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Profunda artery perforator free flaps for breast reconstruction

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Abstract

The gold standard for post-mastectomy autologous breast reconstruction is abdominally based free flaps. For patients with contraindications to abdominal free flap reconstruction, utilization of other donor sites should be considered. The profunda artery perforator flap has become a popular option for autologous reconstruction as it offers many advantages, including a long pedicle, muscle preservation, and easy soft tissue contouring. This review will provide an extensive outline of the history, anatomy, clinical indications, surgical techniques, and outcomes of the profunda artery perforator flap. It will also discuss appropriate preoperative imaging (CTA, MRA) and present a case of a patient who received a profunda artery perforator flap at our institution.

Keywords: Autologous breast reconstruction, profunda artery perforator (PAP) flap, microsurgery

INTRODUCTION

As the number of women diagnosed and surviving breast cancer continues to increase, it is critical to have a diverse arsenal of options for breast reconstruction to customize care for each patient[1-3]. While implants remain the most common modality and provide successful reconstruction for many women, autologous tissue accomplishes the objective of breast reconstruction while avoiding a permanent prosthesis which can be subject to complications such as capsular contracture and rupture[4]. Additionally, patients who undergo autologous breast reconstruction are more satisfied with their breast reconstruction and experience better

health-related quality of life compared to patients with implant-based reconstruction[5].

The gold standard for autologous breast reconstruction is abdominally based free flaps[4]. The creation of the conventional pedicled transverse rectus abdominus myocutaneous (TRAM) flaps and the free TRAM set the stage for autologous breast reconstruction[6,7]. Since its introduction in 1994, the deep inferior epigastric perforator (DIEP) free flap has been established as the most widely used operation for autologous breast reconstruction, offering less donor site morbidity with equally successful results[8-10].

In patients where there are contraindications to abdominally based flaps, other donor sites for autologous reconstruction should be considered. Thigh-based flaps have become the second most common option. These include the gracilis-based flaps (Transverse [TUG], diagonal [DUG], and vertical upper gracilis [VUG] myocutaneous flaps), the lateral thigh perforator (LTP) flap, and the profunda artery perforator (PAP) flap. The PAP flap has emerged as a commonly utilized thigh-based flap, given its favorable ability to be oriented according to the patient's body habitus and scar preference. Originally, the PAP flap was described for posterior thigh V-Y flaps in the 1980s[11]. In 2001, a study with 20 cadaveric dissections and 25 PAP flaps was published describing the anatomy and soft tissue territory for this flap with a reported vessel diameter of 2 mm and a pedicle length of 7-9 cm[12]. It was not until 2012 that Allen *et al.* described the use and technique of the PAP flap as a reliable option for autologous breast reconstruction. Their initial reports included a series of 27 flaps detailing the harvest of perforators off the profunda femoris artery to transfer posterior thigh soft tissue to the breast[13].

There are several reasons why the PAP flap has become a more popular option compared to other donor sites. Compared to gracilis-based flaps mentioned above, the PAP flap is a perforator flap that does not require muscle sacrifice, potentially reducing donor site pain, functional morbidity, and dead space[14,15]. In a systematic review, the PAP flap had a longer pedicle length, increased flap weight, decreased occurrence of donor site wound dehiscence, and similar rates of partial flap necrosis and total flap loss compared to the TUG flap[16]. An additional advantage of the PAP flap is that it is located more posteriorly on the thigh, further away from the major lymphatic drainage of the lower extremity. This location reduces the devastating risk of postoperative lymphedema that can be seen with the TUG flap[15,17]. Compared to other alternate options for breast reconstruction (i.e., gluteal artery perforator [IGAP, SGAP] flaps, lumbar artery perforator [LAP] flaps), the incisions of a transversely-oriented PAP flap can be concealed within the gluteal crease, providing an inconspicuous scar that does not disrupt the gluteal crease or contour. Upper medial thigh tissue exhibits greater malleability than gluteal and lumbar tissue, making it easier to shape into a breast with a natural ptotic appearance[4]. Additionally, sensory nerves in the thigh have been identified as suitable for harvesting and neurotization of PAP flaps[18,19]. Dayan and Allen, Jr. successfully performed the first neurotized PAP flap through end-to-end coaptation of the anterior branch of the obturator nerve to the lateral branch of the T4 intercostal nerve[19].

The main disadvantage of PAP flaps for breast reconstruction remains the relatively limited volume when larger volume reconstructions are desired[4,20]. It has been reported that the average volume of a hemi abdominal DIEP flap is approximately 700 g, while volumes for PAP flaps range from 220 to 405 g, with the possibility of higher volumes through modifications in the flap design[20,21]. Haddock published a review of his experience of a decade of PAP flaps and reported an average flap weight of 354.3 g across the 405 PAP flaps he performed[22]. Other disadvantages include the potential for sensory changes to the posterior thigh, patient positioning during surgery, and conspicuous scars on the posterior thigh (with transversely or vertically oriented PAP flaps).

Given its long pedicle, muscle preservation, easy contouring of the soft tissue, and minimal aesthetic shortcomings of the donor site, PAP flaps are an excellent second choice for autologous breast reconstruction. This review will summarize the indications, vascular anatomy, preoperative planning, operative technique, and postoperative care when utilizing a PAP flap in breast reconstruction.

CLINICAL CONSIDERATIONS

Ideal patients for PAP flaps require small to moderate breast volume and have excess tissue in the posterior thigh region. Ideal candidates are pear-shaped, carrying most of their weight in their thighs, or massive weight loss patients that would benefit from a thigh lift. PAP flap patients often have a contraindication to abdominally based flaps. This includes patients with prior abdominal surgeries that have affected the blood supply to the lower abdomen (i.e., liposuction, abdominoplasty, laparotomy) or those patients who have already had a DIEP flap[23]. If there is concern about the integrity of the vascularity when evaluating a patient for potential abdominally based free tissue transfer, imaging with CTA or MRA can provide additional information to determine candidacy.

Other patients may not have enough abdominal tissue to provide adequate volume flaps. Multiple studies have found that individuals with low body mass index (BMI) and without adequate abdominal tissue can harvest enough soft tissue for breast reconstruction with PAP flaps. The average BMI of patients across studies ranges from roughly 22 to 26, with PAP flap weights averaging 300 to 400 g[24-26]. In situations where additional soft tissue is needed for breast reconstruction, the PAP flaps can be stacked together for unilateral reconstructions or with other donor sites for bilateral reconstructions[27,28].

PAP flaps are contraindicated in patients with prior surgery to the donor site, venous insufficiency of the lower extremity, history of deep vein thrombosis of the legs, lower extremity lymphedema, and body mass index > 35 kg/m^2.

Abdominal-based flaps are generally considered safe for the obese population. However, a higher BMI is linked to an increased risk of wound healing issues, infection, and flap failure[29,30]. These findings have translated to similar results in the PAP population, showing that increased BMI also raises the risk of donor site complications[31]. The decision to limit PAP flap reconstruction to patients with a BMI less than 35 is a relative contraindication. Typically, these patients have limited laxity in their thigh region and are prone to complications such as seroma formation and wound dehiscence. Furthermore, patients with a higher BMI face an increased risk of deep vein thrombosis, which is further compounded by the meticulous manipulation of the soft tissues in the thighs required for this procedure. Nevertheless, each patient is unique, and an individualized assessment should be undertaken to evaluate the risks and benefits of the procedure thoroughly.

PREOPERATIVE PLANNING

Successful microsurgery requires meticulous preoperative planning and routinely includes preoperative imaging. As imaging has become more accurate in predicting perforator anatomy, computed tomography angiography (CTA) and magnetic resonance angiography (MRA) are being more commonly utilized to assess perforator location, size, and anatomic variations preoperatively[32]. Thin slice CTA has been commonly used in preoperative imaging as it is widely available, fast, familiar to most surgeons, and provides accurate anatomic localization of the perforators. Limitations of CTA include the requirement for radiation, complexity in the timing of contrast bolus, and poor opacification of veins. Additionally, the images obtained through CTA may not be of the highest quality if radiation dosage constraints are imposed. As an alternative, MRA has lower spatial resolution but makes up for it with superior contrast resolution.

This enables the identification of even the smallest perforators, which can be easily distinguished from the background of fat or muscle, allowing for clearer visualization of the perforator intramuscular course without the need for radiation[33].

Overall, MRA studies provide optimal preoperative imaging, given their high-definition visualization of perforator anatomy using 3D reprocessing techniques. In MRA reports, the overall mapping of the perforators is accurate and the level of detail for each perforator is unmatched. Accurate identification and selection of perforators, detail of the intramuscular course, and perforator length allow for reliable marking and planning of the location of the skin paddle. This is particularly helpful when planning a transverse PAP (tPAP) flap, as the dominant perforator must be found within 5-6 cm of the inferior gluteal crease (IGC) to ensure the resulting scar lies in the ICG. When the dominant perforator is not in proximity to the IGC, a diagonal PAP (dPAP) flap can be planned to include the lower dominant perforator.

RELEVANT VASCULAR ANATOMY

As it passes under the inguinal ligament, the external iliac artery becomes the common femoral artery. Approximately 1-4 cm distal to the inguinal ligament, the common femoral artery bifurcates into the femoral artery and the profunda femoris artery. The femoral artery continues to travel superficially without any major branches to the thigh and distally transitions to the popliteal artery passing through the adductor hiatus[34]. The profunda femoris artery takes a posterolateral trajectory between the pectineus and adductor longus muscles, entering the posterior compartment of the thigh and providing significant blood supply to the proximal lower extremity[35]. The medial and lateral circumflex femoral arteries are the most proximal branches of the profunda. Progressing distally, the profunda femoris typically gives off three lateral branches before terminating as a fourth perforating vessel. The first branch supplies the adductor muscles and the gracilis, while the second and third branches nourish the biceps femoris, semimembranosus, and vastus lateralis. Each of these branches contributes a septocutaneous and/or musculocutaneous perforator, supplying the skin of the posterior thigh[34,35]. The number of adequate perforators varies by patient, with most patients having at least two but as many as five perforators[33,34]. Perforators are commonly located along the axis extending from the ischium to the lateral femoral condyle, with the initial skin perforator typically found within 8 cm of the IGC[32,34,36]. The length of the pedicle typically ranges from 8 to 13 cm[4]. Arterial and vein diameters measure around 1.5 to 2.4 mm and 1.8 to 3.0 mm, respectively[23,26].

OPERATIVE TECHNIQUE

Flap designs

The transverse PAP (tPAP) consists of a crescent-shaped skin paddle based on a PAP perforator in the proximal thigh. The tPAP design allows for scars to be discreetly placed along the IGC, but the width of the flap is limited to only 6-8 cm to ensure that closure can be achieved without excess tension. Although the transverse scar design is more easily hidden within the IGC, it is subjected to significant tension especially when the patient is in a seated position. Due to the location of the skin paddle, there is also a risk of paresthesias to the posterior thigh if there is an injury to the posterior cutaneous nerve[19].

The vertical PAP (vPAP) flap has a modified skin paddle orientated in a longer vertical dimension to allow for increased dissection and flap volume. This orientation provides the surgeon with more distal perforator options and a resulting scar that can be hidden in the medial thigh[37,38].

The “fleur-de-lis” modification of the PAP flap (the “fleur-de-PAP”) combines the principles of the tPAP and vPAP to maximize the soft tissue volume from one donor site but results in vertical and horizontal scars[39]. This option is ideal for the massive weight loss patient with excess, loose skin in multiple planes of

the thigh.

Another modification of the PAP flap is the diagonal PAP (dPAP) flap, where the skin paddle is placed diagonally along the resting skin tension lines. This orientation allows for a larger skin paddle that can be closed with minimal tension, decreasing the risk of complications at the donor site[19]. This design also avoids scars over bony prominences where there is increased pressure when sitting. Due to these advantages, the dPAP has become the ideal skin paddle design.

While the ipsilateral thigh is generally preferred for breast reconstruction, contralateral reconstruction is also possible since most PAP flaps have a single perforator in a central location. If a unilateral reconstruction is being done, both PAP flaps can be stacked or combined to achieve additional volume. In a bilateral reconstruction, PAP flaps can be combined safely with other flaps for additional volume[22,40,41].

Markings

The classic skin paddle orientation for the PAP flap is the diagonal modification. The patient is first marked standing in the preoperative area. The IGC is marked, as well as the location and distribution of the ideal fat to be included in the flap design. Once in the operating room, the gracilis and adductor longus muscles are marked and identified with the patient in the frog-legged position. Next, the patient is transitioned to the lithotomy position. The anticipated locations of the dominant perforators identified on MRA are marked and confirmed using a hand-held Doppler ultrasound. The anterior incision is marked starting from the posterior edge of the gracilis and gradually curves posteriorly starting approximately 8 cm inferior to the IGC. To determine the location of the posterior incision, a pinch test is performed along Langer's lines to assess the area that can be closed with minimal tension. Subsequently, the posterior incision is marked out, creating an ellipse, making sure to include the PAP perforator which runs through the adductor magnus muscle. Dissection in lithotomy maximizes exposure and ergonomics for the surgeon. Positioning the patient on a split-leg bed or leaving the patient in the frog-legged position are also options, but both are less ideal for maximizing exposure during surgery. The case is run as a 2-team approach where preparation of the breast pocket and vessels is performed at the same time as the flap harvest.

OPERATIVE STEPS

To begin, the anterior incision is made, and dissection is continued down through the subcutaneous tissue with electrocautery to the gracilis muscle. The fascia of the gracilis is incised and dissection is carried out posteriorly while retracting the gracilis muscle anteriorly, exposing the adductor magnus muscle. The investing fascia of the adductor magnus muscle is incised throughout the length of the incision. This step is key to prevent working in a narrow tunnel which limits visualization of the surgical field and increases the risk of injuring or potentially avulsing perforators. At this point, dissection proceeds subfascially and posteriorly along the adductor magnus until perforators arising through the muscle into the skin island are identified. The perforators are then dissected retrograde using bipolar cautery along their course through the adductor magnus muscle. Dissection is continued until adequate pedicle length and vessel size for anastomosis in the chest are obtained. If we are not satisfied with either the pedicle length or caliber of the vessels, dissection can continue proximally to the profunda femoral vessel. (The vein is usually larger than the artery, so surgeons should continue dissection to a point where the artery is an appropriate size match, which is usually 8-10 cm.). The entire perforator and pedicle dissection is performed while leaving the posterior incision intact. Once the pedicle is completely dissected, we then ligate and divide the main pedicle. Regaining this exposure is difficult to replicate, so the pedicle is divided before the posterior incision is made. The flap remains perfused from posterior perforators, allowing time for recipient vessel preparation and limiting the ischemia time of the flap. Once the vessels are ready on the chest, the posterior

incision is made, and the flap is harvested. To increase the volume of the flap, the subcutaneous tissue along the posterior incision can be beveled to include more tissue. If a second flap is being harvested, dissection can take place while the first microsurgical anastomosis is being completed.

In the chest, standard microsurgical anastomosis is performed, typically to the antegrade internal mammary artery (IMA) with a 9-0 nylon suture and appropriately sized venous coupler to the antegrade internal mammary vein (IMV). In cases where the antegrade IMA and/or IMV are not available or suitable for anastomosis, or when stacked flaps are being used, the retrograde IMA and IMV, or thoracodorsal vessels, can be used as alternatives for microvascular anastomosis. Once the anastomosis is completed, SPY-PHY fluorescence imaging (Stryker Corp., Kalamazoo, MI, USA) is used to evaluate flap perfusion. Anesthesia administers ICG and the device is positioned, so that the fluorescent angiogram is visualized in real time. Any areas with little to no fluorescence are considered poor or questionable perfusion and the tissue is removed to prevent fat necrosis[42,43]. The buried portion of the flap around the monitoring skin paddle is de-epithelialized and the flap is secured into the breast envelope. The tissue is shaped with care to set adequate medial pole fullness and ptosis. A closed suction drain is placed and kept far from the anastomosis.

The donor site closure sometimes requires selective posterior skin flap elevation off muscle fascia to help reduce tension. This undermining is limited to maximize perfusion of the skin edges and minimize dead space. To decrease seroma formation, a multilayered closure is performed over a closed suction surgical drain. We inject liposomal bupivacaine subfascially and into the surrounding soft tissues of the donor site to reduce postoperative pain.

CASE PRESENTATION

The patient is a 48-year-old female with a history of right breast stage IA invasive ductal carcinoma and morbid obesity status post gastric bypass, for which she lost 79 kilograms [Figure 1]. After her significant weight loss, she had redundancy and laxity of her skin and tissue in her abdomen and medial thighs. It was determined that there was a more suitable amount of tissue for PAP flap reconstruction compared to DIEP, so PAP flaps were chosen. She underwent bilateral mastectomies (wise pattern) and immediate pre-pectoral tissue expander placement in preparation for autologous PAP flap reconstruction [Figure 2]. Following her mastectomies and adequate volume expansion, the patient underwent preoperative MRA imaging for the localization of perforators [Figures 3-5].

On the day of autologous reconstruction, the patient was met in the preoperative area, and the ideal soft tissue of the posteromedial thighs was marked with her in the standing position [Figure 6]. In the operating room, the patient was positioned in lithotomy. Preoperative markings clearly outlined the gracilis (G) and adductor longus (AL) muscles. Flaps had dimensions measured to be 11 × 26 cm. The location of each perforator was confirmed with a hand-held Doppler ultrasound [Figure 7].

To start, the anterior incision was completed, and dissection was carried down to the gracilis muscle. The fascia surrounding the gracilis muscle was incised, and the muscle was retracted anteriorly to expose the adductor magnus muscle. The investing fascia of the adductor magnus was then incised, and a subfascial dissection was carried out posteriorly to identify the perforators supplying the skin. The perforators were then dissected retrograde through the adductor magnus muscle, sparing the muscle and the nerves supplying it [Figure 8]. Once adequate vessel length and caliber were obtained, the vessels were ligated, and the posterior incisions were completed.

Figure 1. Preoperative breast photo of a 48-year-old female with right breast, stage IA, invasive ductal carcinoma with a history of morbid obesity status post gastric bypass, for which she lost 175 pounds.

Figure 2. The patient in Figure 1 shown here 3 months following wise pattern mastectomies and prepectoral tissue expander placement.

Figure 3. Reprocessed 3-dimensional image of preoperative MRA, showing the location of the profunda artery perforators on the proximal posterior thigh for the patient in Figure 1. (MRA = magnetic resonance angiography).

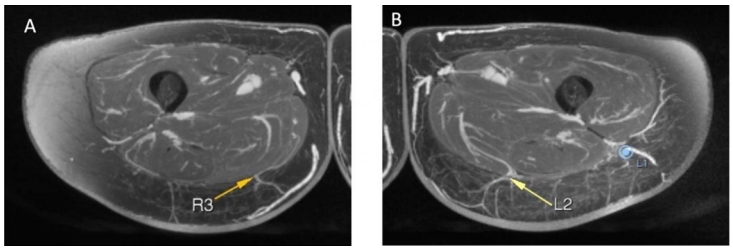

Figure 4. Axial MRA images of the thigh for the patient in Figure 1. The perforator labeled R3 measures 1.5 mm in diameter (A). The perforator labeled L2 measures 1.7 mm in diameter (B). (MRA = magnetic resonance angiography).

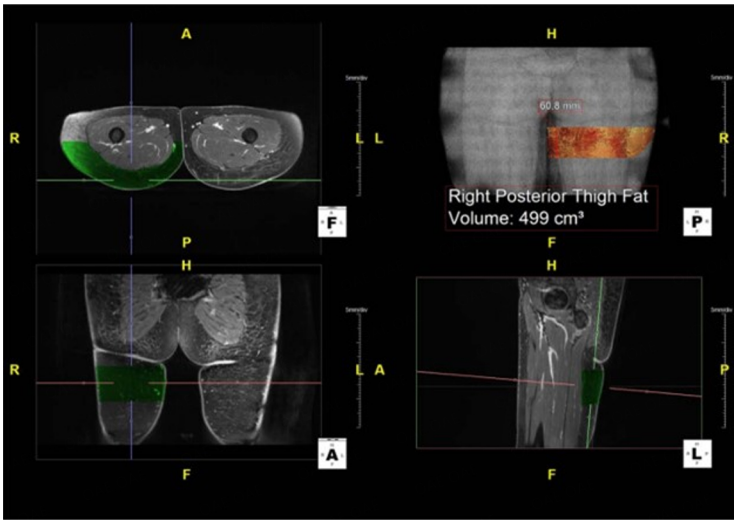

Figure 5. Volumetric assessment of right posterior thigh donor site. The estimated fat volume of a 6 × 22 cm flap on the posterior right thigh is 499 cc.

Figure 6. Initial markings of the profunda artery perforator flap in the holding area. With the patient in the standing position, the inferior gluteal crease is marked. The ideal soft tissue for capture in the flap is then marked with the dotted purple marker.

The flap weights were 512 g for the left thigh and 507 g for the right thigh, and each PAP flap was transferred to the ipsilateral chest. The microvascular anastomosis was completed in standard fashion to the

Figure 7. Preoperative markings in the lithotomy position. Flaps measured 11 × 26 cm. Perforators are confirmed with Doppler (blue dots). (AL = adductor longus muscle; G = gracilis muscle).

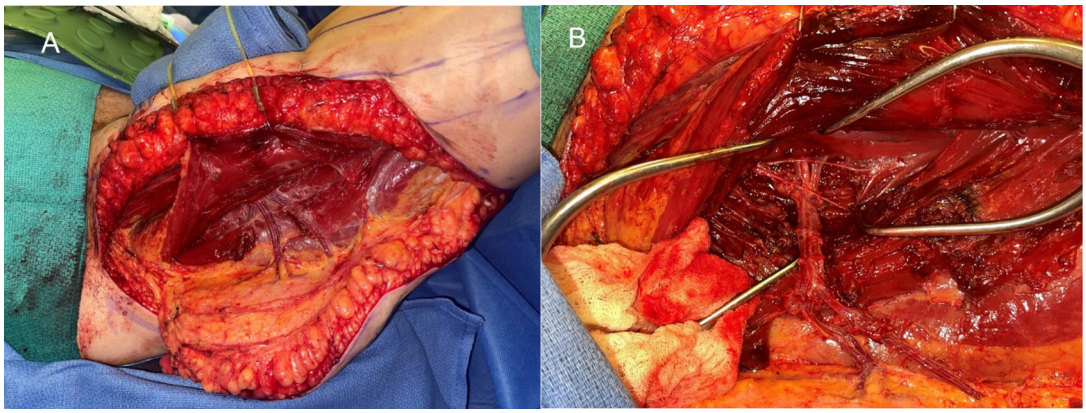

Figure 8. The anterior incision is made first. Dissection is carried down through the fascia surrounding the gracilis muscle, which is then retracted anteriorly. The investing fascia of the adductor magnus is incised behind the gracilis muscle, and a subfascial dissection continues posteriorly until perforators are identified. (A) The perforators are dissected retrograde through the adductor magnus muscle, sparing the muscle and muscular nerves supplying it. This continues until adequate length and caliber vessels are obtained (B). Two perforators that joined quickly in the muscle were chosen for perfusion for this left-sided diagonal PAP flap. (PAP = profunda artery perforator).

antegrade internal mammary vessels bilaterally. The flaps were de-epithelialized and inset with absorbable sutures.

The patient's postoperative course was uncomplicated, and she was discharged on postoperative day 2 with drains and compression garments for her lower extremity donor sites. Her most recent follow-up was 4 months post operation. Her breast and posterior thigh incisions are well healed [Figure 9].

POSTOPERATIVE CONSIDERATIONS

In the postoperative period, flaps are typically monitored with clinical examination and pencil Doppler assessments by nursing and house staff. The foley is removed and patients are mobilized out of bed on postoperative day 0. Using enhanced recovery after surgery (ERAS) protocol, patients are generally ready for discharge from the hospital on postoperative day 1 for unilateral flaps and day 2 for bilateral flaps. Before discharge, patients receive education on incision and drain care and are advised on clinical flap monitoring. ERAS protocols have been commonly used in abdominally based flaps and more recently have been found to be beneficial after PAP flaps, decreasing length of stay and minimizing opioid use[44].

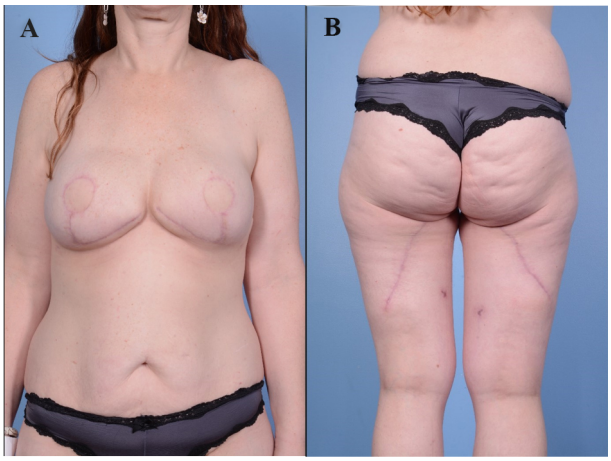

Figure 9. The patient in Figure 1 shown here 4 months following bilateral dPAP flap breast reconstruction. Her breast (A) and posterior thigh incisions (B) are well healed. (dPAP = diagonal profunda artery perforator).

Compression garments are utilized in the immediate postoperative period and patients are instructed to use them for a month following surgery. This compression decreases fluid production to help decrease seroma risk and allow drains to be removed earlier. If no compression is used, drains may remain for an extended period. The compression may also improve postoperative contour and minimize scar hypertrophy or widening. There are no activity restrictions on postoperative movement other than avoiding strenuous activity for 6 weeks.

CLINICAL OUTCOMES AND COMPLICATIONS

The overall success rate of PAP flaps is consistently high, with published flap success rates ranging from 97% to 100%[25,26,45,46]. Donor and recipient site complications following PAP flaps are low and acceptable, with comparable rates to abdominally-based reconstruction[45]. Typical complications at the donor site include seroma, hematoma, infection, and/or dehiscence. Similar rates have been reported across three of the most extensive single-center series. Of 265 PAP flaps, Haddock *et al.* revealed the following rates of complications of the donor site: wound infection (4.9%), seroma (4.5%), hematoma (2.6%), and dehiscence (2.6%)[25]. Similarly, Allen *et al.* illustrated the following complication rates: seroma (6%), hematoma (1.9%), and wound dehiscence 3.6%[26]. Of the 116 PAP flaps reported by Atzeni *et al.*, complications at the donor site consisted of seroma (2.6%), wound dehiscence (2.6%), hematoma (1.7%), and fat necrosis (1.7%)[46]. These complications are generally managed non-operatively. The overall success rates were comparable among all three investigators. Total flap loss was low, 0%-3%, with a similar OR take-back rate[25,26,46].

The complication profile remains low in situations requiring stacked DIEP/PAP flaps. Mayo *et al.* reported on 20 patients who underwent stacked flaps. There was only 1 donor-site hematoma, 1 donor-site dehiscence, 1 arterial and venous thrombosis treated with anastomotic revision, and 3 episodes of minor mastectomy skin flap necrosis[47]. A similar study by Martinez *et al.* reported no postoperative tack-backs or vascular complications following stacked DIEP/PAP flaps in 28 consecutive patients[48]. Haddock *et al.* reported that of 200 flaps in 50 patients undergoing stacked DIEP/PAP flaps, only 5 flaps were lost (2.5 percent). Due to flap-related concerns, 7 patients required take-backs resulting in 2 negative explorations and 1 flap salvage. Thigh wounds of the PAP flap donor site were the common non-flap-related complication[27].

The BREAST-Q is a validated metric to assess patient-reported outcomes (PROs) following breast reconstruction and normative data have been published for comparative purposes. Despite being an alternative donor site, PROs following PAP flap reconstruction are comparable to normative values[49]. Haddock *et al.* report that patients who underwent PAP flaps had favorable reported outcomes compared to the normative data in all BREAST-Q segments except the physical well-being of the chest. Following reconstruction with PAP flaps, they found lower extremity functional scale scores of 75/80 (94%) by 6 months. Patients reported high scores for both satisfaction with breasts and thigh domains, 78.9% and 82.1%, respectively[25]. After stacked autologous reconstruction, the BREAST-Q scores were comparable to bilateral DIEP and bilateral PAP flap reconstructions[41]. Such findings further reinforce the use of the PAP flap as an additional donor site for autologous breast reconstruction[50].

SUMMARY WITH SOME KEY POINTS

• Given its long pedicle, muscle preservation, easy contouring of the soft tissue, and minimal aesthetic shortcomings of the donor site, the PAP flap is an excellent choice for autologous breast reconstruction.

• Ideal candidates for PAP flaps are those who are pear-shaped, carrying most of their weight in their thighs, or massive weight loss patients who would benefit from a thigh lift.

• Smaller flaps in patients with limited skin laxity may not completely replace the breast footprint. In these cases, stacking smaller flaps is a good option to reduce donor site morbidity and add adequate volume. These are the same patients who have undergone radiation to the chest or those undergoing delayed reconstruction following a mastectomy without tissue expander placement. In these cases, more skin may be needed for resurfacing of the chest and/or to recreate the natural ptotic shape of the breast. Frequently, you can plan a diagonally orientated PAP or stack flaps, or do a combination of both to achieve enough skin and volume for the reconstruction.

• Dissection in lithotomy maximizes exposure and ergonomics for the surgeon.

• Broadly open the fascia and split the muscle along the entire length of the flap to prevent working in a hole and enhance the exposure of nerves and perforators during the dissection.

• The vein is always larger than the artery along the course of the perforator. Dissection should continue to a point where the length is adequate to reach the recipient vessels and to the point where the artery is a good size match for the recipient artery. This is usually > 8-10 cm.

• Leave the posterior incision intact during dissection of the pedicle. Once the pedicle is completely dissected, it can then be ligated and divided. Regaining this exposure is difficult to replicate, so we like to divide the pedicle before the posterior incision is made. The flap remains perfused from posterior perforators, allowing time for recipient vessels to be prepared and limiting ischemia time.

• Indocyanine green angiography (SPY-PHY) is used after the anastomosis is performed on the chest to confirm that the flap is adequately perfused and to identify poorly perfused areas of the flap for removal

DECLARATIONS

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Author contributions

Contributed equally to the design, editing, review, and approval of the final manuscript: Olla D, Levy J, Nelson JA, Allen RJ

Availability of data and materials

Not applicable.

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

The Institutional Review Board of Memorial Sloan Kettering Cancer Center approved this review, number 18-202. Patient informed consent has been obtained.

Consent for publication

No patient identifiers are included in these photos, so no consent is required.

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