JOURNAL OF PLASTIC SURGERY AND HAND SURGERY
2026, VOL. 61, 146–152
https://doi.org/10.2340/jphs.v61.46066

ORIGINAL RESEARCH ARTICLE

Comparative analysis of breast cancer-related lymphedema after autologous and implant-based reconstruction: emphasizing differences between prepectoral and subpectoral placement of implant

Geun-Young Park[a], Ahran Kim[b], Young Jae Choi[b], Daiwon Jun[b], Ji Young Ryu[c], Pill Sun Paik[c] and Jung Ho Lee[b]*

[a]Department of Rehabilitation Medicine, Bucheon St. Mary Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea; [b]Department of Plastic and Reconstructive Surgery, Bucheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea; [c]Department of Surgery, Bucheon St. Mary Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

ABSTRACT

Background: This study aimed to compare the incidence and long-term progression of breast cancer-related lymphedema (BCRL) following autologous or implant-based breast reconstruction, with subgroup analysis based on prepectoral versus subpectoral implant placement.
Methods: A retrospective review was conducted of 228 patients who underwent mastectomy and immediate breast reconstruction by a single surgeon between 2017 and 2020, using either a deep inferior epigastric perforator (DIEP) flap or a tissue expander. Arm circumference was measured at standardized proximal and distal points. BCRL was diagnosed clinically and confirmed by lymphoscintigraphy demonstrating dermal backflow and/or delayed axillary nodal uptake. Soft-tissue compliance was assessed using ultrasonography to evaluate differences in tissue response with and without compression.
Results: The overall incidence of BCRL showed no significant difference among groups (DIEP 8.9%, prepectoral 14.8%, subpectoral 15.6%). However, during 2-year follow-up, the subpectoral group demonstrated faster progression and greater limb volume increase compared with the DIEP and prepectoral groups. Improvements in soft-tissue compliance were greatest in the DIEP group, followed by the prepectoral group, while the subpectoral group showed the least improvement.
Conclusions: Autologous reconstruction demonstrated the most favorable lymphatic outcomes, supporting prior literature. Among implant-based approaches, prepectoral placement was associated with a milder course of BCRL than subpectoral placement, possibly due to decreased postoperative pain and shoulder restriction. These findings suggest that reconstruction type and implant placement plane may influence BCRL severity and should be considered when planning surgery to reduce complications and optimize long-term outcomes.

ARTICLE HISTORY
Received 26 November 2025
Accepted 23 April 2026
Published 2 June 2026

KEYWORDS
Breast reconstruction; lymphedema; prepectoral; subpectoral; DIEP flap; implant-based reconstruction

Introduction

Breast cancer-related lymphedema (BCRL) is one of the most serious complications of breast cancer treatment that can significantly impact patients' quality of life [1, 2]. In recent years, advances in microsurgical and physiological techniques – such as lymphovenous bypass, vascularized lymph node (LN) transfer, and lymphatic reconstruction, along with non-operative decongestive physical therapy – have led to meaningful improvements in outcomes and expanded the treatment landscape for BCRL [3–5]. These developments have shifted management strategies from focusing on prevention to a more comprehensive approach that integrates early detection, risk reduction, and active treatment. Despite these advances, BCRL remains a clinically significant and multifactorial condition influenced by both oncologic treatment and reconstructive technique.

BCRL is known to be associated with factors such as body mass index (BMI), type of mastectomy, axillary LN dissection, postoperative irradiation, and LN involvement by tumor cells [6–8]. Although previous comparative studies between autologous and implant-based reconstruction (IBR) have shown mixed results [9–11], a significant body of literature suggest that IBR may carry a higher risk or lead to more unfavorable clinical outcomes than autologous techniques [12–17].

Nowadays, prepectoral IBR is an increasing trend due to its clinical advantages, including quicker expansion, improved aesthetic outcomes, and reduced postoperative pain [18–25]. However, this approach may entail a higher risk of acute complications such as skin flap necrosis, and its long-term impact on the lymphatic system remains to be fully elucidated [26, 27]. In other words previous studies comparing reconstruction types (autologous vs. implant) on the development of lymphedema have primarily focused on subpectoral placement or failed to specify the implant plane.

To address this gap, our study specifically differentiated IBR into prepectoral and subpectoral groups to compare both the incidence and long-term clinical progression of BCRL according to the surgical technique, using autologous reconstruction as a control group.

Methods

Outcomes of patients with breast cancer who underwent mastectomy and immediate reconstruction using a tissue expander (Mentor

CONTACT Jung Ho Lee tfm0822@catholic.ac.kr; tfm0822@gmail.com Department of Plastic and Reconstructive Surgery, The Catholic University of Korea, Bucheon St. Mary's Hospital, 327 Sosa-ro, Wonmi-gu, Bucheon-si, Gyeonggi-do, 14647, South Korea

Supplemental data for this article can be accessed online at https://doi.org/10.2340/jphs.v61.46066

Worldwide LLC, Irvine, CA, USA) or deep inferior epigastric artery perforator (DIEP) flap by a single senior surgeon (J.H.L) between 2017 and 2020 were analyzed in this study. The tissue expander group was further divided into subpectoral and prepectoral groups. In the subpectoral reconstruction group, the upper two-thirds of the expanders were covered by the pectoralis major muscle, while the lower one-third was covered by acellular dermal matrix (MegaDerm®; L&C Bio Inc., Seoul, Korea). For the prepectoral reconstruction group, reconstructions were performed in a subcutaneous pocket with anterior coverage of the tissue expander using an acellular dermal matrix. Postoperatively, patients underwent systematic surveillance by rehabilitation specialists every 3 months during the first year and every 6 months thereafter for at least 5 years. Arm swelling within the first 3 months was regarded as a transient reaction. To capture late-onset cases, patients were assessed for subjective symptoms during routine visits and educated to report any changes between appointments. Once diagnosed with lymphedema after the surgery, charts were reviewed for a minimum of 2 years to assess the incidence and severity of lymphedema.

Patients with missing data, pre-existing lymphedema before mastectomy or at presentation, operative treatment for lymphedema, or preoperative radiation therapy were excluded from the study. Patients undergoing breast reconstruction with autologous flaps combined with implants or tissue expanders, direct-to-implant reconstruction, or delayed reconstruction were also excluded.

Data collection

Data were collected from the individual patient's medical records, including preoperative patient characteristics such as age, BMI, and co-morbidities such as diabetes mellitus and hypertension, and smoking status. Additionally, information on reconstruction method, axillary operation (sentinel LN biopsy only with simple mastectomy or axillary LN dissection with modified radical mastectomy), number of dissected LNs, number of tumor-positive LNs, and the administration of preoperative or postoperative chemotherapy or radiotherapy (RT) was also recorded.

Regarding the timing of RT relative to BCRL, 'pre-RT' was defined as cases where BCRL was diagnosed before the first fraction of postoperative RT, whereas 'post-RT' referred to a diagnosis made after the initiation of RT.

Definition of lymphedema

Circumference measurements were taken by rehabilitation doctors at two standardized points on the upper extremity: the upper point (Point A), defined as 10 cm proximal to the lateral epicondyle of the elbow, and the lower point (Point B), defined as 10 cm distal to the lateral epicondyle. Measurements were performed with the patient in the sitting position, with the elbow fully extended and the forearm pronated. A diagnosis of lymphedema was made when the circumference difference between the affected and unaffected upper extremities was greater than 2 cm at either location. In accordance with institutional protocol, the diagnosis was additionally confirmed by lymphoscintigraphy demonstrating dermal backflow and/or delayed or absent axillary nodal visualization.

All patients diagnosed with lymphedema underwent a standardized program of complex decongestive therapy performed by trained physical therapists, which included manual lymphatic drainage in a distal-to-proximal direction, compression bandaging, and individualized exercise therapy. Specifically, Mobiderm® (Thuasne, St-Etienne, France) was utilized during the intensive phase of compression bandaging to enhance lymphatic drainage and prevent soft-tissue fibrosis. Additionally, patients received weight management counseling from the Department of Rehabilitation Medicine to maintain BMI stability and minimize confounding effects on lymphedema progression.

Soft tissue compliance measurement using ultrasonography

Once lymphedema was diagnosed, skin and subcutaneous tissue thickness were measured using ultrasonography by a single rehabilitation doctor. Soft tissue thickness was defined as the sum of skin and subcutaneous tissue thicknesses on ultrasonography. For compliance measurements, soft tissue thickness was measured without any pressure and once again while applying maximal compression.

Based on a previous study, compliance was defined as the difference in soft tissue thickness with and without compression divided by the soft tissue thickness without compression [27, 28]. In cases of severe lymphedema where tissue becomes fibrotic, the soft tissue thickness will not change with compression, resulting in decreased compliance. Compliance was measured at identical points, along with circumference measurements, at the time of diagnosis and 2 years after diagnosis. The compliance ratio was calculated by dividing the compliance of the affected upper extremity by that of the unaffected side.

$$\text{Compliance} = \frac{\text{Thickness without pressure} - \text{Thickness with maximal pressure}}{\text{Thickness without pressure}}$$

Statistical analysis

The clinicopathological characteristics were compared among three different groups. Categorical variables were compared using the chi-squared (χ^2) test or Fisher's exact test, while continuous variables were compared using one-way analysis of variance or the Student's t-test. Univariable and multivariable Cox proportional hazard regression models were used to identify prognostic factors for lymphedema development. A Bonferroni correction was used to account for multiple comparisons among the three groups. A *P*-value of less than 0.016 was considered statistically significant.

Results

Analysis of the overall study population

Initially, a total of 298 patients undergoing breast reconstruction during the study period were identified. After excluding 70 patients based on the selection criteria, 228 patients who underwent immediate reconstruction following a mastectomy were included in the analysis. Among the 228 mastectomies, 90 patients received DIEP reconstruction (Group 1), while 138 patients underwent two-stage tissue expander/implant reconstruction. Within the two-stage reconstruction group, 61 patients underwent the prepectoral approach (Group 2), and 77 underwent the subpectoral approach (Group 3). Table 1 summarizes the patient demographics, and there were no significant differences in preoperative patient demographics and operative details among the three groups, except for a significantly higher BMI in the DIEP group ($P = 0.003$).

As presented in Table 1, there were no significant differences in the proportion of patients undergoing axillary LN dissection (52.2% in DIEP, 45.9% in prepectoral, and 35.1% in subpectoral; $P = 0.083$) or adjuvant RT (40.0%, 41.0%, and 41.6%, respectively; $P = 0.979$).

Table 1. Comparison of clinicopathological characteristics in autologous and tissue expander/implant reconstruction groups.

Characteristics		DIEP (n = 90)	Prepectoral (n = 61)	Subpectoral (n = 77)	P
Patient characteristics					
Age		51.1 ± 7.7	50.4 ± 8.4	51.8 ± 8.0	0.618
DM (%)		8 (8.9)	5 (8.2)	5 (6.5)	0.86
HTN (%)		12 (13.3)	5 (8.2)	9 (11.7)	0.619
Smoking (%)		4 (4.4)	4 (6.6)	5 (6.5)	0.818
BMI		24.3 ± 1.7	23.2 ± 2.9	23.1 ± 3.3	0.003**
Pathological characteristics					
Tumor type (%)	*In situ*	10 (11.1)	11 (18.0)	9 (11.7)	0.418
	Invasive carcinoma	80 (88.9)	50 (82.0)	68 (88.3)	
Mean no. of dissected LNs		6.8 ± 8.8	6.1 ± 1.9	6.0 ± 2.0	0.715
Tumor-positive LNs		0.7 ± 1.5	0.6 ± 1.2	0.9 ± 1.4	0.53
Surgical characteristics					
Axillary operation (%)	SLNB only	43 (47.8)	33 (54.1)	50 (64.9)	0.083
	ALND	47 (52.2)	28 (45.9)	27 (35.1)	
Treatment characteristics					
Chemotherapy (%)	None	21 (23.3)	16 (26.2)	20 (26.0)	0.464
	Adjuvant	64 (71.1)	38 (62.3)	47 (61.0)	
	Neoadjuvant & adjuvant	5 (5.6)	7 (11.5)	10 (13.0)	
Radiotherapy (%)	None	54 (60.0)	36 (59.0)	45 (58.4)	0.979
	Adjuvant	36 (40.0)	25 (41.0)	32 (41.6)	

DIEP: deep inferior epigastric artery perforator; DM: diabetes mellitus; HTN: hypertension; BMI: body mass index; SLNB: sentinel lymph node biopsy; ALND: axillary lymph node dissection.

Follow-up duration was also uniform, with a minimum of 2 years for all patients.

These findings indicate that the three groups were comparable with respect to the major determinants of lymphedema risk and suggest that the differences observed in clinical progression between subpectoral and prepectoral reconstruction are unlikely to be explained solely by imbalances in axillary surgery or RT exposure.

BCRL incidence and associated risk factors

During the study period, 228 patients underwent immediate breast reconstruction (90 DIEP, 61 prepectoral, and 77 subpectoral). Lymphedema developed in 29 patients during follow-up, with no significant difference in the overall incidence among the three groups (P = 0.37; Table 2). While the initial incidence was not affected by the reconstruction method, the plane of implant placement significantly influenced the clinical course after BCRL onset.

Univariable analysis revealed that patients' characteristics were not related to lymphedema risk. However, surgical and treatment factors were significantly associated with an increased risk of lymphedema: axillary surgery type, the number of tumor-positive LNs, and postoperative RT (all $P < 0.001$), as well as the total number of dissected LNs ($P = 0.011$) (Table 3). In the subsequent multivariable model, all of these factors remained independent and statistically significant predictors for BCRL development, with the exception of axillary surgery type (Table 3).

To evaluate potential confounding factors, we compared key treatment and baseline characteristics across the groups (Table 4). The distribution of Axillary lymph node dissection (ALND) versus

Table 2. Overall 2-year incidence of lymphedema by the reconstruction method.

Reconstruction Method	Total no. of patients	No. of patients with lymphedema	Incidence of lymphedema (%)	P
Overall	228	29		0.37
DIEP	90	8	8.9	
Prepectoral	61	9	14.8	
Subpectoral	77	12	15.6	

DIEP: deep inferior epigastric artery perforator.

Sentinel lymph node biopsy (SLNB) (P = 0.371), RT exposure (P = 0.962), and other clinicopathological variables (all $P > 0.05$) were well-balanced.

In addition, we compared the BMI of patients diagnosed with lymphedema across the three groups. At the time of diagnosis, BMI was 23.2 ± 1.45 kg/m^2 in the DIEP group, 24.52 ± 3.76 kg/m^2 in the prepectoral group, and 23.1 ± 2.54 kg/m^2 in the subpectoral group (P = 0.447). Two years post-diagnosis, the values remained similar at 23.15 ± 1.96 kg/m^2, 23.89 ± 2.79 kg/m^2, and 22.50 ± 2.14 kg/m^2, respectively (P = 0.406). These findings indicate that BMI was consistent across all groups and did not significantly influence lymphedema progression.

Severity of BCRL

As the incidence of BCRL did not significantly differ between reconstruction types, we further analyzed the longitudinal changes in arm circumference and soft tissue compliance to evaluate the severity and progression of lymphedema among groups.

Circumference of the upper extremity

Table 5 and Figure 1 display the circumference changes over a 2-year follow-up period after the first diagnosis, comparing different types of breast reconstruction. At both measurement sites (Point A and B), significant differences were found among the three reconstruction groups in terms of the time to reach maximum circumference, the circumference increase from baseline to peak, and the overall circumference increase from diagnosis to 2 years of follow-up.

Post hoc analysis revealed that the DIEP group exhibited a more benign course compared to the implant-based breast reconstruction group. Specifically, significant differences were observed between the DIEP and subpectoral groups across all measured indicators ($P < 0.016$), including maximum circumference and overall circumference increase (Supplementary Table 1). Compared to the prepectoral group, the subpectoral reconstruction group exhibited a more aggressive progression of lymphedema, with a higher magnitude of lymphedema (circumference increase from baseline to peak) and a greater overall increase in circumference over the 2 years following the first diagnosis. Prepectoral-to-subpectoral comparisons

Table 3. Univariable and multivariable analyses of risk factors for lymphedema.

Characteristics	Univariable analysis		Multivariable analysis	
	Hazard ratio	*P*	Odds ratio	*P*
Patients' characteristics				
Age	0.98 (0.93–1.03)	0.386		
DM	0.38 (0.05–2.99)	0.359		
HTN	0.54 (0.12–2.42)	0.42		
Smoking	2.18 (0.56–8.44)	0.259		
BMI	0.99 (0.86–1.14)	0.894		
Surgical characteristics				
Reconstruction method				
DIEP	1.00 (reference)			
Prepectoral	1.77 (0.64–4.89)	0.268		
Subpectoral	1.89 (0.73–4.9)	0.189		
Axillary operation				
SLNB	1.00 (reference)			
ALND	4.67 (1.91–11.46)	< 0.001**	0.81 (0.23–2.82)	0.74
Pathological characteristics				
Tumor type				
In situ	1.00 (reference)			
Invasive carcinoma	2.21 (0.5–9.82)	0.297		
No. of dissected LNs	1.27 (1.06–1.53)	0.011**	1.1 (1.04–1.18)	0.0002**
Tumor-positive LNs	2.67 (1.96–3.64)	< 0.001**	2.49 (1.7–3.64)	<0.001 **
Treatment characteristics				
Postoperative RT (vs. none)	57.72 (7.68–433.58)	< 0.001**	198.55 (7.72–5109.38)	0.001**
Chemotherapy				
None	1.00 (reference)			
Adjuvant	3.12 (0.9–10.86)	0.074		
Adjuvant & neoadjuvant	4 (0.82–19.6)	0.087		

DM: diabetes mellitus; HTN: hypertension; BMI: body mass index; DIEP: deep inferior epigastric artery perforator; SLNB: sentinel lymph node biopsy; ALND: axillary lymph node dissection; LN: lymph node; RT: radiation therapy.

were significant for magnitude at both points and for the 2-year increase at Point B (all $P < 0.016$); the 2-year increase at Point A showed a trend ($P = 0.018$). In addition, the time to maximum circumference at Point A did not reach the Bonferroni-adjusted threshold ($P = 0.04$).

These findings suggest that the subpectoral reconstruction group experienced a more aggressive progression of lymphedema, reaching maximum circumference more quickly and with a greater magnitude compared to both the prepectoral and DIEP groups.

Soft tissue compliance of the upper extremity

In the unaffected upper extremity, compliance measured at both the upper and lower parts did not significantly change over the 2 years following diagnosis, regardless of the type of reconstruction. However, in the affected upper extremity, a significant difference in compliance change was observed among the three groups (Table 6).

Post hoc analysis confirmed that the DIEP group exhibited a greater increase in compliance compared to the IBR groups. In other words, autologous reconstruction resulted in improved soft tissue stiffness relative to IBR. In addition, the prepectoral group demonstrated a more significant enhancement in compliance than the subpectoral group (Supplementary Table 2).

In summary, both circumference and compliance analyses demonstrated that autologous reconstruction was associated with the most favorable lymphatic outcomes, whereas subpectoral reconstruction showed the most aggressive progression of BCRL.

Discussion

The impact of breast reconstruction type on the incidence of BCRL remains controversial. Some literature suggests that autologous reconstruction, particularly the DIEP flap, reduces BCRL risk through the 'lymphatic bridge' effect. This mechanism proposes that vascularized tissue transfer promotes lymphatic regeneration by providing a physical scaffold for neovascularization and releasing pro-lymphangiogenic growth factors, which helps to reconnect interrupted lymphatic channels across axillary defects [13–15]. However, other studies report no significant differences across reconstruction

Table 4. Comparison of clinicopathological characteristics in selected autologous and tissue expander/implant reconstruction groups.

Characteristics		DIEP ($n = 8$)	Prepectoral ($n = 9$)	Subpectoral ($n = 12$)	*P*
Patient characteristics					
Age		51.5 ± 1.6	48.7 ± 7.3	52.0 ± 8.5	0.532
DM (%)		0 (0.0)	1 (11.1)	0 (0.0)	0.316
HTN (%)		1 (12.5)	0 (0.0)	1 (8.3)	0.578
Smoking (%)		0 (0.0)	0 (0.0)	1 (8.3)	0.480
BMI		23.2 ± 1.4	24.5 ± 3.8	23.1 ± 2.5	0.447
Pathological characteristics					
Tumor type (%)	*In situ*	0 (0.0)	1 (11.1)	1 (8.3)	0.644
	Invasive carcinoma	8 (100)	8 (88.9)	11 (91.7)	
Mean no. of dissected LNs		9.6 ± 1.1	9.8 ± 1.4	9.6 ± 0.7	0.911
Tumor-positive LNs		2.9 ± 0.4	3.2 ± 1.0	2.7 ± 1.0	0.353
Surgical characteristics					
Axillary operation (%)	SLNB only	2 (25)	2 (22.2)	5 (41.7)	0.371
	ALND	6 (75)	7 (77.8)	7 (58.3)	
Treatment characteristics					
Chemotherapy (%)	None	0 (0.0)	2 (22.2)	1 (8.3)	0.305
	Adjuvant	8 (100)	6 (66.7)	8 (66.7)	
	Neoadjuvant & adjuvant	0 (0.0)	0 (0.0)	0 (0.0)	
Radiotherapy (%)	None	4 (50.0)	5 (55.6)	6 (50.0)	0.962
	Adjuvant	4 (50.0)	4 (44.4)	6 (50.0)	
Radiotherapy timing (%)	BCRL before RT	2 (50.0)	1 (25.0)	3 (50.0)	0.694
	BCRL after RT	2 (50.0)	3 (75.0)	3 (50.0)	

DIEP: deep inferior epigastric artery perforator; DM: diabetes mellitus; HTN: hypertension; BMI: body mass index; SLNB: sentinel lymph node biopsy; ALND: axillary lymph node dissection; BCRL: breast cancer-related lymphedema; RT: radiotherapy.

Table 5. Circumference ratio change between the different reconstruction groups.

Parameter	DIEP	Prepectoral	Subpectoral	*P*
Time for reaching the maximum circumference (month)				
Point A	18.00 ± 3.21	16.00 ± 4.24	12.25 ± 2.99	0.004**
Point B	18.75 ± 2.12	16.67 ± 4.00	14.00 ± 4.49	0.02**
Circumference increase (baseline to peak) (%)				
	DIEP	Prepectoral	Subpectoral	*P*
Point A	8 ± 2	12 ± 2	16 ± 2	< 0.001**
Point B	7 ± 1	12 ± 2	18 ± 3	< 0.001**
Circumference increase over two years after the first diagnosis (%)				
	DIEP	Prepectoral	Subpectoral	*P*
Point A	7 ± 2	11 ± 2	13 ± 3	< 0.001**
Point B	7 ± 1	11 ± 2	17 ± 3	< 0.001**

DIEP: deep inferior epigastric artery perforator.

modalities, indicating that oncologic treatments such as ALND and RT may be more dominant risk factors than the reconstructive technique itself [16, 17]. Consistent with these latter findings, our study observed no significant difference in the overall 2-year incidence of BCRL among the groups (DIEP: 8.9%, prepectoral: 14.8%, subpectoral: 15.6%; $P = 0.37$) [30, 31].

In this context, it is crucial to recognize that the clinical significance of BCRL extends beyond its initial occurrence. While existing literature has focused predominantly on incidence rates, this study provides a comprehensive longitudinal analysis of symptomatic progression, including soft tissue compliance and arm circumference. Monitoring these changes is essential because, as DiSipio et al. demonstrated, advanced BCRL often leads to chronic soft tissue fibrosis and a significantly increased risk of recurrent cellulitis [2]. Furthermore, Hayes et al. highlighted that the progression of lymphedema severity is a major determinant of long-term disability, showing a strong correlation with a decline in upper-body function and overall quality of life [10]. As the disease progresses, the resulting tissue stiffness becomes increasingly irreversible due to protein-rich fluid accumulation and subsequent adipogenesis [11, 12]. Therefore, identifying reconstructive factors that mitigate such progression, rather than merely measuring incidence, is vital for optimizing long-term therapeutic outcomes [13, 14].

Consistent with the necessity of monitoring progression, our results reveal distinct symptomatic patterns across the three groups. Although all groups generally exhibited a phase of aggravation for 12 to 18 months post-diagnosis before reaching a plateau, the magnitude and timing of these changes varied by reconstruction method. The DIEP flap group showed the most favorable course, characterized by a delayed progression and a smaller magnitude of aggravation compared to implant-based groups. Conversely, implant-based groups experienced more rapid and significant limb volume increases, with the subpectoral group exhibiting the most pronounced aggravation. Notably, 41.7% of BCRL cases in the subpectoral group occurred after sentinel lymph node biopsy (SLNB) alone (Table 4). This suggests that the subpectoral environment may lower the physiological threshold for BCRL, enabling even minimal axillary disruption to trigger significant progression. Ultimately, while the initial incidence may be comparable across techniques, the reconstructive modality dictates the subsequent disease course, highlighting its critical role in modulating long-term severity. The physiological mechanisms underlying these outcomes reside in the interplay between anatomical preservation and the efficacy of postoperative rehabilitation. Beyond the benefits of vascularized regeneration, the intrinsic properties of the DIEP flap as a soft,

Table 6. Compliance ratio changes between different reconstruction groups.

Site	Compliance differences over two years (%)			
	DIEP	Prepectoral	Subpectoral	*P*
Unaffected limb				
Point A	2.78 ± 1.07	4.45 ± 2.35	3.85 ± 1.42	0.162
Point B	2.46 ± 1.56	2.41 ± 1.35	2.13 ± 1.48	0.908
Affected limb				
Point A	17.55 ± 1.42	12.73 ± 2.69	12.42 ± 1.97	< 0.001**
Point B	14.11 ± 1.71	8.43 ± 2.51	8.14 ± 1.67	< 0.001**

DIEP: deep inferior epigastric artery perforator.

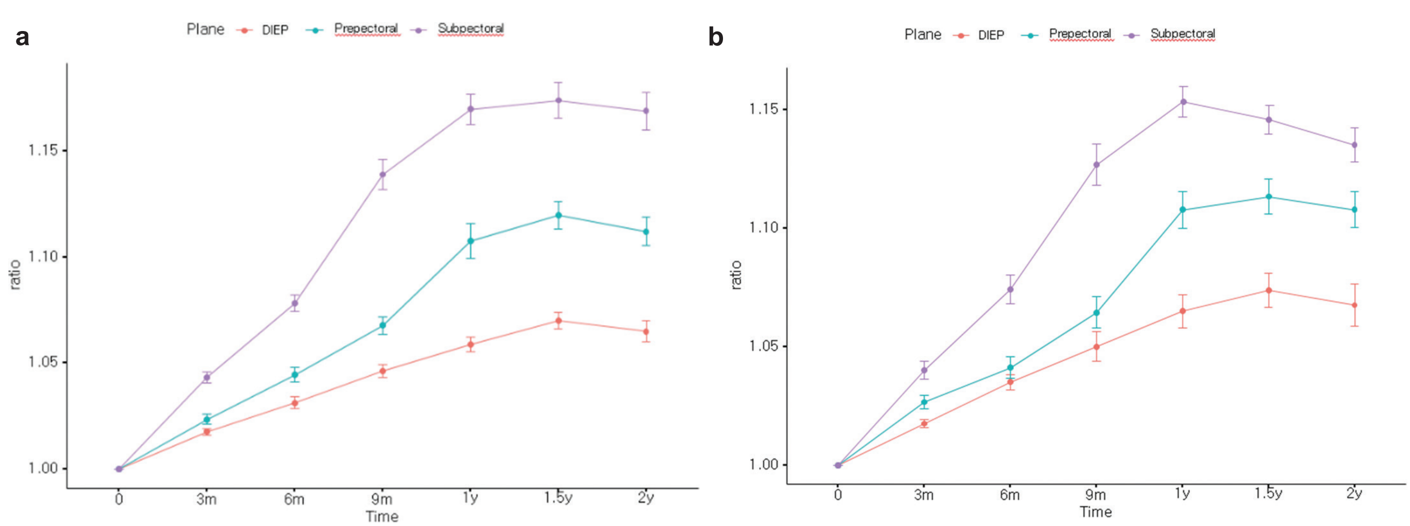

Figure 1. Circumference changes over a two-year follow-up after the first diagnosis, comparing various reconstruction types (*1a*: Point A, *1b*: Point B). DIEP, deep inferior epigastric artery perforator.

compliant tissue provide a distinct biomechanical advantage [29]. Unlike the rigid surface of an implant, autologous tissue maintains a physiological environment that allows for natural pressure distribution during movement. This high tissue compliance minimizes mechanical resistance against interstitial fluid flow, and the absence of foreign body reactions typically associated with periprosthetic fibrosis prevents the sustained inflammatory state that can exacerbate lymphatic stasis [18].

Interestingly, in IBRs, the prepectoral technique offers similar advantages by preserving the pectoralis major muscle in its entirety, maintaining its natural anatomical position and functional tension without the need for muscle disinsertion [19, 21, 32]. Unlike subpectoral placement, which induces a 'clinching' effect through muscular contraction against a fixed prosthesis, the prepectoral approach avoids chronic mechanical compression of deep lymphatic pathways and prevents the elevation of interstitial pressure [33]. Furthermore, differences in postoperative shoulder joint mobility between the two groups likely contributed to the variations in lymphedema progression. Compared to the subpectoral approach, the prepectoral technique is associated with superior shoulder range of motion (ROM) and reduced postoperative pain, which facilitates earlier and more effective physical exercise [22, 23]. This favorable reconstructive environment is critical for maximizing the benefits of clinical interventions. As Scaffidi et al. and Lu et al. demonstrated, a progressive strength training program can lead to an approximate 50% reduction in the risk of lymphedema exacerbations (7.0% in the exercise group vs. 12.0% in the control group) [34-36].

This study has several limitations. Firstly, this was a retrospective, single-institution study with a modest number of events. Secondly, we did not include a control group of patients who underwent mastectomy without reconstruction, as our primary focus was on comparing reconstructive planes. Thirdly, standardized Quality of Life (QoL) assessments were not performed due to the retrospective nature of the analysis. Future prospective studies incorporating non-reconstructed controls and validated QoL instruments are warranted to provide more comprehensive evidence.

Conclusion

In conclusion, this study is the first to compare both the incidence and clinical course of BCRL across autologous, prepectoral, and subpectoral reconstruction. While the 2-year incidence of BCRL was comparable among groups, the clinical progression differed significantly: autologous and prepectoral IBR were associated with a less severe course than subpectoral IBR. These findings suggest that the reconstructive approach may influence the subsequent trajectory of BCRL. Confirmation in larger, prospective cohorts – incorporating both objective clinical markers and validated QoL instruments – will be essential to validate these observations and to inform strategies aimed at minimizing lymphedema burden and improving postoperative quality of life.

Funding

None.

Ethical approval

Not required.

Disclosure statement

The authors have no financial interest to declare in relation to the content of this article. The study did not receive any funding.

References

[1] Lang JE, Summers DE, Cui H, et al. Trends in post-mastectomy reconstruction: a SEER database analysis. J Surg Oncol. 2013;108:163–168. https://doi.org/10.1002/jso.23365
[2] DiSipio T, Rye S, Newman B, et al. Incidence of unilateral arm lymphoedema after breast cancer: a systematic review and meta-analysis. Lancet Oncol. 2013;14:500–515. https://doi.org/10.1016/S1470-2045(13)70076-7
[3] Leung N, Furniss D, Giele H. Modern surgical management of breast cancer therapy-related upper limb and breast lymphoedema. Maturitas. 2015;80:384–390. https://doi.org/10.1016/j.maturitas.2015.01.012
[4] Suami H, Chang DW. Overview of surgical treatments for breast cancer-related lymphedema. Plast Reconstr Surg. 2010;126:1853–1863. https://doi.org/10.1097/PRS.0b013e3181f44658
[5] Ciudad P, Manrique OJ, Date S, et al. Advances in microsurgical breast reconstruction: the role of lymphatic surgery in preventing and treating breast cancer-related lymphedema. Plast Reconstr Surg. 2021;147:865e-878e.
[6] Chang DW, Suami H, Skoracki R. Lymphaticovenular bypass for lymphedema management in breast cancer patients: a prospective study on long-term outcomes. J Surg Oncol. 2020;122:1015–1022.
[7] Ridner SH, Dietrich MS, Stewart BR, et al. Body mass index and breast cancer treatment-related lymphedema. Support Care Cancer. 2011;19:853–857. https://doi.org/10.1007/s00520-011-1089-9
[8] Togawa K, Ma H, Sullivan-Halley J, et al. Risk factors for self-reported arm lymphedema among female breast cancer survivors: a prospective cohort study. Breast Cancer Res. 2014;16:414. https://doi.org/10.1186/s13058-014-0414-x
[9] McLaughlin SA, Wright MJ, Morris KT, et al. Prevalence of lymphedema in women with breast cancer 5 years after sentinel lymph node biopsy or axillary dissection: objective measurements. J Clin Oncol. 2008;26:5213–5219. https://doi.org/10.1200/JCO.2008.16.3725
[10] Hayes SC, Janda M, Cornish B, et al. Lymphedema after breast cancer: incidence, risk factors, and effect on upper body function. J Clin Oncol. 2008;26:3536–3542. https://doi.org/10.1200/JCO.2007.14.4899
[11] Lee KT, Mun GH, Lim SY, et al. The impact of immediate breast reconstruction on post-mastectomy lymphedema in patients undergoing modified radical mastectomy. Breast. 2013;22:53–57. https://doi.org/10.1016/j.breast.2012.04.009
[12] Blanchard M, Arrault M, Vignes S. Positive impact of delayed breast reconstruction on breast-cancer treatment-related arm lymphoedema. J Plast Reconstr Aesthet Surg. 2012;65:1060–1063. https://doi.org/10.1016/j.bjps.2012.03.019
[13] Siotos C, Sebai ME, Wan EL, et al. Breast reconstruction and risk of arm lymphedema development: a meta-analysis. J Plast Reconstr Aesthet Surg. 2018;71:807–818. https://doi.org/10.1016/j.bjps.2018.01.012
[14] Lee KT, Bang SI, Pyon JK, et al. Method of breast reconstruction and the development of lymphoedema. Br J Surg. 2017;104:230–237. https://doi.org/10.1002/bjs.10397
[15] Yan A, Avraham T, Zampell JC, et al. Mechanisms of lymphatic regeneration after tissue transfer. PLoS One. 2011;6:e17201.

https://doi.org/10.1371/journal.pone.0017201

[16] Menezes MM, Bello MA, Millen E, et al. Breast reconstruction and risk of lymphedema after mastectomy: a prospective cohort study with 10 years of follow-up. J Plast Reconstr Aesthet Surg. 2016;69:1218–1226. https://doi.org/10.1016/j.bjps.2016.06.001

[17] Crosby MA, Card A, Liu J, et al. Immediate breast reconstruction and lymphedema incidence. Plast Reconstr Surg. 2012;129:789e–795e. https://doi.org/10.1097/PRS.0b013e31824a2ab1

[18] Basta MN, Fischer JP, Kanchwala SK, et al. A propensity-matched analysis of the influence of breast reconstruction on subsequent development of lymphedema. Plast Reconstr Surg. 2015;136:134e–143e. https://doi.org/10.1097/PRS.0000000000001417

[19] Sigalove S, Maxwell GP, Sigalove NM, et al. Prepectoral implant-based breast reconstruction: rationale, indications, and preliminary results. Plast Reconstr Surg. 2017;139:287–294. https://doi.org/10.1097/PRS.0000000000002950

[20] Copeland-Halperin LR, Yemc L, Emery E, et al. Evaluating post-operative narcotic use in prepectoral versus dual-plane breast reconstruction following mastectomy. Plast Reconstr Surg Glob Open. 2019;7:e2082.

[21] Schaeffer CV, Dassoulas KR, Thuman J, et al. Early functional outcomes after prepectoral breast reconstruction: a case-matched cohort study. Ann Plast Surg. 2019;82:S399–S403. https://doi.org/10.1097/SAP.0000000000001669

[22] Wormer BA, Valmadrid AC, Ganesh Kumar N, et al. Reducing expansion visits in immediate implant-based breast reconstruction: a comparative study of prepectoral and subpectoral expander placement. Plast Reconstr Surg. 2019;144:276–286.

[23] Salibian AA, Frey JD, Choi M, et al. Subcutaneous implant-based breast reconstruction with acellular dermal matrix/mesh: a systematic review. Plast Reconstr Surg Glob Open. 2016;4:e1139. https://doi.org/10.1097/GOX.0000000000001139

[24] Plachinski SJ, Boehm LM, Adamson KA, et al. Comparative analysis of prepectoral versus subpectoral implant-based breast reconstruction. Plast Reconstr Surg Glob Open. 2021;9:e3709.

[25] Frederik GH, Diana LD, Camila B, et al. Prepectoral and subpectoral direct-to-implant breast reconstruction yield high cosmetic scores: surgeon ratings favor prepectoral placement-secondary results from a randomized controlled trial. JPRAS Open. 2025:48:12–17. https://doi.org/10.1016/j.jpra.2025.10.008

[26] Vidya R, Casado-Sanchez C. Prepectoral breast reconstruction: a comprehensive review of current trends and outcomes. J Clin Med. 2024;13(1):257.

[27] Anete A, Christopher J, Luia A, et al. Prepectoral breast reconstruction with and without acellular dermal matrix: a systematic review and meta-analysis. Gland Surg. 2025;14(11):2238–2257. https://doi.org/10.21037/gs-2025-309

[28] Lee JH, Shin BW, Jeong HJ, et al. Ultrasonographic evaluation of therapeutic effects of complex decongestive therapy in breast cancer-related lymphedema. Ann Rehabil Med. 2013;37: 683–689. https://doi.org/10.5535/arm.2013.37.5.683

[29] Jeon HB, Jung JH, Im SH, et al. Association between immediate breast reconstruction and the development of breast cancer-related lymphedema. Plast Reconstr Surg. 2023;151:214e–222e. https://doi.org/10.1097/PRS.0000000000009831

[30] Card A, Crosby MA, Liu J, et al. Reduced incidence of breast cancer-related lymphedema following mastectomy and breast reconstruction versus mastectomy alone. Plast Reconstr Surg. 2012;130:1169–1178. https://doi.org/10.1097/PRS.0b013e31826d0faa

[31] Lee KT, Kim J, Jeon BJ, et al. Association of the breast reconstruction modality with the development of postmastectomy lymphedema: a long-term follow-up study. Eur J Surg Oncol. 2023;49:1177–1183. https://doi.org/10.1016/j.ejso.2023.01.027

[32] Lee JS, Park E, Lee JH, et al. A prospective comparison study of early functional outcomes after implant-based breast reconstruction: subpectoral versus prepectoral technique. Ann Palliat Med. 2021;10:2520–2529. https://doi.org/10.21037/apm-20-1550

[33] Shikhman A, Erz L, Brown M, et al. Prepectoral conversion of subpectoral implants for animation deformity after breast reconstruction: technique and experience. Plast Reconstr Surg Glob Open. 2022;10:e4132. https://doi.org/10.1097/GOX.0000000000004132

[34] Lu SR, Hong RB, Chou W, et al. Role of physiotherapy and patient education in lymphedema control following breast cancer surgery. Ther Clin Risk Manag. 2015;11:319–327. https://doi.org/10.2147/TCRM.S77669

[35] Scaffidi M, Vulpiani MC, Vetrano M, et al. Early rehabilitation reduces the onset of complications in the upper limb following breast cancer surgery. Eur J Phys Rehabil Med. 2012;48:601–611.

[36] Schmitz KH, Troxel AB, Cheville A, et al. Physical activity and lymphedema (The PAL Trial): assessing the safety of progressive strength training in breast cancer survivors. Contemp Clin Trials. 2009;30(3):233–245. https://doi.org/10.1016/j.cct.2009.01.001