# Paramuscular Perforators in DIEAP Flap for Breast Reconstruction

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One of the main steps in perforator flap surgery is to identify the dominant perforator. Using multidetector row computed tomography (MDCT) for the preoperative planning of deep inferior epigastric artery perforator (DIEAP) flap surgery, we identified a perforator with a large caliber, an excellent location in the middle abdominal region, and a totally extramuscular trajectory in a significant number of patients. We describe the frequency of this perforator and determine its characteristics.

**Patients and Methods:** We conducted a retrospective study of 482 patients who underwent 526 DIEAP flaps for breast reconstruction from October 2003 to October 2011. Mean age at surgery was 51.3 years old. A preoperative MDCT of abdominal vascularization was performed in all patients.

**Results:** MDCT identified a dominant perforator with a paramuscular course in 12.4% of abdominal walls. In all cases, it was located in the midline and emerged directly from the deep inferior epigastric system. Its mean caliber was 1.9 mm. The flap was harvested based on this perforator in all these patients, and mean harvest time was 51 minutes. The characteristics of this perforator made dissection easier and reduced morbidity at the donor site. There were no flap losses and the only complications were minor.

**Conclusion:** We located a paramuscular perforator in 12.4% of patients undergoing breast reconstruction with abdominal perforator flaps. Its morphological features and extramuscular course make it the perforator of choice in DIEAP flap surgery.

**Key Words:** paramuscular perforator, DIEAP flap, breast reconstruction, perforator flaps, multidetector row computed tomography, CT angiography, septocutaneous perforator

(*Ann Plast Surg* 2013;00: 00–00)

Over the past 2 decades, perforator flaps have become the gold standard in breast reconstruction.[1,2]

They offer substantial advantages as they use living tissue similar to the original breast and morbidity in the donor site is low. Perforator flap surgery, however, is complex and it involves a steep learning curve.[3] It not only requires mastery of specific microdissection techniques but entails the gathering of as much information as possible to accurately locate the best perforator. In October 2003, we performed the first multidetector row computed tomography (MDCT) in the preoperative study of perforator flaps for breast reconstruction,[4] and we demonstrated its efficacy in planning abdominal perforator surgery.[5]

MDCT enables us to locate the best perforator for each flap and provides valuable information about the cutaneous vascular anatomy in each patient.[6] Using our protocol, we have found that a significant number of patients have a perforator with particular features that make it ideal for flap surgery. In this work, we describe the anatomic features of these perforators, their frequency of appearance, and the advantages of their location.

## PATIENTS AND METHODS

From October 2003 to October 2011, 526 deep inferior epigastric artery perforator (DIEAP) flaps were performed for breast reconstruction in 482 patients (mean age 51.3 years). Breast reconstruction surgery was immediate in 15.1% of cases (73 patients) and delayed in 84.8% of cases (409 patients). In all patients, we carried out a preoperative study of abdominal vascularization with MDCT.[7] From 2003 to 2005, we used the 16–detector-row CT scanner (Aquilion 16; Toshiba Medical, Tokyo, Japan) and after 2005 we used the 64-detector-row CT scanner (Aquilion 64; Toshiba Medical). The images obtained allowed us to make a 3-dimensional reconstruction of the abdomen on which we marked the precise points where each perforator vessel pierced the muscular fascia on the abdominal skin surface. The perforator considered most suitable for the flap was ideally that with the most adequate location, the largest caliber, and the shortest intramuscular course. On the day before surgery, preoperative markings based on the MDCT data were transferred to the patient's abdominal skin.

We began surgery by dissecting and preserving the superficial inferior epigastric venous system as a safeguard against venous drainage complications. We then raised the DIEAP flap with the location of the dominant perforator at the suprafascial level. Next, we dissected the perforator through the gap of the muscular fascia and followed its course until we reached the deep inferior epigastric vessels.

Intraoperative findings were compared to the results obtained by MDCT. We recorded the following data for each patient: flap dimensions, analysis of the accessory venous drainage (superficial epigastric system), the amount of flap discarded because of insufficient vascularization, operative time required to raise the flap, and immediate postoperative evolution.

## RESULTS

After analyzing MDCT images, we observed a paramuscular perforator in 12.4% of abdomens (60 patients), and the results corresponded with the intraoperative findings in all cases (Figs. 1, 2).

The paramuscular perforator was located in the middle of the abdominal flap. In 88.3% of cases (53 cases), this perforator had a periumbilical location, at an infraumbilical distance of 1.5 to 3.5 cm, and in the remaining 11.6% (7 patients) it had a lower location, at an infraumbilical distance of more than 3.5 cm.

These perforators were large, with a mean caliber of 1.9 mm (range: 1.2–3.2 mm) and a visible and palpable pulse. Once the perforator was located under the muscular fascia (Fig. 3A), we followed its course close to the medial border of the rectus abdominis muscle and later behind the muscle (Fig. 3B) until it reached the deep inferior epigastric system (Fig. 3C). Throughout this trajectory, the perforator kept a completely paramuscular course and gave off only a few branches to the border of the muscle. In 8 cases (13.3%), the perforator gave off branches to the septum of the linea alba and pierced the deep muscular fascia. Most paramuscular perforators (86%, 52 of 60 patients) were terminal cutaneous branches of the deep inferior epigastric vessels, and they all originated in the medial branch. As

Received June 15, 2012, and accepted for publication, after revision, December 31, 2012.

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Preliminary results were presented at the 10th International Course on Perforator Flaps in Ankara, Turkey on September 8, 2006.

Conflicts of interest and sources of funding: none declared.

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ISSN: 0148-7043/13/0000-0000
DOI: 10.1097/SAP.0b013e318285873e


**FIGURE 1.** Axial MDCT view of a paramuscular perforator emerging from the medial border of the left rectus abdominis muscle and branching into the subcutaneous tissue.

they did not coincide with motor nerves at any point, there was no risk of damaging rectus abdominis functionality.

MDCT study showed a clear connection between this paramuscular perforator and the superficial epigastric system, indicating excellent flap vascularization and allowing the use of almost the entire flap (Fig. 4).

Knowing beforehand that the paramuscular perforator was the dominant perforator, we were able to dissect it directly. Flap raising time that was 51 minutes (range: 32–70 min). Morbidity at the donor site was minimal; the incision at the muscular fascia was easily mended by continuous suture.

We observed fewer complications with the DIEAP flap with a paramuscular perforator than with the conventional DIEAP flap. There were no cases of total or partial flap necrosis and just 1 case (1.6%) of fat necrosis less than 20%. In contrast, the rate of flap loss using the conventional DIEAP flap with an intramuscular perforator was 0.6%, partial flap necrosis was 5.3%, and fat necrosis was 10.3%. Major complications (intraoperative vasospasm and arterial or venous thrombosis) occurred in 1.6% cases with the paramuscular DIEAP flap compared to 6.8% in the DIEAP flap with intramuscular perforator. Donor-site morbidity (abdominal wound dehiscence, infection, hematoma, seroma, bulging, or hernia) occurred in 6.6% but in 12.8% of conventional DIEAP flaps. These data indicate a clear trend towards a favorable outcome when the DIEAP flap with the paramuscular perforator was used compared to DIEAP flaps with intramuscular perforators.

## DISCUSSION

After preoperatively studying abdominal perforators for several years, we realized that a number of patients had a paramuscular perforator. Its particular features make it an excellent perforator for the DIEAP flap.

In a first revision published in 2008,[8] we reported that 9% of patients undergoing DIEAP flap surgery had a paramuscular perforator. However, in this later retrospective revision we found a frequency of 12.4%.

We believe that the explanation for this difference is that in our early period we did not recognize some paramuscular perforators in the MDCT study. As a result, our incidence was under-reported. Since then, when we assess MDCT images we pay special attention to all perforators located in the midline so that no paramuscular perforator goes under-detected.

In a review of the literature, we found that the paramuscular perforator we describe in this study has the same features and anatomical disposition as that described by Vandervoort et al in 2002.[9] They found that 5% of perforators were paramedian and their mean dissection time was 122 minutes. In contrast, we located 12.4% of paramuscular perforators in our study, and dissection took a mean time of 51 minutes.

We consider that our preoperative planning with MDCT accounts for this difference as Vandervoort et al selected the perforator for their flap based on intraoperative clinical assessment only. Although they found that the paramedian perforator was easy and fast to dissect, they did not consider it as the best perforator of the abdomen because of the painstaking search in the midline to locate it. We consider that Vandervoort et al likely found a lower percentage of these perforators because they selected a more lateral perforator before reaching the midline.

A preoperative MDCT study is now a routine procedure for perforator flap surgery in most leading microsurgery units,[10–12] but this is the first report where paramuscular perforators are presented based on MDCT findings as the ideal perforator for the DIEAP flap.

Several criteria have been established in the literature to define the dominant perforator. It should have a good vascular flow, a palpable pulse, and a large caliber; it should be situated in the periumbilical area and have a minimal intramuscular course—parallel to the muscular fibers if possible—and it should have few muscular branches[13,14] but optimal subcutaneous branching pattern.[15] The paramuscular perforator we describe here meets all these criteria for a dominant perforator. However, its main advantage and the feature that makes it stand out from other perforators is the fact that it has no intramuscular course.

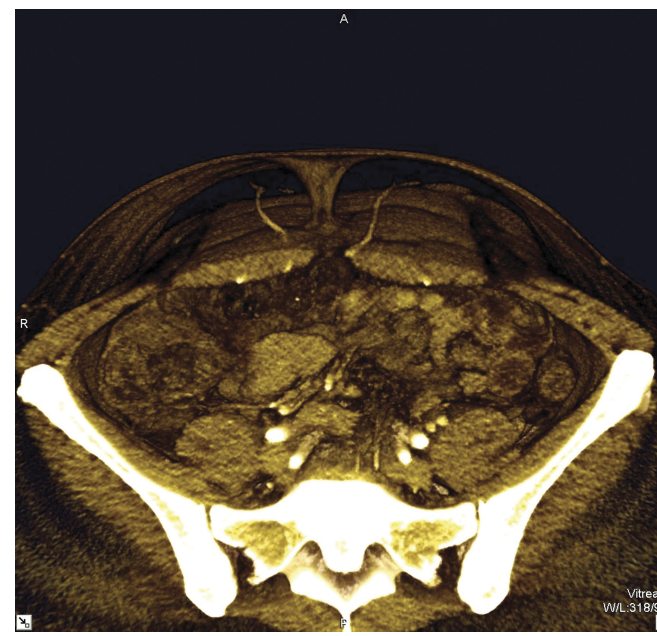


**FIGURE 2.** Volume-rendered axial MDCT image of a left paramuscular perforator rising from the medial border of the rectus muscle and reaching the abdominal cutaneous tissue.

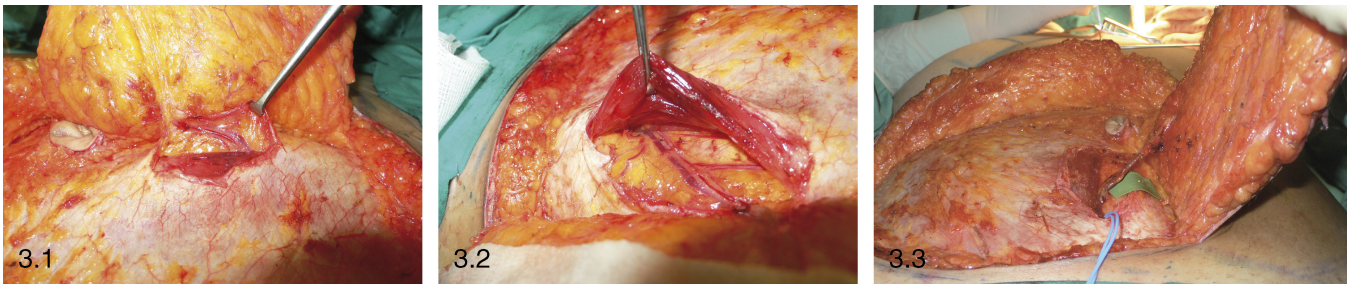


**FIGURE 3.** A, Intraoperative view of a paramuscular perforator under the muscular fascia and close to the linea alba. B, Intraoperative view of the retromuscular dissection of the paramuscular perforator. C, Intraoperative view of the paramuscular perforator completely dissected.

Therefore and according to the terminology on perforator flaps,[16] the paramuscular perforator can be considered a septal perforator because it traverses the intermuscular septum only to supply the overlying tissue before piercing the outer layer of the deep fascia.

## CONCLUSION

Preoperative evaluation of abdominal perforators with MDCT locates a paramuscular perforator in a significant number of patients. We consider its morphological features, position, and total absence of an intramuscular course make it the elective perforator in DIEAP flap for breast reconstruction as it allows safer, easier, and faster surgery.


**FIGURE 4.** MDCT sagittal view of a paramuscular perforator emerging from the rectus fascia and connecting with the superficial epigastric system.

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