

Fewer Revisions in Abdominal-based Free Flaps than Latissimus Dorsi Breast Reconstruction after Radiation

Summer E. Hanson, MD, PhD*

Benjamin D. Smith, MD†

Jun Liu, MD, PhD*

Geoffrey L. Robb, MD*

Steven J. Kronowitz, MD*

Patrick B. Garvey, MD*

Background: The most commonly chosen flaps for delayed breast reconstruction after postmastectomy radiation therapy (PMRT) are abdominal-based free flaps (ABFFs) and pedicled latissimus dorsi (LD) musculocutaneous flaps. The short- and long-term advantages and disadvantages of delayed ABFFs versus LD flaps after PMRT remain unclear. We hypothesized that after PMRT, ABFFs would result in fewer postoperative complications and a lower incidence of revision surgery than LD flaps.

Methods: We retrospectively reviewed a prospectively maintained database of consecutive patients who underwent unilateral, delayed breast reconstruction after PMRT using ABFFs or pedicled LD flaps with implants at the MD Anderson Cancer Center between January 1, 2001, and December 31, 2011. We compared outcomes and additional surgeries required between the 2 groups. Univariate and multivariate logistic regression modeling analyzed the relationships between patient and reconstruction characteristics and postoperative outcomes.

Results: A total of 139 consecutive patients' breast reconstructions were evaluated: 101 ABFFs (72.7%) versus 38 LDs (27.3%). Average follow-up was similar for ABFF and LD reconstructions. Although ABFF and LD reconstructions experienced similar rates of overall (30.7% vs 23.7%, respectively; $P = 0.53$), donor-site (8.91% vs 5.13%, respectively; $P = 0.48$), and flap (20.7% vs 17.9%, respectively; $P = 0.37$) complications, the LD reconstructions required more additional surgeries (92.1% vs 67.3%; $P < 0.001$). Furthermore, LDs required more revision surgeries more than 1 year after reconstruction (37.1% vs 14.7%; $P = 0.02$).

Conclusion: Although early complication rates were similar for both types of reconstructions, ABFFs seem to have the advantage of providing a more durable result that required fewer revision surgeries in the long term. (*Plast Reconstr Surg Glob Open* 2016;4:e866; doi: 10.1097/GOX.0000000000000811; Published online 20 September 2016.)

Despite the fact that radiation therapy after mastectomy has been shown to adversely affect breast reconstruction,¹⁻⁷ evidence to support more liberal indications for external beam radiation therapy for local control continues to increase,⁸⁻¹⁴ and it is likely that increasingly more patients will receive postmastectomy radiation therapy (PMRT)

in the setting of early stage breast cancers. Despite variation in certain details regarding PMRT target volumes, delivered doses, and sequencing with reconstruction, autologous tissue-based breast reconstruction is generally preferred over implant-only reconstruction in patients who undergo PMRT because it allows for the removal of fibrotic chest wall skin, creates an adequate shape, and provides a more natural-looking long-term aesthetic outcome.¹ Implant reconstruction alone without autologous tissue after PMRT has been shown to be associated with an unacceptably high rate of complications and poor long-term durability.^{2,15}

From the *Departments of Plastic Surgery and †Radiation Oncology, the University of Texas MD Anderson Cancer Center, Houston, Tex. Received for publication March 17, 2016; accepted May 17, 2016. Presented at the American College of Surgeons 2013 Clinical Congress in Washington, DC, October 6-10, 2013.

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Currently, the 2 most commonly chosen types of flaps for delayed breast reconstruction after PMRT are abdominal-based free flaps (ABFFs) and pedicled latissimus dorsi (LD) musculocutaneous flaps.^{16,17} The most commonly used ABFFs include the microvascular deep inferior epigastric perforator (DIEP), microvascular or pedicled transverse rectus abdominis musculocutaneous (TRAM), and microvascular superficial inferior epigastric artery flaps.^{18,19} LD flaps can sufficiently meet the skin requirements for breast reconstruction; however, an implant is typically required to augment the reconstruction to achieve sufficient volume. A widely held, but unproven, belief by many reconstructive surgeons is that ABFFs and LD flaps with implants have equivalent outcomes after delayed breast reconstruction and PMRT. However, the specific short- and long-term advantages of ABFFs versus LD flaps with implants for delayed breast reconstruction after PMRT are unclear, particularly with respect to the comparative rates of postoperative complications and reconstruction revision surgery. We hypothesized that ABFFs would be associated with superior surgical outcomes compared to LD flaps with implants for delayed breast reconstruction in the setting of PMRT, specifically with respect to postoperative complications and the need for revision surgery.

PATIENTS AND METHODS

We retrospectively reviewed a prospectively maintained database of consecutive, delayed, unilateral breast reconstructions after mastectomy and PMRT with either a pedicled LD with implant or an ABFF at a single center between January 1, 2001, and December 31, 2011. The LD with implant reconstructions included LD musculocutaneous flaps that were combined with either a direct-to-permanent implant or a 2-stage tissue expander plus implant reconstruction. The ABFFs included muscle-sparing free TRAM, DIEP, and superficial inferior epigastric artery flaps.¹⁸ We excluded patients who had bilateral reconstructions, immediate reconstructions, less than 1 year of follow-up, other autologous flaps (eg, gluteal- or thigh-based flaps), “delayed-immediate” reconstructions,²⁰ muscle-only LD flaps, endoscopically or robotically harvested LD flaps, delayed reconstructions without PMRT, or additional radiation therapy after reconstruction.

Patient, reconstruction, and outcome data were analyzed and directly compared between the groups. Medical comorbidities examined included cardiac disease, cerebrovascular disease, diabetes mellitus, pulmonary disease, and hypertension. Overall complications included one or more of the following: breast wound complications (infection, skin dehiscence, delayed wound healing, hematoma/seroma); donor-site complications (infection, skin dehiscence, delayed wound healing, hematoma/seroma, abdominal wall bulge); perfusion-related complications (fat necrosis, partial flap necrosis, mastectomy skin flap necrosis); need for implant explantation; and microvascular complications

(arterial or venous thrombosis). Infection was defined as cellulitis or an abscess that was treated with antibiotics with or without surgery. Skin dehiscence was defined as a separation of the incision 0.5 cm or greater. Hematoma and seroma were subcutaneous fluid collections that required percutaneous or operative drainage. Delayed wound healing was defined as any wound requiring debridement and healing by secondary intention. Abdominal wall bulge was a contour deformity noted on physical examination, with (hernia) or without (bulge) fascial defect.²¹ Fat necrosis was defined as a palpable firmness 1 cm or greater that persisted beyond 3 months postoperatively. Partial flap necrosis was necrosis of the flap skin island and underlying fat. Both abdominal hernia and bulge and fat necrosis and partial flap necrosis were mutually exclusive conditions.

Need for additional surgery included surgery for complications, for aesthetic revision, and to the contralateral breast for symmetry. We defined complications that required surgical management as major complications. The exchange of a tissue expander for an implant is a necessary step in staged reconstruction and therefore was not included as an “additional surgery.” An additional surgery was considered an “aesthetic revision” when it was performed on the reconstructed breast and altered the size or shape of the breast. This included raising or lowering the inframammary fold, extensive capsulotomy, capsulectomy or plication, thinning or debulking of the flap, and fat grafting to address contour irregularities. It did not include procedures for nipple reconstruction or nipple-areolar micropigmentation. Surgery performed on the contralateral breast for symmetry was recorded as well and was commonly performed at the same time as the revision surgery. Symmetry procedures included mastopexy, reduction mammoplasty, breast augmentation with implant or fat grafting, and augmentation and mastopexy combined.

Patients were routinely followed up postoperatively at least monthly after discharge for approximately 6 months and then at least yearly thereafter. The timing of additional surgery was recorded and categorized as within 1 year from the initial reconstruction and beyond 1 year from the initial reconstruction (defined as a late additional surgery).

Mean values and SDs were used to summarize continuous variables. Frequencies and proportions were used to present the categorical clinical characteristics. Pearson’s chi-square test and Fisher’s exact test were used to test associations between categorical variables. A 2-sample *t* test was used to compare the continuous variables between patient groups. Univariate logistic regression models were used to determine the risk factors for overall complications, additional surgeries, and late additional surgeries. All tests were 2-sided. A *P* value of less than 0.05 was considered significant. The analyses were performed in SAS 9.2 (SAS Institute Inc.; Cary, N.C.). A senior staff biostatistician (J.L.) performed all statistical analyses.

RESULTS

Patient Characteristics

We analyzed a total of 139 consecutive, unilateral, delayed breast reconstructions after PMRT: 101 ABFFs (72.7%) versus 38 LD flaps (27.3%). The mean follow-up was 27.1±24.1 months and was similar between the 2 groups. The preoperative patient characteristics were also generally similar between the 2 reconstruction groups (Table 1). Patients who underwent reconstruction with LD flaps and implants were found to have a significantly lower mean body mass index than the ABFF patients (25.4 vs 27.9 kg/m²; *P* = 0.004). Significantly fewer of the LD patients (10.5%) had a body mass index greater than or equal to 30 kg/m² compared with the ABFF patients (26.7%; *P* = 0.004). The ABFF group had more patients with preexisting medical comorbid conditions than did the LD group (26.7% vs 10.5%, respectively; *P* = 0.022).

Reconstruction Characteristics

Among ABFFs, the microvascular DIEP and muscle-sparing TRAM flaps were used at similar rates (45.5% vs 54.5%, respectively). For the LD with implant-based reconstructions, the majority were 2-stage reconstructions in which a tissue expander was placed at the time of the flap harvest; only 3 patients in the LD group had an immediate, permanent implant placed (92.1% vs 7.9%, respectively). Saline or silicone implants were used as the final implant after tissue expander removal with similar frequency (52.6% vs 47.4%, respectively). The average hospital stay after flap reconstruction was significantly shorter in patients undergoing LD plus implant reconstructions than ABFFs (3.2±1 vs 4.9±1.1 d; *P* < 0.001).

Outcomes

The overall rate of complications for all of the unilateral delayed breast reconstructions in our study was 28.8% (Table 2), and there was no difference in the overall complication rates between the LD and ABFF groups (23.7%

Table 2. Surgical Outcomes by Reconstruction Type

Complications	LD with Implant (n = 38)	ABFF (n = 101)	<i>P</i>
Overall complications, n (%)	9 (23.7)	31 (30.7)	0.529
Any breast complication, n (%)	7 (18.4)	21 (20.8)	0.81
Breast wound-related complication, n (%)			
Infection	2 (5.9)	2 (2)	0.30
Delayed healing	1 (2.6)	4 (4)	0.99
Skin dehiscence	3 (7.9)	2 (2)	0.13
Hematoma/seroma	1 (2.6)	1 (1)	0.99
Mastectomy skin necrosis	1 (2.6)	5 (5)	0.99
Perfusion-related complications, n (%)			
Fat necrosis	0 (0)	20 (19.8)	0.002
Partial flap necrosis	0 (0)	12 (11.9)	0.04
Implant failure	2 (5.3)	—	0.07
Microvascular complications, n (%)			
Arterial thrombosis	—	1 (1)	—
Venous thrombosis	—	1 (1)	—
Any donor-site complication, n (%)	3 (7.9)	13 (12.9)	0.24
Donor-site wound complications, n (%)			
Infection	0 (0)	0 (0)	0.99
Delayed healing	1 (2.6)	3 (3)	0.99
Skin dehiscence	0 (0)	4 (4)	0.58
Hematoma/seroma	3 (7.9)	3 (3)	0.35
Bulge/hernia	—	5 (5)	0.32

vs 30.7%; *P* = 0.53). There were no failed reconstructions in either group. Breast-related complications were more common than donor site-related complications for both groups. Correspondingly, both reconstruction groups required additional surgery to manage major complications at similar rates (17.1% vs 22.1% for the LD and ABFF groups, respectively; *P* = 0.56). Univariate logistic regression analysis did not demonstrate any factors associated with overall complication rate for either group.

The overall rate of additional surgery was significantly higher for the LD plus implant reconstruction group than for the ABFF group (92.1% vs 67.3%, respectively; *P* < 0.001) (Table 3). It was expected that an additional surgery would be included within the first year for exchange of the tissue expander to implant in the LD plus implant group; however, isolated exchanges beyond 1 year were rare (*n* = 1) and recorded distinctly from additional revision surgeries. We found that additional surgery was performed on the

Table 1. Patient Characteristics

Characteristic	LD with Implant (n = 38)	ABFF (n = 101)	<i>P</i>
Age, y	47.9±11.6	47.8±8.8	0.96
Length of follow-up, mo	28.3±27.6	26.7±22.8	0.72
BMI	25.4±4	27.9±4.6	0.004 ^a
Obesity (BMI >30), n (%)	3 (7.9)	31 (30.7)	0.004 ^a
Preoperative chemotherapy	34 (89.5)	99 (98)	0.04 ^a
Postoperative chemotherapy	0 (0)	10 (9.9)	0.06
Comorbidity, n (%)			
Cardiac disease	0 (0)	3 (3)	0.56
Cerebrovascular disease	0 (0)	2 (2)	0.99
Diabetes mellitus	1 (2.6)	2 (2)	0.99
Hypertension	3 (7.9)	21 (20.8)	0.08
Pulmonary disease	1 (2.6)	6 (5.9)	0.67
Smoking, n (%)			
Nonsmoker	36 (94.7)	93 (92.1)	—
Active smoker	2 (5.3)	8 (7.9)	0.73
Medical illness, n (%)			
None	34 (89.5)	74 (73.3)	—
≥1	4 (10.5)	27 (26.7)	0.02 ^a
Hospital stay, d	3.2±1.0	4.9±1.1	<0.001 ^a

BMI, body mass index. ^a*P* < 0.05 is statistically significant.

Table 3. Additional Surgeries by Reconstruction Type

	LD with Implant (n = 38)	ABFF (n = 101)	<i>P</i>
Any additional surgery, n (%)	35 (92.1)	68 (67.3)	<0.001 ^a
Reason for additional surgery, n (%)			
Complication	6 (17.1)	15 (22.1)	0.56
Revision	35 (100)	52 (76.5)	<0.001 ^a
Fat grafting	9 (21.1)	1 (1)	<0.001 ^a
Symmetry (contralateral)	15 (42.9)	50 (73.5)	0.002 ^a
Type of symmetry procedure, n (%)			
Mastopexy	10 (26.3)	35 (34.7)	0.42
Breast reduction	6 (15.8)	19 (18.8)	0.81
Augmentation	3 (7.9)	8 (7.9)	0.99
Augmentation and mastopexy	0 (0)	5 (5)	0.32
Timing of additional surgery, n (%)			
Within 1 y	22 (62.9)	54 (79.4)	0.1
>1 y	13 (37.1)	10 (14.7)	0.02 ^a

^a*P* < 0.05 is statistically significant.

reconstructed breast to change the position of the inframammary fold, alter the implant pocket, or debulk the flap. Of the secondary procedures, fat grafting to improve contour deformities was significantly more common in LD plus implant reconstructions than in ABFF reconstructions (21.1% vs 1.0%, respectively; $P < 0.001$). Furthermore, we found a significantly higher rate of multiple additional surgeries (ie, >1) in the LD with implant group compared with the ABFF group (45.7% vs 20.6%, respectively; $P < 0.004$). Surgery to the contralateral breast to improve symmetry was common in both groups but significantly more common in the ABFF reconstructions (73.5% vs 42.9%; $P = 0.002$). The most commonly performed procedure to address asymmetry was mastopexy.

In both reconstructive groups, most additional procedures were performed within 1 year from the original reconstruction. When we evaluated the timing of additional surgery, although the ABFF group had fewer additional surgeries overall than the LD group, the rates of additional surgery within 1 year were statistically similar (79.4% vs 62.9% for the ABFF and LD groups, respectively; $P = 0.10$). However, LD flaps required significantly more revision surgeries more than 1 year after initial reconstruction (37.1% vs 14.7%; $P = 0.02$).

DISCUSSION

In this study, representing the largest comparison to date of the 2 most commonly performed types of delayed autologous breast reconstruction after PMRT, we hypothesized that abdominal-based free tissue transfer would provide a more sustainable result than pedicled LD flaps, requiring fewer revisions or additional surgeries and having lower complication rates. Contrary to our original hypothesis, we found similar early complication rates between the 2 types of reconstruction. However, in support of our hypothesis, we found evidence of superior long-term durability for ABFFs compared with LD flaps, in particular a significantly lower rate of additional revision surgeries with no additional perioperative morbidity.

As breast reconstruction techniques evolve, the options available to patients continue to expand. Still, surgeons are charged with the task of choosing the optimal reconstruction for a given patient. To this end, many studies have sought to identify the best reconstructive technique, and the data—primarily patient satisfaction and complication rates—are widely variable.^{22–28} Most of this literature compares autologous and implant-based reconstructions; few studies have included a specific comparison of abdominal flaps with LD flaps. Spear et al²⁶ reviewed their experience with immediate reconstructions, including autologous ($n = 80$; LD = 28; TRAM = 52) and implant-based ($n = 106$) techniques, in patients with or without previous irradiation. In contrast to our findings, the autologous tissue subset in that study demonstrated similar reoperation rates for complications between the LD flaps and TRAM flaps (10.7% vs 5.8%, respectively); however, that study included a more heterogeneous study population consisting of immediate rather than delayed reconstructions with a lower incidence of previous radiation therapy (16%). Likewise, Saulis et al²⁵

reported on 319 patients undergoing immediate rather than delayed breast reconstruction (172 LD vs 147 TRAM with implant) and showed similar patient satisfaction and complication rates and significantly shorter hospital stay and shorter subjective recovery time in the LD group.

Moreover, no previous study has specifically analyzed outcomes of delayed autologous breast reconstruction after mastectomy and PMRT with comparable power and patient follow-up. In the setting of PMRT, studies have lacked sufficient patient numbers and follow-up to adequately evaluate the durability of LD or ABFF reconstruction with respect to the long-term need for revision. One study reported similar overall complication rates between LD flaps and all abdominal-based flaps, free or pedicled, after PMRT (28.0% vs 30.4%, respectively; $P = 0.846$) but had limited patient numbers and short-term follow-up.²⁷ Another study showed a trend toward higher complication rates with LD reconstructions compared with abdominal flaps; however, the data were underpowered and did not achieve statistical significance.²⁹

With considerably higher patient numbers and longer patient follow-up, we found no difference in initial complication rates between the 2 reconstructive cohorts but significantly higher rates of additional surgery in the LD with implant-based reconstructions. Two-stage reconstructions in the LD group do not explain the significantly higher rates of secondary surgery observed in the LD group more than 1 year after the initial reconstructive surgery or the higher percentage of LD group patients having multiple (>1) secondary revisions. Interestingly, most of the multiple revisions primarily involved fat grafting to the reconstructed breast for upper pole defects or to provide a more natural-appearing breast mound compared with the implant alone (Fig. 1). Additionally, the higher rate of revision surgeries over time in the LD with implant group may have been due to the evolution of tissue injury after radiation therapy, including atrophy of the skin and subcutaneous tissue. This injury seems to have occurred more commonly in our practice in the presence of a prosthetic device than with abdominal-based reconstruction (Fig. 2). Moreover, ABFFs include not only additional skin but also perhaps more significantly, autologous adipose tissue, which is rich in progenitor cells and secretomes that have been demonstrated to be important for tissue regeneration, although this has yet to be completely elucidated, particularly in delayed breast reconstruction patients.^{30–33}

Unilateral delayed breast reconstruction after complete mastectomy and PMRT offers the additional challenge of approximating symmetry between the patient's contralateral, nonirradiated, native breast and the ipsilateral reconstructed breast. For this reason, our comparison of these 2 reconstruction techniques analyzed not only complication rates and revision surgery on the reconstructed breast but also the need for contralateral surgery for symmetry. Although there were fewer additional surgeries overall in the ABFF group, we did find that these patients were more likely to have an additional operation on the contralateral native breast for symmetry, commonly mastopexy or reduction, which may be explained by the higher prevalence of obesity observed in the ABFF group.

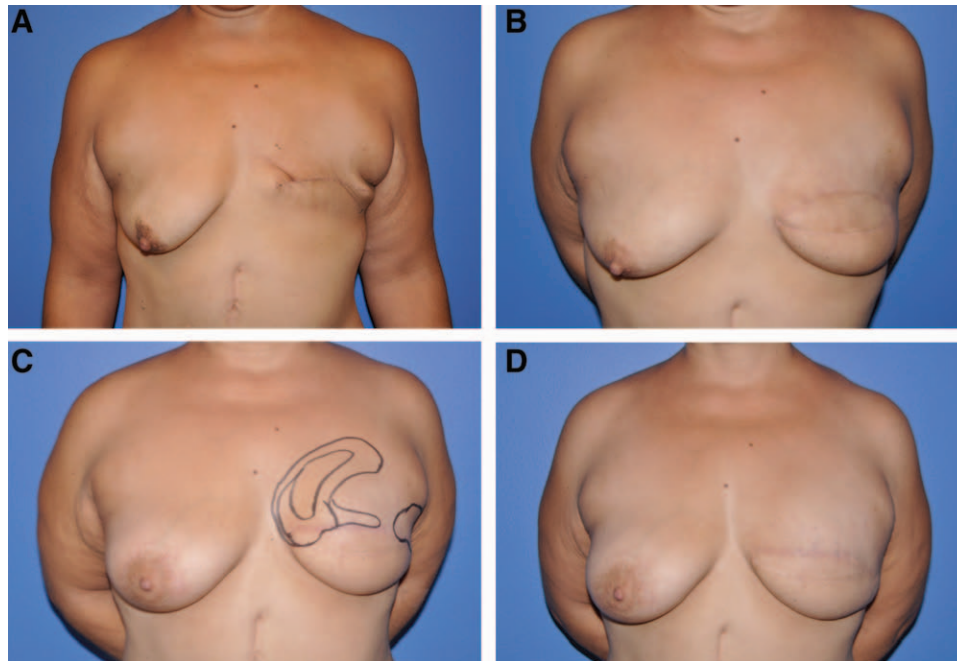


Fig. 1. Example of left unilateral delayed breast reconstruction with a pedicled LD flap and implant after PMRT. A, Preoperative photograph. B, After autologous reconstruction with a pedicled latissimus flap and placement of a tissue expander. The patient subsequently had an augmentation mastopexy of the right breast and tissue expander to implant exchange on the left. C, After right breast augmentation mastopexy and left breast implant placement, the patient presented for revision of the left reconstructed breast given upper pole contour irregularities and raised inframammary fold. D, Postoperative photograph after revision of the left reconstructed breast with capsulectomy, lowering of the inframammary fold and autologous fat grafting of the superior pole. Note that she did not want nipple reconstruction or micropigmentation.

Radiation is associated with tissue fibrosis, chronic inflammation, vasculitis, and a compromised capacity for wound healing.³⁴ In the setting of breast reconstruction, the adverse effects of radiation therapy can result in higher complication rates and compromised cosmesis.^{35–37} It is generally agreed upon that autologous tissue is preferred over implants for delayed breast reconstruction after mastectomy and PMRT. Because the remaining chest wall skin is scarred and fibrotic after PMRT, reconstruction typically requires not only tissue volume but also skin replacement to create an aesthetically optimal breast mound. Of the patients undergoing planned two-stage procedures with a tissue expander placed at the time of the LD flap placement and then exchanged for an implant, all had additional revisions to the reconstructed side. These were most commonly lowering of the inframammary fold and advancement of the musculocutaneous flap.

The strengths of this study include a large cumulative experience with delayed breast reconstruction after PMRT, consecutive patients at a major U.S. cancer center, data obtained from a prospectively maintained patient database, use of regression analysis, exclusion of patients with less than 1 year of follow-up, mean patient follow-up duration of over 2 years, and strict inclusion and exclusion criteria delineating 2 specific study groups for comparison and to control for confounding. Limitations include the study's retrospective design and potential for selection

bias (as patients were not randomized to the 2 reconstruction techniques).

We believe these data support our hypothesis that ABFFs for delayed breast reconstruction after PMRT provide superior long-term durability compared to LD with implant breast reconstructions. Delayed, unilateral breast reconstruction after standard mastectomy and PMRT represents one of the most aesthetically challenging types of breast reconstruction. Previous studies have been more heterogeneous in reconstructive methods (ie, immediate vs delayed, delayed-immediate with preservation of the breast envelope, and with or without PMRT). In our study population, where the breast envelope has been removed and the remaining native skin has been radiated, the surgeon has few options to recreate the breast mound with adequate soft tissue to match the native contralateral breast. The best reconstruction for each patient is dependent on a multitude of factors, including body habitus, comorbidities, and patient and surgeon preference, and not every patient is a candidate for delayed breast reconstruction with an ABFF. Nevertheless, we believe that the current study adds to our knowledge and understanding of not only the short-term complications of delayed breast reconstruction after PMRT but also, perhaps more importantly, the long-term durability of our reconstructive options. Based on our data, we believe that surgeons should favor ABFFs over LD with implants for delayed breast re-

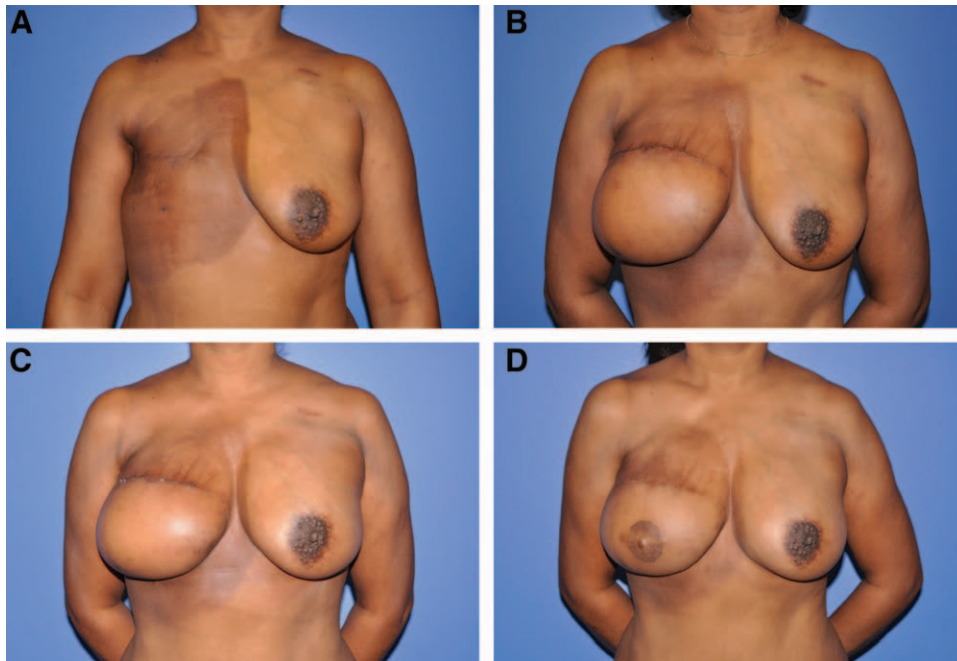


Fig. 2. Example of right unilateral delayed breast reconstruction with ABFF after PMRT. A, Preoperative photograph. B, After free muscle-sparing transverse rectus abdominis myocutaneous (type 2) free flap. C, After left breast augmentation for symmetry. D, After nipple reconstruction and micropigmentation.

construction after standard mastectomy and PMRT in patients for whom an ABFF is an option.

CONCLUSION

Although the early complication rates between ABFFs and LD with implants for delayed breast reconstruction after standard mastectomy and PMRT are similar, ABFFs seem to provide a more durable reconstruction with fewer additional revision surgeries in the long term. Although not all patients are candidates for ABFF breast reconstruction, based on the results of our study, we believe that surgeons should favor ABFFs over LD flaps for delayed breast reconstruction after PMRT if both options exist.

Summer E. Hanson, MD, PhD

Department of Plastic Surgery—Unit 1488
The University of Texas MD Anderson Cancer Center
1400 Pressler Street
Houston, TX 77030
E-mail: sehanson@mdanderson.org

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