of complete autologous latissimus dorsi (LD) flaps in breast reconstruction. To achieve the desired volume without implants, autologous fat transfer can be used to enhance the breast size. Fat-augmented LD (FALD) flap is an alternative technique for volume enhancement that incorporates autologous fat grafting, thereby replacing the need for implants.
Methods: A systematic literature search was performed according to the preferred reporting items for systematic reviews and meta-analyses protocol using the PubMed, Embase, Web of Science, Scopus, CENTRAL, ICTRP and Clinicaltrials.gov databases. Data on patient-reported outcomes and clinical outcomes were extracted.
Results: The electronic database search identified 2606 records, among which 71 met the inclusion criteria. A total of 67 articles were included in the statistical analysis, reporting on 1185 FALD and 3958 implant-based LD flap breast reconstructions. Patient demographics and treatment characteristics were generally comparable across studies. The reported minor complication rate for implant-based LD was 23.9% (95% confidence intervals [CI]: 18.2–30.6%) and 25.1% (95% CI: 17.5–34.5%) for FALD. The major complication rate was 2.4% (95% CI: 1.3–4.4%) in the FALD group and 4.9% (95% CI: 3.4–7.2%) in the implant-based LD group.
Conclusion: This systematic review provides an overview of the current literature on both techniques and presents the available data on complication rates and patient-reported outcomes. The findings suggest that FALD is a safe alternative, with a potential trend towards

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lower major complication rates. Further high-quality comparative studies are needed to enable direct comparison and to draw more definitive conclusions.

Contents

Breast reconstruction is evolving rapidly and offers a wide array of techniques. Although implant-based reconstruction remains the conventional approach, it has inherent drawbacks that are associated with the use of foreign materials. Implants and expanders pose specific risks such as infection, extrusion, peri-prosthetic capsular contraction and limited lifespan. Recently, researchers have discovered an association with anaplastic large-cell lymphoma.[1] Autologous reconstruction is a viable solution to mitigate these complications, although it introduces its own set of challenges, including donor-site morbidity and a more complex surgical procedure. Furthermore, autologous reconstruction has demonstrated superiority over implant-based reconstruction in improving the overall quality of life, which represents the final goal of breast reconstruction.[2]

The deep inferior epigastric perforator (DIEP) flap is currently considered the gold standard for autologous breast reconstructions. However, free flap failure remains a significant concern, often due to microvascular anastomosis malfunction.[3] As a first-line alternative, the pedicled latissimus dorsi (LD) flap is used in patients who are unsuitable for DIEP reconstruction owing to factors such as insufficient abdominal skin or fat and high-risk comorbidities such as diabetes, obesity or tobacco use. Additionally, LD flap can provide well-vascularised tissue to the ischaemic chest wall after radiation therapy.[1]

The LD muscle is a thin muscle that lacks the volume required to construct a natural ptotic breast on its own. Therefore, LD flap reconstruction is typically combined with an implant to create the desired volume, which introduces implant-related drawbacks. Other techniques to improve volume, such as extended dissection, have higher donor-site morbidities, such as seroma, wound-related complications and lumbar hernias.[4,5] An innovative development in volume enhancement is the use of fat grafting. Often referred to as lipofilling, fat grafting involves the injection of autologous fat and is known to correct contour deformities and improve breast volume. This is an oncologically safe and effective method for enhancing breast volume.[6] Combining fat grafting with autologous LD enables the use of LD in a

fully autologous manner while achieving the desired volume.

The combination of fat grafting and LD flap is often referred to as fat-augmented latissimus dorsi (FALD) flap. The term FALD encompasses the LD and immediate fat transfer (LIFT), emphasising the immediate nature of fat grafting. Escandón *et al*. conducted a meta-analysis of the LIFT subgroup and reported promising results.[7] In the current review, in contrast to Escandón *et al.*, the FALD group contained immediate (LIFT) and delayed or secondary fat grafting.

The objective of this review was to evaluate FALD alongside implant-based LD flap (LDF + implant) in terms of patient-reported outcome measures (PROM) and complication rates. This assessment aimed to evaluate the efficacy and safety of fat grafting in enhancing the volume of LD flap in breast reconstruction.

Methods

The protocol for this systematic review was registered in PROSPERO (registration number CRD42023440910) and conducted according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement.[8] The University Hospitals Leuven's Research Ethics Committee approved this review (MP024204).

Search strategy

A literature search was conducted using the PubMed, Embase, Web of Science, Scopus, CENTRAL, ICTRP and Clinicaltrials.gov databases on 12 July 2023. To incorporate the most recent articles, a subsequent search was performed on 31 January 2024 (Table, Supplemental Digital Content 1). The search focused on PROM and clinical outcomes in the FALD and LDF + implant groups for breast cancer reconstruction.

Study selection

After removing duplicates using Endnote, a two-stage screening process was performed by 2 independent blinded reviewers (JT and JP) in Rayyan. The first stage involved a review of titles and abstracts, while the second stage involved the assessment of the full texts. The third reviewer (AC) resolved disagreements and doubts during the selection process. Articles were included if they met the following criteria: (i) observational studies and case series with more than 10 cases and (ii) studies reporting on PROM or clinical outcomes following breast cancer reconstruction with pedicled FALD (intervention group) or pedicled LD flap + implant/tissue expander (control group). Review articles, preclinical studies, conference abstracts, non-English or non-full-text available articles (access through the KU Leuven association), articles reporting on LD flap without implants and LD flap for chest wall reconstruction were excluded. Following the initial selection, a time-based exclusion criterion was introduced, specifically in the year 2010. This decision was based on the absence of any reported studies of FALD before this date.

Data extraction

A single author (JT) conducted data extraction, which was subsequently reviewed by JP. The extracted data included patient demographics (age, BMI, comorbidity and follow-up time), treatment characteristics (chemotherapy, radiotherapy, mastectomy type and immediate or delayed reconstruction) and clinical outcomes (operative time, hospital stay, complications, fat graft volume, number of additional fat grafting sessions and PROM).

Systematic Review Data Repository-Plus software served as a standardised electronic collection form for data extraction and management. Patient demographics and outcomes were estimated as weighted means $\left(\sum_{i=1}^{n}[x_i w_i]/\sum_{i=1}^{n} w_i\right)$ and presented as mean and standard deviation.[9,10]

Quality assessment

The risk of bias was assessed using the risk of bias in non-randomized cohort studies (ROBINS-I).[11] The methodological quality assessment tool (MQAT) was used to assess the case series (performed by JT and checked by JP).[12] The level of evidence was evaluated using the Oxford centre for evidence-based medicine (OCEBM).[13] Studies deemed suitable for inclusion in the analysis were not excluded because of their degree of bias.

Data analysis

Data analysis was conducted using IBM SPSS Version 29.0 for descriptive statistics and comprehensive meta-analysis software Version 4 for meta-analytical computations. Continuous data are presented as mean ± standard deviation, while categorical data are expressed as n (%). A proportional meta-analysis was performed using a random-effects model to compare FALD and LDF + implant, accounting for potential heterogeneity across the studies. Effect summaries were recorded, and mean differences with 95% confidence intervals (CI) were calculated to estimate the pooled differences between the 2 techniques. The prediction interval was visualised using a forest plot.

Heterogeneity was assessed using I^2 statistics, tau^2, and significance testing. To further investigate heterogeneity, a meta-regression and sensitivity analyses were performed. These analyses aimed to identify potential confounders and assess the robustness of the pooled results. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant.

Results

Study selection

The complete search strategy is illustrated in Figure 1. After careful selection, 71 studies met our inclusion criteria. One study detailing the combination of FALD and implants was excluded from further analysis because of its impact on both the groups.[14] Studies were excluded from the analysis

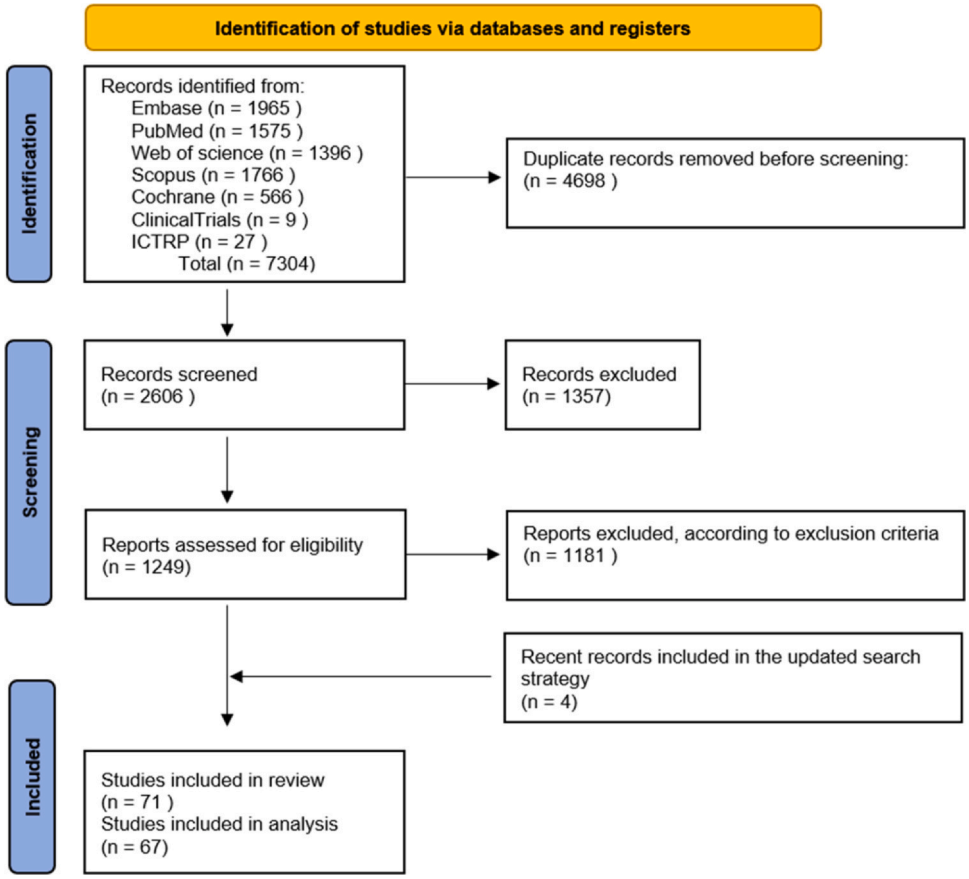

Figure 1 Flow diagram according to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) with the detailed search process.[8]

if the sample overlapped.[15-17] The data analysis included the remaining 67 studies, which reported 5143 patients who underwent FALD (1185 patients) or LDF + implant (3958 patients). A total of 486 (9%) bilateral breast reconstructions were performed.

Quality assessment

Four studies had an OCEBM level of III (6%) and the remaining 63 studies had an OCEBM level of IV. According to the MQAT, 6 articles scored level 6, 18 scored level 5, 8 scored level 4, 2 scored level 3 and 2 scored level 1 (Table, Supplemental Digital Content 2). Risk of bias visualisation software was used to present the ROBIN-I assessment (Table, Supplemental Digital Content 3).[18] There was no blinding or randomisation in the included studies. There were 53 (78%) retrospective studies and 14 (22%) prospective studies. Four retrospective cohort studies reported on both the FALD and LDF + implant groups.

Data analysis

The supplementary list presents the individual article data (Table, Supplemental Digital Content 4,5).

1. Demographics and treatment characteristics
   The demographic characteristics of the 2 groups (FALD and LDF + implant) are listed in Table 1. The patients showed no clinically relevant differences in mean age or (48.0 ± 4.6 years for LDF + implant vs 49.9 ± 4.6 years for FALD) or BMI (24.7 ± 2.8 kg/m^2 for LDF + implant vs 25.0 ± 3.1 kg/m^2 for FALD). However, there may be a disparity in the average follow-up time, with the LDF + implant group having a longer follow-up duration (35.2 ± 22.6 months vs 24.4 ± 17.9 months for FALD).
   There were no clinically relevant differences in the timing of surgical reconstruction between the groups. The FALD group reported immediate reconstruction in 54% of the cases compared to 61% in the LDF + implant group. Consequently, delayed reconstruction rates were 46% and 39%, respectively. However, the rate of missing data in the LDF + implant group was 39%.
   The treatment characteristics revealed no skewed distribution difference between the groups: 48% of the cases in the FALD group received radiotherapy (14% missing data) compared to 43% in the LDF + implant group (39% missing data). In the FALD group, 46% of the

Table 1 Patient demographics.

	LDF + implant	FALD
Patients	3958	1185
Age (mean, years)	48 ± 4.6	49.9 ± 4.6
BMI (mean, kg/m^2)	24.7 ± 2.8	25.0 ± 3.1
Follow-up (mean, months)	35.2 ± 22.6	24.4 ± 17.9

BMI: body mass index.

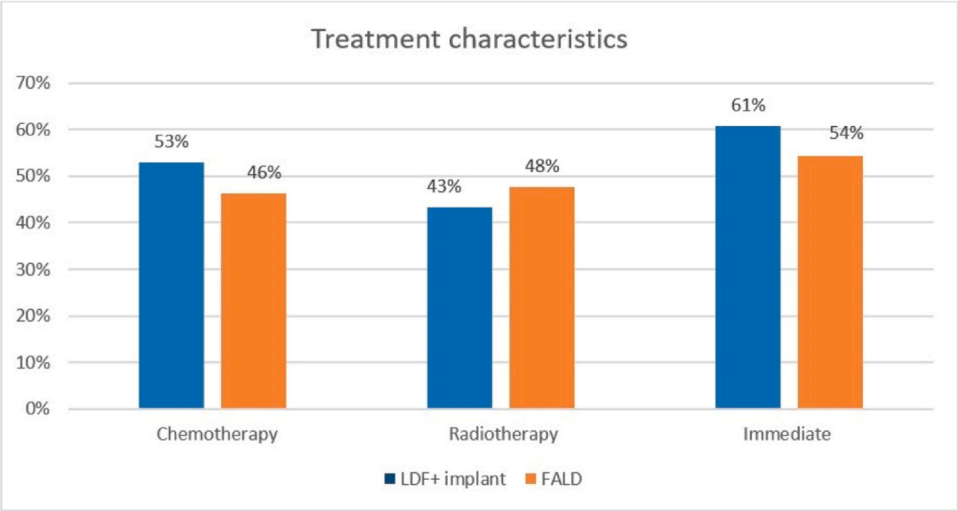

Figure 2 Treatment characteristics.

patients (48% missing data) received chemotherapy, which was comparable to 53% of the patients in the LDF + implant group (Figure 2). This analysis did not distinguish between adjuvant and neoadjuvant therapies, nor did it account for the timing of radiotherapy.

2. Fat grafting
   The average volume of intraoperative fat injection was 199.64 ± 86.24 cc.[15,19-42] On an average, 1.49 ± 0.02 lipofilling sessions were conducted,[19,21-24,27,28,30,31,34,37,38,42] including the intraoperative session, with an additional volume of 147.8 ± 66 cc injected during the additional session.[23,24,26,28-33,38,42]
   Most of the FALD articles used immediate fat grafting on the LD muscle. However, one study reported immediate fat grafting solely in the pectoralis muscle, without grafting in the LD flap.[32] Five articles reported on the use of delayed fat grafting.[24,37,38,40,43]
3. Clinical outcome
   The average operative time for unilateral reconstruction was as follows: FALD (220.85 ± 61.52 min) and LDF + implant (226.71 ± 57.50 min). No adjustments were made for the difference in operative time between immediate and delayed reconstruction. De Lorenzi *et al.* reported a longer operative time in the immediate setting in an LDF + implant group.[44]
   The significant heterogeneity in the definition of complications necessitated the division of the complications into 2 groups. Following an approach similar to that of Alves *et al.*'s meta-analysis on the complications in the DIEP, they were classified into minor and major complications.[45] The classification was based on the necessity for surgical intervention: minor complications were could be managed conservatively, whereas major complications required extensive surgical treatment. Minor complications were defined as capsular contraction, infection, wound dehiscence (or delayed wound healing), skin necrosis (mastectomy flap or nipple-areola complex necrosis), seroma (donor and recipient sites), haematoma, fat necrosis and oil cyst. Major complications were characterised by the necessity for surgery, including partial flap necrosis, flap failure and implant failure (rupture, deflation, dislocation or removal).
   Figure 3 illustrates the analysis of minor and major complications in both the groups (FALD and LDF + implant). The pooled proportion of minor complications in the LDF + implant group was 23.9% (95% CI: 18.2 to 30.6%), while the FALD group had a minor complication rate of 25.1% (95% CI: 17.5 to 34.5%) (Table, Supplemental Digital Content 6 and 7). The rate of major complications was 4.9% (95% CI: 3.4 to 7.2%) in the LDF + implant group and 2.4% (95% CI: 1.3 to 4.4%) in the FALD group.
   The meta-analysis showed significant heterogeneity in minor and major complications. This heterogeneity may stem from various factors, including differences in time, location, patient subgroups and study design, and is often highly significant in large proportional meta-analyses.[46] To address this issue, the prediction interval was computed to gauge the overall variance of the results. Despite high heterogeneity, employing a random-effects model and conducting sensitivity analyses yielded robust results. Additionally, meta-regression was performed to explore the potential influence of the study year, patient age, proportion of chemotherapy and radiotherapy and immediate versus delayed reconstruction. However, the results of the meta-regression analysis did not show any statistical significance. Detailed results of the meta-regression analysis are presented in the supplementary list (Table, Supplemental Digital Content 8).
4. PROM: Breast-Q
   The included studies used different PROM scoring systems. Upon data extraction, the Breast-Q, renowned for its efficacy and reliability in evaluating satisfaction and well-being in breast cancer reconstruction, emerged as the most frequently used score.[47] Two comparative cohort studies, involving 6 LDF + implant studies, and 6 FALD studies reported Breast-Q scores (Table 2).[22,39,41,43,48,49] The only item consistently reported in the Breast-Q was the 'satisfaction with breast' item. Owing to the limited utilisation of the Breast-Q and variability in reporting its items, statistical analysis was not conducted for PROM.

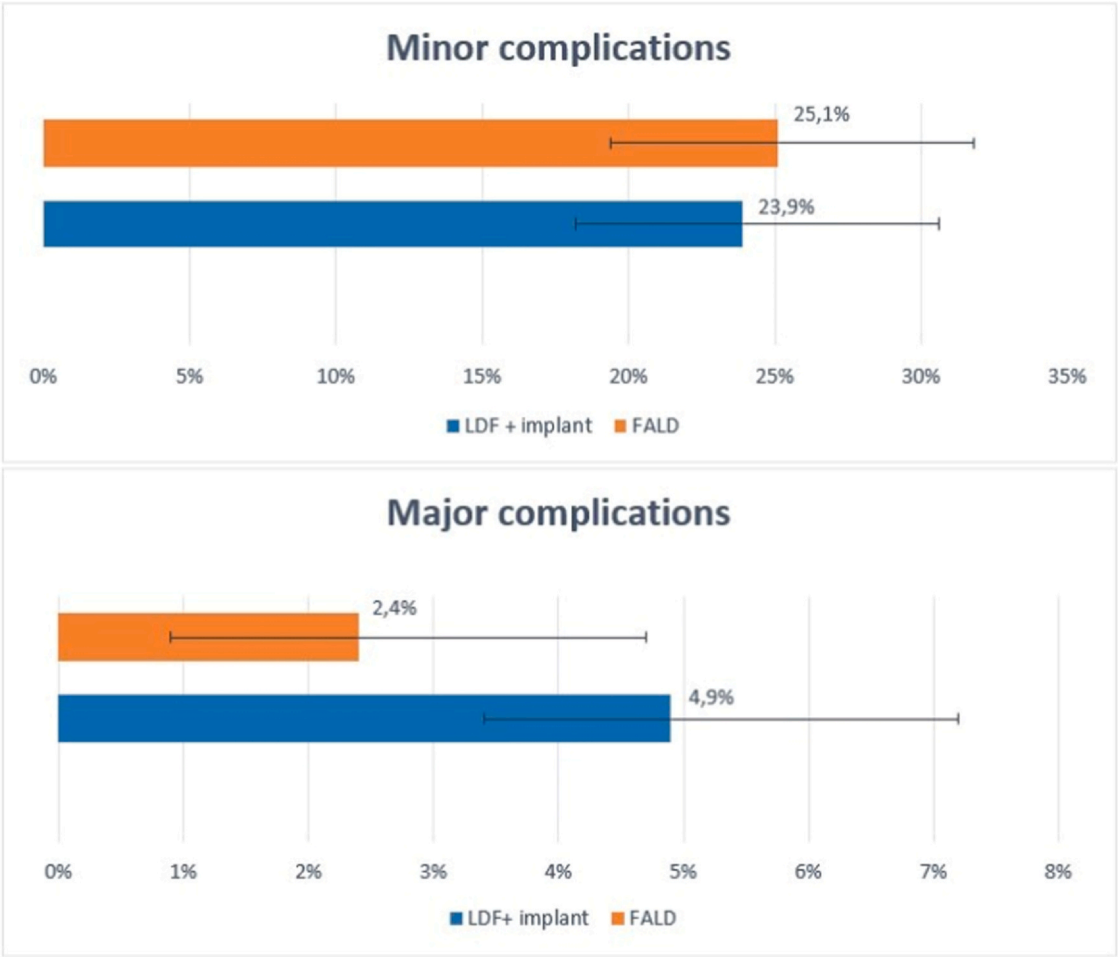

Figure 3 Pooled proportions of minor and major complications.

Table 2 'Satisfaction with breast' item and 'psychosocial well-being' item of the Breast-Q, scored on a scale ranging from 0 to 100.

Study	Group	Patients	Satisfaction with breast	Psychosocial wellbeing
Akita et al. 2023	FALD	15	77.3 ± 10.3	NR
	LDF + implant	10	75.7 ± 13.4	NR
Asaad et al. 2023	LDF + implant	10	70.5 ± 21.4	70.1 ± 27.1
Brito et al. 2020	LDF + implant	37	59.1 ± 14.1	NR
Kim J. M. et al. 2021	LDF + implant	26	59.8 ± 13.7	64.0 ± 20.8
Leuzzi et al. 2019	FALD	25	70.2 ± 24.3	75.5 ± 24.5
	LDF + implant	34	61.7 ± 23.0	71.3 ± 21.2
Ménez et al. 2018	LDF + implant	48	56.4 ± 14.9	63.9 ± 26.5
Patrinely et al. 2019	LDF + implant	58	73.8 ± 24.3	85.3 ± 22.8
Taminato et al. 2021	FALD	41	67.8 ± 15.5	NR
Tomita et al. 2023	FALD	70	67.8 ± 13.2	NR
Wang et al. 2021	LDF + implant	44	72.9 ± 13.5	92.2 ± 12.7

NR: not reported.

Discussion

Breast carcinoma is the most common cancer in women, affecting 2.3 million women worldwide annually.[50] Although some tumours can be managed via breast-conserving techniques and adjuvant therapy, mastectomy is often necessary. Additionally, prophylactic mastectomy may be offered to genetically burdened patients as a risk-reducing procedure. Recognising the significant impact of mastectomy on women's physical appearance and psychological well-being, breast reconstruction has become an integral component of a comprehensive treatment plan for individuals with breast cancer. By restoring the

natural contours of the breast and enhancing self-image, reconstruction addresses the physical effects of surgery and plays a crucial role in improving psychosocial outcomes and overall quality of life for breast cancer survivors.[51]

Given the preference sensitivity in breast reconstruction, patients carefully weigh multiple factors when choosing between implant-based and autologous options. Autologous reconstruction offers superior patient-reported benefits, especially in terms of sexual well-being and satisfaction with breast appearance. However, autologous reconstruction is a more intricate surgical procedure with a greater physical impact on the patient and involves donor-site morbidity. Furthermore, implant-related reconstruction is associated with higher complication rates in cases involving postmastectomy radiation therapy and medical comorbidities.[52]

Latissimus dorsi flap

Breast reconstruction using LD flap, first described by Tansini *et al.*, offers several advantages.[53] It is associated with few complications, eliminates the need for microvascular anastomosis, and provides well-vascularised tissue to previously irradiated chest walls. Its consistent and reliable vascular pedicle, along with ease of harvest, has contributed to its popularity among reconstructive surgeons.[54] However, a major drawback is the sacrifice of the LD muscle at the donor site, which leads to shoulder function impairment. Nonetheless, LD flap has proven beneficial in cases of prior reconstructive failure, previous radiation therapy, recurrent cancer following breast conservation therapy, and implant infection.[54] Owing to its limited volume, implants are often required to achieve the desired breast size, which introduces implant-related drawbacks. Fat grafting has emerged as a solution to replace implants, while achieving an appropriate volume. However, fat grafting has drawbacks in terms of fat viability depending on the blood supply, leading to fat necrosis or oil cysts.[55]

Autologous reconstruction

Although DIEP remains the gold standard for autologous breast reconstruction, there are several other options for autologous reconstruction with thigh flaps, such as the transverse upper gracilis, profunda artery perforator and lateral thigh perforator flaps. However, these options have limitations, including insufficient volume for a single flap, often necessitating the use of 'stacking' flaps and uncomfortable scar placement when sitting. Trunk-based flaps, such as superior/inferior gluteal artery perforator and lumbar artery perforator flaps, are also reasonable options. However, they often have short pedicles that require vein grafts and surgeries that involve time-consuming position changes.[56] In contrast, pedicled LD flap offers advantages, such as reliable blood supply without the risk of microvascular anastomosis, shorter operative times and shorter hospital length of stay. Additionally, its potential for fat grafting to enhance volume makes it a viable alternative for complete autologous reconstruction.[33] Because FALD is relatively new, data comparable to conventional implant-based approaches are lacking. This review aimed to assess the FALD technique alongside the implant-based approach in terms of PROM and clinical outcomes. We aimed to provide a critical evaluation of both techniques, aiding in the decision-making process regarding the choice of surgical technique in breast reconstruction, particularly in comparison with other autologous reconstructive options.

Fat grafting

The challenge of achieving larger breast volumes persists in LD reconstructions, because of which they were initially reserved for small-to medium-sized non-ptotic breasts.[57] The volume of LD flap tends to decrease over a two-year period, with 24% attributed to muscle atrophy.[58] When lipofilling is used in LD, fat resorption rates of approximately 21% result in an additional decrease in volume.[59] This unpredictability in the final volume often necessitates additional lipofilling sessions; this analysis showed that 49% of the patients required an additional fat grafting session. It is not always ideal to inject large amounts of fat in a single session to achieve the desired volume. The average volume in additional sessions was 199.64 cc. Large fat injections have the potential to compromise fat viability, leading to fat necrosis and calcification.[60] However, Couto-González *et al.* demonstrated satisfactory results with larger immediate fat grafting volumes (416.00 $\pm$ 145.79 cc).[27] Achieving the desired breast volume is challenging in obese patients with large ptotic breasts. Novak *et al.* demonstrated that FALD provides favourable outcomes and is a viable alternative to DIEP flap breast reconstruction, even in such cases (with a mastectomy weight of 956.7 g).[33] When lipofilling alone cannot achieve the desired volume, its combination with an implant serves as the interim solution. This approach enables a reduction in the implant volume, thereby reducing the risk of implant-related complications.[14]

The scope of this study did not include the specific location of fat grafting. Fat grafting has been reported in various areas including the LD muscle, LD flap adipose tissue, serratus muscle, mastectomy flaps and pectoralis major muscle. The optimal recipient site for lipofilling remains unclear, with most reports favouring the LD muscle because of its higher adipogenic microenvironment.[7,26] However, intramuscular fat injection may elevate pressure and compromise vascularisation, potentially leading to impaired wound healing and higher risk of flap failure.[39]

Demographics and treatment characteristics

The average follow-up period was longer in the LDF + implant group, which may have influenced the reported complication rates. Capsular contraction, considered a minor complication, can manifest with delayed onset over several years in the LDF + implant group.[61] Conversely, complications in the FALD group such as fat necrosis and oil cysts presumably did not exhibit this delayed phenomenon. Hence, a longer follow-up period in the LDF + implant group was beneficial for detecting delayed complications that were only present in this group.

Regarding surgical timing, immediate reconstruction was performed in 54% of the cases in the FALD group and in 61% of the cases in the LDF + implant group. Generally, immediate reconstruction is preferred despite the potential benefits of delayed reconstruction on the complication

rate. In immediate reconstruction, preservation of the native skin facilitates better shaping of the reconstructed breast, whereas delayed reconstruction often requires additional contouring techniques owing to the contracted and less elastic skin.[62,63] Additionally, immediate breast reconstruction with FALD has important implications for patients requiring postmastectomy radiotherapy. Radiotherapy negatively impacts reconstructive outcomes, particularly in implant-based reconstruction, and may also influence fat graft viability in FALD. Although FALD offers an autologous alternative with a lower risk of implant-related complications after radiotherapy, the potential effects of radiotherapy on graft survival and long-term aesthetic outcomes warrant further consideration.

In terms of adjuvant therapy, there were no clinically relevant differences. The FALD group received slightly less chemotherapy but underwent more radiotherapy (Figure 2). In contrast to chemotherapy, radiotherapy negatively affects the outcomes of breast reconstruction.[64–66] Moreover, if these factors introduced a confounding effect, they would likely increase the complication rate in the FALD group rather than biasing the results in its favour.

Clinical outcome

The average in hospital stay was not calculated owing to the widely varying results reported in the included studies, ranging from 1.65 to 15.5 days.[23,67] It could be argued that hospital stay is primarily determined by the hospital's standard recovery procedure, with the surgical technique being of secondary importance. A comparative cohort study by Leuzzi *et al*. found no significant difference in the length of hospital stay between patients with FALD and LDF + implant.[43] Operative time was clinically similar between the groups, and along with hospital stay, is unlikely to influence the decision-making process for FALD or LDF + implant. However, factors such as operative time, hospital stay and associated costs may play a role in choosing between other autologous techniques (such as DIEP or trunk and thigh flaps), where the relative simplicity of the LD flap procedure offers an advantage.[68–70]

When comparing FALD with LDF + implant, each group exhibited complications that were specific to their nature. Capsular contraction is a relatively frequent implant-related complication that requires reintervention, depending on the Baker grade.[71] However, FALD is susceptible to oil cysts and fat necrosis due to impairment of the vascularisation of the injected fat.[39] As capsular contraction, oil cysts and fat necrosis are categorised as minor complications, they have the potential to complement each other in the meta-analysis. This may have contributed to a similar incidence of minor complications (approximately 25%). However, FALD appeared to have a lower incidence of major complications compared to implant-based reconstruction. A contributing factor to this difference is implant failure, which can occur due to multiple causes such as infection, rupture or dislocation. Combined with the fact that fat grafting does not appear to increase the risk of flap necrosis or failure, presumably explains the differences in major complications. Furthermore, the risk of implants persists for a lifetime, with an additional need for implant replacement every 10–15 years. However, fat grafting entails no anticipated delay risk and does not require reoperation after achieving the final result.

PROM

This review exclusively used the Breast-Q, as comparing different scales was not feasible. The 2 comparative cohort studies, Akita *et al*. and Leuzzi *et al*., did not observe a significant difference in the Breast-Q score.[22] However, Leuzzi *et al*. showed a trend that favoured the FALD group on 'satisfaction with breast' item ($p = 0.089$).[43] The meta-analysis by Peschel *et al*. confirmed this finding.[72] Additionally, Varnava *et al*. reported similar scores for the 'satisfaction with breast' item for profunda artery perforator (63 ± 12) and DIEP (72 ± 17) procedures.[73] As the reports on PROM using the Breast-Q score are limited, it is not yet possible to pool the data and objectively compare different studies.

Strengths and limitations

The primary limitation of this review lies in its statistical methodology. As FALD is an innovative technique, only a limited number of scientific studies are currently available, making it impossible to perform a meta-analysis of randomised trials or an indirect comparison using a reference group. Given these constraints, a direct comparison is not feasible, and any attempt to compare the complication rates must be interpreted with caution due to the high risk of bias from potential confounding factors. Therefore, we did not perform a statistical comparison between the 2 groups. To mitigate this as much as possible, sensitivity and meta-regression analyses were performed, neither of which identified any significant confounders (Table, Supplemental Digital Content 8). Additionally, we reason that the choice of surgical technique is not dependent on specific patient characteristics. Furthermore, the exclusion of studies before 2010 was applied to reduce potential confounding factors.[46]

Another key limitation of this review is the heterogeneity among the included studies, particularly in the definition and reporting of complications. Variations include different cutoffs for partial flap necrosis, distinctions between skin and flap necrosis, severity of infections or wound dehiscence and reporting of seromas (donor or recipient). Despite these variations, categorising complications as minor or major allows for valid comparison of outcomes. This classification system allowed for a standardised and systematic assessment of complications across the included studies while accounting for the variability in complication severity ensuring that severe cases of minor complications requiring extensive surgical intervention were classified as major complications. However, in 4 studies, the applied definitions were incompatible, rendering their data unsuitable for analysis.[37,74–76] Therefore, there is a critical need for high-quality comparative cohort studies to evaluate these 2 surgical techniques under consistent conditions. This review provides an objective assessment of FALD and compares it to implant-based LD flap. However, caution is required due to the high risk of bias associated with the direct comparison in the meta-analysis. The findings can

still be used to contextualise complication rates when comparing different reconstructive options.

This review included 26 articles in the FALD group, in contrast to the 19 articles in the LIFT group analysed by Escandón *et al.*, which focused solely on immediate fat grafting.[7] The variation in article selection is primarily due to the inclusion of delayed fat grafting and exclusion of Portuguese or Spanish articles.[49,77] The results of Escandón *et al.* are consistent with the findings of this review. However, this review surpasses that of Escandón *et al.* by incorporating a control group (LDF + implant) and considering delayed fat grafting, reflecting the clinical scenario where the need for lipofilling may arise after the initial volume resorption.

Future of FALD

Several further refinements are possible in the surgical techniques for FALD. The type of mastectomy influences the reconstruction outcome, with skin- or nipple-sparing mastectomies combined with immediate reconstruction generally leading to superior aesthetic and functional results.[15,20-22,26,35] Skin sparing mastectomy facilitates the use of muscle only FALD without a back scar. This enables LD flap to be harvested endoscopically.[20,22] Another approach to further reducing donor-site morbidity is muscle-sparing LD flap, which improves shoulder functionality.[20,31,35] In contrast, extended LD flap is associated with higher donor-site morbidity, for which lipofilling in FALD is a worthy replacement. A third refinement is the orientation of the flap's skin paddle from the classic horizontal to vertical position, creating a better shape and breast projection.[15] With further optimisation of this technique, muscle-sparing, scarless FALD is possible with limited donor-site morbidity, resulting in even better PROM and clinical outcomes. The choice of the reconstructive technique should involve shared decision-making by considering factors such as patient preference (e.g. scarless or preserved shoulder mobility), natural breast size and shape, patient demographics and type of mastectomy.

Conclusion

This systematic review offers a comprehensive understanding of LD flap surgery, using a sizeable database to derive reliable conclusions regarding the complication rate of FALD alongside implant-based LD flap. By categorising the complications, this review enables a structured analysis of the complication rates. The findings suggest that FALD is a safe alternative, with a potential trend towards lower incidence of major complication rates. Approximately half of the patients required an additional fat grafting session. PROM tended to favour the FALD approach. However, the direct comparison between FALD and implant-based LD flap should be interpreted with caution due to the high risk of bias from potential confounding factors. Therefore, future randomised comparative studies are essential to allow for a direct comparison and provide more robust evidence to validate these findings. Although FALD does not replace DIEP as the gold standard, it exhibits advantages over conventional implant-based LD flap. Continued advancements and refinements in FALD surgical techniques are anticipated to yield further improvements in the outcomes.

Ethical approval

The University Hospitals Leuven's Research Ethics Committee approved this review (MP024204).

Conflicts of interest

None declared.

Financial disclosure statement

There are no conflicts of interest, this paper did not receive any funding.

Supplementary Digital Content legend

- Table, Supplementary Digital Content 1. The search terms were employed in the following databases: PubMed, Embase, Web of Science Core Collection, Scopus, CENTRAL, ICTRP and Clinicaltrials.gov. We conducted searches on 12 July 2023 and a subsequent search on 31 January 2024 to incorporate the latest articles.
- Table, Supplementary Digital Content 2. Traffic light plot of the ROBIN-I methodological quality assessment.[18]
- Table, Supplementary Digital Content 3. Traffic light plot of the MQAT methodological quality assessment.[18]
- Table, Supplementary Digital Content 4. Patient demographics and treatment characteristics. NR: not reported, Total: total mastectomy (radical, modified or simple mastectomy), SSM: skin sparing mastectomy, NSM: nipple-sparing mastectomy, HT: arterial hypertension.
- Table, Supplementary Digital Content 5. Clinical outcome of included studies. NR: not reported.
- Table, Supplementary Digital Content 6. Meta-analysis concerning the minor complications.
- Table, Supplementary Digital Content 7. Meta-analysis concerning the major complications.
- Table, Supplementary Digital Content 8. Meta-regression analysis for major complications, models performed separately (random effects, Knapp Hartung and Logit event rate).

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.bjps.2025.04.003.

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