The Deep Circumflex Iliac Artery Perforator Flap for Breast Reconstruction

Un lambeau perforateur de l'artère iliaque circonflexe profonde pour la reconstruction mammaire

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Abstract

Autologous breast reconstruction using abdominal-based perforator flaps produces excellent aesthetic results with minimal donor site morbidity. The superficial inferior epigastric artery and deep inferior epigastric perforator (DIEP) flaps reliably perfuse a hemi-abdomen, up to the anterior axillary line. Beyond this line laterally, the flank or “love handle” tissue is primarily perfused by the deep circumflex iliac artery (DCIA) or secondarily by the superficial circumflex iliac artery. The flank tissue is a valuable addition to increase flap size when harvested with a DIEP flap or to provide vascularized tissue when the abdomen has been previously harvested. Harvesting the flank tissue in combination with the anterior abdominal tissue improves the contour of the trunk, accentuates the waist, and minimizes secondary revisions to excise prominent “dogears.” The DCIA flap is a novel technique for breast reconstruction. In this article, we describe our technique, pearls and pitfalls, and early results.

Résumé

La reconstruction mammaire autologue à l'aide de lambeaux perforateurs abdominaux produit d'excellents résultats esthétiques et une morbidité minimale au siège du donneur. Les lambeaux de l'artère épigastrique inférieure superficielle et du perforateur épigastrique inférieure profond (PÉIF) perfusent en toute fiabilité un hémicorps, jusqu'à la ligne axillaire antérieure. Au-delà de cette ligne latérale, la perfusion primaire des tissus du flanc, ou de la « poignée d'amour », est d'abord assurée par l'artère iliaque circonflexe profonde (AICP) ou secondairement par l'artère iliaque circonflexe superficielle. Les tissus du flanc sont un ajout précieux à l'accroissement de la dimension du lambeau lorsqu'il est prélevé avec un lambeau du PÉIF ou qu'il vise à fournir des tissus vascularisés après avoir été prélevé dans l'abdomen. Le prélèvement des tissus du flanc en combinaison avec les tissus abdominaux antérieurs améliore le contour du tronc, accentue la taille et réduit les révisions secondaires pour exciser les « oreilles de chien » proéminentes. Le lambeau de l'AICP est une nouvelle technique de reconstruction mammaire. Dans le présent article, les auteurs décrivent leur technique, leurs perles et leurs écueils de même que leurs résultats préliminaires.

Keywords

autologous reconstruction, breast reconstruction, DCIA flap, DIEP flap, flow-through flap

Anatomy

The deep circumflex iliac artery (DCIA) originates from the lateral or posterior-lateral external iliac artery in 90% of cases, opposite (lateral) to the deep inferior epigastric artery, 5 mm cephalad and deep to the inguinal ligament.¹ In 10% of cases, the DCIA arises from the femoral artery. The DCIA ascends on the medial surface of the ilium between the transversalis fascia and the transversus abdominis, toward the anterior superior iliac spine (ASIS). Just proximal to the ASIS, the DCIA gives off an ascending branch. The ascending branch travels through the transversus abdominis and

then along the deep surface of the internal oblique.² The ascending branch supplies the transversus abdominis, internal and external oblique, and inferior-lateral peritoneum. The DCIA continues its course laterally, travelling through the abdominal wall musculature to reach the overlying

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Figure 1. The DCIA and its vena comitantes travel from the inner ilium to the skin cephalad and lateral to the ASIS. The vessels pass sequentially through the transversus abdominis, internal oblique, and external oblique to the overlying subcutaneous tissue and skin. ASIS indicates anterior superior iliac spine; DCIA, deep circumflex iliac artery.

Figure 2. The DCIA and its vena comitantes are dissected along their winding course through the abdominal wall musculature to maximize the pedicle length. DCIA indicates deep circumflex iliac artery.

subcutaneous tissue and skin (Figures 1 and 2). The DCIA gives off perforators that supply the iliacus, iliac crest bone, and a 10×20 cm area of skin cephalad and lateral to the ASIS.³ The ascending branch is divided during DCIA pedicle harvest to increase the pedicle length. The DCIA reenters the transversus abdominis posterior-laterally. Its terminal branches anastomose with branches of the lumbar, iliolumbar, and superior gluteal arteries.^{2,4}

Figure 3. Cadaveric dissections have demonstrated DCIA perforators 5 cm to 10.5 cm (average 7.4 cm) posterior to the ASIS and 1 to 35 mm (average 8 mm) superior to the iliac crest.⁴ ASIS indicates anterior superior iliac spine; DCIA, deep circumflex iliac artery.

Two vena comitantes travel with the DCIA. They converge at the level of the inguinal ligament to form a single vein that continues into the external iliac vein.⁴ The DCIA is typically 2 mm in diameter (range: 1.5-3 mm).⁵ The vena comitantes have a diameter of 1.5 to 2 mm. The vessels are typically 6 to 8 cm in length, measured from where the perforator exits the transversalis fascia to where it enters the subcutaneous flank tissue.

Anatomic studies by Morris et al determined that there are an average of 1.6 DCIA perforators to the overlying skin with an average diameter of 0.7 mm.⁴ Using lead oxide injection cadaver studies, these perforators were found 5 to 10.5 cm (average 7.4 cm) posterior to the ASIS and 1 to 35 mm (average 8 mm) superior to the iliac crest with a perforator zone of 31 cm^2 (Figure 3).⁴ Clinically, we have found that there is most commonly 1 dominant DCIA perforator present, accompanied by 2 vena comitantes, located in a more cephalad and medial position, 1 to 4 cm posterior and 1 to 2 cm cephalad to the iliac spine. The dominant perforator is typically accompanied by 2 to 3 markedly smaller, nearby perforators. During the flap harvest, the secondary perforators are identified and clamped. If adequate DCIA flap perfusion is maintained on the single dominant perforator, as assessed clinically or with indocyanine green (ICG) angiography, the secondary perforators are clipped and divided.

Figure 4. The combined DIEP (outlined in grey)-DCIA (outlined in black) flap markings are shown. DCIA indicates deep circumflex iliac artery; DIEP, deep inferior epigastric perforator.

Indications

The combined deep inferior epigastric perforator (DIEP)-DCIA flap is most commonly used when the DIEP flap would provide inadequate volume for breast reconstruction. The DCIA flap is used alone in cases where the anterior abdominal wall has previously been harvested, for example, after a superficial inferior epigastric artery (SIEA), DIEP, or transverse rectus abdominus (TRAM) flap, abdominoplasty, or liposuction.

Markings

Combined DIEP-DCIA Flap

With the patient standing, a standard DIEP flap is marked over the anterior abdomen from ASIS to ASIS. The superior incision is marked above the umbilicus (Figures 4 and 5). The inferior incision is marked using a pinch test, approximately 8 cm above the anterior vulvar commissure.

The DCIA flaps are marked over the bilateral flanks. The inferior incision is a continuation of the inferior DIEP incision, placed 2 cm below the iliac crest. The superior incision is marked using a pinch test on the flanks at the anterior axillary line, similar to the markings made for a lower body lift. The markings are continued from the anterior axillary line to the posterior axillary line with the superior and the inferior incisions marked parallel to each other. From the posterior axillary line to the midline of the buttocks, the superior marking is tapered to meet the inferior marking no farther posterior than the midgluteal line, depending on the flap size needed.

Isolated DCIA Flap

The DCIA flap is marked with its widest dimension at the midaxillary line (Figure 6). The inferior incision is marked 2 cm below the iliac crest. The superior incision is marked using a pinch test at the anterior axillary line. This flap width is maintained from the anterior axillary line to the posterior

axillary line by extending the superior and inferior incision markings parallel to each other. The flap markings are tapered to a point just medial to the linea semilunaris anteriorly and to the midgluteal line posteriorly. A Doppler ultrasound can be used preoperatively to identify arterial signals on the skin flap. The DCIA perforator will exit the anterior abdominal wall superior and lateral to the ASIS.

Patient Positioning

The patient is seated on the operating table and their back is sterilely prepped. A sterile drape is placed on the bed and then the patient lies supine with their arms out laterally on arm boards. A second drape is placed over the patient anteriorly and general anesthesia is induced. After intubation, the anterior drape is removed and discarded. The chest and abdomen are prepped down to the bed lines of the operating table and final draping is completed.

Flap Harvest

Combined DIEP-DCIA Flap

The inferior skin incision is made. The medial vein and SIEA are identified. If present, these vessels are dissected toward their origins. If the SIEA diameter is 1.5 mm or greater and can be dilated to 2 mm, these vessels are used to supply the anterior abdominal tissue. A combined SIEA-DIEP flap is used in these cases. If the SIEA is too small, a combined DIEP-DCIA flap is harvested.

The umbilicus is cut out and a vertical infraumbilical midline incision is made. From the midline incision, starting medially and working laterally, the DIEP perforators are isolated. The dominant perforator(s) is(are) identified, from either the medial or the lateral row. From the midline incision, and working from inferior and superior, the DIEP flap is isolated on the dominant perforator(s).

Figure 5. The preoperative markings are shown for a patient undergoing bilateral skin-sparing mastectomies for right invasive ductal carcinoma and left prophylaxis. Immediate reconstruction was performed using bilateral DIEP-DCIA flaps to reconstruct the breast volumes desired by the patient. The postoperative results are presented in Figure 12. DCIA indicates deep circumflex iliac artery; DIEP, deep inferior epigastric perforator.

Figure 6. This patient had undergone a failed right breast TRAM flap reconstruction. After removal of the flap, chemotherapy, and radiation, she underwent an expander-implant reconstruction. She presented to our institution for revision. We removed her implant and its contracted capsule and performed autologous reconstruction with bilateral DCIA flaps to the right breast. Her preoperative flap markings are shown. DCIA indicates deep circumflex iliac artery.

Once the DIEP perforator(s) has(have) been identified, the focus shifts to the DCIA flap elevation. The patient is rolled to the contralateral side to allow the tissue from the back to be incised and elevated. The most posterior-lateral incision is made and the flap is elevated from the back, around the flank, to the anterior abdomen. At the level of the posterior axillary line, dissection slows and care is taken to stay on the fascia as the intercostal and DCIA perforators come into view. All flank perforators are identified. An intercostal artery perforator can be harvested to supply the same flap angiosome as the DCIA if the DCIA is absent, injured during dissection, or has a small diameter. The intercostal artery perforators are located posterior to the DCIA perforators. They run posteriorly through the abdominal wall musculature, while the DCIA perforators course anteriorly. The intercostal and lumbar artery perforators are accompanied by nerves, while the DCIA perforators are not.⁴

The dominant DCIA perforator is dissected along with its accompanying vena comitantes (Figure 7). The external

oblique fascia is opened in an oblique direction 2 cm cephalad and 2 cm caudal to the perforator. The external oblique muscle is spread sequentially in the direction of its fibers (from superior-lateral to inferior-medial) to allow further deep dissection of the pedicle for 1 to 3 cm (Figure 8). As the DCIA perforator travels deep through the internal oblique muscle, the muscle fibers are spread (from superior-medial to inferior-lateral) and a similar dissection is performed (Figure 9). The DCIA and its vena comitantes travel for 1 to 2 cm between the muscle layers before piercing the next most superficial muscle layer. Spreading in the plane parallel to the fibers of the oblique muscles, rather than dividing the muscle fibers, limits the risk of a hernia and minimizes pain postoperatively. No intercostal nerves are sacrificed.

The ascending branch of the DCIA is divided and the pedicle is dissected free from the external oblique, internal oblique, and transversus abdominis muscles. The pedicle length and perforator vessel diameter are assessed. A pedicle length of 6

Figure 7. The DCIA and its 2 vena comitantes are identified using lateral to medial dissection during DIEP-DCIA flap harvest. They are shown exiting through the external oblique muscle cephalad and lateral to the ASIS here in a long-shot and a close-up photograph. ASIS indicates anterior superior iliac spine; DCIA, deep circumflex iliac artery; DIEP, deep inferior epigastric perforator.

Figure 8. The external oblique muscle is opened in the direction of its fibers to allow further dissection of the DCIA pedicle. DCIA indicates deep circumflex iliac artery.

Figure 9. The internal oblique muscle is spread in the direction of its fibers, opposite to the previous external oblique dissection. Gelpi retractors facilitate the dissection.

to 8 cm, a DCIA diameter of 1.5 mm, and 2 vena comitantes with diameters of 2 mm are generally present at this level. The DIEP flap vessels are temporarily clamped and the DCIA flap perfusion is assessed clinically and with ICG fluorescence

imaging if available. If flap perfusion is adequate with all perforators clamped, the DCIA and its vena comitantes are divided at the level of the transversus abdominis. The DCIA vessels continue deep to the transversus abdominis and travel along the

Figure 10. On the back table, the DCIA and its vena comitantes are anastomosed to a side branch of the DIEA/V. The flap is folded into the desired shape with the vessels sandwiched in between. DCIA indicates deep circumflex iliac artery; DIEA/V, deep inferior epigastric artery and vein.

medial iliac crest; further dissection can be performed in this area if the pedicle length or vessel diameter is inadequate. To date, we have not found this to be needed. The peritoneum is not entered and the periosteum of the iliac crest is not incised or elevated as previously described for the Rubens flap.⁶

Based on the DCIA pedicle length, the extent of the DIEP pedicle dissection can be determined. The DIEP pedicle must be harvested with a side branch, a medial or lateral row perforator, or the cephalad extent of the harvested medial or lateral row to allow anastomosis of the DCIA pedicle on the back table. The DIEP pedicle will perfuse the DCIA flap as a flow-through segment. Longer DIEP pedicles are harvested for combined DIEP-DCIA flaps compared to DIEP flaps alone as the effective pedicle length is reduced due to the folding of the DCIA flap on the DIEP flap and the thickness of the DIEP flap. The flaps are folded to allow the pedicle to exit from between the 2 flaps (Figure 10). At a minimum, the pedicle must be dissected so that its length is equal or longer than the thickness of the DIEP flap.

Once the DIEP and DCIA vessels are divided, the flaps are moved to the back table. Prior to abdominal closure, the inferior mammary fold and lateral breast pocket are sutured to recreate the normal footprint of the breast. Next, the muscle splits in the external and internal obliques used to dissect the DCIA pedicle are repaired using absorbable sutures. The incision in the anterior rectus fascia used for dissection of the DIEP pedicle is closed with nonabsorbable sutures. No hernias have been noted postoperatively in our first 50 DCIA flaps.

A drain is placed in each side of the abdomen. The operating table is flexed at the patient's waist and the anterior abdominal wall is closed with dissolving sutures along its length. The closure along the midaxillary line can be tight. Progressive tension sutures along the abdomen and midaxillary line help to reduce the tension at the suture line. A multilayered closure is performed. Scarpa's fascia is closed followed by deep dermal and subcuticular sutures. By limiting the posterior extent of the DCIA flap to the midgluteal line, closure can be performed without patient repositioning.

Isolated DCIA Flap

The DCIA flap dissection begins medially, from the linea semilunaris. The skin and subcutaneous fat are incised. The flap is elevated off of the abdominal fascia, from medial to lateral, taking care to preserve all perforators. The DCIA and intercostal artery perforators are identified. Flap elevation then proceeds from posterior, from the mid gluteal line to the flap perforators. The perforators are assessed clinically and with ICG angiography. The most robust perforator is selected and dissected until an adequate vessel size and pedicle length are reached.

Flap Inset

Combined DIEP-DCIA Flap

The DIEP pedicle is positioned so that it exits from most medial portion of the deep (DIEP) flap. Depending on the perforator position and pedicle length of the DIEP flap, the most favourable anatomic arrangement of the DIEP-DCIA flap can be established on the back table to determine whether the flap should be used for the right or left breast reconstruction. The DIEP and DCIA flaps are not divided, but folded on themselves. The DCIA flap is folded on top of the DIEP flap, creating a stacked flap with the DCIA superficial and the DIEP deep. The tips of the flaps are slightly offset to widen the upper pole of the reconstructed breast and are angled 15° to 20° toward the axilla to restore the breast's axillary tail of Spence. The flaps can be sewn to each other on the back table to prevent inadvertent shearing of the vessels prior to inset, although we do not generally find this to be necessary. The advantages of this flap configuration include:

1. The lateral component of the DCIA flap, which is the narrowest point of the DIEP-DCIA flap, will be positioned at the axillary tail of the breast to restore the anatomical contour of the breast laterally.
2. The thinner, tapered DCIA flap will be positioned superficially, while the thicker, wider DIEP flap will be deep. This recreates the desired pyramidal breast shape (Figure 11).

Figure 11. To create an anatomic breast shape, the DIEP-DCIA is folded so that the DCIA flap is placed superficially and the DIEP flap is deep. The DCIA flap is thinner and narrower, while the DIEP flap is thicker and wider, restoring a pyramidal breast shape. The DIEA/V pedicle is positioned medially on the chest and anastomosed to the IM vessels. DCIA indicates deep circumflex iliac artery; DIEP, deep inferior epigastric perforator; DIEA/V, deep inferior epigastric artery and vein; IM, internal mammary.

We prefer to establish perfusion to the DCIA flap using a flow-through anastomosis to the DIEP flap. To monitor the flow-through DCIA flap, it must be positioned superficially with the skin paddle visible on the external breast. If placed deep, the DCIA flap would not be visible for clinical monitoring postoperatively.

For autologous breast reconstruction, the internal mammary artery (IMA) and internal mammary vein (IMV) are preferred for flap anastomosis. There are 2 options for the microsurgical anastomoses for the combined DIEP-DCIA flap, with selection based on the size match and length of the vessels. When the DCIA pedicle is long (over 8 cm), either method can be utilized (option 1 or 2 below), but a flow-through is preferred (option 1). When the DCIA pedicle is short, anastomosis to a side branch of the DIEP pedicle is necessary (option 1). Using either option, the effective pedicle length is short. Care must be taken during flap inset to avoid avulsion of the anastomoses.

A flow-through (supercharge) of the DCIA flap to the DIEP is our preferred way to perfuse the DCIA flap. Using a side branch of the DIEP pedicle provides the best vessel size match for anastomosis to the DCIA. Alternatively, if the DIEP flap is harvested on the medial row of the DIEA, then a branch of the lateral row can be used for anastomosis to the DCIA, or vice versa if the DIEP flap is harvested on the lateral row of the DIEA. A third option is to anastomose the DCIA vessels to the cephalad extent of the deep inferior epigastric artery and vein (DIEA/V) pedicle. The DCIA-DIEP anastomoses are performed on the back table to allow the microsurgery to be performed in a controlled setting.

The entire DIEP flap is deepithelialized. It is positioned on the chest as a buried flap. The distal DCIA flap (area of the flap from the back) is deepithelialized. The preserved, non-deepithelialized skin paddle of the DCIA flap (area of the flap from the flank) is tailor tacked into the desired position, based on the mastectomy incisions used. The skin paddle allows postoperative monitoring with (1) Doppler ultrasound to assess the

arterial and venous signals and (2) clinically to assess the flap colour, capillary refill, turgor, and temperature. A problem with the perfusion of the flow-through DCIA flap skin paddle alerts the surgeon that there is either an isolated DCIA flap problem or a problem with both the DCIA and DIEP flaps. It would be extremely rare for an isolated DIEP flap problem to occur, while the flow-through flap (DCIA) is still perfused.

The DIEP and the DCIA pedicles can be anastomosed to separate recipient vessels. Most commonly, the IMA is used antegrade and retrograde to the DIEA and the DCIA, respectively. When retrograde anastomoses are needed, the fourth intercostal space is used as the venous system typically has branched into 2 separate veins at this level and distal, allowing the DIEV and DCIV to be separately anastomosed to the IMV in antegrade fashion. Skin paddles from both flaps are monitored postoperatively.

Isolated DCIA Flap

When the anterior abdominal tissue has been previously resected, unilateral or bilateral DCIA flaps can be used for breast reconstruction, depending on the volume required. When one flap is sufficient for unilateral breast reconstruction, the ipsilateral flank is used. Once harvested, the DCIA flap is moved up to the chest without rotating it. The DCIA pedicle comes off the inferior-medial aspect of the flap and is anastomosed to the internal mammary (IM) vessels. When bilateral DCIA flaps are used for unilateral breast reconstruction, the IMA is used for antegrade and retrograde anastomoses to perfuse the flaps.

Postoperative Management

An abdominal binder is worn for 4 to 6 weeks postoperatively. With a tight anterior abdominal wall closure, patients often ambulate partially flexed at the waist for approximately 2 weeks postoperatively.

Figure 12. The 1-year postoperative results are demonstrated here after bilateral breast reconstruction with DIEP-DCIA flaps for the patient previously shown preoperatively in Figure 5. Postoperative radiation therapy to the right breast resulted in skin tightening and flap volume loss. Irregular posterior flap donor site scars were present. The patient was happy with her functional and aesthetic result and declined further surgery. DCIA indicates deep circumflex iliac artery; DIEP, deep inferior epigastric perforator.

Results

From 2012 to 2014, 20 DCIA flaps were performed for 12 patients by the senior author. Fourteen combined DIEP-DCIA flaps were performed to increase the donor site volume available for breast reconstruction. The remaining 6 isolated DCIA flaps were selected due to the unavailability of the anterior abdominal wall tissue following a previous SIEA, DIEP, or TRAM flap or abdominoplasty. The average patient age was 52 years, with a mean BMI of 23 kg/m². The mean hospital stay was 3.9 days.

There were no flap failures. There was one return to the operating room for pedicle kinking; this flap was successfully salvaged. Four of the 20 donor sites had a wound dehiscence requiring packing; 2 sites were treated with daily packing and 2 required repeat surgical closure in the clinic using local anesthetic. There were no cases of flank asymmetry or lateral abdominal wall hernias. One mild flank bulge was noted.

Patients used an average of 28.5 mg of morphine via a patient-controlled analgesia while in hospital and 15 tablets of acetaminophen 325 mg–codeine 30 mg after discharge from the hospital. Patient-reported outcomes revealed that subjective pulling and tightness were greater for the abdomen than the flanks postoperatively, despite tighter flank closure clinically. Patients reported high satisfaction rates with their flank shape and symmetry, flank scars, and hip contour. Lower rates of satisfaction were reported by the patients for their abdominal scars. All patients returned to their previous employment.

Pearls and Pitfalls

- The DCIA perforator may have been resected if the patient had a previous SIEA, DIEP, or TRAM flap or abdominoplasty. In cases where there is concern of the vessel integrity, a preoperative computed tomography

angiogram is ordered. Otherwise, no imaging is necessary.

- Indocyanine green angiography is used frequently in the operating room to confirm the perfusion of the DIEP and DCIA flaps prior to pedicle division. In our experience, the ICG studies have shown that the DCIA perforator reliably perfuses the skin for 15 cm medial, lateral, and superior to the perforator entry point into the flap.
- If the DCIA perforator is injured during dissection, the lateral flank tissue can be harvested based on the superficial circumflex iliac artery or an intercostal artery perforator.
- Pedicle length:
 - If an SIEA flap is used, its pedicle must be dissected out to a length where the SIEA vessel diameter is suitable for anastomosis, typically right to its origin from the femoral artery.
 - If a DIEP flap is used, the DIEA/V are dissected through the rectus abdominis, but not fully to their origin. The pedicle is clipped once (1) an appropriately sized side branch, a medial or lateral row perforator, or the cephalad extension of the DIEP flap pedicle has been dissected to allow flow-through anastomoses with the DCIA flap and (2) its length and vessel diameter are adequate for anastomosis to the IM vessels.
 - The DCIA pedicle is short and must be dissected to the level of the transversus abdominis prior to division.
- Fat necrosis can occur, most commonly at the posterior-lateral aspect of the DCIA flap. Limiting the width of the flap can minimize the amount of inadequately perfused fat harvested.
- The posterior donor site scars can be irregular due to difficulty with patient positioning during surgery (Figure 12). Minor revisions under local anesthetic can be performed secondarily with the patient positioned in

lateral decubitus or prone. If a single DCIA flap was harvested for breast reconstruction, liposuction or direct excision of the contralateral flank tissue can be performed secondarily to provide a symmetric waist contour.

Conclusion

The DCIA flap is an excellent secondary autologous option for breast reconstruction to augment flap volume or to allow alternate tissue harvest when the anterior abdominal tissue has been previously resected. The flanks frequently have excess fat and skin for flap harvest making this flap possible in most patients. The donor site closure improves the contour of the waist and removes the patient's "love handles." Reconstructed breasts are typically equal or larger than the patient's original breast volume when a combined DIEP-DCIA flap is used.

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