Neurotized Diagonal Profunda Artery Perforator Flaps for Breast Reconstruction

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Summary: Although the deep inferior epigastric artery perforator flap remains the gold standard for autologous breast reconstruction, many patients are not candidates for this surgery. A variety of thigh-based flaps have been used including the diagonal upper gracilis (DUG) flap, vertical upper gracilis flap, profunda artery perforator (PAP) flap, and lateral thigh perforator flap. However, each of these techniques has a unique set of benefits and drawbacks in terms of wound healing, donor site morbidity, and potential for lymphedema. We describe the first report of a sensate diagonal PAP flap for breast reconstruction: combining the benefits of the DUG (wider skin paddle and reliable wound healing) with the benefits of the PAP (muscle-sparing technique and greater distance from the lymphatic collectors). This was the authors’ sentinel case in a woman with paraplegia and chronic leg swelling. Preoperative imaging, markings, and technical details are presented along with postoperative results. In the appropriately selected patient, this flap offers several advantages: a 2-team approach to reconstruction, ample tissue for breast reconstruction, potential neurotization for breast sensibility, wound closure in resting skin tension lines, and avoidance of the lymphatic drainage to the lower extremity. The diagonal PAP flap provides a muscle-sparing alternative to the DUG flap while minimizing the risk of lymphedema. Future studies are needed to assess the donor site morbidity of this flap; however, this case proves the safety and reliability of the diagonal PAP flap in our breast reconstruction population.

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INTRODUCTION
The profunda artery perforator (PAP) flap has been a useful technique for breast reconstruction.1,2 The original description involved a transverse skin paddle intended to be hidden within the gluteal crease.3 Although good results have been reported in patients with a favorable “banana roll” donor site, there can be several challenges in patients without this body habitus. The transverse line of closure is under tension which may increase the risk of wound healing complications and limit flap width. The patient is also sitting on their scar, and long-term sensory loss can occur in the posterior thigh.

More recently, the vertically designed PAP (VPAP) and diagonal upper gracilis (DUG) flaps have been proposed to address concerns related to a horizontal flap design.4–6 Although these flaps result in an incision that can be avoided while sitting, decrease the risk of wound healing complications, and avoid major cutaneous nerves of the posterior thigh, several limitations persist.

A new modification of the PAP flap combining its benefits with the DUG flap design is described in this article. The diagonal PAP (DPAP) is positioned more posteriorly than the DUG, farther away from the lymphatic vessels draining the lower extremity but maintains the same flap design oriented along the axis of Langer’s lines. This allows for a wide skin paddle and reliable healing and sparing of the gracilis muscle. In this article, the sentinel case that resulted in the DPAP is presented and a strategy for neurotization.

CLINICAL PRESENTATION
A 49-year-old woman with paraplegia presented with recurrent left breast cancer following lumpectomy and radiotherapy complicated by breast lymphedema (Fig. 1). She elected to undergo bilateral mastectomies and autologous breast reconstruction. Her paralysis was the result of a motor vehicle accident requiring a left thoracotomy to

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repair her torn aorta and an exploratory laparotomy. She completely relied on her core and upper body muscles for movement and, consequently, favored the thigh donor site. However, she did have some hip flexor and adductor function. Complicating matters was her chronic bilateral lower extremity swelling which could either be related to her injury or potentially lymphedema.

Preoperative workup included magnetic resonance angiography of the thighs demonstrating a single sizable PAP on either side. This also confirmed that the only viable muscles were her adductor longus and sartorius muscles, making gracilis muscle sacrifice inconsequential (Fig. 2). The operative plan was bilateral DUG flaps with the back-up of bilateral diagonal PAP flaps if the gracilis pedicle was inadequate. The denervated gracilis muscle would provide some additional stable volume and the anterior branch of the obturator nerve was to be used as a recipient nerve for neurotization.  

OPERATIVE TECHNIQUE

The patient underwent surgery on October 16, 2017. Before incision, bilateral lower extremity indocyanine green lymphangiography was performed to assess the lymphatic system. The patient had a normal linear pattern of functional lymphatic vessels which ruled out lymphedema and confirmed that it was safe to proceed with thigh flap harvest. This also allowed us to map the course of the major lymphatic collectors to ensure these would be avoided in our flap design as her anatomy was atypical. The standard DUG flap markings were made with the anterior border of the flap along the posterior border of the adductor longus muscle (if the gracilis muscle is not included, the anterior marking of the DPAP should be placed 3 cm posterior to the posterior border of the adductor longus muscle).5,7,8 This anterior mark curves posteriorly after a pinch test along Langer’s lines. The posterior marking completed the ellipse and was made to include the PAP perforator which runs through the adductor magnus muscle (Fig. 3).  

Intraoperatively, the gracilis muscle was atrophied as expected but the gracilis pedicle also appeared attenuated with an overall loss of vessel integrity. Thus, the PAP perforators were fully dissected on each side (Fig. 4). Flap angiography using the SPY device (Stryker Corporation, Kalamazoo, MI) revealed overwhelming dominance of the PAP perforators in this case. Division of the gracilis pedicles demonstrated back-bleeding based on the PAP system, allowing us to include the gracilis muscle for volume in the flap.

Following harvest, the DPAP vessels were anastomosed to the internal mammary vessels in standard fashion. Neurotrophaphy was performed from the anterior branch of the obturator nerve to the lateral branch of the T4 intercostal nerve for flap sensory neurotization. The patient had 1 closed suction drain placed in each thigh and in each breast. There were no postoperative range of motion or mobility restrictions. The patient had an unremarkable postoperative course and maintained baseline thigh function (Figs. 5, 6).

DISCUSSION

When compared with implant-based techniques, autologous reconstruction provides the patient with a permanent, natural option that has been shown to decrease cost and improve patient outcomes.9,10 Since its first description in 1992, the deep inferior epigastric artery perforator (DIEP) flap has become the gold standard for autologous breast reconstruction.11 Unfortunately, all patients are not candidates for a DIEP flap. For these patients, the thigh has quickly become the donor site of choice.

The PAP flap is considered by many as the ideal second choice for breast reconstruction to the DIEP flap, as it captures ample tissue of the posteromedial thigh, provides an inconspicuous scar, and has a reliable blood supply with a long pedicle.1,3,12–15 The transverse orientation, however, places the incision at maximal tension, limiting the width of the flap and potentially increasing wound healing complications. In addition, long-term paresthesias of the posterior thigh can occur with damage to the posterior cutaneous nerve to the thigh.

The VPAP is a more recent modification of the PAP flap that aims to address these issues.4,6 In addition, the VPAP allows for easy identification of perforators as the entire field is exposed following anterior skin incision.
However, for the purposes of breast reconstruction, the most abundant fat is located in the posteromedial thigh which is not fully captured with a vertical design. Perhaps this is why the VPAP has seen more popularity as an alternative to the anterolateral thigh flap for head and neck and extremity reconstruction.16–20

Another thigh-based alternative to a horizontal flap design is the DUG flap which is oriented obliquely along the line of least tension. This allows the surgeon to capture the greatest area of fat and leaves the superior two-thirds of the incision in the medial thigh. This also provides the widest possible flap dimension, reliable wound healing, and no pressure on the scar when seated. Potential drawbacks of the DUG include gracilis muscle sacrifice and closer proximity to the major lymphatic collectors given its more anterior pedicle. Other limitations of the DUG flap include the shorter pedicle and smaller caliber vessels offered for microvascular anastomosis.

This case example is the first report of the neurotized DPAP flap and demonstrates its advantages and limitations. The ability to neurotize a thigh flap for potential sensory recovery is a potentially important component of reconstruction for patients and continues to be a topic of further investigation.21 The DPAP flap maintains the advantage of a long pedicle with sizable vessels for microvascular
anastomosis, but the diagonal design offers a response to the limitations of the PAP flap. Like the DUG flap, it is oriented in Langer’s lines, increasing the skin available for harvest and potentially improving wound healing by decreasing tension on the closure. Like the VPAP and DUG flaps, this flap results in an incision that can be avoided with sitting, decreases the risk of permanent paresthesias of the posterior thigh, and provides ample exposure of the PAPs. Unlike the VPAP flap, however, it captures the ideal fat for breast reconstruction located in the postero-medial thigh. Unlike the DUG flap, it does not sacrifice a muscle of the thigh which may be a concern for some patients. Taken together, the DPAP is another viable thigh-based option for breast reconstruction in the appropriately selected patient. Potential drawbacks of the DPAP is that it is more posteriorly located on the thigh compared with the DUG flap which is more medial. The DPAP also requires preoperative imaging, and ultimately, the type of flap is a shared decision between patient and surgeon after informed consent.

CONCLUSIONS

The case presented in this article demonstrates the safety and reliability of the sensate DPAP flap, even in the setting of complicated patient anatomy and medical history. This flap is a direct evolution of the PAP and DUG flaps. The DPAP addresses the limitations of the transversely oriented PAP, provides a muscle-sparing alternative to the DUG flap, and combines the benefits of both to give plastic surgeons another reliable alternative for autologous breast reconstruction.

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