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Authors
Salibian, Ara
Patel, Ketan

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Microsurgery in oncoplastic breast reconstruction

Ara A. Salibian[1]^, Ketan M. Patel[2]

[1]Division of Plastic & Reconstructive Surgery, University of California Davis School of Medicine, Sacramento, CA, USA; [2]Division of Plastic & Reconstructive Surgery, Cedars-Sinai Medical Center, Los Angeles, CA, USA

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Correspondence to: Ketan M. Patel, MD. Division of Plastic & Reconstructive Surgery, Cedars-Sinai Medical Center, 8635 W 3rd Street #770W, Los Angeles, CA 90048, USA. Email: Ketan.m.patel.md@gmail.com.

Abstract: Oncoplastic breast reconstruction has allowed for the optimization of oncologic and reconstructive outcomes after breast-conserving surgery (BCS). Volume replacement procedures in oncoplastic reconstruction most commonly utilize regional pedicled flaps, though several studies have reported benefits to free tissue transfer for oncoplastic partial breast reconstruction in the immediate, delayed-immediate and delayed settings. Microvascular oncoplastic breast reconstruction is a useful technique in the appropriate patients with small-to-medium size breasts and larger tumor-to-breast ratios who desire to preserve breast size, those with a paucity of regional breast tissue and patients that wish to avoid chest wall and back scars. Several free flap options for partial breast reconstruction exist, including superficially-based abdominal flaps, medial thigh-based flaps, deep inferior epigastric artery perforator (DIEP) flaps and thoracodorsal artery-based flaps. However, special consideration should be given to preserving donor sites for potential future total autologous breast reconstruction with any flap choice that should be tailored to individual recurrence risk. Aesthetically placed incisions should take recipient vessel access into consideration which include the internal mammary vessels and perforators medially, and then intercostal, serratus branch and thoracodorsal vessels laterally. The utilization of a thin strip of lower abdominal tissue based on the superficial abdominal circulation allows for a well-concealed donor site with minimal morbidity and preservation of the abdominal donor site if future total autologous breast reconstruction is needed. Optimizing outcomes requires a team-based approach to appropriately design recipient and donor-site considerations while individualizing tumor and patient-specific plans.

Keywords: Oncoplastic breast reconstruction; breast-conserving surgery (BCS); microsurgery; free flap

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Introduction

Breast conserving surgery has demonstrated survival benefits when compared to mastectomy in recent population-based studies (1). Oncoplastic breast surgery has become increasingly accepted as a multidisciplinary team-based approach to optimizing oncologic and reconstructive outcomes after breast-conserving surgery (BCS) (2). Studies have demonstrated fewer positive margins (3), lower re-excision rates (4), decreased complications (5) and improved patient satisfaction (6) compared to standard BCS. Oncoplastic breast surgery has therefore preserved the oncologic benefits of breast conserving therapy while minimizing the negative aesthetic sequelae associated with radiation therapy.

^ ORCID: 0000-0002-0659-6242.

The goals of on oncoplastic breast reconstruction include the restoration of breast shape and contour while optimizing breast symmetry through aesthetically-placed incisions. This is achieved either through glandular rearrangement, volume displacement techniques, or using volume replacement with regional or remote tissue to minimize deadspace and restore contour. Oncoplastic reconstruction is typically indicated for Level 2 BCS procedures, or when 15–20% of the breast volume is to be removed (7).

Several factors are taken into consideration when deciding on the appropriate reconstructive technique including tumor size, breast size and patient desired breast size, tumor-to-breast ratio and tumor location. Many algorithms have been described to help guide patients and surgeons to the appropriate displacement and replacement techniques based on these factors (8). Volume displacement procedures typically capitalize on larger breast size and/or ptosis to rearrange the breast parenchyma and redrape the skin through mastopexy and reduction-type procedures. On the other hand, volume replacement techniques are preferred in patients with inadequate residual breast tissue to restore shape and contour or in smaller-breasted patients that wish to preserve breast size. The most common volume replacement techniques utilize regional tissue based on chest wall perforators including the intercostal vessels, thoracodorsal and lateral thoracic vessel and internal mammary perforators (9-16). In certain select cases, free tissue transfer for volume replacement also serves as an excellent technique to restore shape and contour.

Microvascular oncoplastic reconstruction

Microvascular partial breast reconstruction was first described by Rizzuto *et al.* in 2004 in which a superficial inferior epigastric artery (SIEA) flap was used to reconstruct a partial mastectomy defect in a delayed fashion after completion of radiation (17). Since then, multiple small series have utilized both abdominal and non-abdominal donor sites for oncoplastic breast reconstruction in the immediate, delayed-immediate and delayed settings (18-20).

While not as common as pedicled techniques, free tissue transfer for oncoplastic volume replacement offers unique advantages in appropriately indicated cases including flexibility in flap design and volume, limited disruption of the anatomic borders of the breast and avoidance of chest wall and back scars. Microvascular oncoplastic reconstruction also has unique considerations compared to traditional volume replacement techniques including incision planning, recipient vessel access and flap choice with preservation of options for future autologous breast reconstruction. Understanding the appropriate indications, available techniques, donor site morbidity and common challenges for these procedures can help optimize the use of free tissue transfer in the oncoplastic algorithm.

Preoperative considerations

Patient selection

Volume replacement oncoplastic procedures have traditionally been indicated for patients with small-to-medium sized breasts and planned resections of greater than 50% of breast tissue (7). However, patients with smaller breasts and smaller tumor-to-breast resection ratios can also benefit from volume replacement, as opposed to simple glandular rearrangement (21), if they wish to preserve breast size. Volume replacement with both pedicled and free tissue transfer is feasible in these patients, and several defect and patient-specific factors help guide decision-making.

Pedicled chest wall perforator flaps are particularly well-suited for lateral and central tumors when rotated or transposed from the lateral chest wall (9,22,23). Medial and superior defects can also be reached with anterior intercostal and internal mammary perforator-based flaps (10,24); however, these locations can be more challenging to address with pedicled options. Infero- and supero-medial defects are particularly well-suited for partial reconstruction with free flaps (18,20) given the proximity to internal mammary perforators for recipient vessels.

Estimated defect size should also be considered in relation to the available donor tissue volume. Patients with lower body mass index (BMI) and a paucity of regional chest wall tissue may be better suited for free tissue transfer for volume restoration. Remote donor sites should also be assessed for adequate volume, especially if preservation of future total autologous breast reconstruction sites is attempted. Finally, concealed remote donor sites such as the lower abdomen and medial thigh can be considered in patients who do not desire additional back or chest wall scars (8).

Timing

Oncoplastic breast reconstruction is most commonly performed at the time of BCS. Volume displacement procedures have demonstrated significantly higher rates of complications when performed in a delayed fashion after

Figure 1 Inframammary fold incision for medial tumor with use of internal mammary perforators as recipient vessels.

Figure 2 Vertical incision with lateral inframammary fold extension for lateral tumor access with use of intercostal perforators for recipient vessels.

completion of radiation therapy (25). Parenchymal fibrosis, skin contracture, scarring, and tissue damage impede wound healing and also present challenges for reconstructive planning. Delayed oncoplastic reconstruction with free tissue transfer, however, has not demonstrated higher rates of wound healing complications in small series (19). Comparable outcomes to immediate reconstruction are likely secondary to use of non-radiated healthy tissue from remote sites, similar to delayed outcomes with pedicled flaps (25). However, reconstruction prior to radiation may be desired to prevent the sequelae associated with radiation fibrosis and the likely need for skin replacement in true delayed procedures.

Confirmation of negative tumor margins is critical particularly in cases with higher concern for adequate margins, such as patients with ductal carcinoma in situ (DCIS). In these higher-risk cases, a delayed-immediate approach (26) can be utilized to allow for margin confirmation, but reconstruction prior to radiation. Delayed-immediate reconstruction should still be performed in an expedient manner to avoid delaying radiation greater than 12 weeks and increasing risk of recurrence (27).

Preoperative planning

Preoperative planning for microvascular oncoplastic reconstruction requires a thorough understanding of both the extirpative procedure at the recipient site and the available options for donor tissue. Estimated tumor size, focality and location, as well as discussion of the planned resection with the breast surgeon help guide free flap planning. Patient tolerance of additional breast and remote donor site scars as well as desired breast size also play an important role in deciding on the appropriate reconstructive option.

Incision planning should be discussed preoperatively with both the patient and the breast surgeon to arrive at the optimal design. In the immediate setting, variations of incisions for aesthetic breast surgery are typically attempted including partial periareolar, vertical and inframammary fold (IMF) incisions. These incisions must allow for appropriate access for the extirpative procedure but also for recipient vessel access and microsurgery. IMF (*Figure 1*) and vertical incisions typically allow for access to the medial internal mammary perforators whereas variations of vertical and IMF incisions can provide access to the lateral chest wall vessels (*Figure 2*). When planning to use recipients along the lateral chest wall, axillary incisions used for sentinel node biopsies can also provide excellent access, though require tunnel the pedicle. Superior pole tumors may require more visible transverse incisions on the breast mound depending on tumor location (18). In delayed cases, existing incisions with or without the use counter-incisions can be utilized to access the lumpectomy defect as well as recipient vessels.

Multiple different types of free flaps have been described

Table 1 Free flap options for oncoplastic microsurgical breast reconstruction

Flap
DIEP*
Gracilis (transverse, diagonal)
Omentum**
PAP
SIEA†
SCIA†
TDAP

*, sacrifices abdominal donor site for future total autologous reconstruction; **, does not allow for cutaneous reconstruction; †, low and narrow flap design can still preserve the abdominal donor site for future total autologous reconstruction. DIEP, deep inferior epigastric artery perforator; PAP, profunda artery perforator; SIEA, superficial inferior epigastric artery; SCIA, superficial circumflex iliac artery; TDAP, thoracodorsal artery perforator.

for partial breast reconstruction (*Table 1*). The largest series of microvascular partial breast reconstruction preferentially utilized the abdominal donor site based on the SIEA system, and less frequently deep inferior epigastric artery perforator (DIEP) flaps (20) when the SIEA was intraoperatively deemed to be insufficient (3). A unique consideration in microvascular oncoplastic reconstruction, however, is the preservation of potential donor site for future total breast reconstruction. The SIEA and DIEP flap designs by Spiegel *et al.* necessitate umbilical transposition and were acknowledged to "burn the bridge" for future abdominally-based breast reconstruction. The authors therefore recommended against this procedure in higher risks patients.

Alternatively, non-abdominal donor sites have also been utilized for microvascular oncoplastic reconstruction. Zaha *et al.* described a laparoscopically-harvested free omental flap for immediate partial breast reconstruction that maintained size and contour through adjuvant radiation (28). However, as the omentum does not provide skin for resurfacing, this flap is not ideal for delayed reconstructions that often have some component of a cutaneous defect from scar contracture. The medial thigh has also been utilized with smaller transverse and diagonal gracilis flaps as well as profunda artery perforator (PAP) flaps (18,19). These donor sites can provide adequate flap volume and pedicle length for most partial defects. However, the medial thigh is also a common donor site for total autologous reconstruction in thinner patients that lack abdominal volume. Finally, the back has also been described for free tissue transfer in the form of thoracodorsal artery perforator (TDAP) flaps (19), which similarly can provide excellent volume and pedicle length for partial defects. Issues of desired scar placement as well as sacrifice of pedicled bail out options, however, should also be considered at this site.

The abdominal donor site can also be utilized while still preserving the majority of abdominal tissue for future reconstruction, if needed. Planning a low transverse incision and a "mini-flap" of limited height (*Figure 3*) allows for preservation of the DIEP flap donor site while still providing adequate tissue based either on the SIEA or superficial circumflex iliac artery (SCIA) systems for partial breast reconstruction. However, this technique does have volume limitations in order to minimize the height of the flap and preserve the abdominal donor site. While some volume can be increased by flap folding, defects significantly larger than 100 g require alternative donor sites or procedures. Additionally, certain studies have elucidated concerns over superficial-dominant drainage of DIEP flaps. As the mini-flap does require sacrifice of the SIEV, this may require adjustments in perforator selection in the case of a "superficial dominant" flap.

Intraoperative considerations

Recipient vessels

All procedures performed in this work were in accordance with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for publication of this manuscript and any accompanying images. A copy of the written consent is available for review by the editorial office of this journal. Recipient vessel access is likely the most important consideration in microvascular oncoplastic reconstruction (*Table 2*). Limited incisions, partial defects and limited pedicle length depending on flap choice can provide significant challenges for free tissue transfer and require appropriate planning of incisions and flap design. In the medial chest, the internal mammary vessel perforators serve excellent recipient vessels when preserved during the partial mastectomy. While the proper internal mammary vessels are ideally preserved for potential future total autologous reconstruction (29), use of the internal mammary vessels for partial reconstruction still allows for their proximal/

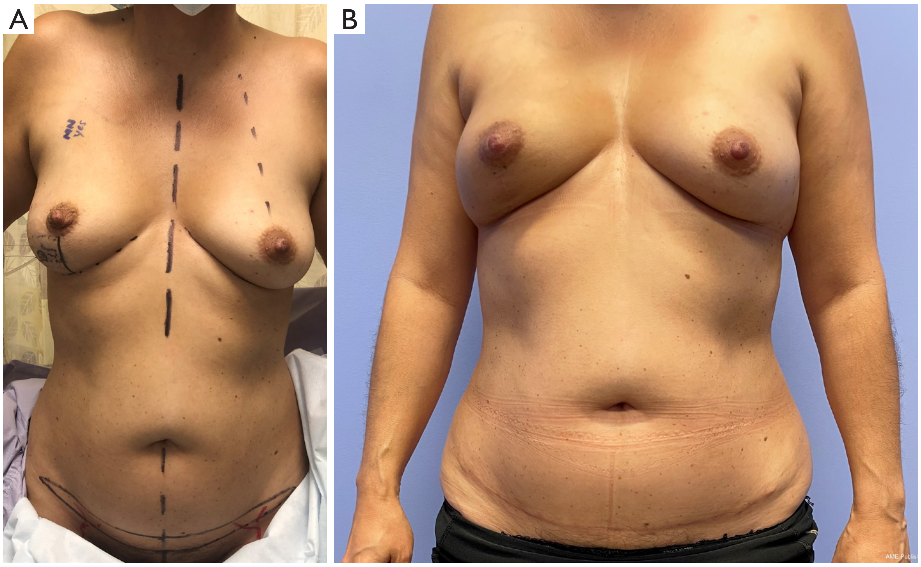

Figure 3 A 46-year-old female with right lower quadrant ductal carcinoma in situ. (A) The patient underwent partial mastectomy through a vertical and lateral inframammary fold incision and immediate reconstruction with a small superficial circumflex iliac artery-based flap anastomosed to a chest wall perforator. (B) Postoperative photo 3 months after completion of radiation.

Table 2 Recipient vessels for oncoplastic microsurgical reconstruction

Recipient vessel location
Medial
Internal mammary perforators
Internal mammary vessels
Lateral
Intercostal perforators
Lateral thoracic vessels
Serratus branch
Thoracodorsal vessels

distal utilization beyond intact branches, anastomosis to the prior pedicle, or lateral chest wall vessels, if needed (19). The lateral chest wall has an abundance of vessels that can be used as recipients including the intercostal perforators, serratus branch and lateral thoracic vessels. The thoracodorsal vessels are typically avoided, as possible, to preserve the latissimus flap as a future potential backup option in the future.

Flap choice and defect location also have significant implications for recipient vessel usability. The DIEP, medial thigh-based and TDAP flaps should provide pedicle length to reach either the medial or lateral chest from most breast defect locations. Smaller SIEA and SCIA-based flaps, however, have shorter pedicles that may have difficulty reaching medial or lateral recipients from central defects in wide-chested patients, necessitating the use of vascular grafts.

Flap design

Flap design should take into consideration the necessary volume to eliminate deadspace and restore shape, the need for skin, and the optimization of pedicle length for the desired recipient vessels. In immediate reconstruction, final flap size should be based on the final size and/or weight of the lumpectomy specimen. In delayed cases, this can be more challenging due to fibrosis of subcutaneous tissue and gland as well as contracture of the skin envelope that may require design of a larger flap, including a skin component, after thorough scar release.

Typically, volume goals for the therapeutic breast in oncoplastic reconstruction are made slightly larger than the contralateral to account for radiation fibrosis and shrinkage (30). Spiegel *et al.* designed flaps around 20% larger than the respective defect to account for radiation changes in immediate cases (20) whereas Smith *et al.* advocate for achieving breast symmetry without oversizing regardless of timing (19). The latter authors recommend

Table 3 Oncoplastic microsurgical breast reconstruction

Key points
Design aesthetic incisions for oncologic and recipient vessel access
Confirm final resection size prior to flap isolation
Preserve options for total autologous breast reconstruction
Maximize pedicle length (eccentric flap design)
Define recipient vessels prior to final flap design
Design flap slightly larger than lumpectomy size if maintaining breast size is desired
Consider delayed-immediate approach in high-risk cases for recurrence (i.e., DCIS)
Team-based approach with oncologic surgeon in all cases
Shared decision-making and preoperative counseling on expected outcomes is critical

DCIS, ductal carcinoma in situ.

addressing radiation volume loss by reducing the contralateral breast; however, patient desiring to preserve as much breast size as possible may benefit from oversizing to avoid contralateral reductions. Excess volume present after completion of radiation therapy easily be addressed with suction lipectomy.

Flap design in abdominally-based reconstructions is particularly critical if attempting to preserve the abdomen for potential future total breast reconstruction. Rizzuto *et al.* initially described the lower SIEA design in partial mastectomy reconstruction to avoid transposing the umbilicus (17). This principle can be taken a step further to design the flap as a narrow strip of lower abdominal tissue in the underwear line based on either the dominant SIEA or SCIA system, while preserving the majority of abdominal tissue for future DIEP flaps, as needed. In these instances, it is critical to design flaps eccentrically around their respective pedicle to maximize pedicle length.

Postoperative considerations

Small series in the literature have demonstrated low rates of complications with microvascular oncoplastic reconstruction in the immediate, delayed-immediate and delayed settings (17,19,20). Expeditious completion of radiation therapy in immediate cases is critical to maintaining the efficacy of breast conserving therapy (27), and any wound healing complications regardless of how minor should be addressed aggressively. Patients should continue routine postoperative cancer monitoring according to oncologic guidelines similar to traditional oncoplastic procedures. Spiegel *et al.* reported no cases of recurrence in 12 patients with a mean follow-up length of 5 years (20). Secondary revisions can include fat grafting, liposuction, skin paddle excision and contralateral procedures as needed. Smith *et al.* reported overall revision rates of 27% in free flap oncoplastic reconstructions, comparable to 20% in traditional pedicled volume replacement procedures (19).

Conclusions

Volume replacement techniques in oncoplastic breast reconstruction have traditionally been limited to regional pedicled flaps; however, ongoing data has suggested a role for free tissue transfer in these cases as well. Consideration free tissue transfer options after breast conserving surgery only expands the potential tools in oncoplastic breast reconstruction through a collaborative approach that may optimize aesthetic results in patients that may not otherwise be good candidates for volume replacement techniques. Microsurgical oncoplastic breast reconstruction is particularly well-suited for small-breasted patients desiring to preserve breast size, those with a paucity of regional tissue and for medial breast defects in the immediate, delayed-immediate and delayed settings. Important considerations include aesthetically designed incisions, recipient vessel access, maximizing pedicle length and ensuring flap design preserves autologous options for potential future total breast reconstruction (*Table 3*). Larger comparative studies will help refine indications for this procedure within the overall algorithm of oncoplastic reconstruction.

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