Inferior Gluteal Perforator Flaps for Breast Reconstruction

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ABSTRACT

Perforator flaps represent the latest in the evolution of soft tissue flaps. They allow the transfer of the patient's own skin and fat in a reliable manner with minimal donor-site morbidity. The powerful perforator flap concept allows transfer of tissue from numerous, well-described donor sites to almost any distant site with suitable recipient vessels. The inferior gluteal artery perforator (I-GAP) flap is one option that allows a large volume of tissue to be used for breast reconstruction with minimal donor site morbidity. The ideal tissue for breast reconstruction is fat with or without skin, not implants or muscle. Absolute contraindications specific to perforator flaps in our practice include history of previous liposuction of the donor site, some previous donor site surgery, or active smoking (within 1 month prior to surgery). Perforator flaps are supplied by blood vessels that arise from named, axial vessels and perforate through or around overlying muscles and septa to vascularize the overlying skin and fat. The I-GAP flap is based on one or more perforators from the inferior gluteal artery. During flap harvest, these perforators are meticulously dissected free from the surrounding muscle, which is spread in the direction of the muscle fibers and preserved intact. The vascular pedicle is anastomosed to recipient vessels in the chest and the donor site is closed directly. The I-GAP flap provides an excellent option for the safe, reliable tissue transfer from the buttock for breast reconstruction with minimal donor site morbidity.

KEYWORDS: Perforator flap, microsurgery, free flap, I-GAP, breast reconstruction

Breast reconstruction most commonly involves the use of saline or silicone gel implants. The initial advantages of expanders and implants include a lack of a donor site and technical simplicity. Although initial aesthetic results can range from good to excellent, the results often change with time. Many patients note that the result feels less than natural and they commonly can feel the implant under the chest muscle or breast tissue. In our experience, ~25% of the women presenting to our practice for breast reconstruction have had previous attempted implant reconstruction.

The transverse rectus abdominis myocutaneous (TRAM) flap in the early 1980s ushered in the new era of autogenous reconstruction. At first, plastic surgeons were eager to embrace this procedure. However, the magnitude of the donor-site morbidity in some cases, including abdominal wall weakness and hernia, became more apparent over time.

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The search for a better solution led plastic surgeons to develop new techniques. The previously developed concepts of free-tissue transfer had already been shown to have a significant potential for an increasing range of donor and recipient sites.[1] Refinements of these techniques led to the advent of perforator flaps, which have allowed the transfer of the patient's own skin and fat in a reliable manner with minimal donor-site morbidity.

Perforator flaps allow the transfer of a large volume of tissue based on only one or more perforating vessels. The relatively low metabolic demands of the tissues allow an amazingly small blood supply to adequately perfuse a large flap of skin and fat.

The flow of a noncompressible liquid through a tube is governed by Poiseuille's Law according to the following equation:

$$\Phi_V = \frac{\pi r^4}{8\eta}\frac{\Delta p^*}{l}$$

The flow of a volume of liquid, Φ_V, is proportional to the fourth power of the radius of tube through which it is carried. Thus, a single large perforating vessel that is 2.0 mm in diameter will carry $\sim$16 times the blood flow of an otherwise similar vessel that is only 1.0 mm in diameter. Therefore, it is preferable to use a single large perforator than multiple, smaller perforators when choosing among vessels to carry a perforator flap.

In 1989 Koshima and Soeda succeeded in transferring skin territory above the rectus abdominis muscle based off a perforator vessel to reconstruct floor of mouth and groin defects.[2] In 1992, breast reconstruction using the same principles were developed by Allen and Treece, who used abdominal tissue supplied by perforators to the rectus abdominis muscle in what is now known as the deep inferior epigastric perforator flap.[3] Buttock tissue overlying the gluteus maximus muscle was then transferred with the gluteal artery perforator flap.[4]

The use of buttock tissue for breast reconstruction is not new. In 1978, Le-Quang performed the first breast reconstruction with an inferior gluteal myocutaneous free flap.[5] Shaw popularized the myocutaneous superior gluteal artery free flap; however, a short vascular pedicle often led to additional vein grafting, thus tempering enthusiasm.[6–9] The inferior gluteal myocutaneous flap championed by Paletta et al was mostly abandoned due to sciatic nerve injury, exposure, and pain when sitting.[10]

Gluteal artery perforator (GAP) flaps have certainly decreased the donor-site morbidity of the buttock, and we have used both the superior gluteal artery perforator (S-GAP) and inferior gluteal artery perforator (I-GAP) flaps since 1993. Tissue can now be transferred safely from this donor site with minimal morbidity when the abdomen is not available as a primary donor site. In our breast reconstruction patient population, the buttock is the donor site in 22% and the abdomen in 78%. As with perforator flaps taken from the abdomen, the donor-site morbidity is minimal and no sacrifice of muscle is required.

However, this technique has brought new challenges. First and foremost, these techniques require microsurgical expertise. Dr. Bill Shaw expressed that the superspecialist might perform certain types of free flaps beyond the realm of the occasional microsurgeon and postulated that a learning curve for the perforator flap breast reconstruction might be 50 to 100 procedures (personal communication, 2000).

Variability of vascular anatomy contributes to the difficulties with these procedures. Factors such as how many, what size, and the location of perforators to select affect the length of operation and incidence of fat necrosis. Flap insetting affects flap circulation.

Various locations, orientations, and dimensions of the skin island have been tried over the years. Each has advantages and disadvantages. Initially we used an oblique ellipse totally over the muscle oriented in the direction of the muscle fibers. This gave the greatest chance of finding an adequate perforator under the flap. With a better appreciation of the vascular anatomy and confidence in the handheld Doppler, there is more freedom is designing the skin island. An oblique ellipse extending superiorly from medial to lateral is now commonly used and has the advantage of concealing the scar in swimwear and undergarments. By beveling superiorly, a nicely shaped flap can be obtained. However, in many women, the harvest of an S-GAP flap may leave a significant contour deformity at the donor site of the upper buttock.

In 2004 we began designing the I-GAP so that the donor site scar would be in the natural inferior gluteal crease. By harvesting tissue from the lowest part of the buttock, the shape of the rounded upper buttock was preserved. The pedicle length was also longer than that of the S-GAP, making the anastomosis easier and allowing greater freedom in flap insetting.

However, we have found the I-GAP flap not to be without its disadvantages. Sitting directly on the healing incision causes more pain than with the S-GAP and the rate of dehiscence increases. This is particularly true in bilateral simultaneous reconstructions where the patient cannot shift her weight to a nonoperated side.

The sciatic nerve has never been a problem in our experience of $\sim$100 I-GAPs. No patients have been found to have weakness or radiculopathy after the procedure. The nerve is only rarely seen, and the intact gluteal muscle, which is preserved intact, provides more than enough cover for the nerve.

The ideal candidate for a GAP flap has a large buttock (pear shape) and a "B" size breast. Those candidates with more inferior buttock fat may have an excellent breast reconstruction with an I-GAP flap with a minimally noticeable donor site. However, in other patients the inferior donor site and scar are more visible. After an initial enthusiasm with the in-the-crease I-GAP, we are now using the S-GAP again in slightly more than 50% of patients. We find most of our patients do their own research before and after their initial consultations and come with their opinions about which GAP they prefer.

INDICATIONS

The buttock has a high fat-to-skin ratio whereas the abdomen has a high skin-to-fat ratio. Patients who require mostly fat and little skin may be candidates for GAP flaps. Patients in whom the abdomen cannot be used as a donor site, or who have more tissue in the buttock area than in the abdomen, are the best candidates. We prefer the I-GAP to the S-GAP in those women with a greater amount of inferior buttock fat and a low or flat inferior gluteal fold. In our experience using I-GAP flaps for breast reconstruction, the average final inset weights of our I-GAP flaps were slightly greater than weights of the mastectomy specimens removed.[11]

Absolute contraindications specific to I-GAP flap breast reconstruction in our practice include previous liposuction at the donor site or active smoking (within 1 month prior to surgery). Liposuction of the central buttock is rare but liposuction of the saddle bag area might affect the I-GAP donor site.

ANATOMY

The inferior gluteal artery is a terminal branch of the anterior division of the internal iliac artery and exits the pelvis through the greater sciatic foramen.[12] Landmarks can also be used to identify the location of the emergence of the inferior gluteal artery outside the pelvis. A line is drawn from the posterior superior iliac spine to the outer part of the ischial tuberosity; the junction of its lower third with its middle third marks the point of emergence of the inferior gluteal and its surrounding vessels from the lower part of the greater sciatic foramen. The artery accompanies the greater sciatic nerve, internal pudendal vessels, and posterior femoral cutaneous nerve. In this subfascial recess, the inferior gluteal vein will receive tributaries from other pelvic veins. The inferior gluteal vasculature continues toward the surface by perforating the sacral fascia. It exits the pelvis caudal to the piriformis muscle. Once under the inferior portion of the gluteus maximus, perforating vessels are seen branching out through the substance of the muscle to feed the overlying skin and fat.

The course of the inferior gluteal artery perforating vessels is more oblique through the substance of the gluteus maximus muscle than the course of the superior gluteal artery perforators, which tend to travel more directly to the superficial tissue up through the muscle. Thus, the length of the inferior gluteal artery perforator and the resultant pedicle length for the overlying I-GAP flap is typically 7 to 10 cm. Because the skin island is placed inferior to the origin of the inferior gluteal vessels, a longer pedicle is also assured.

The direction of the perforating vessels can be superior, lateral, or inferior. Perforating vessels that nourish the medial and inferior portions of the buttock have relatively short intramuscular lengths, between 4 and 5 cm, depending on the thickness of the muscle. Perforators that nourish the lateral portions of the overlying skin paddle are observed traveling through the muscle substance in an oblique manner 4 to 6 cm before turning upward toward the skin surface. By traveling through the muscle for relatively long distances, these vessels are much longer than their medially based counterparts. The perforating vessels can be separated from the underlying gluteus maximus muscle and fascia and traced down to the parent vessel, forming the basis for the I-GAP flap. Between two and four perforating vessels originating from the inferior gluteal artery will be located in the lower half of the gluteus maximus.[13]

After giving off perforators in the buttocks, the inferior gluteal artery then descends into the thigh accompanied by the posterior femoral cutaneous nerve and follows a long course, eventually surfacing to supply the skin of the posterior thigh.[14] The branches of the inferior gluteal nerve (L5, S1–2) supply the skin of the inferior buttock. A neurosensory flap can be elevated if these nerves are preserved in the dissection of the flap.[15,16]

The posterior femoral cutaneous nerve innervates the skin of the perineum and posterior surface of the thigh and leg. It arises partly from the dorsal divisions of the first and second sacral nerves and from the ventral divisions of the second and third sacral nerves, and issues from the pelvis through the greater sciatic foramen below the piriformis muscle, along with the inferior gluteal artery. As it courses with the inferior gluteal artery, it should be identified and preserved intact during the dissection of the I-GAP pedicle.

SURGICAL TECHNIQUE

The patient usually is seen in the office one day prior to surgery. The surgical plan again is reviewed with the patient, and any remaining questions answered.

For the I-GAP flap, the gluteal fold is noted with the patient in a standing position (see Fig. 1). The inferior limit of the flap is marked 1 cm inferior and parallel to the gluteal fold. The patient is then placed in

Figure 1 (A) Flap elevation. (B) Identification of perforator. (C) Perforator dissection through gluteus maximus. (D) Completed I-GAP dissection.

the lateral position and the Doppler probe used to find perforating vessels from the inferior gluteal artery. An ellipse is drawn for the skin paddle to include these perforators, which roughly parallels the gluteal fold with dimensions of $\sim 8 \times 18$ cm.

For unilateral procedures the patient is placed in the lateral decubitus position and a two-team approach is used. The recipient vessels are prepared by an assistant surgeon simultaneously while the I-GAP flap is harvested. For breast reconstruction, the internal mammary vessels or internal mammary perforators are preferred as anastomosis to these vessels allows easier medialization of the flap when it is inset. However, the I-GAP flap often has a long enough pedicle that will allow the use of the thoracodorsal vessels if necessary.

The skin incisions are made and bovie electrocautery is used to divide the flap down to the muscle of the gluteus maximus. Significant beveling is used as needed, particularly in the superior direction, to harvest more tissue for the width and volume to create a good breast reconstruction. The flap is elevated from the muscle in the subfascial plane and the perforators approached beginning from lateral to medial. A single large perforator is preferred, if it is present, but several perforators that lay in the same plane and the direction of the gluteus maximus muscle fibers can be taken together as well. Subfascial elevation is also performed from medial to lateral as needed to ensure that a large perforator is found. The muscle is then spread in the direction of the muscle fibers and the perforating vessels are meticulously dissected free. The dissection continues until both the artery and the vein are of sufficient size to be anastomosed to the recipient vessels in the chest. The small artery usually is the limiting factor in this dissection and may be challenging to harvest as the accompanying vein often becomes very large with multiple branches in and around the artery. It is essential that the arterial perforator is visualized and preserved as it enters the main descending inferior gluteal artery to allow a proper vessel size match to the vessels in the chest. The preferable artery and vein diameter for anastomosis are 2.0 to 2.5 mm and 3.0 to 4.0 mm, respectively. When using the internal mammary perforators as recipients, a shorter pedicle and smaller artery will suffice, thereby simplifying flap harvest.

Harvesting the in-the-crease I-GAP allows more beveling superiorly and inferiorly as soft tissue deficiency in the crease is less noticeable. Laterally, thicker fat from trochanteric area can be taken, increasing flap volume and improving a saddlebag deformity. When harvesting the I-GAP flap, care must be taken to preserve the lighter-colored medial fat pad that overlies the ischium

Figure 2 (A) Areola-sparing mastectomy with I-GAP first-stage reconstruction prior to nipple reconstruction. (B) Donor site left I-GAP flap.

medial to the gluteus maximus muscle. Preservation of this fat pad will reduce possible donor-site discomfort when sitting in the future.

When the recipient vessels are ready, the gluteal artery and vein are divided and the flap harvested and weighed. The skin and fat overlying the gluteus maximus muscle and posterior thigh are elevated superiorly and inferiorly to allow layered approximation of the fat and fascia of the donor site to minimize a contour deformity and provide a buttock lift. The donor site is closed in layers over a suction drain with absorbable suture.

The patient is then returned to the supine position and again prepped and draped. The anastomosis is performed to the recipient vessels under the operating microscope. The flap is inset over a suction drain placed away from the pedicle with care taken not to twist or kink the pedicle. To create a spherical flap the ends of the ellipse may be excised. The flap may be inset horizontally, vertically, or obliquely as needed.

POSTOPERATIVE CARE

The postoperative care is the same as with other perforator flap breast reconstructions and patients typically go home on the fourth postoperative day. The suction drain at the donor site must usually be left in place for several days longer than with an abdominal donor site (1 to 2 weeks).

CLINICAL EXAMPLES

1. A 42-year-old female with ductal carcinoma in situ (DCIS) in the left breast and mild ptosis underwent a left areolar-sparing mastectomy with I-GAP reconstruction (Fig. 2).
2. A 52-year-old female underwent right subcutaneous mastectomy with failed implant reconstruction. Her implant was removed and reconstructed with I-GAP flap (Fig. 3).

COMPLICATIONS

In a review of 170 GAP flaps performed by our unit for breast reconstruction, the incidence of complications was low. The overall take-back rate was ~8% with a 6% rate of vascular complications. The total flap failure rate was ~2%. Donor-site seroma occurred in 15% of patients and ~20% of patients required revision of the donor site.[11]

Figure 3 (A) I-GAP right breast reconstruction after subcutaneous mastectomy. (B) Donor site right I-GAP flap.

SUMMARY

Perforator flaps have raised the standard in breast reconstruction. By replacing breast tissue with similar, living autologous tissue we can achieve permanent natural results with minimal donor site deformities. The I-GAP flap is one of a wide choice of donor site options that make most patients candidates for this method of autogenous reconstruction. The in-the-crease I-GAP offers the advantages of preservation of buttock shape, a scar hidden in a natural crease, and an adequate thickness of fat for a youthful and attractive breast. Additional work may further decrease the length of procedure, improve scars, and lessen complications.

I-GAP Advantages

- Excellent for breast reconstruction when 200 to 600 g is needed.
- The I-GAP is a thick flap that may allow correct breast width to be preserved when rotated 90 degrees.
- Flap has a longer pedicle (7 to 10 cm), which can be sutured into the thoracodorsal system for breast reconstruction.
- Donor-site contour defects may be minimal in properly selected patients.

I-GAP Disadvantages

- I-GAP donor site may cause discomfort when sitting on uncushioned chairs for the initial 3 to 6 weeks after surgery.
- Injury to the posterior femoral cutaneous nerve postoperatively is unlikely but possible and may result in cutaneous numbness. Visualization of the sciatic nerve is uncommon and injury very unlikely.
- Donor site scar may show with high-cut swimsuits.

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