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Review

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Gluteal artery perforator free flaps for breast reconstruction

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Abstract

Free flap autologous breast reconstruction is becoming more and more common for post-mastectomy reconstruction. Abdominally-based tissue flaps are the first choice for many reconstructive breast microsurgeons, but not all patients are candidates, whether due to their leaner habitus or a history of prior abdominal surgery. The gluteal donor site in many patients can provide adequate soft tissue for autologous breast reconstruction, even in lean patients, with a scar that remains well-hidden. This review presents an overview of the superior gluteal artery perforator (SGAP) flap as an invaluable tool for autologous breast reconstruction.

Keywords: Autologous breast reconstruction, reconstructive surgery, microsurgery, SGAP, gluteal artery perforator flap

INTRODUCTION

In the United States, more than 150,000 breast reconstruction procedures were performed in 2022[1]. Of those procedures, approximately 33,000 were autologous-based reconstructions, including deep inferior epigastric artery perforator (DIEP) flap, free transverse rectus abdominis muscle (TRAM) flap, and latissimus dorsi muscle flaps. Since its introduction in 1994, DIEP flaps for breast reconstruction have become the first choice for autologous-based breast reconstruction[2]. However, not all women are

candidates for abdominally-based tissue reconstruction due to the lack of available tissue from a leaner habitus and/or prior surgeries including open abdominal procedures, abdominoplasty, and liposuction, which can potentially disrupt vascularity.

Although abdominally-based free flaps for breast reconstruction have been popularized, the first free flap for breast reconstruction following mastectomy was actually the gluteus maximus myocutaneous flap, described by Fujino *et al.* in 1976[3]. While the surgery was a technical success, the authors commented that due to the short pedicle length, the breast mound was superiorly displaced. In 1983, Shaw modified this flap with good aesthetic results and well-tolerated donor site morbidity[4]. However, the pedicle length remained short at 2-3 cm and 7 out of 10 patients required either vein grafts or anastomosis to other recipient veins. The internal mammary vessels, if used, were at the level of the fifth intercostal rib.

The introduction of gluteal perforator flaps by Koshima *et al.* in 1993 for sacral pressure injury reconstruction provided the first opportunity to modify the gluteal myocutaneous flap[5]. They found reliable cutaneous perforators in cadaveric dissections for pedicled-flap reconstruction, including ones based off the superior gluteal vessels supplying the superolateral gluteal tissue. Shortly after, Allen and Tucker introduced the superior gluteal artery perforator (SGAP) flap for breast reconstruction[6]. Expanding on Koshima's gluteal perforator flap, the previously described gluteal myocutaneous flap was improved by sparing the muscle to reduce donor site morbidity and thereby increasing the vascular pedicle length up to 8 cm, obviating the need for vein grafts. Blondeel later shared his positive experiences with SGAP flaps as a primary option for breast reconstruction in patients who were not DIEP flap candidates[7].

Since its first introduction, the SGAP flap has gone through other modifications, a common critique of the flap being its steep learning curve. One such modification is the development of a septocutaneous SGAP (sc-GAP), which avoids the tedious and difficult intramuscular dissection altogether by following perforators that travel between the gluteus maximus and medius, while still maintaining adequate pedicle length[8,9]. During flap harvest, dissection can also be paired with nervi clunii superioris nerves for a sensate flap[7,10].

Although technically challenging, the SGAP flap provides a reliable second choice for autologous breast reconstruction in women who may not have available abdominal donor sites with outcomes comparable to other autologous options for breast reconstruction[11-15].

CLINICAL CONSIDERATIONS

In women where the abdomen as a donor site is contraindicated due to prior surgeries or a relative lack of abdominal soft tissue, as seen in thinner patients, the SGAP should be considered. The buttock will often provide an adequate amount of tissue, even in leaner patients, to reconstruct a patient habitus-appropriate unilateral breast or one that matches the contralateral breast [Figure 1]. In several studies, the average body mass index (BMI) of patients with SGAPs ranged from 20.2 to 25.5[7,9,11-14] and flap weight ranged from 190 to 894 grams[6,7,9,13,15]. Because the gluteus maximus muscle is spared, this flap can also be considered for patients who are more active, compared to other flap options such as TRAM or latissimus dorsi, where muscle is harvested and may affect an active patient's lifestyle. Although the donor site morbidity to the muscle is low, patients must be informed of the possible change in the contour of the buttock, especially in unilateral reconstruction.

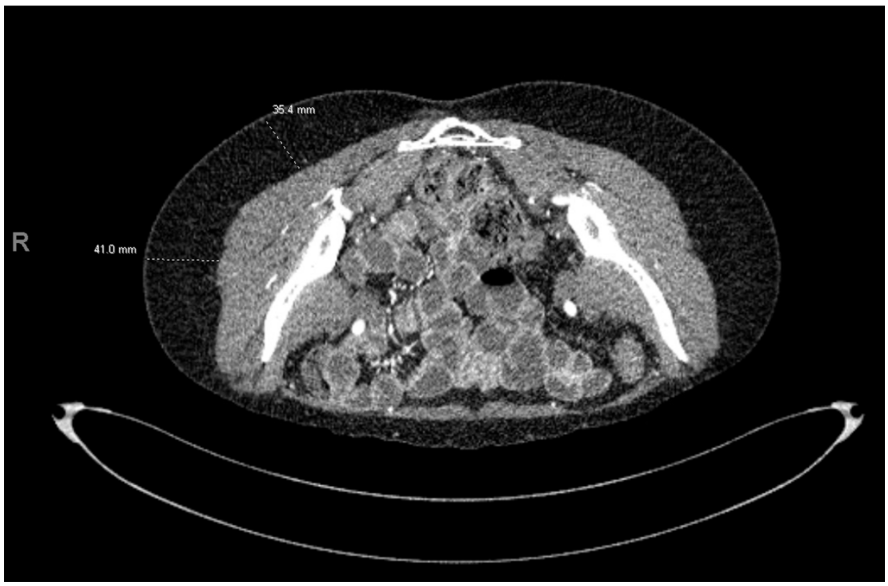

Figure 1. CTA demonstrating adequate available soft tissue donor in buttock compared to abdomen on a lean patient. CTA: Computed tomography angiography.

A possible contraindication to SGAP flap reconstruction would be a history of liposuction of the gluteal region. Preoperative imaging would be warranted to assess for the presence of perforators.

PREOPERATIVE PLANNING

Preoperative imaging for a standard SGAP is not an absolute necessity; however, CT angiography or MR angiography can be helpful for perforator selection and dissection by providing important information on location and course. The most lateral perforator will often provide the longest pedicle and the understanding of the intramuscular course of the perforator can save time on flap dissection. In the cases of sc-GAP, preoperative imaging has been found to be essential, as not all patients will be candidates based on their anatomy[8]. Patients who have had previous gluteal surgeries should also undergo preoperative imaging to ensure candidacy.

RELEVANT VASCULAR ANATOMY

The anatomy of the superior gluteal artery (SGA) has been well studied and found to be consistent. Following its exit from the suprapiriformis foramen, the SGA splits into a deep branch and a superficial branch[16]. The deep branch travels between the ilium and the gluteus medius muscle before crossing the plane between the medius and minimus. The superficial branch travels deep to the gluteus maximus and splits into two branches, the ascending (or superior) branch and the transverse branch. One or both branches will then give off a third branch called the intermediate branch. The intermediate branch travels under the gluteus maximus, occasionally giving off muscular perforators but mainly supplying the musculocutaneous perforators used in the SGAP flap. The ascending branch travels under the gluteus maximus before emerging between the superior border of the gluteus maximus and the inferior border of the gluteus medius as a terminal septocutaneous perforator used in the sc-GAP modified flap[8]. While there are no sensory nerves that accompany the perforators of the SGA, as stated previously, a sensate flap can be harvested by including the nervi clunii superioris. These nerves innervate the upper buttock, emerging off the rami of T12 through L3 and crossing over the posterior iliac crest approximately 6-7 cm from the midline. After passing through the thoracolumbar fascia, they become more superficial and may be seen along the superior edge of the flap[17].

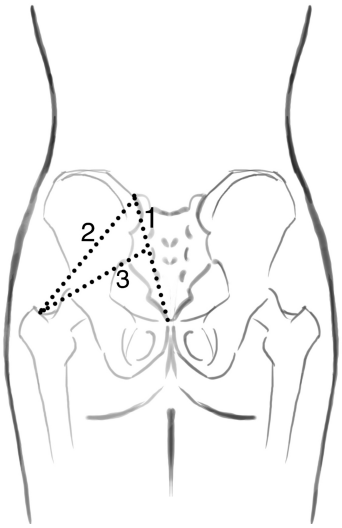

Figure 2. SGAP landmarks. Line 1: PSIS to coccyx. Line 2: PSIS to greater trochanter. Line 3: Greater trochanter to one-third of the way down Line 1. SGAP: Superior gluteal artery perforator; PSIS: posterior superior iliac spine.

There are important landmarks for ease of identification of perforators once the patient is positioned in the operating room. The coccyx, posterior superior iliac spine (PSIS), and the greater trochanter should all be identified [Figure 2]. When performing a traditional SGAP, three lines can be drawn: (1) PSIS to coccyx; (2) PSIS to the greater trochanter; and (3) a third of the way down along line #1 connecting to the cranial edge of the greater trochanter[10]. Line #3 will delineate the general location of the piriformis and the surgeon should use Doppler above this line to identify the SGA perforators. For sc-GAP flaps, Tuinder identified perforators on average 12.9 cm from the midline and 5.1 cm inferior to the iliac crest[9], whereas Rodrigeuz-Vegas *et al.* found perforators 6-10 cm above and 0-3 cm posterior to the greater trochanter[8].

OPERATIVE TECHNIQUE

SGAP flap

Positioning

In cases of unilateral mastectomy and immediate reconstruction, the patient can be positioned in the lateral decubitus position so that the breast surgeon and reconstructive surgeon can operate simultaneously, with the reconstructive surgeon utilizing the ipsilateral flap. In cases of delayed reconstruction and/or a two-team microsurgery approach, the patient can also be positioned lateral decubitus for simultaneous recipient vessel preparation and flap elevation. Due to the complexity and steep learning curve of this flap, the authors recommend performing the flap elevation in the prone position. In this prone position, bilateral SGAPs could also be raised simultaneously for bilateral breast reconstruction. The authors prefer to perform contralateral reconstruction in a delayed fashion in a second procedure. After the patient is padded and secured in the prone position, the bed should be flexed slightly at the hips (jackknife) to open up the soft tissue and muscle dissection planes. The recipient vessels in the chest can be prepared first in the supine position, followed by the prone position for flap harvest. Once the donor site is closed, the patient can then be re-positioned supine for ease of microsurgery and inset.

Markings

Once the patient has been satisfactorily positioned, the landmarks as described above [Figure 2] should be

Figure 3. Elliptical skin design drawn around perforators identified with pencil Doppler. White arrow marks the lateral-most perforator. Black lines indicate the planned beveling superiorly.

marked and the perforators identified with pencil Doppler. The Doppler signals can be correlated with findings from the preoperative CT angiogram. An elliptical skin flap design [Figure 3] should be centered around the perforator of choice. To increase the length of the pedicle, the lateral-most perforator should be selected.

Several flap designs have been described with their own unique advantages as well as disadvantages. The oblique design orients the flap from a superomedial to an inferolateral direction. This flap orientation will optimize fatty tissue incorporation[14] at the cost of postoperative contour deformity and a scar that is not well-hidden in undergarments[13,14]. The transverse design orients the flap along a more horizontal to slightly superolateral trajectory. While it contains less fatty tissue, the scar will often be well-hidden and there is less contour deformity, making it the more popular choice[10,13,14,18]. With either pattern, the mastectomy defect will dictate how much skin is needed, and the SGAP can comfortably provide a flap that is 8-12 cm in width and 25-32 cm in length[6,15,18].

Surgical technique

Because the fat is firmer, more projecting, and less pliable in the buttock, shaping the flap begins from the moment of incision. Cranially, the dissection of the subcutaneous fat can be beveled out about 2-3 cm below the superficial fascia to capture superolateral soft tissue excess and even lumbar fat [Figure 4]. Some authors bevel inferiorly, thereby creating a mound tapered on both ends[13,14]. We minimize inferior beveling to decrease the risk of hollowing out the donor site and resulting in a significant postoperative contour deformity [Figure 5]. The flap is inset without rotating the skin island. Conversely, some authors take the dissection straight down at the cranial edge and only bevel out at the caudal edge[12,15,18]. At the time of inset, the flap is turned 180 degrees, creating a gentler upper pole slope that leads into lower pole fullness. Blondeel has also reported improved donor site shape from the wide undermining caudally in what is essentially a thigh lift[7].

The dissection is taken down through the deeper subcutaneous fat until the gluteus maximus fascia is encountered. The fascia is incised, and the dissection is continued parallel to the muscle fibers until the musculocutaneous perforators are identified. The flap can be based off a single larger perforator or several

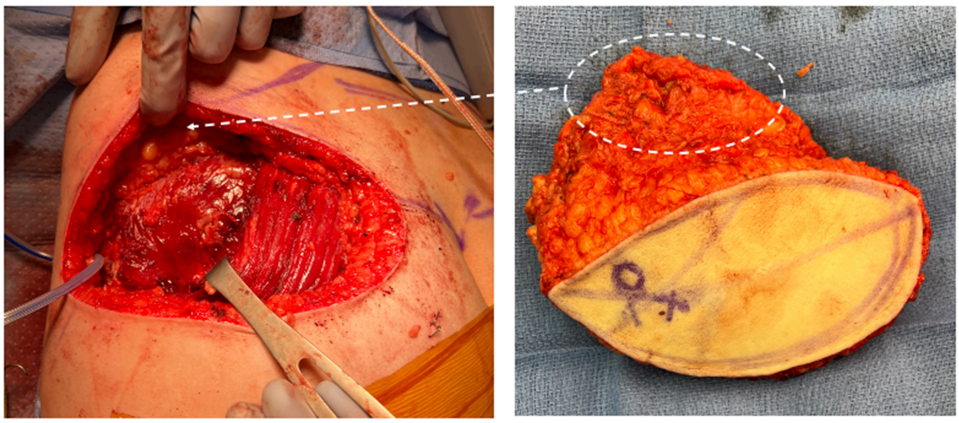

Figure 4. Flap beveling out superiorly to capture superolateral fat (circled).

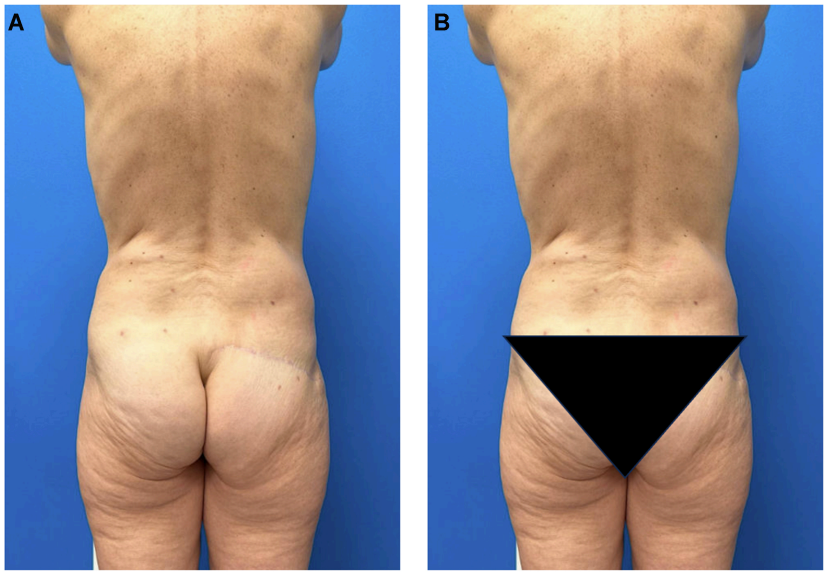

Figure 5. (A) Donor site without significant asymmetry compared to contralateral buttock; (B) Scar that will be well-hidden beneath undergarment.

adjacent perforators. At this point, the muscle fibers are split longitudinally along their axes to avoid transecting any fibers and the perforators are carefully followed, clipping muscular side branches. The pedicle length is generally at least 6 cm if taken just through the muscle and the diameter of the artery can be about 1-1.5 mm. If the length and/or size of the pedicle is insufficient, the dissection can be extended submuscularly, but the operation becomes technically more challenging. In this deeper plane, the sacral fascia is incised and a complex venous plexus [Figure 6] crosses the pedicle[7]. It is crucial to take time to correctly identify the pedicle's path within this friable plexus and to control any bleeding. Although tedious and demanding, this can increase the length of the pedicle up to the final length of 12 cm with diameters ranging from 2-3 mm (artery) and 2-4.5 mm (vein)[13,15]. Artery mismatch with the mammary vessels can be challenging to overcome, and this extended dissection helps to minimize this issue. Intraoperative indocyanine green imaging can be performed at this time to ensure adequate perfusion prior to flap harvest.

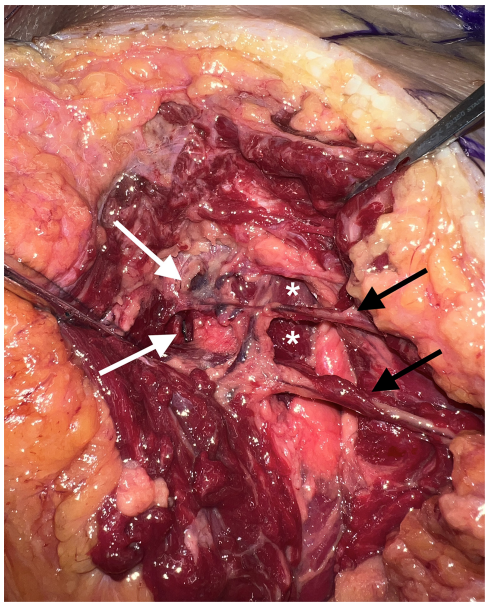

Figure 6. The gluteus maximus has been split along its fibers to follow along the course of two perforators indicated with black arrows. Just inferior to the perforators and deep to the gluteus maximus is the piriformis (white asterisks). As the perforators are followed along deeper, the plexus is encountered (white arrows).

After the flap has been successfully harvested, it can be further shaped on the back table while the donor site is closed. Meticulous hemostasis should be achieved. The donor site is closed in layers over a closed suction drain.

Microsurgery is then performed in the typical fashion with end-to-end venous anastomosis and arterial anastomosis to the internal mammary vessels. We generally select the internal mammary vessels at the level of the fourth rib or lower to minimize mismatch with the internal mammary artery. Inadequate length or mismatch in vessel diameter may warrant vein grafts, which can be obtained from the saphenous vein, cephalic vein, or the superficial inferior epigastric vein. Alternatively, the deep inferior epigastric pedicle can be harvested via a low transverse abdominal incision as a composite vascular conduit to improve length and vessel match.

For flap inset, a hammock-style inset has been described. This is done by suspending the flap onto the pectoralis fascia obliquely in a superolateral and medial fashion[7,10]. As already described, due to the firmer qualities of the SGAP flap, projection will be improved compared to the DIEP flap, but it also lacks flexibility. By manipulating the flap with the tapered fat along the superior side of the breast reconstruction and the firmer, more projecting fat along the caudal side of the reconstruction, the SGAP characteristics can be optimized for the pocket[12,15,18].

Sc-GAP flap

Positioning

The patient can be positioned in the lateral decubitus position as described above for simultaneous flap harvesting with recipient vessel preparation. The patient can also be positioned prone. Rodriguez-Vegas *et al.* found that the sc-GAP can be performed in the supine position, due to the more lateral and superior location of the septocutaneous perforators compared to the musculocutaneous perforators[8].

Markings

Once the patient has been adequately positioned, the septocutaneous perforator should be identified by pencil Doppler and this should be confirmed with preoperative computed tomography angiography (CTA) for appropriate selection. The flap design should again be centered around this perforator. Because of the more supero-lateral location of this perforator, the flap is designed as an elliptical island oriented in a more horizontal fashion[8,9]. Although no exact measurements of the skin islands have been recorded, a pinch test can ensure that the width will not be too large to close[19].

Surgical technique

The incision will begin at the cranial edge of the flap. Unlike the traditional musculocutaneous SGAP, undermining or beveling is generally not recommended due to the potential for creating a depressed scar along the hip[8]. The flap is dissected down to the superior margin of the gluteus maximus and the fascia is incised. Taking the dissection caudally toward the inferior edge, the septocutaneous perforator is identified, emerging from the plane and the fascial band connecting the gluteus medius and maximus. A cuff of fascia may be taken with the pedicle due to the thickness of this fascial connection and the dissection is taken further in the intermuscular space. As described above, there is a venous plexus submuscularly deep to the sacral fascia that may need to be dissected away to obtain more length and improve the diameter of the pedicle. Pedicle length will average between 7.4 and 7.8 cm, with vessel sizes ranging from 1.8 to 3 mm. Intraoperative indocyanine green can be performed at this time to ensure adequate perfusion prior to flap harvest. Once the flap is harvested, the donor site is closed in a layered fashion over a closed suction drain. Microsurgery and flap inset are performed in a similar fashion as described in the previous section.

POSTOPERATIVE CONSIDERATIONS

Patients should remain on bed rest overnight following their surgery. Due to the muscle-sparing technique in both the traditional SGAP and the sc-GAP, patients are able to mobilize, including ambulation, as early as postoperative day 1. To avoid tension on the donor site closure, they should avoid sitting completely upright for the first 2 weeks. Compression garments are not necessary but may help prevent the development of seromas at the donor site.

CLINICAL OUTCOMES AND COMPLICATIONS

Flap success rates for SGAPs are generally between 93% to 98%[7,12-14]. Both venous and arterial thrombosis can occur with no propensity for either. Hunter *et al.* compared DIEP flaps and SGAP flaps and found that there were no differences between rates of seroma, hematoma, delayed healing, partial flap loss or total flap loss, as well as arterial and venous thrombosis[14].

Donor site seromas are commonly reported, ranging from as low as 2% to as high as 35%[7,9,12-14]. Lower rates of seroma may be associated with the use of compression garments for at least 6 weeks[13] in addition to the use of closed-suction drains. Donor site dehiscence was reported in 1 study to be 10%[7]. Contour deformity was more frequently seen in the initial years following the introduction of this flap, up to 20%[7], particularly due to the oblique orientation of the skin paddle[13]. However, more recently, Zoccali *et al.* reported donor site deformity to be about 9.7%[15]. This was a retrospective review of 119 patients who had undergone SGAP free flaps for breast reconstruction. The patients were grouped into four donor site classes (1: minimal tissue availability; 2: insufficient tissue to achieve breast symmetry; 3: sufficient tissue for tension-free closure and contralateral symmetry; 4: patient experienced massive weight loss). What they found was that patients in class 3 were protected from donor site morbidity, which one might expect. While these results may not seem novel, it is worth noting that breast reconstruction patients must be chosen carefully for their candidacy for SGAP reconstruction.

Importantly, the purpose of reconstructive surgery for women who have undergone mastectomy must not be disregarded. Opsomer *et al*. compared BREAST-Q scores of lumbar perforator (LAP) flaps (50 patients) and SGAP flaps (25 patients) with DIEP flaps (153 patients)[11]. While there were no significant differences in satisfaction with their breast outcomes among the three flaps, patients with LAP and SGAP flap reconstruction were found to have lower psychosocial well-being and sexual well-being scores compared to those who underwent DIEP flap reconstruction. Patients with LAP flaps had lower physical well-being scores associated with their donor site than DIEP and SGAP patients. An explanation of the differences in these scores could include a variety of factors. DIEP flap scars tend to be well hidden beneath undergarments while giving improved abdominal contour, whereas LAP flap scars will reside higher above undergarments. While SGAP flap scars will remain hidden beneath undergarments as we have described, there is an effect on the overall contour of the buttocks. This study takes into consideration the importance of "holistic" care, where the quality of postsurgical survivorship is evaluated in addition to the technical outcomes. An important limitation of this study was its retrospective nature and the lower number of SGAP and LAP patients compared to DIEP patients, which leaves the potential for underpowering.

Overall, the final breast mound shape will tend to have greater projection compared to other autologous reconstructions. However, the final breast mound may require revisions due to the more rigid nature of the flap that may not drape as aesthetically. Fat grafting and revisions can be performed to tailor the breast mound, similar to abdominal-based breast reconstruction [Figure 7]. Contour deformity, especially in unilateral reconstruction, can be treated with fat grafting and/or liposuction to taper the interface of the flap with the chest wall.

CURRENT AND FUTURE DIRECTIONS

The existing literature on SGAP flaps for breast reconstruction presents opportunities for advancement. The retrospective nature of all the studies reviewed certainly introduces the potential for biases and threats to validity. These studies also are limited by their small number of patients. Hunter *et al.*, Werdin *et al.*, and Beaumeister *et al*. had 16, 72, and 81 flaps, respectively[12,14,18]. Guerra *et al.* had approximately double the number of flaps at 142, although this was over the course of 9 years, which they averaged 15 flaps per year[13]. The studies involving Sc-SGAP flap had even smaller cohorts of 11-36 patients[8,9]. A multi-institutional review of SGAP data and outcomes for breast reconstruction is warranted.

Lastly, although the SGAP flap has been compared to the gold-standard DIEP flap[14] and to the LAP flap[11], many other flap options exist for breast reconstruction in lean patients, including transverse upper gracilis (TUG) flaps and profunda artery perforator (PAP) flaps. To our knowledge, no comparison studies have been conducted on these options, but they may spark important discussions and possibly change algorithms for reconstruction in this patient population.

SUMMARY AND KEY POINTS

Since its introduction, the SGAP flap, over the years, has proven to be a constant and reliable option for autologous reconstruction of the breast for patients with a lack of soft tissue available at the abdominal site. Sufficient tissue can be harvested from the buttocks to adequately reconstruct a breast. When performing this flap, one must be prepared for position changes during harvesting and final inset. While septocutaneous modifications have been identified that address the short pedicle length, vessel diameter discrepancy with the relatively larger internal mammary may need to be addressed with pedicle dissection in the submuscular plane or the use of vascular conduits. SGAP flaps have a reliable success rate of 93%-98%, with comparable patient satisfaction compared to DIEP flaps. Common donor site morbidities include seroma and contour

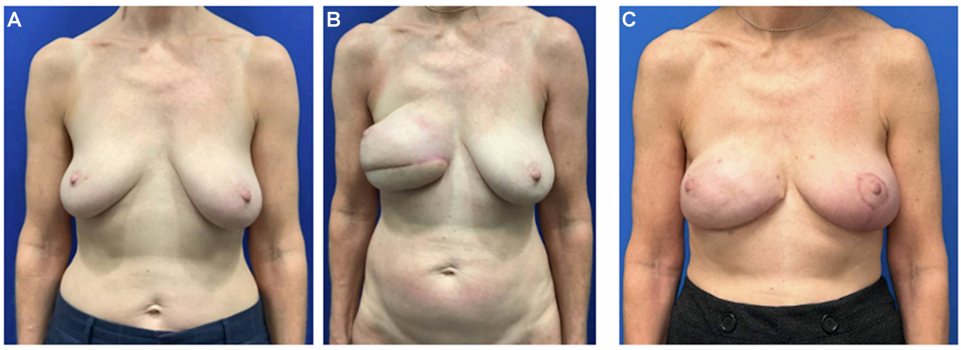

Figure 7. (A) Prior to right unilateral nipple-sparing mastectomy; (B) Post-unilateral mastectomy with SGAP flap reconstruction of the right breast; (C) Final reconstruction after removal of SGAP skin paddle on the right and contralateral mastopexy for symmetry on the left. SGAP: Superior gluteal artery perforator.

deformity. Overall, the flap is technically challenging with its difficult dissection; however, mastery of this flap will provide a valuable tool in the reconstructive surgeon's armamentarium for breast reconstruction.

DECLARATIONS

Authors' contributions

All authors provided significant contributions to the literature review and drafting of the manuscript: Baek A, Chong T

Created illustration for manuscript: Baek A

Availability of data and materials

Not applicable.

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None.

Conflicts of interest

Both authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

VCU institutional review board (IRB) provided exemption. IRB Is not required due to the full nature of the paper as a review article rather than a study.

Consent for publication

A written informed consent for publication was obtained for all patient photos.

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