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Bipedicle-conjoined perforator flaps in breast reconstruction



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ABSTRACT

Background: For some patients seeking autologous breast reconstruction, there may be insufficient abdominal skin and soft tissue to reconstruct an adequately sized breast. Perfusion from a single-pedicle deep inferior epigastric perforator artery flap has a high degree of variability across the midline, and this further limits perfusion. We have found that bipedicle-conjoined abdominal perforator flaps are a novel and reliable technique for reconstruction in these women, and this study examines our experience.

Materials and methods: A retrospective review was performed over a 2-y period of bipedicle-conjoined abdominal perforator flaps in 28 patients. For each reconstruction, the pedicle of one flap was anastomosed to the anterograde internal mammary artery vessels and the pedicle of the second flap to a side branch of the primary flap or the retrograde internal mammary vessels.

Results: Mean age and body mass index were 50.2 y (standard deviation, 8.0) and 25.9 kg/m² (standard deviation, 2.8), respectively. In total, 15 patients (53.6%) received radiation therapy before surgery. There were no flap losses; fat necrosis was found in one flap (3.2%). The large contiguous skin island of the bipedicle-conjoined deep inferior epigastric perforator flaps allowed for extensive replacement of damaged or absent breast skin when necessary. Aesthetically satisfactory results were achieved in all patients.

Conclusions: Bipedicle-conjoined abdominal perforator flaps represent a novel technique in select patients seeking breast reconstruction. The added complexity was safe and reliable in this series of patients. Compared to unipedicle flaps, the increased skin and volume allow greater flexibility to achieve the desired shape and projection.

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1. Introduction

Autologous free-flap breast reconstruction has become a common and reliable method for immediate and delayed reconstruction of the female breast [1]. Despite recent reports indicating a paradigm shift toward implant-based procedures after mastectomy, advances in microsurgical techniques have continued to develop, rendering autologous tissue transfer an excellent option for reconstructing a natural appearing breast [2]. Currently, the deep inferior epigastric perforator (DIEP) flap is considered the gold standard in microsurgical breast reconstruction owing to its favorable donor site morbidity, complication rates, and patient satisfaction [3–9]. In 2012, DIEP flap reconstruction was shown to be the most widely used method of autologous breast reconstruction in the United States [10]. The American Society of Plastic Surgeons reported on 95,589 breast reconstruction procedures in 2013, of which 7220 (8.1%) involved DIEP flap reconstruction [11].

To perform a satisfactory autologous reconstruction, sufficient skin and subcutaneous fat is necessary to create a teardrop-shaped natural-looking breast with adequate volume to match the contralateral breast. For some patients, the single-pedicle DIEP artery flap does not adequately satisfy one or more critical components necessary to achieve an aesthetically satisfactory breast reconstruction, namely the restoration of the “footprint,” “conus,” and “skin envelope.” [12] Satisfying all three of these critical elements is particularly challenging in women who have relatively scant abdominal tissue in the distribution of a single-pedicle DIEP flap and for those undergoing delayed reconstruction where there is a significant skin deficiency, especially after radiotherapy. Alternatively, implant-based reconstruction could be considered; however, this method does not adequately resolve inadequacies of the skin envelope, particularly in irradiated patients, leading to further shortfalls in shape and ptosis [13]. In addition, recently published data describe a higher risk of reconstructive failure and surgical site infection in tissue expander with implant reconstruction relative to abdominal free-flap tissue transfer [14].

To address these challenges in breast reconstruction, an increasing number of studies describe the use of bipedicle DIEP flaps [15–19]. The bipedicle concept relies on the entire lower abdominal flap with perfusion based on two sets of perforators, with at least one perforator on each side of the midline. This approach can be considered when a patient presents with the need for unilateral breast reconstruction and only has adequate adipocutaneous tissue when all or most of the entire lower central abdominal wall is used. We have extended the bipedicle-conjoined DIEP flap concept to capture volume and skin over the flank region in women requiring bilateral autogenous reconstructions by conjoining one DIEP flap with one deep circumflex iliac artery (DCIA), superficial circumflex iliac artery (SCIA) or superficial inferior epigastric artery (SIEA) perforator flap from each side of the abdomen.

In this study, we describe our experience with bipedicle-conjoined abdominal perforator flap reconstruction in post-mastectomy breast reconstruction. We have found that bipedicle-conjoined abdominal flaps can be reliably used to achieve aesthetically satisfactory unilateral and bilateral

breast reconstructions in women who would otherwise have a paucity of tissue using single-pedicle DIEP flaps.

2. Methods

2.1. Patient selection

We performed a retrospective review of women undergoing unilateral or bilateral breast reconstruction using bipedicle-conjoined abdominal perforator flaps at two institutions between December 2012 and December 2014. All surgeries were performed by two plastic surgeons (D.T.G. and H.A.E.). The study received institutional review board approval before data recruitment. Data on patient demographics, relevant comorbidities (smoking, coronary artery disease, hypertension, diabetes, hypertension, and coagulopathy), preoperative and intraoperative imaging, and postoperative outcomes (flap failure, breast and/or abdominal hematoma, breast and/or abdominal seroma, breast and/or abdominal delayed wound healing, breast and/or abdominal infection, and fat necrosis) were collected from medical records and stored in a comprehensive database.

2.2. Preoperative planning

Routine workup at our institutions included assessment of patient risk factors associated with increased risk of complications. Volume and quality of the abdominal tissue were assessed clinically to determine the possibility of reconstructing an aesthetically shaped new breast of the desired size. Treatment options were discussed, including tissue expander placement and autologous breast reconstruction. At the time of consultation, the operating surgeon determined if a unipedicle abdominal perforator or a bipedicle-conjoined abdominal perforator flap would be needed to reconstruct the breast or breasts.

Preoperative perforator mapping was performed with either multiple-detector computed tomography angiography or magnetic resonance angiography.

2.3. Surgical technique

Before surgery, skin markings were made according to previously described studies on DIEP reconstruction where conjoined DIEP + DIEP flap were planned [19,20]. When bilateral conjoined flaps were planned, the bilateral DIEP flaps were marked along with the distribution of the secondary flaps. When a DIEP + DCIA or DIEP + SIEA or DIEP + SCIA flap was planned, the skin incisions were modified to create a longer ellipse incorporating the distribution of the additional vessels (Fig. 1).

Perforator selection was based predominantly on preoperative imaging; however, direct intraoperative observations, and in select cases, the results of intraoperative fluorescence angiography, were also taken into account. In cases of immediate breast reconstruction, the mastectomy was performed by a breast surgeon, whereas the abdominal perforator dissection was performed simultaneously.

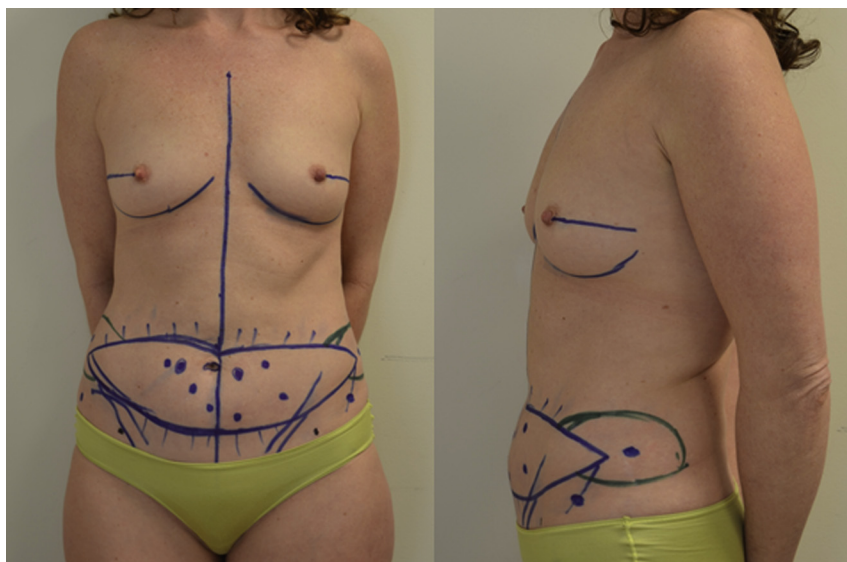


Fig. 1 – Preoperative marking for bilateral nipple-sparing mastectomies and immediate bilateral-conjoined abdominal perforator flaps. The standard bilateral DIEP flap marking (blue ink) was modified to include tissue beyond the perfusion zone of the deep inferior epigastric vessels (green ink). The more lateral markings in green were in the distribution of the SCIA and DCIA perforators and the blue dot in the center of the green marking represents the target perforator for the secondary flap. SCIA = superficial circumflex iliac artery. (Color version of figure is available online.)

To harvest the abdominal flaps, the superior and inferior abdominal incisions were made and the SIEA and the accompanying vein (superficial inferior epigastric vein) were identified and dissected to preserve additional vascular anastomosis opportunities for stacking of two hemi-abdominal flaps or for possible additional venous drainage in DIEP + DIEP conjoined flaps. If present, the superficial inferior pudendal veins were also dissected as a backup for additional venous drainage. Each flap was then raised above the level of the abdominal wall fascia to expose the desired perforators, which were then dissected under loupe magnification in a retrograde manner to their respective origins. This technique was used bilaterally. Intraoperative fluorescence angiography to assess perfusion to each hemiabdominal flap and/or to assess patency of the intraflap anastomoses (Fig. 2) was performed selectively based on the surgeon's intraoperative judgment.

By convention, we define the pedicle with the most optimal perforator the “primary flap.” All primary flaps were anastomosed to the anterograde internal mammary artery (IMA) and internal mammary vein (IMV) by a hand-sewn arterial anastomosis and a venous coupling system, respectively. We define the flap conjoined to the primary flap as the “secondary flap.” Secondary flaps were either anastomosed to a branch of the primary flap pedicle, thus making the primary flap a flow-through flap, or separately to the retrograde internal mammary vessels (Fig. 3).

Each conjoined flap was positioned on the chest wall before anastomosis so that the primary flap would be positioned more medially when inset and the secondary flap would be positioned more laterally. This required rotating the conjoined flap construct 180° when the primary flap was harvested ipsilateral to the recipient defect and no rotation

when the primary flap was harvested contralateral to the recipient defect.

Each conjoined flap construct was folded and carefully inset into the breast pocket, allowing for optimal sculpting into the desired shape. In most cases, the secondary flaps were folded inferolaterally, such that a portion of the secondary flap was tucked below the primary flap. This allowed for volume replacement along the chest wall and allowed for a wider base width of the breast than could be achieved with a unipedicle flap. When necessary, the secondary flap was

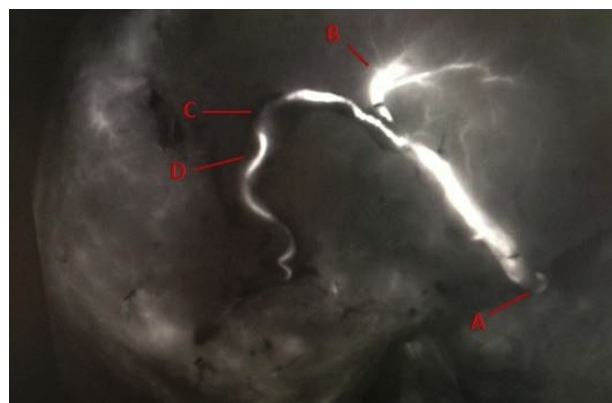


Fig. 2 – Spy image of the undersurface of bipedicle-conjoined DIEP flap. A: arterial and venous anastomoses of primary pedicle to internal mammary vessels; B: primary perforator entering the tissue; C: site of arterial and venous anastomoses of secondary pedicle to primary pedicle; and D: flow within secondary pedicle distal to anastomoses. (Color version of figure is available online.)



Fig. 3 – Intraoperative image of a bipedicle-conjoined DIEP flap showing primary and secondary pedicles coupled to one another. (Color version of figure is available online.)

inset toward the axilla to replace the tissue deficit created by axillary dissection and radiation therapy. Tacking sutures, either between different segments of a flap or between a flap and the chest wall, were used to hold flaps in place. In delayed reconstructions, an irregularly shaped “fish tail” skin island pattern was used to adequately shape the skin envelope and provide a rounded shape to the reconstructed breast. This improved the overall aesthetic shape to the breast and allowed increased ptosis without flattening of the breast or narrowing of the base width. Two drains were used in each breast pocket.

All patients received continuous postoperative monitoring with the application of a ViOptix tissue oximetry probe (ViOptix, Inc., Fremont, CA)[21,22], regular clinical assessment by trained nursing staff, and hand-held Doppler surveillance.

3. Results

3.1. Patient and flap demographics and comorbidities

A total of 28 female patients who underwent breast reconstruction with bipedicle-conjoined abdominal flaps were included in our study. Of these, 25 patients (89%) underwent unilateral reconstruction and three patients (11%) had bilateral reconstruction. Average age and body mass index were 50.2 y (standard deviation [SD] 8.0; range, 31–67 y) and 25.9 kg/m² (SD, 2.8), respectively. Right-sided breast reconstruction was performed in 15 cases (48.4%), and the other 16 cases (51.6%) involved a left-sided reconstruction. Thirteen patients presented for immediate reconstruction after mastectomy, and 15 patients underwent delayed reconstruction. In total, 16 patients received chemotherapy, and 15 patients had been treated with radiotherapy before reconstruction.

With respect to significant comorbidities, none of the patients in this series used nicotine at the time of surgery

Table 1 – Demographics and comorbidities.

Demographics	Mean (SD)
Age (y)	50.2 (8.0)
BMI (kg/m ²)	25.9 (2.8)
Comorbidities	n (%)
Active smokers	0
Hypertension	5 (17.9)
Diabetes	1 (3.6)
Chemotherapy	16 (57.1)
Radiotherapy	15 (53.6)
Coagulopathy	2 (7.1)
Previous abdominal surgery	16 (57.1)
Previous breast surgery	16 (57.1)
Preoperative Imaging	
Preoperative CTA	5 (17.9%)
Preoperative MRA	23 (82.1%)

CTA = computed tomography angiography; MRA = magnetic resonance angiography.

or experienced coronary artery disease. Few patients had a history of hypertension ($n = 5$) or diabetes ($n = 1$); however, one patient had a history of hemophilia A and another patient presented with systemic lupus erythematosus. Furthermore, one patient reported a history of deep venous thrombosis, and one patient experienced colitis, for which she used an immunosuppressive agent. Sixteen patients (57.1%) had previous abdominal surgeries. All patient demographics and comorbidities are summarized in Table 1.

The average mastectomy weight and harvested flap weight were 620 (SD, 248) and 701 (SD, 212) g, respectively. In all cases, flap weight was more than sufficient to match the resected breast tissue. For conjoined DIEP + DIEP flaps, a medial

Table 2 – Flap characteristics.

	Total (%)
Timing of reconstruction [*]	
Immediate	13 (46.4)
Delayed	15 (53.6)
Side [†]	
Right	15 (48.4)
Left	16 (51.6)
Vascular pedicle construct [†]	
DIEP/DIEP	23 (74.2)
DIEP/SIEA	4 (12.9)
DIEP/DCIA	2 (6.5)
DIEP/SCIA	2 (6.5)
	Mean (SD)
Mastectomy weight [†] (g)	620 (248)
Flap weight [†] (g)	701 (212)
Vein coupler size [†] (mm)	
Primary	3.1 (0.3), range 2.5–3.5
Secondary	2.2 (0.5), range 1.5–3.0

SCIA = superficial circumflex iliac artery.

^{*} Data presented per patient ($n = 28$).

[†] Data presented per flap ($n = 31$).



Fig. 4 – Preoperative view (left) and postoperative views (center and right) after left breast reconstruction with a bipedicle-conjoined DIEP flap and right mastopexy. The bipedicle-conjoined DIEP flap was inset with a portion of the secondary flap folded and tucked beneath the inferolateral flap tissue to achieve the desired projection. Even with the net loss of a portion of the total skin island that necessarily resulted from folding the lateral portion of the secondary flap to shape the conus, the remaining flap skin island was still large enough to allow for the replacement of the skin envelope required to reconstruct a breast with a natural shape and contour. The linear scar in the lateral aspect of the flap resulted from the closure of the periumbilical incision. (Color version of figure is available online.)

periumbilical perforator from each hemiabdominal flap was used in the majority of cases (43.5%). The next most frequent combination was that of medial and lateral perforators (34.8%) followed by the combination of two lateral perforators (21.7%). In 16 cases (51.6%), intraflap anastomoses were created by connecting the secondary pedicle to the primary pedicle. In 15 cases (48.4%), branches of the primary flap pedicle were deemed suboptimal to serve as recipient vessels for the secondary flap pedicle, and in these cases, the secondary flap was anastomosed directly to the retrograde IMA/IMV. In all cases of DIEP + DCIA, DIEP + SIEA, or DIEP + SCIA, the secondary flap was anastomosed to the primary pedicle rather than the

retrograde mammary vessels. Specific flap characteristics are summarized in Table 2. An example of a flap inset is demonstrated in Figure 4.

There was one return to the operating theatre because of venous congestion with impending flap loss in a DIEP + DIEP conjoint flap reconstruction. At the time of reoperation, a thrombus was removed from the deep inferior epigastric vein of the secondary flap at the level of its anastomosis to the primary flap pedicle. A thrombectomy was performed, and the deep inferior epigastric vein of the secondary flap was then anastomosed to a branch of the thoracodorsal vein rather than back to a branch of the primary pedicle.



Fig. 5 – Preoperative view (left) demonstrating unsatisfactory right breast implant reconstruction and postoperative view (right) after removal of implant and right breast reconstruction using a bipedicle-conjoined DIEP flap and revision of the prior left breast reduction. (Color version of figure is available online.)



Fig. 6 – Preoperative view (left) after left mastectomy and radiation therapy. Postoperative views (center and right) after bipedicle-conjoined DIEP flap left breast reconstruction and right mastopexy. The reconstruction used all four Hartrampf zones and a large contiguous skin island that overlies both the primary and secondary flaps. (Color version of figure is available online.)

There were no flap losses in our case series, and aesthetically satisfactory results were achieved in all patients (Figs. 5–7). Two patients (6.5%) developed recipient-site seroma, which was managed in an outpatient setting. Fat necrosis >2 cm was seen in one flap (3.2%) but needed no further management at the time. All postoperative complications are summarized in Table 3.

4. Discussion

The unipedicle DIEP flap is a mainstay of postmastectomy autologous breast reconstruction because of its low abdominal wall morbidity and high degree of patient satisfaction [23]. Unipedicle DIEP flaps, however, do not provide sufficient volume and/or skin surface area for all women who present for

breast reconstruction. Bipedicle-conjoined abdominal perforator flaps are an excellent option for autologous reconstruction in many situations when traditional unipedicle DIEP flaps are inadequate.

Blondeel *et al.* introduced a conceptual triptych of aesthetic and anatomic features (the “footprint,” the “conus,” and the “skin envelope”) that may be applied to guide the surgeon in preoperative flap selection, as well as to systematically shape the reconstructed breast [13]. We use this conceptual triptych when evaluating patients and selecting flaps for use in breast reconstruction. For patients who have a relative paucity of abdominal tissue volume or abdominal skin surface area, unipedicle DIEP flap reconstruction often proves to be an inadequate solution for either unilateral or bilateral autologous breast reconstruction. This is because in such cases, unipedicle flaps fail to satisfy all three of the critical elements



Fig. 7 – Preoperative view (left) and postoperative view (right) after bilateral nipple-sparing mastectomies and immediate bipedicle-conjoined DIEP + SCIA flaps. SCIA = superficial circumflex iliac artery. (Color version of figure is available online.)

Table 3 – Postoperative outcomes after bipedicle-conjoined abdominal flap reconstruction.

Complication	Total (%)
Breast [*]	
Flap loss	0
Mastectomy skin loss	1 (3.2)
Hematoma	0
Seroma	2 (6.5)
Persistent edema	3 (9.7)
Fat necrosis >2 cm	1 (3.2)
Fat necrosis <2 cm	5 (16.1)
Infection	0
Abdomen [†]	
Hematoma	0
Seroma	4 (14.3)
Delayed wound healing	2 (7.1)
Cellulitis	1 (3.6)
General	
Pulmonary embolism	0
Deep venous thrombosis	0

^{*} Calculated as a proportion of the total number of flaps (*n* = 31).
[†] Calculated as a proportion of the total number of patients (*n* = 28).

of the conceptual triptych by Blondeel *et al.* This is particularly the case for women who have relatively scant abdominal tissue and for those undergoing delayed reconstruction where a significant skin deficiency is present, especially when the skin deficiency is associated with prior radiotherapy.

When a traditional two-zone flap, based on the zones of Holm or Hartrampf, is inadequate for unilateral reconstruction [24], some surgeons harvest abdominal tissue beyond the zone of reliable perfusion of a unipedicle DIEP flap. This increases the risk of fat necrosis or partial flap loss. Multiple studies have demonstrated unreliable perfusion by DIEP vessels across the abdominal midline [25,26]. In such situations, we prefer to use bipedicle-conjoined abdominal perforator flaps and thus avoid the inclusion of potentially marginally perfused tissue [16,17,27].

In our series, there were no partial or complete flap losses and only one case of clinically significant fat necrosis >2 cm. Although six patients developed minor donor-site complications such as wound healing delay and seroma, flap-related complications were very low and similar to reported rates for unipedicle DIEP flaps [28].

Selection of the “primary flap” was based on several factors, including perforator diameter, perforator dominance within each hemiabdominal flap, the branching patterns of both deep inferior epigastric systems, perfusion zones, and location of a dominant perforator as assessed on multiple-detector computed tomography angiography or magnetic resonance angiography as previously described [29]. Our primary objective was to connect the best perforator and/or pedicle to the best recipient vessels, namely the anterograde internal mammary vessels. When the retrograde internal mammary vessels were not suitable for use as recipient vessels or when the branching pattern of the primary pedicle allowed for easy connection to the secondary flap, the primary pedicle was used as a flow-through pedicle.

By taking perforator vessel diameter into account, previous studies have demonstrated dominance of the medial row perforators over the lateral row [30,31]. In this study, the

majority of harvested flaps relied on a medial vessel perforasome allowing for optimal flap perfusion. In 14 cases, the primary flap functioned as a flow-through flap to which the secondary flap was connected. Additionally, 13 flaps were anastomosed directly to the retrograde IMA and IMV, providing the secondary flap with a separate unique blood supply. We based this decision on the anatomic features of the branches of the primary flap pedicle. If the primary flap pedicle does not have a branch of adequate diameter or length that comfortably reaches the secondary flap pedicle, then the retrograde internal mammary vessels are used for the secondary flap.

When a conjoined flap is required for unilateral breast reconstruction, we prefer to use the DIEP + DIEP flap construct, as this procedure is technically the most straightforward of the conjoined abdominal flap procedures. However, when confronted with the challenge of simultaneously reconstructing two breasts for women who cannot be adequately reconstructed with two unipedicle flaps, we have also extended the conjoined flap concept. By adjusting flap design to incorporate two pedicles and perfusion zones from each side of the abdomen and trunk, a bipedicle-conjoined flap for each breast can be harvested. The bilateral-conjoined abdominal perforator flap dramatically increases the volume tissue and skin surface area that can be harvested, thus rendering autologous tissue an option where historically implant-based breast reconstruction has been preferred. The perforasome supplied by the DCIA, SCIA, or SIEA can be included in a conjoined flap, which, in conjunction with the ipsilateral DIEP flap, can satisfy the need for increased volume (conus), footprint dimensions, and skin envelope to reconstruct each breast (Fig. 7).

Our series differs in a number of important ways from other reported series of conjoined or stacked DIEP flaps. DellaCroce *et al.* reported a series of stacked DIEP flaps in which the DIEP flaps were divided at the abdominal midline thus allowing the combination of the two DIEP flaps in a layered fashion into the breast pocket [18,32]. This configuration maximized projection of the conus at the expense of the footprint and skin envelope. Furthermore, transection along the abdominal midline potentially jeopardizes midline crossing vasculature where such crossing vessels are present [18,33,34]. Besides a theoretically increased risk of partial flap failure, we feel that an intact abdominal skin bridge between both hemiabdominal perforasomes provides an important benefit when shaping the flap into a teardrop-shaped breast mound. Thus, we favor the conjoined approach over the stacked approach.

Bipedicle-conjoined abdominal flaps solve a number of aesthetic challenges in breast reconstruction. In comparison to unipedicle flaps, bipedicle-conjoined perforator flaps provide greater tissue volume with a robust blood supply, greater skin surface area, and greater freedom for the surgeon to shape and sculpt the breast mound while maintaining all the donor-site advantages that perforator flaps have over musculocutaneous flaps.

5. Conclusions

Bipedicle-conjoined abdominal flaps solve a number of aesthetic challenges in unilateral and bilateral breast

reconstruction. The shape and volume of bipedicle-conjoined abdominal flaps provide improved opportunities for the aesthetic sculpting of a reconstructed breast and present as an excellent and reliable alternative when single-pedicle flaps do not provide adequate tissue to address the critical elements of an aesthetically optimal breast reconstruction—the footprint, conus, and skin envelope. It offers a number of important advantages including greater tissue volume, a larger skin island, and enhanced ability to sculpt the conus and achieve the desired shape and projection of the reconstructed breast. This series demonstrates that the technique can be used safely and reliably.

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Authors' contributions: P.G.L.K. was involved in acquisition and analysis of data, drafting the article, final approval, and agreement to be accountable for all aspects of the work. B.T.L. was involved in interpretation of data for the work, drafting the article, final approval, and agreement to be accountable for all aspects of the work. S.J.L. was involved in interpretation of data for the work, drafting the article, final approval, and agreement to be accountable for all aspects of the work. H.A.E. was involved in acquisition and analysis of data, drafting the article, final approval, and agreement to be accountable for all aspects of the work. D.T.G. was involved in acquisition and analysis of data, drafting the article, final approval, and agreement to be accountable for all aspects of the work.

Disclosure

The authors have no financial disclosures and report no conflicts of interest with any of the companies or products mentioned in this article.

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