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Breast

The Extended Chest Wall Perforator Flap: Expanding the Indication for Partial Breast Reconstruction

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Background: The intercostal artery perforator flap has traditionally been used to reconstruct small or moderate-sized single defects in the lateral or lower medial breast during breast-conserving surgery. We report a modification of the intercostal artery perforator flap that allows for reconstruction of larger breast tumors than previously described flap designs.

Methods: A retrospective study of breast cancer patients undergoing breast-conserving surgery and immediate partial breast reconstruction with an extended chest wall perforator flap. Primary outcomes were successful tumor excision, adequate radial margins, postoperative complications, and delays to adjuvant radiotherapy.

Results: Thirty patients were included. Mean radiological tumor size was 27 mm (11–56 mm) and excision volume, 123 cm^3 (18–255 cm^3). All tumors had satisfactory excision margins, and no patient required further surgery for re-excision. In the early postoperative period, one patient required radiological drainage of seroma, and one returned to theater for debridement of fat necrosis affecting the flap. Ten other patients were managed on an outpatient basis for minor wound complications. All patients were followed up annually for 5 years. No patients had a delay to adjuvant treatment or required revisional procedures for cosmesis.

Conclusions: The modified chest wall perforator flap allows for breast conservation for larger tumors from all quadrants of the breast, including centrally located tumors and reconstruction of the axillary defect following lymph node clearance. The length of the flap allows for the use of multiple perforators in the pedicle area and freedom of the flap to reach the defects. This can be performed with low morbidity and no delay to adjuvant radiotherapy. *(Plast Reconstr Surg Glob Open 2024; 12:e5697; doi: 10.1097/GOX.0000000000005697; Published online 26 March 2024.)*

INTRODUCTION

The oncological safety of breast-conserving surgery (BCS) in early breast cancer has been established since the 1980s with the publication of randomized trials showing that the overall survival and local control after BCS and radiotherapy were equivalent to that of mastectomy.[1] Oncoplastic breast surgery (OPBS) techniques extend the role of BCS, enabling the surgeon to not only surgically treat breast cancer, but aim for the best possible aesthetic outcome, preserving the patients' quality of life. Up to 75% of women with non-invasive and 80% of women with invasive cancer are now being managed with BCS.[2] Published evidence supports the oncological safety of OPBS. A meta-analysis of 31 studies by Mohamed and colleagues showed equivalent outcomes in terms of re-excision rate and loco-regional recurrence to conventional BCS.[3] Down and colleagues reported that larger cancers can be removed with OPBS compared with standard BCS.[4] A variety of techniques have been described that allow excision of sizeable tumors without compromising the natural shape of the breast, including simple glandular reshaping, therapeutic mammoplasty, and autologous volume replacement. The first reported use of muscle-sparing pedicled chest wall perforator flaps (CWPFs) based on intercostal perforating vessels in reconstruction of the breast was by Hamdi et al,[5] who described the lateral intercostal artery perforator (LICAP) flap to fill defects in the outer breast. The design of the LICAP flap has been modified by reconstructive surgeons in the intervening years; however; its indication is somewhat limited to small or moderate-sized, single defects in the lateral or lower medial breast.

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ANATOMY

The vascular anatomy of the breast and chest wall has been extensively studied by Palmer and Taylor[6] and Hamdi et al.[7] The cutaneous blood supply has been demonstrated to arise from paired perforating vessels, which form a "continuous network of interconnecting arteries and arterioles."[6] The internal thoracic, posterior intercostal, acromiothoracic, and lateral thoracic arteries are the dominant supplying vessels to the skin and subcutaneous tissue of the chest wall and breast.

The internal thoracic artery, a branch from the first part of the subclavian artery, arises at the first intercostal space to travel caudally down the inner surface of the anterior chest wall 1–2 cm lateral to the sternum. At the sixth intercostal space, it divides into the superior epigastric and musculophrenic terminal branches. Between the second and fourth intercostal spaces, the artery gives off large lateral perforating branches, which provide around 60% of the blood supply to the breast parenchyma. Smaller lateral branches of the internal thoracic and musculophrenic arteries course with the intercostal bundle as the anterior intercostal arteries in the groove of the corresponding rib. These arteries give off a number of small perforating cutaneous branches, which supply the overlying skin and subcutaneous tissue of the chest wall.

The lower nine posterior intercostal arteries arise as branches of the descending aorta, traveling from the posterior trunk, in the intercostal bundle of the corresponding rib, toward the lateral chest. They too provided perforating cutaneous branches to supply the chest wall. At the lateral aspect of the chest wall, the anterior intercostal arteries anastomose with the posterior intercostal arteries to form an arcade. The course of these vessels can be divided into vertebral, intercostal, intermuscular, and rectus segments. It is these intercostal perforating vessels that supply the various CWPFs (Fig. 1A).

The LICAP flap uses redundant tissue from the lateral chest wall (Fig. 1b), is supplied by perforators originating from the intercostal segment, and is most suitable for lateral breast defects.[7] These vessels are most frequently located between the fifth and eight intercostal spaces, approximately 3 cm from the anterior border of the latissimus dorsi (LD) muscle. The most dominant perforator can be found in the sixth intercostal space between 2.5 and 3.5 cm from the anterior border of the LD muscle, as demonstrated by anatomical studies.[7]

In addition to the intercostal artery perforator vessels, the lateral thoracic artery (LTA) provides supply to the lateral breast parenchyma. The LTA arises from the second part of the axillary artery and travels inferomedially along the inferior border of pectoralis minor the towards serratus anterior as far as the fifth intercostal space (Fig. 1C). Clinically, the LTA is found posterior to the lateral curve of the breast and gives off lateral mammary branches, between the third and fifth intercostal space, which supply the breast. The largest and most consistent of these can be found approximately 8–12 cm inferior to the axillary fold which is landmarked by the inferolateral angle of the breast. This perforator can be incorporated, in addition to intercostal perforators, into an LICAP flap to fill lateral and inferior breast defects.

Takeaways

Question: Can the indications for breast conservation and reconstruction be expanded to include larger or multicentric tumors?

Findings: We report the extended chest wall perforator flap modification to replace breast volume after excision of tumors up to 55 mm, also allowing for reconstruction of the defect left following axillar dissection, with good long-term aesthetic outcomes.

Meaning: Our experience of using the modification of the chest wall perforator flap has allowed effective and reliable breast reconstruction after breast conservation, including large, centrally located tumors and reconstruction of the axillary defect after lymph node clearance.

The medial intercostal artery perforator is based on perforating branches originating from the muscular and rectus segments of the intercostal vessels. The anterior intercostal artery perforator is based on perforators originating from these anterior branches. We have developed the technique of extended CWPF which can be used in immediate breast reconstruction to repair larger and even multiple defects including filling the axillary defect following axillary clearance (Fig. 1D).

METHODS

This is a retrospective study of breast cancer patients treated at the Norfolk and Norwich University Hospital undergoing BCS and immediate partial breast reconstruction with an extended CWPF. Patients requiring wide local excision (WLE) with an estimated excision volume greater than or equal to 20% of breast volume or requiring an oncoplastic reconstruction beyond simple glandular reshaping or conventional volume replacement were included for analysis. These patients were diagnosed either via the NHS breast screening program or by symptomatic referral from general practice, underwent standard clinical assessment, diagnostic mammography, ultrasound and core biopsy for diagnosis. Contrast-enhanced mammography, magnetic resonance imaging and staging investigations were performed where indicated. Treatment decisions were discussed in both breast cancer and reconstruction multidisciplinary team meetings. Pre- and postoperative photography was carried out by the hospital medical illustration department.

All operations were carried out by a single surgeon between July 2017 and August 2023. Patients were reviewed by the operating surgeon at weeks 1 and 3 postoperatively, more frequently if required. Patients underwent adjuvant treatment according to local protocol. Postoperative complications were classified by the Clavien-Dindo system.[8] Standard follow-up was on a 12-month basis thereafter.

The primary outcomes were successful tumor excision with adequate radial margins, incidence of postoperative complications, and delay to adjuvant radiotherapy. Data were collected and stored in accordance with hospital ethical and clinical guidelines, and patient's permission was

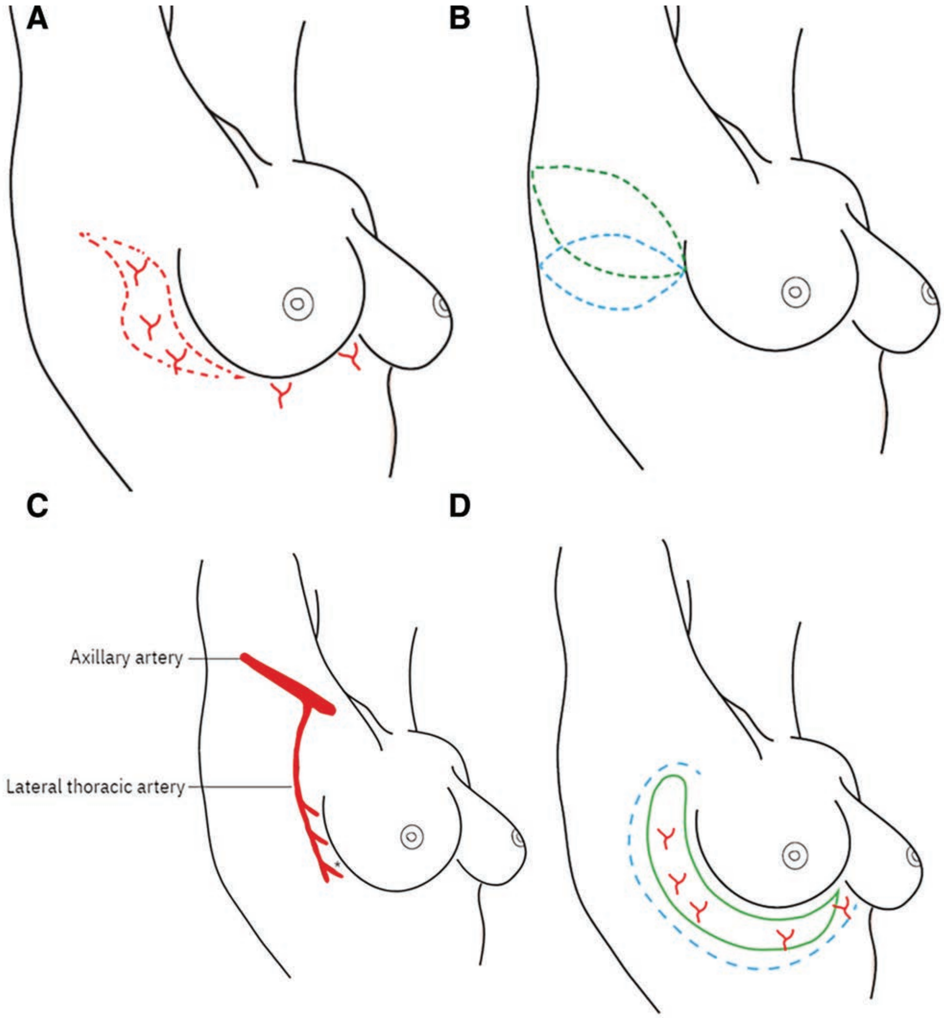

Fig. 1. Chest wall perforator flap relevant anatomy. A, Image of the modified LICAP flap design described by Meybodi et al.[9] The position of chest wall perforators are marked in red. B, Image of LICAP flap designs described by Hamdi et al.[7] C, Image of the LTA and perforators, with the large LTA perforator marked by *. D, Image of our extended LICAP flap design suitable for larger and multiple defects. Flap design (green) and potential extent of subcutaneous dissection (blue).

obtained to use anonymized photographs for educational and publication purposes.

Surgical Technique

Patient markup: preoperatively, with the patient sitting, marking of the mid axillary line, inframammary fold, lateral breast crease, anterior border of the LD muscle, tumor location, and expected excision size. With the patient supine and arm in the operating position, a handheld Doppler was used to assess and mark the position of the LTA and any intercostal perforating vessels located between the lateral breast crease and 1 cm anterior to the LD muscle (Fig. 2A). The flap design is then based on the lateral breast crease, extending superiorly toward the axilla and inferiorly parallel to the inframammary fold (IMF), according to perforator position and available skin laxity (Fig. 1D). Flap measurements can be up to 7–12 cm in width and 30–40 cm in length. In addition, for inner quadrant tumors, the anterior intercostal perforators were located and marked 1–3 cm lateral to the sternal margin at the level of the IMF.

Patient positioning was supine with arm extended, supported by an arm board with a sandbag placed under the shoulder to raise the scapula and shoulder. Alternatively, the arm can be supported using a bar support with the shoulder in 90 degrees of flexion, internally rotated and the elbow flexed to 90 degrees.

Tumor excision is approached from the lateral breast crease or IMF to avoid any injury to perforators. The specimen is weighed, and final flap size and volume adjustment is made (Fig. 2B). The flap length is dependent on both the location of the defect, distance to IMF, or lateral border of the breast. Approximately one-quarter of the flap length is needed for the pedicle, and up to a further quarter by tunneling the flap if required; this needs to be taken into account when designing flap size. Sterile handheld

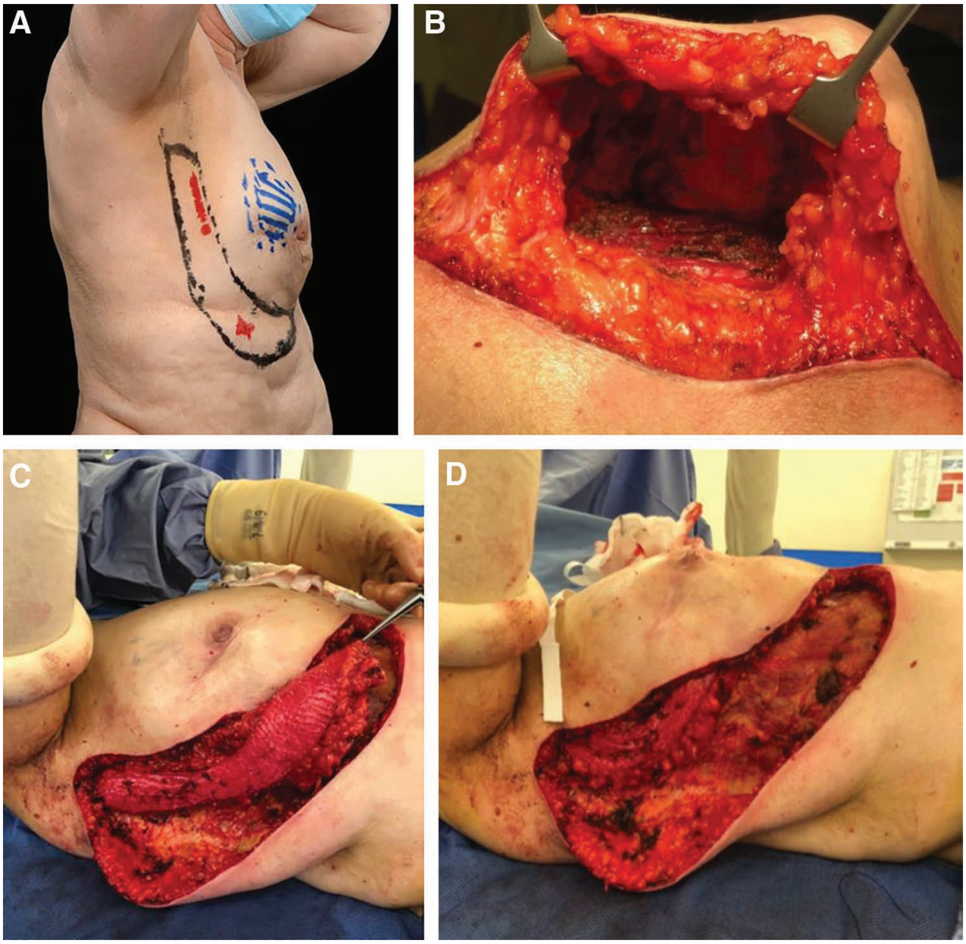

Fig. 2. Chest wall perforator flap relevant anatomy. A, Photograph of the preoperative marking of expected excision (blue), extended LICAP flap (black), LTAP, and intercostal perforating vessels (red). B, Photograph of the excision cavity of the same patient after WLE. C, Photograph showing the extent of flap dissection, based on the LTAP. D, Photograph of the flap rolled and positioned to fill large defect.

Doppler is used to confirm perforator position and course. The flap is then dissected from the chest wall, leaving the muscle fascia intact, from posterior to anterior, taking care to avoid injury to perforator vessels at the anterior border of the LD muscle. The aim is to preserve as many perforators as possible within the flap design, sacrificing only those which restrict movement and reach. Subcutaneous dissection beyond the incision can be carried out if more flap volume is required. The flap is then de-epithelialized and moved as a turnover or propellor flap into the defect and supported in position with nonabsorbable suture to breast parenchyma or pectoralis muscle fascia (Fig. 2C). Volume can be gained by rolling the flap. The longer flap allows for multiple rolls/folds and, hence, a larger volume. Rolling the flap perpendicular to the incision rather than rolling parallel produces more projection if required.

Reconstruction of the IMF and lateral breast border was undertaken using nonabsorbable sutures. Closure of the donor site was carried out with nonabsorbable deep dermal and absorbable subcuticular suture (Figs. 2D, 3, 4). In the case of tumor excision and axillary clearance, the flap can be based on perforating vessels (Fig. 5A–C), either a single perforator located centrally to the flap or two perforating vessels, which allow the flap to be flipped into position (Fig. 5D) to reconstruct both the breast and axillary defects, giving a good cosmetic result (Fig. 6).

RESULTS

Between July 2017 and August 2023, 2791 breast cancer operations were carried out in our unit, comprising 1881 WLEs, 798 mastectomies, 74 therapeutic mammoplasties, and 38 flap reconstructions. Thirty patients with a diagnosis of invasive breast cancer or ductal carcinoma in situ were treated with BCS and reconstruction with an extended CWPF. Preoperatively, tumor size and diagnosis were assessed by mammography, contrast-enhanced mammography, ultrasound, breast magnetic resonance imaging, and core biopsy. The mean age at the time of surgery was 57 years (range 41–77 years), and body mass index, 26 kg per m^2 (range 23–32). Twelve patients were ex-smokers and two were current cigarette smokers. The indication for surgery was invasive ductal carcinoma in 22 patients (73%), ductal carcinoma in situ in four

Fig. 3. Figure of the immediate postoperative appearance (same patient as in Fig. 2).

(13%), and invasive lobular carcinoma in four (13%). The majority of tumors were located in the upper outer (43%) and lower outer (33%) quadrants. Seven (23%) patients received neoadjuvant chemotherapy indicated by triple negative status and human epidermal growth factor receptor 2 positivity. Three (10%) received neoadjuvant endocrine therapy. The mean radiological tumor size was 27 mm with a range of 11–56 mm. Patient characteristics are shown in Table 1.

The mean radiological tumor size was 42.5 mm (range 35–55 mm) in C to D cup patients compared with 20.4 mm (range 13–40 mm) in A to B cup patients. Mean specimen weight was 57 g in A and B cup patients, 76 g in C cup and 125 g in D cup patients. Four patients required axillary lymph node dissection with extended LICAP flap to fill both defects (Figs. 5 and 6). All patients had immediate reconstruction. The mean histological tumor size was 27 mm (range 10–55 mm), specimen weight 72 g (range 18–166 g), and volume 123 cm^3 (range 18–cm^3). All tumors had satisfactory excision margins, and no patients required further surgery for re-excision. The mean radial margin was 4.6 mm (range 1–10 mm) from invasive disease.

The overall rate of complications was 40% with the majority of those being Clavien-Dindo grades I (10%) and II (23%). Three patients developed small area of wound dehiscence and were managed with dressings. Seroma of the donor site occurred in three patients who were managed with needle aspiration only. Three patients developed superficial erythema of the wound, which resolved with short course of oral antibiotics. Three patients required hospital admission for intravenous antibiotics and one of these had radiologically guided drainage of an infected collection at the donor site. One patient developed fat necrosis of the flap requiring return to theater for debridement. No patients had a delay to the start of their adjuvant treatment. Nine patients went on to receive chemotherapy, and 25 had received whole breast

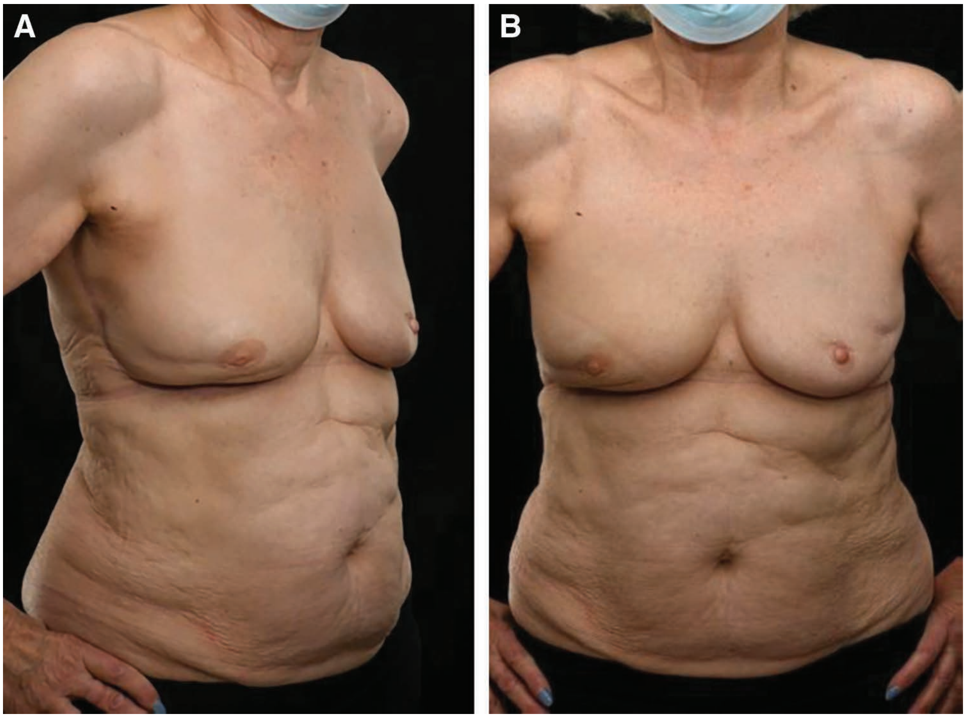

Fig. 4. Figure of the cosmetic result at 2 years (same patient as in Fig. 2).

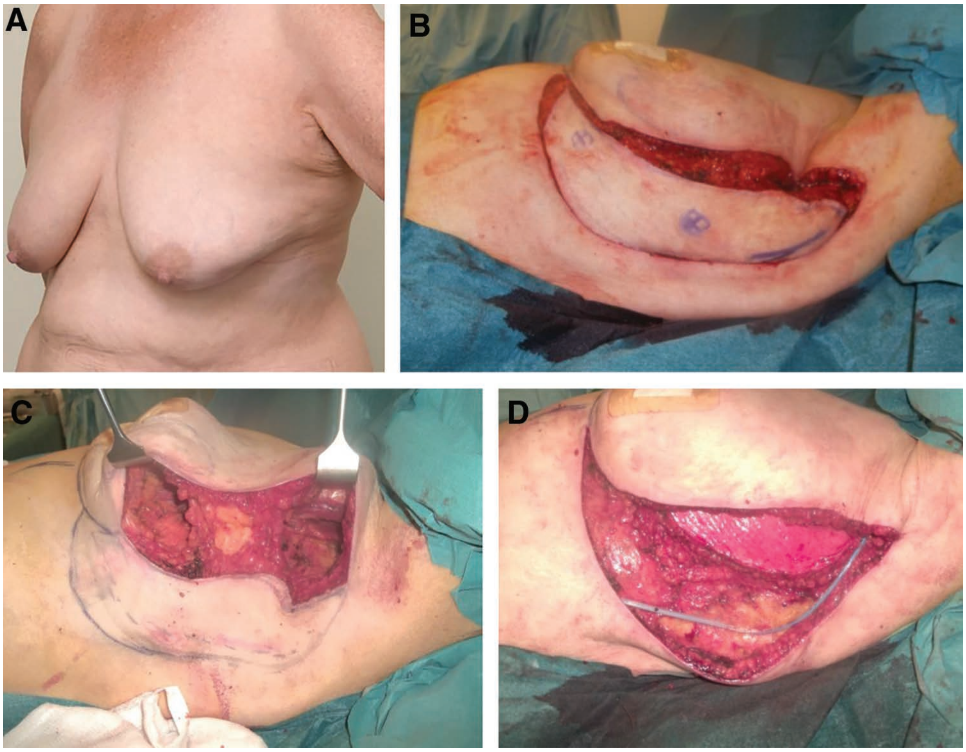

Fig. 5. Patient with lower outer quadrant tumor. A, Image of a patient with a 23-mm lower outer quadrant tumor preoperative appearance. B, Image of the extent of flap design with two perforating vessels marked. C, Image of the size of defects after WLE and axillary clearance. Flap is based on central perforating vessels. D, Image of the inferior part of the flap rolled to fill tumor cavity, superior part flipped in to fill axilla.

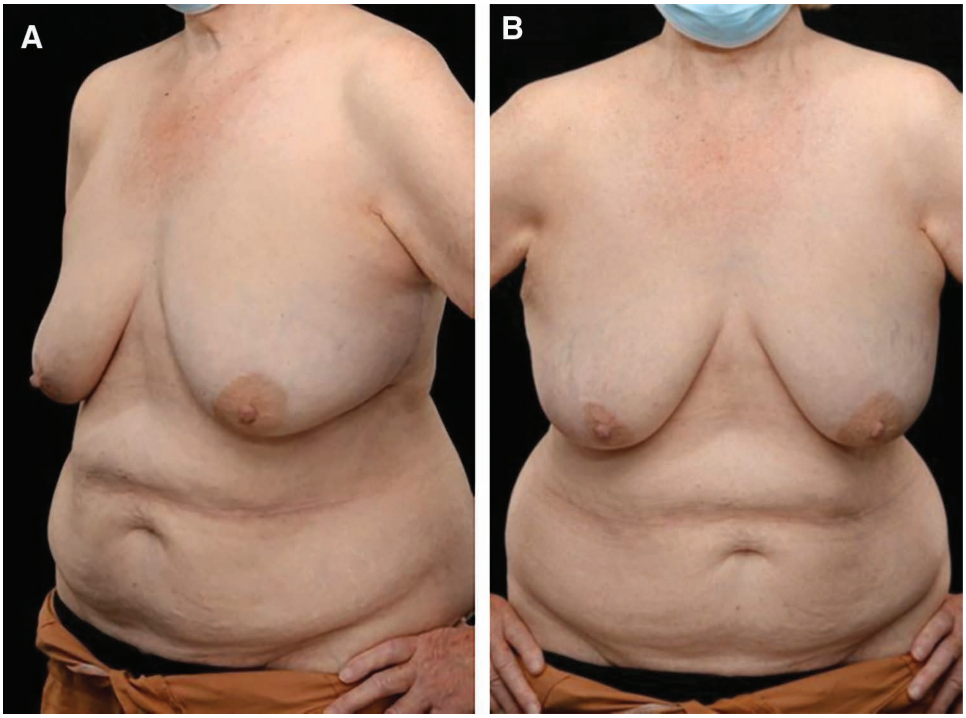

Fig. 6. Image of the cosmetic result at 1 year.

Table 1. Patient and Tumor Characteristics

Parameter	*N* = 30
Mean age (range)	57 y (41–77 y)
Mean BMI (range)	26 kg/m^2 (23–32 kg/m^2)
Smoking Status	
Never smoked	14 (53%)
Ex-smoker	12 (40%)
Current cigarette smoker	2 (7%)
Bra Cup Size (%)	
A	3 (10%)
B	12 (40%)
C	13 (43%)
D	2 (7%)
Pathology (%)	
Invasive ductal carcinoma	22 (73%)
Ductal carcinoma in situ	4 (13%)
Invasive lobular carcinoma	4 (13%)
Mean radiological tumor size (range)	27 mm (11–56 mm)
Tumor Location (%)	
Upper outer	13 (43%)
Lower outer	10 (33%)
Lower inner	4 (13%)
Upper inner	1 (3%)
Central	2 (7%)
Neoadjuvant Treatment (%)	
None	20 (67%)
Endocrine therapy	3 (10%)
Chemotherapy	7 (23%)
Mean specimen weight (range)	72 g (18–166 g)
Mean specimen volume (range)	123 cm^3 (18–255 cm^3)
Mean histological tumor size (range)	27mm (10–55 mm)
Postoperative complications (%)	12 (40%)
Clavien-Dindo Classification (%)	
Grade 1	3 (10%)
Grade 2	7 (23%)
Grade 3	2 (7%)

radiotherapy. Median length of follow-up was 16 months (range: 1–64 months). At the last follow-up, no patient has required revisional surgery to correct cosmesis.

DISCUSSION

The technique of volume replacement using pedicled perforator flaps for immediate breast reconstruction to facilitate BCS in patients who would otherwise require mastectomy was first published by Hamdi et al.[5] The LICAP flap was based on a single intercostal perforating vessel with the dissection extending posteriorly toward the anterior edge of the LD muscle. The maximum flap dimension was suggested to be 25×30 cm and indicated for lateral breast defects only. The flap was relatively restricted in reach by the position of the supplying vessel and resulted in a long scar extending toward the patient's back. The original LICAP flap design was modified by Meybodi et al[9] to negate the need for patient repositioning intraoperatively and produce a more aesthetic scar using two "lazy S" incisions starting from the inframammary fold line and extending toward the lower axilla. It was designed only for lateral defects. Reconstruction of the medial breast after breast cancer excision was detailed by Denning and Hayes[10] with a crescentic anterior intercostal artery perforator flap for inferior pole tumors using a skin paddle based on anterior intercostal artery perforators positioned at the meridian of the breast inferior to the IMF, utilizing extension of the flap into the subcutaneous tissue overlying the upper abdomen inferiorly. The LICAP flaps are an excellent addition to the portfolio of the reconstructive breast surgeon, but their indication is limited to small or moderate-sized tumors, particularly in patients with lower BMIs.

We have described a further modification of the CWPF, allowing for reconstruction of larger breast tumors than previously described flap designs. Traditional LICAP designs are propellor flaps that are based on a single cutaneous perforator. Anatomical studies have shown that perforasomes, the vascular territory specific to a single perforator, are linked to adjacent perforasomes with potential for multidirectional flow.[11] Incorporating multiple perforators into the flap pedicle means that extending both the flap length and extent of subcutaneous tissue dissection can be done safely with low risk of flap necrosis. We have successfully used the extended flap with low morbidity in 30 patients with tumors in the lateral, medial, and central breast as well as those requiring axillary clearance. Our rates of postoperative complications are consistent with other series reporting LICAP flap reconstruction.[12] The inframammary fold was reconstructed in all cases and no displacement was noted, even in postradiotherapy patients.

We have successfully removed larger tumors from all quadrants of the breast, including centrally located tumors. The length of the flap allows for the use of multiple perforators in the pedicle area and freedom of the flap to reach the defects. The extent of subcutaneous dissection, particularly at the flap apex, allows for more volume at the part of the flap required for reconstruction. No patients required nipple repositioning at the time of reconstruction or correction of nipple deviation at a later date. We have also reported reconstruction of the axillary defect at the same time as reconstructing the breast defect. The long length of the flap and subcutaneous dissection at both ends allows for resection of two defects and flap based on multiple perforators in its middle part. This flap allows for maximum use of all the available tissue around the breast for reconstruction if required.

Of particular benefit is the scar position, which is cosmetically acceptable and does not extend toward the patient's back as seen with traditional LICAP designs. The donor site is very acceptable, with low complications. The classical LICAP (Fig. 1A) cannot achieve such length and volume of the extended flap without extending the scar posteriorly into the back region. The modified LICAP length described by Meybodi et al[9] is limited to the length of the lateral mammary crease. Our modification described in this work allows for a very wide dissection, a larger volume of flap to maintain an excellent cosmetic outcome.

We have demonstrated here that patients with larger tumors can have BCS and reconstruction using the pedicled CWPF with low morbidity and no delay to adjuvant treatment. Our further aim is to gather patient-reported outcomes.

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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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