# Perforator Flaps: Recent Experience, Current Trends, and Future Directions Based on 3974 Microsurgical Breast Reconstructions

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**Summary:** Perforator flap breast reconstruction is an accepted surgical option for breast cancer patients electing to restore their body image after mastectomy. Since the introduction of the deep inferior epigastric perforator flap, microsurgical techniques have evolved to support a 99 percent success rate for a variety of flaps with donor sites that include the abdomen, buttock, thigh, and trunk. Recent experience highlights the perforator flap as a proven solution for patients who have experienced failed breast implant–based reconstructions or those requiring irradiation. Current trends suggest an application of these techniques in patients previously felt to be unacceptable surgical candidates with a focus on safety, aesthetics, and increased sensitization. Future challenges include the propagation of these reconstructive techniques into the hands of future plastic surgeons with a focus on the development of septocutaneous flaps and vascularized lymph node transfers for the treatment of lymphedema. (*Plast. Reconstr. Surg.* 124: 737, 2009.)

Breast cancer is a significant national health care issue, as it will affect one in eight of women born today.[1,2] Although breast conservation therapy has been shown to be effective, mastectomy remains a frequent treatment modality.[3,4] *BRCA* genetic mutations have precipitated a new surge of prophylactic mastectomy over long-term surveillance protocols.[5–8]

Mastectomy has been associated with a psychologic insult that prompts many women to seek breast reconstruction.[9–13] The *need* to "become whole again" is a common scenario. Breast reconstruction is characterized either as (1) an implant-based or (2) an autologous reconstruction method. Implant-based reconstructions predominate, followed by muscle-sacrificing autologous methods such as the transverse rectus abdominis musculocutaneous (TRAM) flap, with perforator flaps following at a distant third.[14]

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## RECENT EXPERIENCE

### Established Perforator Flaps

The deep inferior epigastric perforator (DIEP) flap is the most recognized perforator flap today.[15–17] The reason for this may lie in the improved aesthetic appearance of the postoperative abdomen with minimal donor-site morbidity. Others might suggest it is the ease of the technical dissection and adequate size match to common recipient vessels that has supported its popularity. A shift to an abdominal-based, nonperforator flap free flap, namely, the superficial inferior epigastric artery (SIEA) flap, which confers a similar aesthetic improvement, has been described.[18–20] Of note, not all patients with adequate abdominal adiposity are candidates for this approach, as a SIEA diameter of less than 1.5 mm has been associated with a higher arterial thrombosis rate.[21]

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**Table 1. Established Perforator Flaps**

| Perforator Flap | Pedicle Artery Diameter (mm) | VC Diameter (mm) | Pedicle Length (cm) |
|---|---|---|---|
| DIEP | 2.3 | 2.7 | 11 |
| SIEA* | 1.9 | 2.8 | 8 |
| SGAP | 2.5 | 3.4 | 6 |
| IGAP | 2.2 | 3.4 | 9.5 |
| ICPF | NA | NA | 2 |
| TDAP | 2.2 | 2.7 | 13 |

IGAP, inferior gluteal artery perforator; ICPF, intercostal perforator flap; TDAF, thoracodorsal artery perforator; VC, venae comitantes. *The SIEA flap is not a perforator flap, but it was included because it is commonly considered in the setting of an abdominal donor site.

Regardless, not all patients are candidates for DIEP or SIEA flaps as they present with prior surgical procedures of the abdomen or minimal abdominal adiposity. Other perforator flaps have emerged to address alternative donor sites (Table 1). The gluteal artery perforator flap can be designed to recruit adipose tissue from either the upper [superior gluteal artery perforator (SGAP) flap][18,22–25] or lower (inferior gluteal artery perforator flap) buttock.[26,27] Most would agree that the inferior gluteal artery perforator flap is technically more difficult but turn to it as the salvage flap of choice when the abdomen and internal mammary vessels are no longer a viable option for reoperation procedures given its pedicle length.

Intercostal perforator flaps have been introduced to add volume to breast reconstructions.[28] These flaps are rotational in design and can be used in the outpatient surgical setting, typically at the second stage. The thoracodorsal artery perforator (TDAP) flap too has been used to add volume to an existing breast and to augment volume of a prior flap reconstruction, but in select patients can be used to reconstruct an entire breast (Fig. 1).[29,30]

### Failed Implant Reconstruction

U.S. Food and Drug Administration–mandated clinical trials have revealed failure rates of implant-based breast reconstruction in the range of 50 percent at 7 years.[31,32] When breast implants fail to provide a durable reconstructive approach, many women seek alternative forms of secondary reconstruction. Perforator flaps have gained popularity in this regard, as many fear the loss of function associated with the sacrifice of muscle in several rotational flaps.[33–36] They express concern regarding the use of prosthetic mesh and/or homograft in an abdominal donor site in the attempt to avoid abdominal wall bulging and/or frank hernia, which are well known to be associated with the TRAM flap experience.[37–41] Perforator flaps offer a viable solution, as they are performed indepen-

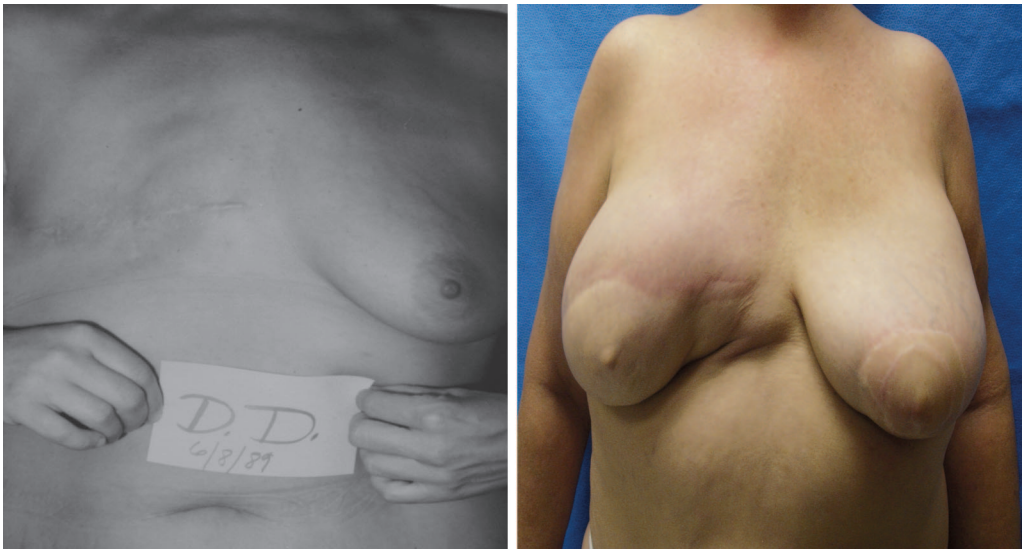


**Fig. 1.** Eighteen-year follow-up of a SIEA flap and 14-year follow-up of a TDAP flap breast reconstruction in a 35-year-old woman who presented with stage I right breast cancer following mastectomy for autologous breast reconstruction (*left*). The patient underwent reconstruction with a SIEA flap on the right and counterbalancing mastopexy augmentation (240 cc, subglandular). The patient presented 4 years later with a contralateral breast cancer treated with mastectomy and TDAP flap reconstruction. Eighteen-year follow-up of the SIEA flap right breast reconstruction and 14-year follow-up of the TDAP flap left breast reconstruction in the setting of patient weight gain of 35 lb is provided (*right*).

dent of muscle/nerve sacrifice and the associated loss of function; also, they typically do not require the incorporation of prosthetic materials or homograft in the repair of the donor site.

**Irradiated Patients**

Recent experience notes a shift in focus from the proven safety of immediate perforator flap breast reconstruction to that of identifying pa-

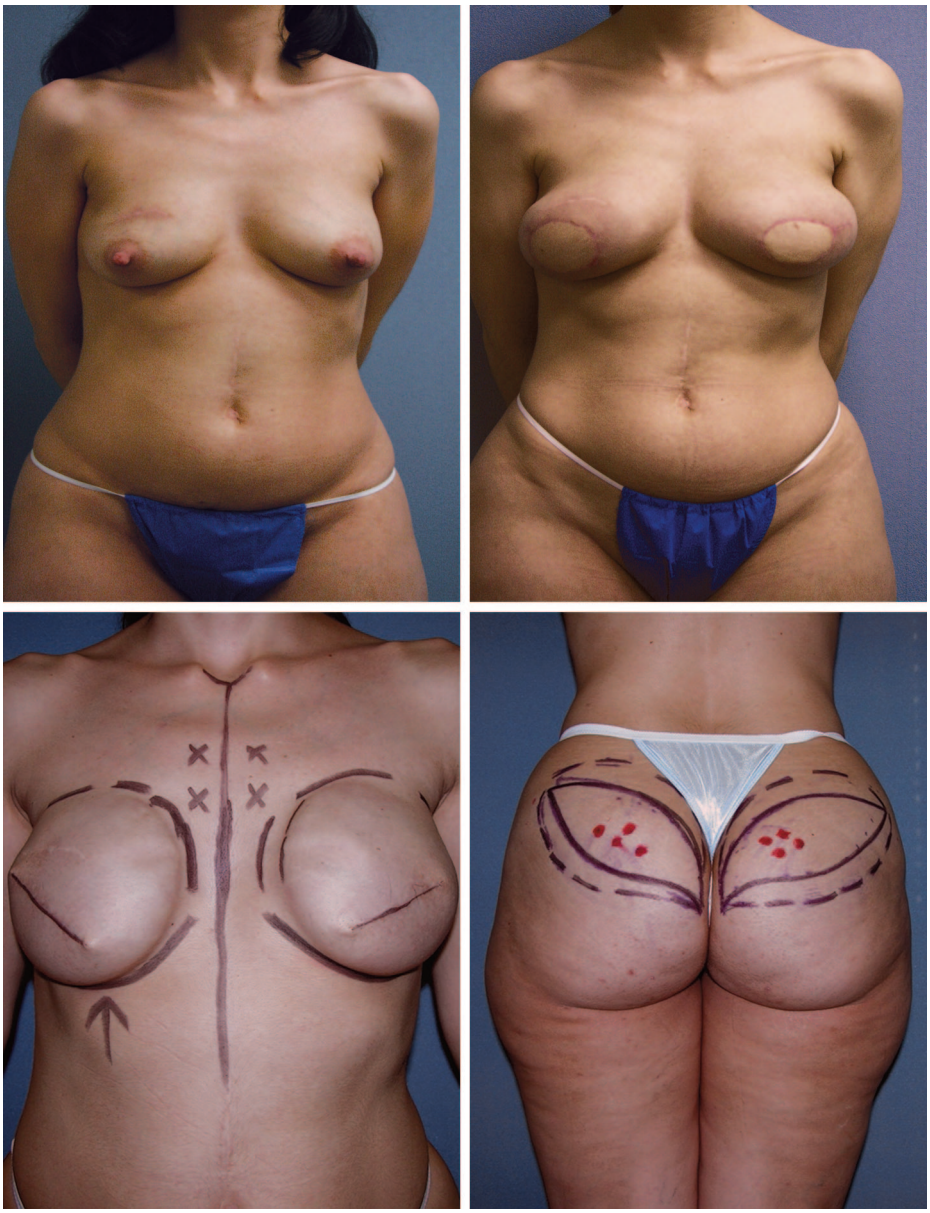

**Fig. 2.** Role of "babysitter" saline-filled implants with staged bilateral SGAP flaps in a 39-year-old woman with a family history of breast cancer who presented with stage I lobular carcinoma of the right breast for bilateral mastectomies and breast reconstruction (*above*, *left*). She underwent a comprehensive educational series regarding her reconstructive options and elected to proceed with bilateral skin-sparing mastectomies (right, 260 g; left, 260 g) and immediate babysitter saline-filled tissue expanders [Mentor Siltex (Mentor Corp., Santa Barbara, Calif.) size 275 cc filled to 120 cc bilaterally]. She underwent staged tissue expansion to a final volume of 280 cc on the right and 300 cc on the left (*below, left*). The patient elected to proceed with autologous reconstruction, namely, bilateral SGAP flaps (*below*, *right*). Her postoperative appearance at 3 months just before nipple reconstruction is shown (*above*, *right*).

tients who will benefit from a *delayed* approach. Most experts agree that irradiation of a perforator flap is less desirable and can be associated with an increased incidence of fat necrosis and decreased aesthetic acceptability.[42,43] Our preoperative approach includes the aggressive use of radiographic and surgical staging before mastectomy, namely, breast magnetic resonance imaging plus diagnostic lumpectomy and the sentinel lymph node procedure. Breast magnetic resonance imaging also is used in the context of prophylactic mastectomy to increase the identification of mammographic occult malignancies in high-risk patients.[44–47]

Some patients requiring irradiation elect to defer all reconstructive plans until 6 months after the completion of adjuvant therapy. Others elect to proceed with more novel approaches in which "babysitter" saline-filled breast implants or tissue expanders may be placed as temporary devices (Fig. 2). The choice of a submuscular tissue expander over a saline-filled subcutaneous implant rests on the viability of mastectomy skin flaps and final reconstructive size requirements. Notably, there are regions of the country that have failed to embrace skin-sparing mastectomy. Tissue expansion can be attained quickly for these patients during chemotherapy with the use of a submuscular tissue expander. It is important to note that the pectoralis major muscle is returned to its native position when patients return for staged flap reconstruction. Autologous flap reconstructions are always placed superficial to the pectoralis major muscle specifically to avoid the abnormal movement seen in subpectoral breast implants.

One other advantage to this approach is that it "burns no bridges," as patients gain personal experience with a device-based reconstruction. Many patients view it as an opportunity to sport an implant before proceeding with a final silicone prosthesis versus an autologous flap, which bears the burden of a donor-site incision.

## CURRENT TRENDS

### Patient Selection and Safety

Appropriate preoperative evaluation is essential to the success of perforator flap breast reconstruction. High-risk patients are advised as to risk

**Fig. 3.** DIEP flap reconstruction after bariatric surgery in a 45-year-old woman with a history of right breast cancer treated with breast conservation in 1994. She presented for a laparoscopic gastric bypass in 2004 for a body mass index of 62 kg/m$^2$ (350 lb). One month later, she was diagnosed with a second right breast cancer. Given her body mass index, she was advised against immediate breast reconstruction and underwent bilateral mastectomies. At the time of delayed primary reconstruction, her body mass index was 32 kg/m$^2$ (180 lb) (*left*). She underwent bilateral DIEP flaps with flaps weighing 1085 and 1060 g. Her surgery was complicated by a postoperative donor-site seroma that was managed conservatively. She completed her reconstructions with local nipple rotational flaps and areolar reconstructions using a tattoo method (*right*).

reduction in a delayed setting. Surgery is limited to patients with a body mass index of less than 30 kg/m$^2$ and nonsmokers.[16] Moderate weight loss of up to 2 lb per week is encouraged in the setting of lifestyle intervention. All patients are encouraged to start a home exercise routine before surgery. Prior bariatric weight reduction surgery is not an absolute contraindication for abdomen-based procedures (Fig. 3). Patients are screened for cardiovascular and thrombotic risk factors and are referred for additional testing as indicated. Patients are instructed to discontinue herbal medications that may be linked to a prothrombotic state.

**Preoperative Evaluation**

Preoperative testing is directed to defining the overall well-being of potential candidates. For those having undergone chemotherapy or who are older than 55 years, a focus on cardiovascular disease is absolutely necessary. Stress echocardiography is a common preoperative requirement in addition to routine blood evaluations, electrocardiography, chest radiography, and urinalysis.

Preoperative testing is also used to define specific perforator anatomy. Initially, computed tomographic angiography was used exclusively for patients with prior abdominal wall surgical inci-

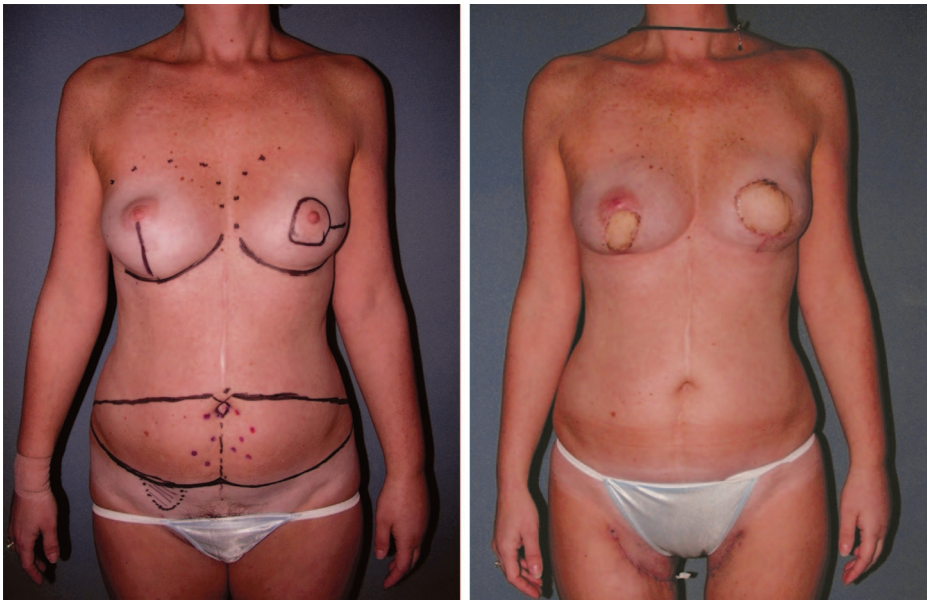

**Fig. 4.** Bilateral transverse upper gracilis flap salvage for postsurgical abdomen and deep inferior epigastric artery and vein transection in a 42-year-old woman who presented with a medical history significant for a stage I left breast cancer treated by breast conservation in 1997 complicated by left arm lymphedema. She was found to have a second invasive left breast cancer with several right-sided abnormalities on screening magnetic resonance imaging followed by nine core biopsy specimens consistent with atypical hyperplasia. The patient elected to proceed with bilateral mastectomies with immediate autologous reconstruction. Preoperatively, she was counseled regarding bilateral DIEP flap reconstruction with vascularized lymph node transposition to address her left arm lymphedema. She was evaluated by routine Doppler examination and marked for her anticipated surgery (*left*). Given the patient's presentation with a low transverse and a midline abdominal incision, the patient then underwent preoperative computed tomographic angiography, which revealed bilateral deep inferior epigastric artery and vein occlusion and significant bilateral rectus abdominis atrophy. The patient returned to the office for discussion regarding possible gluteal artery perforator versus transverse gracilis myocutaneous (transverse upper gracilis) free flap breast reconstructions. The patient elected to proceed with bilateral transverse gracilis myocutaneous flaps. She had her left nipple-areola complex excised because of tumor proximity (left mastectomy, 225 g; transverse gracilis myocutaneous, 392 g); her right nipple-areola complex was preserved (right mastectomy, 360 g; transverse gracilis myocutaneous, 447 g). Her immediate postoperative course was complicated by a 5-mm incisional dehiscence of the right donor site treated with dressing changes. Her postoperative appearance at 4 weeks is shown before her second stage (*right*).

sions or liposuction.[48,49] Some were found to have interrupted deep inferior epigastric arterial and venous systems, resulting in alternative flap planning (Figs. 4 and 5). Magnetic resonance angiography was a logical extension to define perforator diameter and to characterize the intramuscular course of perforators, allowing the surgeon to select the optimal perforator within the flap design (Fig. 6). Magnetic resonance angiography has been instrumental in defining septocutaneous perforators that may dominate this area of microsurgical reconstruction in the future (Fig. 7).


**Fig. 5.** Preoperative computed tomographic angiography scans indicating deep inferior epigastric artery and vein occlusion. Computed tomographic angiography was performed on the patient presented in Figure 3. (*Above*) A dominant septocutaneous perforator (*red arrows*) curving medial to the rectus abdominis muscle on the right at the level of the umbilicus. The dominant lateral row perforator on the left is shown *below* (*red arrows*). Further examination of the abdominal wall revealed bilateral deep inferior epigastric artery and venous occlusion with significant bilateral rectus abdominis atrophy. Preoperative imaging resulted in a change in reconstructive planning. The desire to provide bilateral DIEP flaps with vascularized lymph node transfer was abandoned, with bilateral transverse upper gracilis flaps providing an acceptable alternative reconstruction.

Currently, seven of the coauthors are using some form of preoperative imaging routinely on *every* case of perforator flap breast reconstruction. Some (J.L.L., H.E., D.T.G.) prefer magnetic resonance angiography (3-T magnetic resonance imaging breast coil), whereas others (M.F.M., J.E.C., R.J.K.) rely on computed tomographic angiography imaging and intermittent magnetic resonance angiography (1.5-T magnetic resonance imaging breast coil), given local resources. One of the authors (R.J.A., Sr.) relies on both magnetic resonance angiography (3-T magnetic resonance imaging breast coil) and computed tomographic angiography for preoperative perforator mapping, depending on his practice location and local expertise in the field. As with other organ beds (e.g., brain), magnetic resonance angiography provides exceptional anatomical details and therefore may be the modality of choice for preoperative planning. However, computed tomographic angiography provides an acceptable amount of information and should be considered in those patients who cannot undergo magnetic resonance angiography (e.g., the presence of metal implants, extreme claustrophobia) or in those centers where the appropriate magnetic resonance angiography imaging is unavailable.

One might ask why preoperative imaging has become more common. Initially, it was used only in high-risk patients; within 9 months, it has become routine on nearly every case for the majority of the coauthors. The reason for this is multifactorial. Early on, we began to appreciate increased numbers of patients who had undergone prior abdominal operations (i.e., liposuction) that prompted imaging. With its use, we soon noted shortened operative times; an abatement of the "fear of the unknown" with bipedicle/"stacked" DIEP flaps; an increased use of medially based abdominal septocutaneous perforators; a reduction in the number of abdominal perforators required to support larger flaps; and an unexpected finding, namely, superior migration of our DIEP flap designs and lateral migration of our gluteal artery perforator flaps in an attempt to capture either larger intramuscular perforators or specific septocutaneous perforators. In short, those of us using magnetic resonance angiography/computed tomographic angiography firmly believe that the use of preoperative imaging has signifi-

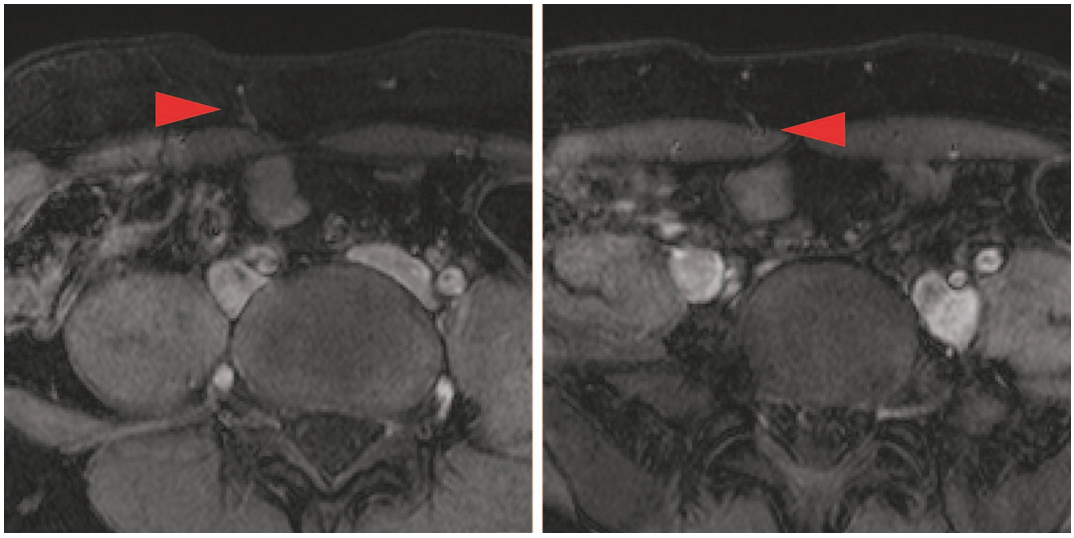

**Fig. 6.** Preoperative magnetic resonance angiography for DIEP flap planning and intraoperative confirmation. 3-T gadolinium-enhanced magnetic resonance imaging scans demonstrate the deep inferior epigastric artery perforator vessels (*red arrows*) as they pass through the anterior rectus sheath and enter the subcutaneous fat of the anterior abdominal wall. Preoperative mapping identified these two perforators as the dominant vessels with the largest diameter of all vessels seen with a course into the infraumbilical subcutaneous tissue. Preoperative mapping of these vessels in relation to the umbilicus suggested that these perforators originated from the medial row branch of the deep inferior epigastric vessels and were aligned along a craniocaudal plane. The craniocaudal alignment of the visualized perforating vessels was confirmed at surgery. This anatomy permitted the harvest of both sets of perforators in continuity without transection of the rectus abdominis muscle. Intraoperative time was minimal, as the need to isolate all surrounding perforators was eliminated.

cantly improved our outcomes, with shortened operative times and decreased fat necrosis.

### Centers of Excellence

Current trends in the operating room are focused on efficiency and patient safety. Two experienced, fellowship-trained microsurgeons commonly work together to complete perforator flap breast reconstructions in a timely fashion.[50] This team approach is of paramount importance in the setting of bilateral simultaneous gluteal artery perforator flap surgery.[25] Furthermore, experienced surgical teams are developed to support this form of reconstruction in hospital settings dedicated to a quality experience. Surgical scrub technicians and nurses are educated as to expectations for autonomy and efficiency.[51–53] Total anesthetic times are shortened, thus promoting the highest level of patient safety.[54]

Surgical techniques are focused on efficiency. Preoperative identification of the dominant regional perforator shortens flap elevation times and promotes ease of perforator selection. Adoption of a venous vascular coupling device[55,56] and a running arterial anastomotic suturing technique has shortened operative times, with no increase in postoperative complications. Routine coaptation of the T11 sensory nerve of the DIEP or SIEA flap to a branch of the third anterior intercostal nerve has become commonplace.[23,57] A trend away from implantable Doppler devices[58] has been replaced by old-fashioned clinical observation that includes temperature, capillary refill, and external Doppler monitoring. The use of perioperative dextran[59] has been abandoned and replaced with subcutaneous administration of heparin, Lovenox (sanofi-aventis, Bridgewater, N.J.), or Arixtra (GlaxoSmithKline, London, United Kingdom). The postoperative anticoagulation regimen is determined with the help of the thromboelastogram, which offers dynamic assessment of the strength of the fibrin clot.[60–62]

Patients are cared for postoperatively in dedicated women's services inpatient units and do not require intensive care unit admissions. Patients return to normal activity levels on postoperative day 1 with removal of the Hep-Lock (Baxter Healthcare, Deerfield, Ill.) and Foley catheter, return to a regular diet, and freedom to ambulate on the floor. Overall, a theme of "keeping it simple" in a standardized 4-day patient care map has promoted the safe execution of this technique in

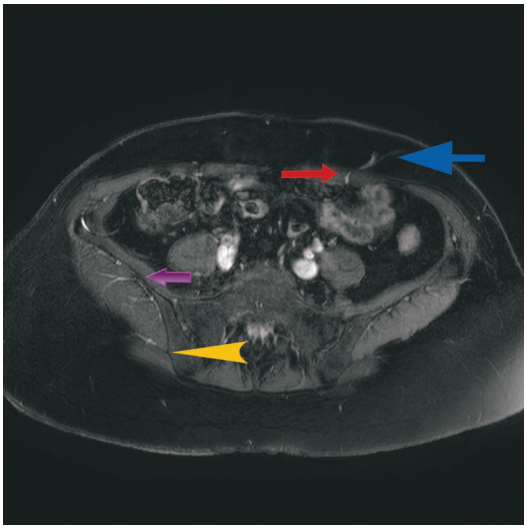

**Fig. 7.** Preoperative magnetic resonance angiography scan demonstrating musculocutaneous and septocutaneous perforators. This 3-T gadolinium-enhanced magnetic resonance imaging scan demonstrates a lateral row perforator that originates from the left deep inferior epigastric artery (*red arrow*) and passes through the anterior rectus sheath to enter the subcutaneous fat of the anterior abdominal wall (*blue arrow*). Preoperative mapping identified this perforator as the dominant vessel on the left side of the patient's abdominal wall. The perforator's intramuscular course, between the deep inferior epigastric artery and the point at which it perforated the anterior rectus fascia, was found to be relatively short and straight and was confirmed intraoperatively. Incidentally noted in the right gluteal region are a septocutaneous perforator that passes between the gluteus medius and maximus muscles (*yellow arrow*) and musculocutaneous perforators (*purple arrow*) that originate from the superior gluteal artery and pass directly through the gluteus maximus muscle. Imaging of these vessels facilitates planning of surgery in patients who elect to undergo breast reconstruction with gluteal perforator flaps.

smaller, nonacademic centers that may be better suited for this form of microsurgical breast reconstruction.

Our collective experience over the past 12 months reflects 600 total microsurgical breast reconstruction cases (416 DIEP, 14 bipedicle stacked DIEP, 18 SIEA, 119 gluteal artery perforator, 24 transverse upper gracilis, six intercostal perforator, and three TDAP flaps), with a 1.0 percent flap failure rate ($n = 6$ total; four losses in a community setting and two losses in a university setting). Seventy percent ($n = 416$) of these reconstructions were completed in a community hospital setting in which specialized teams of providers (surgeons, nurses, operating room personnel, and anesthesiologists) are maintained with low attrition rates. We believe that *the team* experiences a "learning curve" and becomes better given ongoing increased surgical volume. One of our community hospitals in South Carolina with fewer than 100 patient beds serves as home to nine active perforator flap microsurgeons and is reminiscent of the Buncke Clinic in San Francisco, another model of a successful microsurgery effort in a community hospital setting.

## Aesthetics

Perforator flap breast reconstruction has evolved as a technical exercise with specific aesthetic challenges. Recreation of the "footprint" of the breast with autologous tissue provides a more natural reconstruction than that which can be achieved by breast implants. Footprints smaller than the mastectomy specimen can lead to cicatrix between mastectomy skin flaps and the pectoralis major muscle and should be avoided. This is particularly true for patients having undergone prior irradiation (Fig. 8).

External scars secondary to access incisions have been a criticism in the past. Current trends focus on providing flaps by means of limited periareolar incisions, with total nipple-areola complex preservation to improve cosmesis. Novel approaches continue to evolve in which mastectomy incisions appear lateral to the aesthetic unit of the breast mound or hidden within the inframammary fold (Fig. 9). These concepts have been applied to contralateral augmentation scenarios (Fig. 10).

Current trends reflect the use of the internal mammary vessels as the preferred recipient vessels over the thoracodorsal vessels.[63] Aesthetically, most reconstructions do not require the resection of costochondral cartilage. Adequate access can be achieved in the 1.5-cm space beneath the second or third costochondral cartilage. This does require a resection of the intervening intercostal muscle that can result in a depression deformity on the chest wall if the flap footprint is too short. This deformity has been addressed with fat grafting at the second stage. A notable exception to this would include SGAP flap reconstructions. Resection of the costochondral cartilage is common with SGAP flaps based on medial perforators, as the flap pedicle is shorter than other flaps—lack of length on the donor vessels is compensated for with recruited length of the recipient vessels. We have had experience with lateral-based SGAP perforators that lend more length to the donor pedicle, a finding more common as we have been

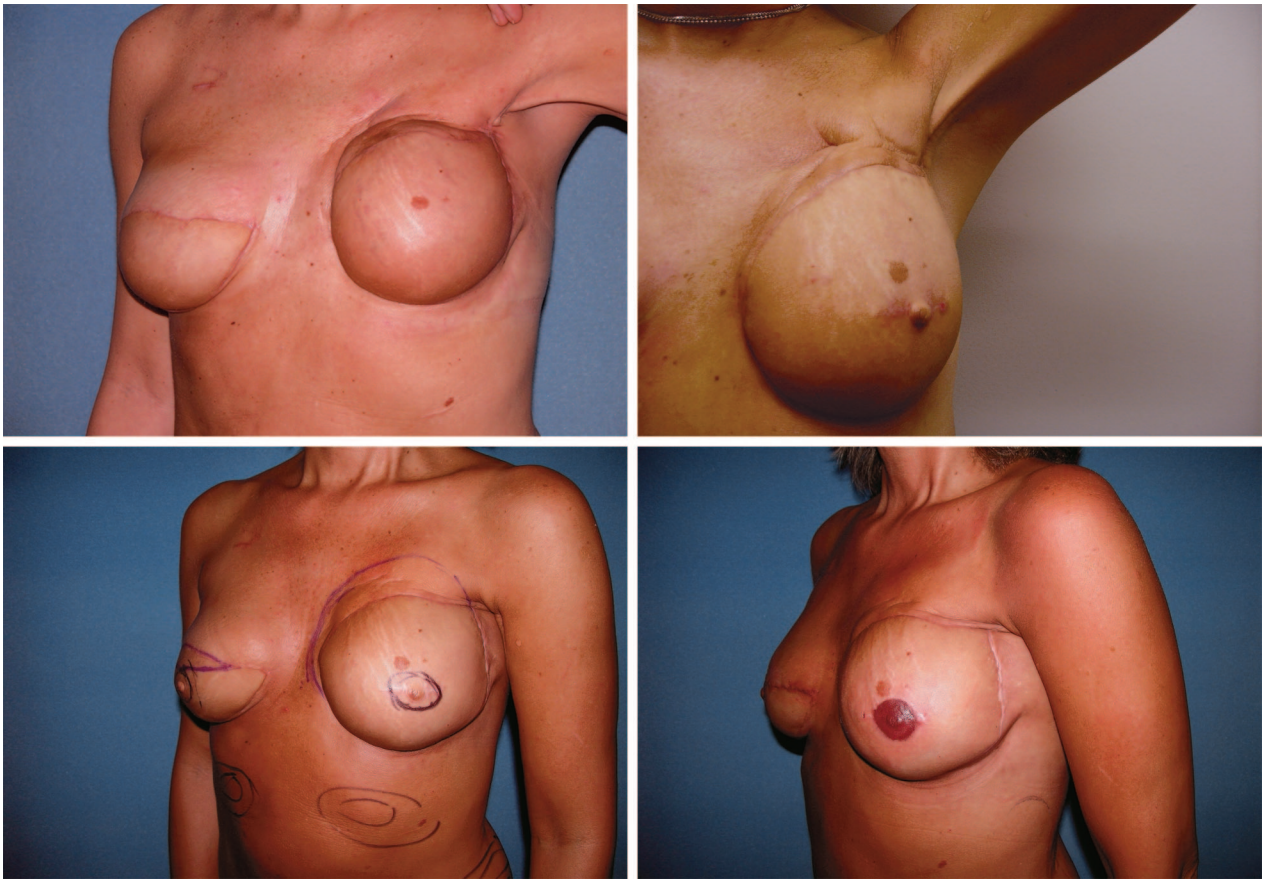

**Fig. 8.** Small flap footprint in an irradiated field results in cicatrix in a 45-year-old woman who presented with failed implant-based breast reconstruction in an irradiated field on the left for bilateral DIEP flap transplantation. Intraoperatively, the left flap footprint was smaller than that which was felt to be optimal. Three months postoperatively (*above*, *left*), she presented for a staged reconstruction that included flap revision, dermal allograft (abdominal harvest, 6 × 2 cm), autologous fat infiltrate (52 cc), and bilateral nipple reconstructions. Six months postoperatively (*above*, *right*), she has persistent cicatrix in the irradiated field, which was addressed with AlloDerm (LifeCell Corp., Branchburg, N.J.) (5 × 2 cm), pectoralis muscle flap advancement, and axillary Z-plasty. Her appearance at 12 months (*below*, *left*) is improved but she has persistent cicatrix and nipple malposition treated with skin excision and autologous fat infiltrate (66 g) in the setting of areolar reconstruction using a tattoo method. Her immediate postoperative result is shown after the final intervention (*below*, *right*). Possible alternatives to this approach include an ipsilateral TDAP flap interposition along the superior and lateral border of the DIEP flap.

imaging patients preoperatively, which has made costochondral cartilage resection more selective.

Gluteal artery perforator flaps have been popularized for patients who present with limited abdominal wall adiposity or prior operations.[22,26] Gluteal artery perforator flaps carry specific aesthetic challenges, as gluteal fat commonly is more firm and less pliable than fat harvested from the abdomen. This rigidity, for lack of a better word, prevents the folding of many gluteal reconstructions, a technical tool used for providing increased projection. Some patients benefit from a vertical inset of gluteal artery perforator flaps to promote an improved aesthetic appearance.

Adding volume or projection to perforator flaps has prompted several technical trends. Volume can be added in the first stage of an abdomen-based reconstruction by using bipedicle DIEP flaps for one breast reconstruction.[64] Also referred to as a stacked DIEP flap, reconstructions such as these provide a reliable blood supply to the entire abdominal flap.[65–67] Both hemiabdominal segments can be used for the reconstruction, with pliability that promotes shaping and increased projection (Fig. 11).

Volume can be added at the second stage by using a variety of techniques. Intercostal perforator and TDAP flaps are rotational perforator flaps that can be performed in an outpatient setting to provide volume to a flap reconstruction at the second stage or as a contralateral augmentation for symmetry. Furthermore, they can be buried

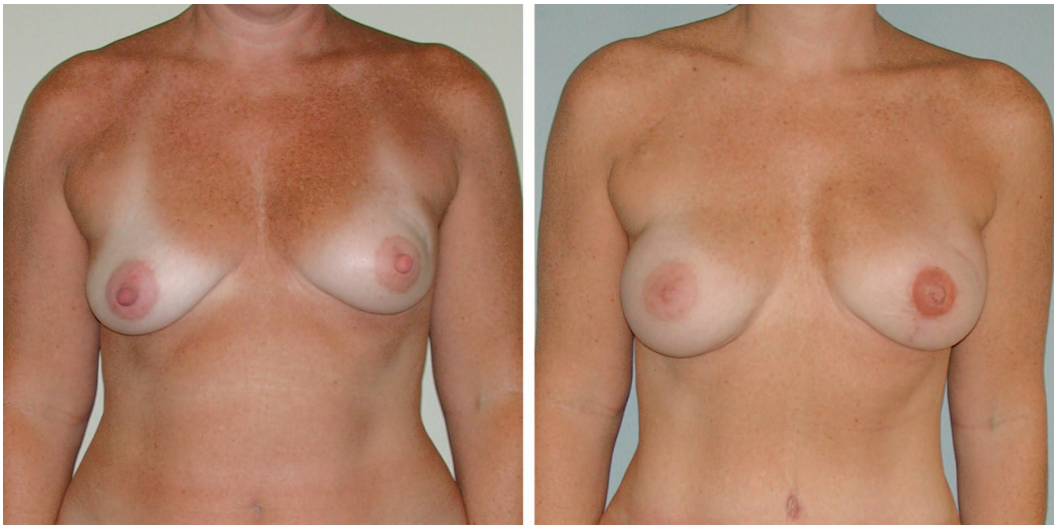

**Fig. 9.** Nipple-areola complex–preserving mastectomy with immediate DIEP flap reconstruction in a 32-year-old woman with recurrent left breast cancer after failed breast conservation. She elected to proceed with a therapeutic left mastectomy, with excision of the nipple-areola complex (mastectomy, 389 g; DIEP flap, 520 g) and a right prophylactic mastectomy in a nipple-areola complex–preserving fashion (mastectomy, 401 g; DIEP flap, 529 g). The right mastectomy was performed through an incision at the inframammary fold, respecting the aesthetic unit of the breast.

beneath a flap to provide additional lower pole projection. More significant volume requirements can be addressed with the addition of a TDAP flap. It is particularly appropriate for superolateral deficits, as the longer pedicle provides a greater arch of rotation and advancement.[30] Volume can further be addressed with fat grafting.[68] It is not uncommon to address donor-site irregularities with liposuction at the second stage. Harvested fat can be used as a graft to promote more flap projection.

A discussion regarding aesthetics would be incomplete without mention of the use of perforator flaps in the setting of failed breast conservation.[30] In a small percentage of cases, breast conservation provides a result aesthetically not acceptable to the patient. Patients may complain of a volume deficit that can be addressed with a buried perforator flap. More severe deformities can be addressed with the addition of a skin island (Fig. 10). In this scenario, patients must be counseled preoperatively regarding the risk of local recurrence. Patients need to understand that they may be using a valuable donor site for a partial breast reconstruction that cannot be revisited in the setting of an ipsilateral recurrence or contralateral primary breast cancer. As a result, patients may request completion mastectomy with immediate perforator flap total breast reconstruction as a means of avoiding continuing screening mammography and/or magnetic resonance imaging. Excision of high-risk, irradiated skin may be required with a reconstruction flap inset at the level of the inframammary fold to preserve the aesthetic unit of the breast (Fig. 12).

## FUTURE DIRECTIONS

This review is based on the collective experience of nine perforator flap microsurgeons with 67 years of combined clinical service currently practicing in six states (South Carolina, Texas, New York, Louisiana, Utah, and Illinois). Our experience comprises a total of 3974 perforator flaps to date, with a success rate of 99 percent. With this as our foundation, we still can only *subjectively* comment on future directions of our subspecialty.

### A Perfect Storm

PubMed lists *The Perfect Storm: A True Story of Men against the Sea* [69] appearing in 99 medical citations since the year 2000. It has been used to address global issues, such as Medicare reform, and more specific medical disorders, such as human immunodeficiency virus. Regrettably so, the term "the perfect storm" describes the future of perforator flap breast reconstruction more aptly that any other idiom at hand.

One force we see affecting the future is the profound escalation of media marketing since the U.S. Food and Drug Administration release of sil-

**Fig. 10.** DIEP flap for failed breast conservation and contralateral DIEP flap breast augmentation in a 48-year-old woman who presented with a history of left-sided stage I breast cancer treated by lumpectomy and MammoSite local irradiation therapy (Proxima Therapeutics, Alpharetta, Ga.). Thirty months later, she presented with significant cicatrix and volume deficiency (*above*). She elected to proceed with volume and skin restoration on the left with a contralateral autologous augmentation using bilateral DIEP flaps (right, 331 g; left, 299 g). The second stage of her reconstruction performed 3 months later included a resection of the monitoring skin island on the right at the level of the inframammary fold and left-sided fat infiltrate (95 cc) (*below*).

icone breast implants into the unrestricted marketplace. This begs the question, "Are we adequately educating our patients regarding unplanned implant reoperation rates of 50 percent at 7 years?"[31,32] Our experience, biased as it may be, suggests that breast reconstructive surgeons as a group may not be dedicating enough time to patient education to counterbalance the effects of implant manufacturer advertising. A significant percentage of *our* patients present in the setting of failed implants and commonly relate that they did not have an adequate understanding of unplanned reoperation rates when they chose breast implants.

Perhaps we need to reinforce the idea that *all* forms of breast reconstruction should be presented to patients seeking our care (implants, myocutaneous flaps, and perforator flaps) in an unbiased educational setting. Patients are interested in a variety of issues that will facilitate their unique and personal decision for a breast reconstructive technique. This is a timely task, one that we have addressed with the use of the "shared medical appointment," supplemental nursing ed-

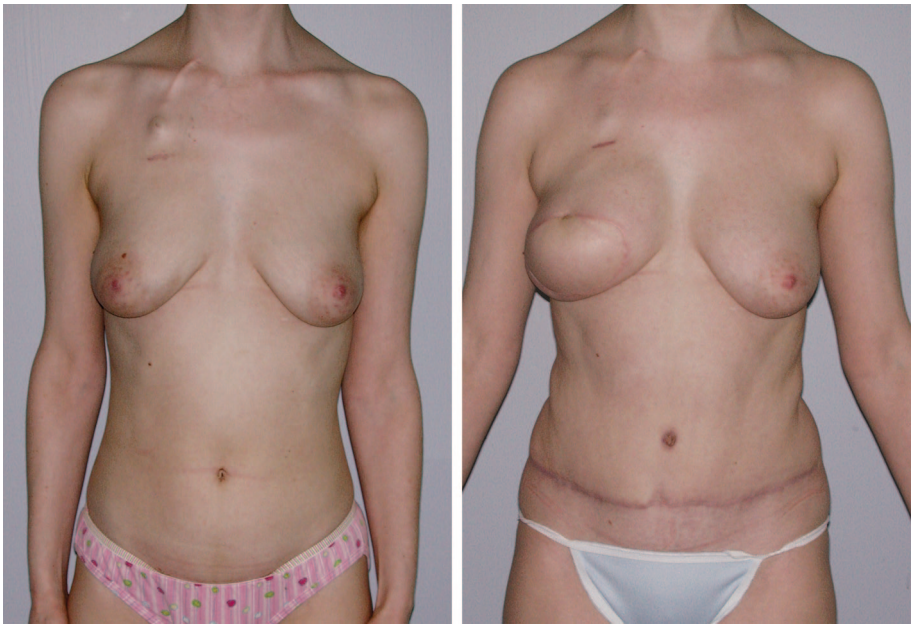

**Fig. 11.** Adding volume with a stacked DIEP flap at the first stage in a 29-year-old woman who presented with an invasive ductal carcinoma of the right breast (*left*). She elected against an implant-based reconstruction and was referred for an autologous method of reconstruction with muscle preservation. Given her body mass index of 20 kg/m$^2$, she was offered a bipedicled stacked DIEP versus gluteal artery perforator flap. The patient elected to proceed with a bipedicled stacked DIEP flap that provided adequate volume (mastectomy, 414 g; bipedicled DIEP flap, 327 g) (*right*).

ucators, and past-to-potential patient introductions. This, in addition to Web-based educational supplements on physician Web sites, may counterbalance the effects of industrial marketing in the future.

We do think that patients should be informed of perforator flaps even if a physician no longer offers microsurgery in their practice. In our experience, we have found that patients do understand and appreciate their local physician if they elect not to perform perforator flaps, given a lack of specialized training, lack of hospital resources, or microsurgical "burnout" that occurs for many mature plastic surgeons. Within our notably biased practice environment, patients seem less understanding when they experience an implant failure or hernia/abdominal weakness and learn after the fact that other options do exist.

A second force on the future of perforator flap microsurgery is the continued threat of decreasing financial reimbursement for reconstructive procedures. This has resulted in limited accessibility of microsurgical breast reconstruction for women dependent on Medicare and Medicaid. Furthermore, we would not be the first to speculate on the negative impact of "budget neutralization" on the field of microsurgical breast reconstruction and the evolution of more sophisticated technical advancements.

The third and most concerning force we see relates to the long-term survival of our subspecialty. Current plastic surgery residents-in-training relate a focus on personal lifestyle and mistakenly believe that microsurgical breast reconstruction cannot be accomplished within the time constraints of a reasonable workday. We understand their concern, as the majority of us have migrated away from the university setting to improve our quality of life. Again, subjective as this may be, the majority of us (M.F.M., J.L.L., J.E.C., R.M.K., K.K., D.T.G., and R.J.A., Sr.) have found refuge in the community hospital setting, an environment without the pressures of trauma, cardiac, neurosurgical, and transplant services and the associated emergencies that stress hospital resources and operating room time; an environment where nursing and support services have lower rates of attrition; and an environment where specialty-specific care teams are commonplace. This begs the question that perhaps *we* are neglecting resident education. Perhaps *we* are failing to be accessible mentors to

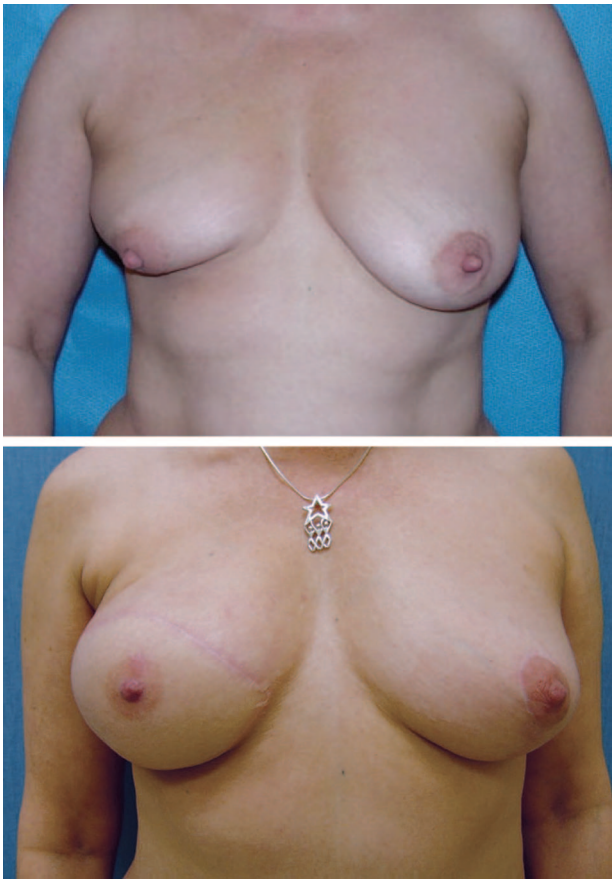

**Fig. 12.** Reconstruction of failed breast conservation with completion mastectomy in a 57-year-old woman who presented 2 years after the diagnosis and treatment of a right-sided invasive breast cancer with complaints of poor cosmesis after breast conservation therapy (*above*). She elected to proceed with completion mastectomy (390 g) and immediate DIEP flap breast reconstruction (550 g) over continued surveillance mammograms and magnetic resonance imaging scans. Radiation-damaged inferior skin was resected along with the nipple-areola complex. The flap was inset along the inframammary fold, respecting the aesthetic unit of the breast. Her staged reconstruction was completed with a nipple-sharing technique and areolar tattoo and contralateral mastopexy (*below*).

residents/fellows as we migrate out into the private sector.

Future concrete directions in perforator flap breast reconstruction will likely focus on self-imposed technical advances. The concept of speed and efficiency will predominate. With this trend, preoperative imaging will become routine for all and may lead to a predominance of the use of septocutaneous flaps. We speculate that septocutaneous flaps will prove to be easier to master technically, as the intramuscular dissection will be eliminated along with the difficult distal dissection encountered with gluteal artery perforator flaps. Septocutaneous flaps may also refocus interest on the use of *recipient* perforator vessels with shortened harvest times. Recipient perforators off of the internal mammary artery and vein superficial to the pectoralis major muscle can be used for the microvascular anastomosis, therefore avoiding the need to resect a portion of the intercostal muscle and costochondral cartilage. A secondary gain to this will be the development of many new flaps, previously not described, with donor sites throughout the trunk. We predict that the most immediate example of this will be the use of a septocutaneous gluteal artery perforator flap.

It is our hope that technical advancements in perforator flap microsurgery will have a positive influence on the next generation of plastic surgeons. We know that residents will master any surgical technique that is placed before them. With speed and efficiency, we may be able to seduce a critical number of our fellows to embrace these techniques. We, as a group, encourage all to continue as clinical faculty members of teaching institutions in the belief that we can continue to mentor residents/fellows in the field of perforator flap breast reconstruction in the community hospital setting.

Lastly, we see the emergence of vascularized lymph node transfers for the treatment of congenital and postsurgical/irradiation-induced lymphedema as a potential area of growth for perforator flap microsurgeons. Many of our patients present with upper extremity lymphedema that can be addressed with a simultaneous DIEP flap breast reconstruction and vascularized lymph node transfer. The key aspects of this procedure include preoperative lymphoscintigraphy and donor-site selection, and appropriate adhesionolyis and neuroplasty in the axilla. Furthermore, these techniques can be applied to lower extremity lymphedema, where we may return to many principles of our more generalized plastic surgery training. We look forward to the future of this emerging extension of our subspecialty.

## CONCLUSIONS

Perforator flap breast reconstruction is an exciting and ever-changing area of plastic surgery. Its rewards are many. The personal desire to master one of surgery's most challenging technical procedures drives many of us to continue on this journey. Most of all, we are pleased to provide a durable and natural solution for patients seeking to redefine themselves after suffering the life-changing event of breast cancer.

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