MDCT in the Preoperative Planning of Abdominal Perforator Surgery for Postmastectomy Breast Reconstruction

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OBJECTIVE. This study aimed to evaluate the utility of MDCT in planning abdominal perforator surgery for breast reconstruction in patients who have undergone mastectomy.

SUBJECTS AND METHODS. One hundred twenty-six consecutive patients scheduled for postmastectomy breast reconstruction using deep inferior epigastric perforator flaps underwent MDCT. The images were evaluated to identify, characterize, and map the dominant musculocutaneous perforator vessels of the deep inferior epigastric artery. In the first 36 patients, we compared the intraoperative findings with the preoperative MDCT findings. In the latter 90 patients, the dominant perforator vessels were directly selected on the basis of MDCT findings.

RESULTS. We found an exact correlation between the intraoperative and radiologic findings in the first 36 cases. In the following 90 cases, the average operating time saved per patient was 1 hour 40 minutes and there was a significant reduction in postsurgical complications. The preoperative evaluation by MDCT confirmed the wide range of variability in the vascular anatomy of the abdominal wall previously described in anatomic studies.

CONCLUSION. MDCT provides valuable information before surgery about the arterial anatomy of the inferior abdominal wall. It enables accurate identification of the most suitable dominant perforator vessel and makes surgical perforator flap procedures for breast reconstruction faster and safer.

Since its introduction in the 1980s [1, 2], abdominal perforator flap surgery has become the mainstay for complex breast reconstruction procedures. A perforator flap consists of a flap of skin and subcutaneous fat that is dissected from a donor site chosen on the basis of a perforator vessel. The underlying muscle can be completely spared (Fig. 1). These flaps are usually named after the blood vessel that is used. The perforator vessel and, on occasion, a section of the vascular trunk form the pedicle of the flap that is anastomosed to recipient vessels.

The chief advantage of using perforator flaps for breast reconstruction [3–5] is that they spare the muscle at the donor site, drastically reducing patient morbidity and achieving a faster recovery for the patient after surgery without any function loss. Perforator flaps can be harvested from several donor areas [6, 7]. For breast reconstruction, the use of abdominal perforator flaps is presently the technique of choice because the skin and subcutaneous fat tissue of the abdomen are comparable with those of the breast [4, 8, 9]. The main vascular trunk in abdominal perforator flaps is the deep inferior epigastric artery. From the deep inferior epigastric artery, the perforator vessels that go through the rectus abdominis muscle and its fascia emerge, irrigating the skin and subcutaneous fat of the subumbilical area that constitutes the flap itself. This flap is transferred to the breast reconstructive area and anastomosed by microsurgery (Fig. 2).

Raising a perforator flap requires meticulous dissection of the perforator vessels, sparing the muscular structure with its segmentary motor nerves. Special skill is needed for such surgical dissection, and the intraoperative time is considerable. Because the vascular anatomy of the abdominal wall varies greatly among individuals and even between one hemiabdomen and the other in the same individual, establishing a vascular map of each patient before surgery would facilitate dissection. Because of its simplicity, Doppler sonography has been used routinely since the early days of microsurgery to locate the best perforator vessels before surgery [10]. However, the number of false-positives is high [11]. Color duplex Doppler sonography

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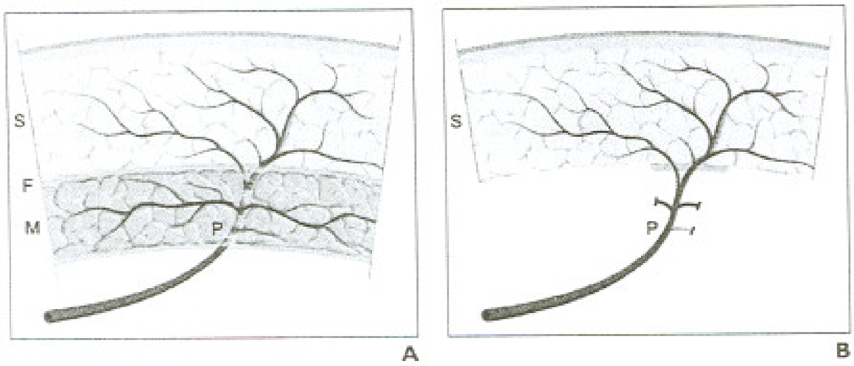

Fig. 1—Blood supply of normal cutaneous tissue of raised perforator flap. F = fascia, M = muscle, P = perforator vessel, S = subcutaneous fat.
A, Drawing shows normal anatomy of perforator artery piercing muscle and fascia to provide blood supply in cutaneous tissue.
B, Drawing shows perforator flap after muscular dissection of vascular pedicle.

has proven effective, although it is not widely accepted for presurgical study [12, 13]. Data regarding MRI are also lacking; we found only one bibliographic reference in the literature [14].

Because a method to assess the perforator vessels before surgery has not yet been established to our knowledge, the aim of our research was to evaluate the use of MDCT toward this end and to analyze its effect on surgical planning and complication rates. To assess the vascular anatomy of the lower anterior abdominal wall, with an emphasis on the deep inferior epigastric artery and its perforator vessels, for the study period we routinely performed MDCT for the presurgical evaluation of deep inferior epigastric perforator (DIEP) flaps used in breast reconstruction.

Because the high spatial resolution of MDCT allows multiplanar evaluation of vessels and 3D volume rendering, it can be used successfully to create a vascular map. The MDCT data obtained may help to improve surgical strategies and perform safer and faster procedures.

This study discusses the usefulness of MDCT in the evaluation of the vascular anatomy of the inferior abdominal wall before DIEP flap breast reconstruction.

Subjects and Methods

Patient Sample

From October 2003 to March 2006, MDCT studies were prospectively performed in 126 consecutive patients before undergoing abdominal perforator surgery. The only selection criterion was an indication for breast reconstruction surgery using a DIEP flap.

The study was approved by the institutional review board for human studies and informed written consent was obtained from all patients. No patients had any comorbid condition that contraindicated breast reconstruction. Two patients with a history of iodine allergy were excluded.

CT Protocol

MDCT studies were performed using a 16-MDCT scanner (Aquilion 16, Toshiba Medical Systems). The patients were placed on a CT table in the supine position.

Before MDCT exploration, a line was drawn on the patient's abdomen from the xiphoid to the umbilicus and used to orient the longitudinal axis of CT. This orientation was repeated at surgery. For the MDCT examination, the patient's arms were extended alongside the body and the patient's elbows were flexed to avoid artifacts. The MDCT parameters were a 0.4-second gantry rotation speed, 1-mm slice thickness (×16), 21-mm table travel per rotation, and pitch of 1.4. The x-ray tube voltage was 200–300 mA. All scanning was performed after IV administration of 100 mL of nonionic iodinated contrast medium at a concentration of 350 mg I/mL (iobitridol [Xenetix 350, Guerbet]). The contrast

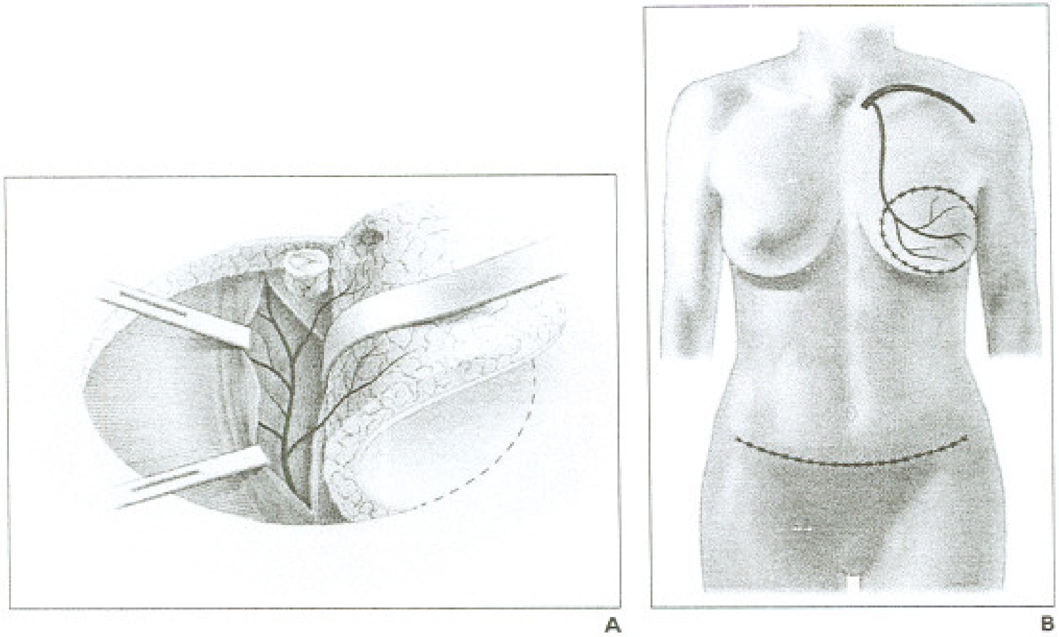

Fig. 2—Deep inferior epigastric perforator (DIEP) flap for breast reconstruction.
A, Drawing shows DIEP flap being raised.
B, Drawing shows immediate postoperative result after transferring abdominal tissue to chest wall with internal mammary microvascular anastomosis.

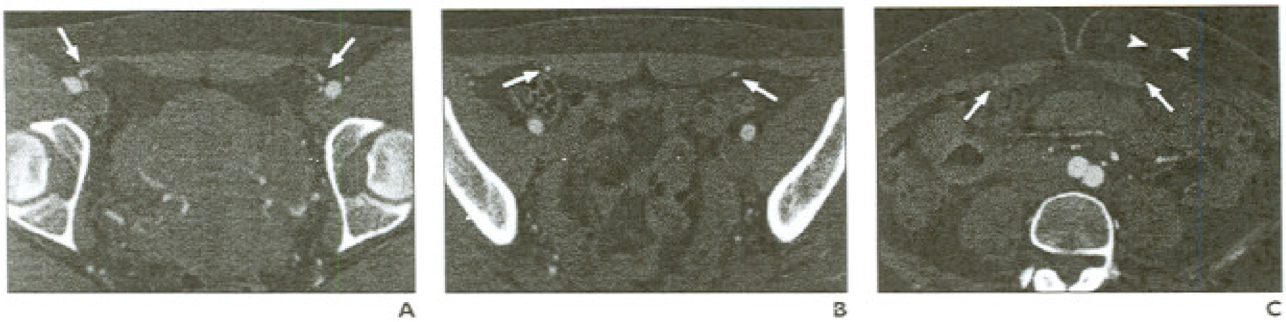

Fig. 3—48-year-old woman undergoing MDCT for preoperative planning of deep inferior epigastric perforator (DIEP) flap surgery for breast reconstruction. Three axial MDCT images show deep inferior epigastric artery course.
A, Most caudal image shows origin of deep inferior epigastric artery in external iliac artery (*arrows*).
B, More cephalad axial image shows course of deep inferior epigastric artery behind rectus abdominis muscles (*arrows*).
C, Most cephalad image shows intramuscular course of deep inferior epigastric artery (*arrows*). Note perforator vessel (*arrowheads*).

material was mechanically injected (injector TC Missouri XD 2001, Ulrich) at a rate of 4 mL/s through an 18-gauge IV catheter inserted into an antecubital vein. The scanning delay was set by an automatic triggering system (Sure Star, Toshiba Medical Systems). The infrarenal aorta was observed with real-time CT fluoroscopy, and helical acquisition was triggered automatically when the attenuation of the abdominal aorta increased 100 H above the baseline value. Sections were obtained from 5 cm above the umbilicus to the lesser trochanter of the hip in a single breath-hold. Once acquired, the volumetric data were reconstructed with a slice width of 1 mm and a reconstruction interval of 0.9 mm. Multiplanar reformatted images and 3D volume-rendered images were generated on a computer workstation (Vitrea, version 3.0.1, Vital Images).

Image Analysis

The preoperative evaluation was performed at a workstation by a single radiologist experienced in abdominal and musculoskeletal sonography, CT, and MRI. All studies were read prospectively. The results were communicated to the surgeon before surgery.

The course of the deep inferior epigastric artery was studied from its origin at the external iliac artery up to the abdominal subcutaneous fat, with special interest in its muscular course including its principal trunk and branches, to determine the dominant perforator vessel (Fig. 3).

We then studied the different perforating artery branches of the deep inferior epigastric artery and determined the precise exit point through the fascia of the rectus abdominis muscle because this point is part of the dissection plan used to harvest the flap (Fig. 4). The criteria used to select the dominant perforator vessel were vessel caliber, location, and anatomic relationships with surrounding structures. The vessel with the largest caliber was used. Regarding location, we selected the vessel that allowed a flap design enabling direct, esthetic closure. Regarding anatomic relationships, we selected the perforator vessel with a course that facilitated dissection, such as a short intramuscular course. We also investigated whether the perforator vessel emerged through a tendinous band or through a muscle to select the best surgical dissection technique (Fig. 5).

Assessment of the two veins that accompany the perforating artery was not performed by MDCT because empiric anatomic evidence indicates that the perforator veins are usually found in close contiguity with the arteries [15]. Therefore,

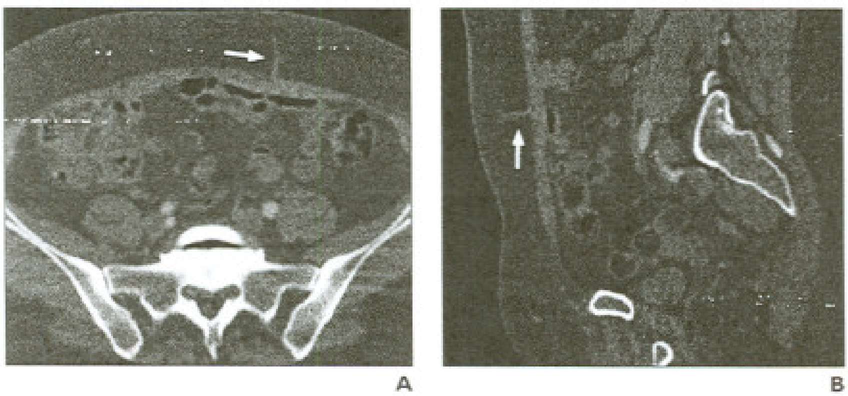

Fig. 4—52-year-old woman undergoing MDCT for preoperative planning of deep inferior epigastric perforator (DIEP) flap surgery for breast reconstruction.
A and **B**, Axial (**A**) and sagittal (**B**) reformatted MDCT images show perforator branch (*arrow*) of left deep inferior epigastric artery emerging from rectus sheath.

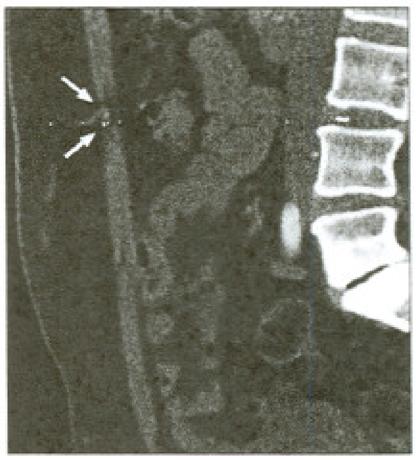

Fig. 5—59-year-old woman undergoing MDCT for preoperative planning of deep inferior epigastric perforator (DIEP) flap surgery for breast reconstruction. MDCT image shows perforator vessel emerging through tendinous band (*arrows*).

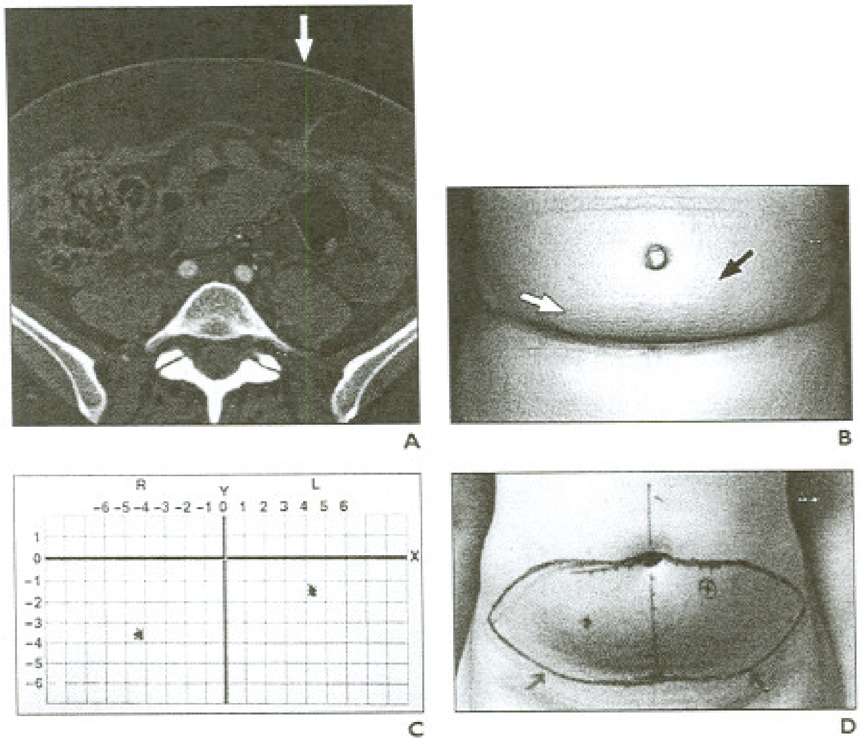

Fig. 6—48-year-old woman undergoing MDCT for preoperative planning of deep inferior epigastric perforator (DIEP) flap surgery for breast reconstruction.
A and **B**, Location of largest perforator vessels is shown on axial MDCT image (**A**) and 3D superficial volume-rendered image (**B**). Arrow in **A** indicates cutaneous location of emerging fascial point of largest perforator vessel (*black arrow* in **B**). White arrow in **B** indicates another perforator vessel not seen in **A**.
C, Results of **A** and **B** are reflected in custom-made form.
D, Photograph shows data obtained from MDCT marked on patient's abdominal skin to facilitate intraoperative location.

knowing the artery's position is sufficient to assess the veins' locations. In addition, the radiation dose is reduced by obviating a venous phase.

We performed multiplanar and 3D reconstruction of the abdomen at a workstation to locate the precise point where the perforating arteries emerged from the fascia. Virtual coordinates were placed with the umbilicus as the center to obtain vascular information. The entire abdominal wall was studied, and the three dominant perforator vessels on each hemiabdomen were marked. The day before surgery the flap design was drawn on the patient's skin. Using this simple system of coordinates, the perforator map was transferred to the data registration sheet before transfer to the patient's skin surface (Fig. 6).

In the first 36 patients, the MDCT images obtained before surgery were reviewed after surgery by the same team of a radiologist and a plastic surgeon. In the following 90 patients, a postoperative review was performed only in cases of discrepancies between the radiologic and intraoperative findings.

Surgical Technique

Patients were placed supine with their arms alongside the body. Surgery was performed by two surgical teams: One raised the abdominal flap and the other located and prepared the receptor vessel, which was the internal mammary artery in most cases. One surgeon assessed the surgical findings. Once a perforator vessel was located, it was approached through a natural split on the fascia or by cutting a small buttonhole (3–4 mm) around the vessel. Perforator dissection was performed by isolating the small muscular branches and preserving all motor segmentary nerves. The perforator route was then extended toward the inferior epigastric vessel depending on the length of the pedicle needed. Once the pedicle was totally dissected, the flap was moved to the receptor area where it was anastomosed to the internal mammary vessels under microscopic magnification (Fig. 2).

In the first 36 cases, all perforator vessels were located while the flap was being elevated because these procedures were performed before the use of preoperative MDCT. The flap was elevated by suprafascial dissection of the entire flap. Once the perforator vessels of a clinically acceptable caliber for microsurgical transfer were dissected, they were located with a ruler in the axes in relation to the umbilicus. Any discrepancy was noted and digital photographs were obtained. The surgical and radiologic results were compared after surgery by the same radiologist and plastic surgeon.

Because the reliability of MDCT to select the dominant perforator vessel was established in the first 36 cases, in the next 90 consecutive cases, the surgeon directly identified and dissected the perforator vessel previously selected using the MDCT images. In this second group of patients, we noted the surgical time and postsurgical complications. The results of this second phase of the study were compared with the results in a prior surgical study of 100 patients without MDCT guidance (Masia J et al., presented at the 2005 III World Society of Reconstructive Microsurgery meeting). The surgical technique was identical for the two groups (90 DIEP flaps from the second phase of our study vs 100 DIEP flaps from the presentation by Masia et al.). In the second group, we were aware of the exact location of the vessel to be dissected. Time keeping was performed in all cases by the same surgical team in an objective fashion.

Surgical complications of the DIEP flaps were measured by observation both during the surgical procedure and clinically in the immediate and midterm (between 24 hours and 6 months) postoperative period. We analyzed the most common intraoperative complication—that is, conversion from DIEP flap to transverse rectus abdominis myocutaneous (TRAM) flap

TABLE 1: Complication Rates of Abdominal Perforator Surgery for Postmastectomy Breast Reconstruction Before and After Using MDCT for Preoperative Planning

	Complication Rate (%)	
DIEP Flap Complication	Before MDCT[a]	After MDCT
Partial necrosis (< 20%)	6	2
Partial necrosis (> 20%)	6	0
Total necrosis	4	1
Conversion of DIEP flap to TRAM flap	1	0

Note—DIEP = deep inferior epigastric perforator, TRAM = transverse rectus abdominis myocutaneous.
[a]Masia J et al., presented at the 2005 III World Society of Reconstructive Microsurgery meeting.

After surgery, fat necrosis of the flap is attributed to a poor vascular supply. In DIEP flaps, if the area of necrosis is larger than 20% of the flap, then there are serious problems in covering the defect or achieving an adequate volume of tissue for breast reconstruction.

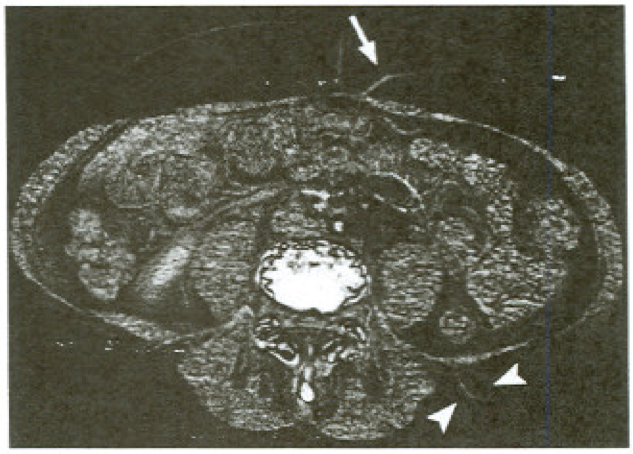

Fig. 7—52-year-old woman with deep inferior epigastric perforator (DIEP) flap preoperative planning for breast reconstruction. Volume-rendered axial MDCT image shows paramuscular perforator vessel piercing fascia at periumbilical level (*arrow*). Note left lumbar perforator vessel (*arrowheads*).

Results

The patients' mean age was 51.8 years. Mean height and weight were 162 cm and 62.3 kg, respectively. All patients underwent breast reconstruction after mastectomy. The majority of patients, 61.9% (78 cases), underwent delayed breast reconstruction, whereas 25.4% (32 cases) of patients had previously undergone conventional breast reconstruction with complications. A third group, 12.7% (16 cases) of patients, underwent breast reconstruction immediately after mastectomy.

The MDCT procedure was technically adequate in all patients and provided the data necessary with optimal arterial opacification to facilitate analysis of the deep inferior epigastric artery and its perforator vessels. In all cases, the deep inferior epigastric artery was correctly visualized from its origins in the external iliac artery. The axial views were of special importance in assessing the artery's route behind and through the rectus abdominis muscle and determining the existence or not of branches within the muscle (Fig. 3).

The axial views and sagittal reconstructions were of great help in the assessment of the perforator vessel (Figs. 4 and 5) to evaluate its dependence on the main trunk or any direct branch of the deep inferior epigastric artery and to delimit its origin on the fascia and its distribution through subcutaneous fat and skin. Rendered reconstructions allow us to mark on the patient's skin the exact point where the perforator vessel emerges through the fascia of the rectus abdominis muscle (Fig. 6).

During the first phase of the study when we aimed to validate the evidence by comparing radiologic data with surgical findings, we did not find any false-positives or false-negatives. In all cases, we compared the radiologic map of the perforator vessels with the intraoperative findings. The predictive value was 100%. By analyzing other potentially suitable perforator vessels, we found one false-negative, which was a misinterpretation of the image probably because the study was performed in an early phase. Regarding localization of the perforator vessels, the dominant perforating artery on each hemiabdomen was located in 45 cases (62.5%) in an infraumbilical area from –3 cm in the *y*-axis and ranging from 5 cm in the left hemiabdomen and –5 cm in the right hemiabdomen.

In the second phase of the study, once we had confirmed that the radiologic and surgical findings matched, we directly located and dissected the dominant perforator vessel. The time elapsed between skin incision and flap elevation decreased significantly. When the surgical time used by the same surgical team for 100 cases before the use of MDCT (Masia J et al., presented at the 2005 III World Society of Reconstructive Microsurgery meeting) was compared with the time taken in the second phase of our study, we found a mean decrease of 1 hour 40 minutes.

Intraoperative conversions of a DIEP flap to a TRAM flap and short- and medium-term postoperative complications (i.e., total or partial necrosis) decreased in comparison with the number of conversions and postoperative complications encountered by the same surgical team before using MDCT (Table 1). The clearest decrease was in postoperative complications, particularly partial necrosis greater than 20%, which was reduced from six cases (6%) before the use of preoperative MDCT to no cases (0%) after the use of MDCT for preoperative planning. As in the first phase, during the second phase we did not find any false-positives or false-negatives for the identification and localization of the dominant perforator vessel.

During the assessment of the MDCT images for each of the 126 studied patients, we located at least one adequate perforator vessel for surgical use. In 93.7% of cases, we identified two or three potentially suitable perforator vessels on each side of the abdomen. In 6.3%, we found only one suitable perforator vessel in the whole abdomen. Several anatomic findings were particularly relevant to surgeons using this surgical technique. In 9% of the cases, we observed perforator vessels with a totally extramuscular course. These vessels initially followed a retromuscular plane before piercing the muscular fascia in the exact abdominal middle line. They were thus paramuscular perforator vessels rather than musculocutaneous perforator vessels (Fig. 7). We consider these perforator vessels to be ideal because their course facilitates dissection. The mean distance between the umbilicus and the point where the deep inferior epigastric artery became intramuscular was 65 mm for the right hemiabdomen and 82 mm for the left side; both mean distance values had large deviations, supporting the enormous variability of vascular anatomy in this area. The right epigastric artery bifurcated into lateral and medial branches in 58.8% of the patients and remained single in the rest. In the left epigastric artery, the division was observed in 52.8% of the cases. The mean distance between the division point and the umbilicus was 50.45 cm for the right epigastric artery and 50.24 cm for the left. However, the range of values was high, again supporting the high anatomic variability among patients.

We also observed that the selected perforator vessel emerged more often from a tendinous band than from the rectus abdominis muscle fascia—in 52.9% of vessels selected on the right hemiabdomen and in 67.6% on the left hemiabdomen. On the contrary, most of the nonselected perforator vessels emerged directly through the muscle.

Our analysis of the distribution of the perforator vessels showed variability not only among individuals but also between the two sides of an individual's abdomen. Symmetric distribution of the perforator vessels on the two sides of the abdomen was seen in only 5.9% of the cases. Symmetry of the dominant perforator vessel on either side of the abdomen was seen in only 14.7% of the patients.

Discussion

As a result of the wider availability of breast screening services, a greater number of breast cancers are diagnosed and a greater number of women undergo mastectomy. Breast reconstruction helps to ease the trauma of cancer, improving psychologic recovery and boosting self-esteem [16]. There are many procedures from which to choose for breast reconstruction after mastectomy. These procedures involve either the use of a breast implant or reconstruction of the breast with autologous tissue. Until recently, synthetic implants were the treatment of choice, but they present considerable limitations. Symmetry is likely affected in the mid- and long-term due to natural changes in the shape and contour of the contralateral breast or changes in body weight. Furthermore, the risk of developing a capsular contracture, a natural reaction to a foreign body, affects 15–25% of patients. This complication not only alters the esthetic outcome but also causes considerable discomfort [17–22]. These consequences can be even greater in patients who have undergone radiation therapy, and cases of prosthetic extrusion have been reported [17]. Finally, prosthetic implants deteriorate over time and may need to be replaced, meaning additional surgery for the patient [18].

Breast reconstruction using the patient's own tissue offers a more natural, softer breast mound, with better symmetry without the need for periodic revisions or additional surgical procedures [22]. The use of autologous tissue is acceptable only if the associated morbidity is low. The first autologous reconstructions used TRAM flaps that included not only skin and subcutaneous fat but also a portion of the rectus abdominis muscle, but this procedure led to functional limitations and an increased risk of abdominal wall hernias. Since Koshima and colleagues [1] and Kroll and Rosenfield [2] reported the results of their studies, new perforator flaps have been developed. These flaps are based on meticulous dissection of the perforator vessels within the muscle with only skin and subcutaneous fat harvested. In breast reconstruction, the perforator flap that provides similar tissue is known as the "DIEP flap." Because of the anatomic variability of the branches of the deep inferior epigastric artery, having a detailed vascular map of each patient before surgery would be useful.

Doppler sonography is used routinely by surgeons to locate the perforating arteries before perforator flap elevation, and it is the most commonly used technique for the preoperative localization of an individual vessel [10]. There is a good correlation between the audible volume of the signal and the diameter of the perforator vessel; however, Doppler sonography can, at times, be imprecise [11, 12]. It offers only a limited amount of information and cannot distinguish perforator vessels from main axial vessels. The number of false-positives is large, rising to up to 47% in a series [11]. Therefore, the value of Doppler sonography in this setting is questionable. Doppler sonography may also be too sensitive because even minuscule vessels that are not large enough to support a perforator flap can be selected for abdominal perforator surgery.

Color Doppler imaging offers more information than Doppler sonography. It provides a good evaluation of the main axial vessels and their branches and the perforator vessels. Moreover, the caliber and hemodynamic characteristics of the perforator vessels can be observed directly on color Doppler imaging. The high sensitivity and the 100% predictive value of this technique have made it an excellent diagnostic tool in the planning of DIEP flaps [12]. Unfortunately, color Doppler imaging also has some limitations; it is time-consuming for the radiologist to perform and patients are often uncomfortable because they must remain in the same position for nearly 1 hour. It requires the presence of highly skilled sonographers with knowledge of perforator flap surgery. In addition, color Doppler imaging does not provide anatomic images that show the relationship between the perforator vessel and other structures along its route. Regarding MRI, we know of only one reference in the medical literature, and it is a descriptive review of a small number of cases and does not assess the diagnostic value of MRI [14].

With the recent development of MDCT, a considerable number of thin-sliced CT images are obtained in a short time. IV contrast medium can be injected at high velocities, and excellent images are obtained of the vasculature. The increased spatial resolution offered by MDCT allows highly accurate multiplanar and 3D reconstructed images to be obtained. MDCT has become a valuable diagnostic procedure for assessing abdominal vessels and disorders of the aorta and its major branches [23–26]. Before our preliminary studies [27], the usefulness of MDCT in detecting and evaluating the deep inferior epigastric artery and its abdominal perforator vessels had not been reported. In the present study, we present a considerably larger number of cases, confirm the results from our previous study, and introduce new conclusions that add to the advantages of breast reconstruction surgery using autologous tissues.

Our results confirm that MDCT is a highly suitable test for identifying and locating the dominant abdominal perforator vessel with a 100% positive indicative value and no false-negatives. Specificity was slightly lower for the assessment of other perforator vessels that may be acceptable for surgery; for example, in one case, a suitable perforator vessel was missed on the radiologic study.

From a radiologist's point of view, MDCT is easy to perform and provides unique and valuable information for surgical planning. This technique is easily reproducible and has immediate value for practices in which patients undergoing breast reconstruction are imaged. Radiologists can read these images independently and create standard viewing protocols in cooperation with referring surgeons. The average time needed to read these MDCT studies was 15 minutes, ranging from 10 to 20 minutes.

Before the use of MDCT in the preoperative planning of DIEP flap surgery, the elevation of the flap lasted an average of 4 hours, because this step included dissecting the inferior epigastric vessels, selecting the dominant perforating artery, and dissecting the dominant perforating artery. The ability to detect the dominant perforating artery preoperatively saves considerable time for the surgeon. In our series, the time needed to elevate the flap was halved. The benefits thus extend to the patient and also to reducing costs and conserving resources. In the present series, we also found a clear decrease in the number of postoperative complications, mainly regarding partial necrosis of the flap. Partial necrosis of the flap (larger and smaller than 20%) diminished from 12% in the previous study of 100 patients to 2% in the 90 patients in the second phase of our study. Therefore, this decrease was due to the preoperative selection of the dominant perforator vessels by MDCT.

If we compare Doppler sonography with MDCT in this setting, we can conclude that the latter has a higher predictive value and is more specific for abdominal perforator mapping. As for color Doppler imaging, despite its higher reliability than Doppler imaging in locating the perforator vessels and assessing their flow, color Doppler imaging does not provide anatomic images that show the surgeon the route and anatomic relationships of the deep inferior epigastric artery and its perforator branches.

Data obtained using MDCT enable surgeons to select a dissection strategy. The dominant perforator vessel can be chosen before surgery on the basis of not only its caliber but also its route and anatomic relationships with surrounding structures. This capability makes the entire procedure safer and faster. In DIEP flap candidates who have undergone previous abdominal surgery, MDCT allows excellent evaluation of postsurgical changes. MDCT also permits anatomic studies, previously feasible only in cadaver dissection, without significant morbidity. Parameters such as differential pressures or the functional state of the vessel can also be well studied without cadaver limitations.

The results of our study confirm the anatomic variability previously reported from cadaver dissections [28, 29] and show that MDCT is a significantly valuable tool for planning of abdominal perforator flap surgery: With the use of preoperative MDCT, operating time can be significantly reduced and surgery can be performed more safely and effectively.

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