Autologous Breast Reconstruction: Preoperative Magnetic Resonance Angiography for Perforator Flap Vessel Mapping

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► MRA
► blood pool contrast agent
► perforator flap artery imaging

Abstract

Background  Selection of a vascular pedicle for autologous breast reconstruction is time consuming and depends on visual evaluation during the surgery. Preoperative imaging of donor site for mapping the perforator artery anatomy greatly improves the efficiency of perforator selection and significantly reduces the operative time. In this article, we present our experience with magnetic resonance angiography (MRA) for perforator vessel mapping including MRA technique and interpretation.

Methods  We have performed over 400 MRA examinations from August 2008 to August 2013 at our institution for preoperative imaging of donor site for mapping the perforator vessel anatomy. Using our optimized imaging protocol with blood pool magnetic resonance imaging contrast agents, multiple donor sites can be imaged in a single MRA examination. Following imaging using the postprocessing and reporting tool, we estimated incidence of commonly used perforators for autologous breast reconstruction.

Results  In our practice, anterior abdominal wall tissue is the most commonly used donor site for perforator flap breast reconstruction and deep inferior epigastric artery perforators are the most commonly used vascular pedicle. A thigh flap, based on the profunda femoral artery perforator has become the second most used flap at our institution. In addition, MRA imaging also showed evidence of metastatic disease in 4% of our patient subset.

Conclusion  Our MRA technique allows the surgeons to confidently assess multiple donor sites for the best perforator and flap design. In conclusion, a well-performed MRA with specific postprocessing provides an accurate method for mapping perforator vessel, at the same time avoiding ionizing radiation.
Breast cancer is the most common cancer worldwide, and causes the most cancer-related deaths among women worldwide.\(^1\) Surgical breast reconstruction after mastectomy is a vital component of the overall breast cancer treatment plan. The goal of reconstruction is to restore breast symmetry and improve quality of life without affecting the prognosis or detection of recurrence as well as offering psychological benefit of alleviating the feeling of deformity following mastectomy, thus eliminating a constant reminder of disease.\(^2\)

Autologous breast reconstruction involves tissue transfer from a donor site on the patient’s own body along with its native vasculature such that the reconstructed breast closely resembles normal breast. Autologous reconstruction comes in various forms, including pedicled, free, and perforator flaps. The traditional myocutaneous flap (latissimus dorsi flap and transverse rectus abdominis muscle flap) involves transfer of muscle along with skin and subcutaneous fat to create a breast mound. These muscle sacrificing flaps are associated with donor site morbidity including abdominal wall laxity and weakness.\(^3,4\)

Perforator flap breast reconstruction involves transfer of autologous skin and subcutaneous fat with its supplying artery/vein bundle: the perforators. Perforator flap breast reconstruction requires specialized surgical expertise and many hours of operative time to first harvest the graft and then reconstruct the breast. Preoperative imaging of donor site with computed tomography (CT)/magnetic resonance (MR) angiography provides a perforator roadmap to facilitate surgical planning, reduce operative time and complications, and improve the patient outcomes.\(^5-7\)

The article describes relevant anatomy of commonly used donor sites and a detailed account of acquisition and interpretation of the preferred MRA approach based upon our experience in over 400 cases.

### Relevant Anatomy

#### Deep and Superficial Inferior Epigastric Arteries

The deep inferior epigastric artery (DIEA) originates medially from the external iliac artery, immediately above the inguinal ligament, and ascends upwards between the rectus abdominis muscle and the posterior lamella of rectus sheath. It gives origin to muscular branches that perforate the rectus muscle and supplies the anterior abdominal subcutaneous fat and skin. Three different DIEA branching patterns have been described by Moon and Taylor.\(^8\) Type I: a single trunk, type II: bifurcation into a medial and lateral branch (most common), and type III: three or more branches (Fig. 1). The DIEA perforating branches are divided into medial row and lateral row perforators that supply the midline and lateral abdomen, respectively. The course of perforating arteries is divided into intramuscular, subfascial, and subcutaneous segments (Fig. 2).\(^9,10\) A pair of venae comitantes accompany each perforator artery.

The superficial inferior epigastric artery (SIEA) arises from the common femoral artery 2 to 3 cm below the inguinal ligament. According to Strauch and Yu, in 48% of the cases SIEA originates as a common trunk with the superficial circumflex iliac artery, in 17% of the cases these arteries have separate origins, and in the 35% of the cases it is absent (Fig. 3).\(^11-13\) It courses superolaterally and lies in the subcutaneous tissue anterior to rectus sheath. A larger caliber SIEA, especially with a common origin with a superficial circumflex iliac artery is favorable for microsurgical anastomosis.\(^11,14\)

The anatomy of the superficial inferior epigastric vein (SIEV) is important as an extra conduit for flap venous drainage because venous congestion is an important cause of deep inferior epigastric artery perforator (DIEP) flap loss.
The SIEV lies superficial to the Scarpa fascia and communicates with the deep inferior epigastric vein through perforator venae comitantes. The communication can be direct or indirect and of varying diameter (►Fig. 4).  

**Superior and Inferior Gluteal Arteries**
The superior and inferior gluteal arteries (SGA and IGA) are terminal branches of posterior division of internal iliac artery. After exiting pelvis through the greater sciatic foramen, the SGA passes superior and the IGA passes inferior to the piriformis muscle. The SGA along with supplying gluteus medius, perforates through the gluteus maximus to supply its upper half and gives branches to overlying skin and subcutaneous fat. IGA supplies the lower half of gluteus maximus and sends perforators to the overlying gluteal skin and subcutaneous fat. The superior gluteal artery perforators (SGAPs) generally course at a more direct angle and the inferior gluteal artery perforators (IGAPs) course more horizontally or obliquely as they pass through the muscle (►Fig. 5).  

**Transverse Upper Gracilis and Profunda Artery Perforator Flap**
The gracilis muscle, receives its blood supply from perforating branches of medial femoral circumflex artery, a branch of the profunda femoral artery. There are considerable variations in number, diameter, and location of perforators to the gracilis muscle. Usually when there are numerous perforators, each individual perforator has a smaller diameter compared with when there are only one or two perforators (►Fig. 6). For tiny perforators, dissection off the muscle is more difficult. As the gracilis muscle tends to have tiny perforators, this muscle is often harvested together with the subcutaneous fat for the transverse upper gracilis (TUG) flap. The profunda femoris artery enters the thigh posterior compartment and typically gives off three main perforators. The first perforator supplies the adductor magnus and gracilis, the second and third supplies the rest of the hamstrings muscles. Other septocutaneous and smaller musculocutaneous perforators are also visualized variably.

**Methods**
**Magnetic Resonance Angiography for Preoperative Imaging of Perforator Flap Artery**
From August 2008 to August 2013 we have performed over 400 MRA examinations for preoperative imaging of perforator flaps for breast reconstruction. Our MRA protocol optimization is driven by on-going feedback from plastic surgeons.
At present, we perform MRA at 1.5 T (GE signa HDx 15.0, GE Healthcare, Waukesha, WI) for all patients who elect to undergo breast reconstruction. CTA is performed only when MRA is contraindicated or when the patient has severe claustrophobia.

Imaging in prone position has several advantages. For DIEP, prone positioning reduces respiratory motion in the anterior subcutaneous fat and allows longer, higher resolution scans with more thin slices covering a large anatomic area. The location at which the perforators exit the anterior rectus fascia in relation to the umbilical stalk’s attachment to anterior rectus fascia is unaffected by the prone position because fascia is a stable structure. For SGAP and IGAP, prone positioning avoids distortion of the curved shape of the buttock and preserves the natural position of inferior gluteal crease. For these reasons, imaging in the prone position allows surgeons to accurately identify the abdominal and gluteal perforators. Posterior thigh perforator imaging is relatively unaffected by patient position.

Phase encoding is set to right-left to ensure that breathing and peristalsis motions do not create ghosting artifacts over the anterior abdominal fat. Eliminating ghosting from bowel peristalsis is particularly important due to strong mucosal enhancement by blood pool magnetic resonance imaging (MRI) contrast agents. We routinely give 0.5 mg glucagon intravenously just before injecting contrast media. We prefer a lower flip angle (15 degrees) combined with fat suppression for MRA to delineate the fat-muscle boundary and intramuscular perforator course for guiding perforator dissection. One of the limitations with MRI can be inhomogeneous fat suppression at the edge of field of view, especially in patients with large body habitus. This problem can be addressed by using the two-point Dixon method for separation of fat and water signals.
At our center, we routinely inject 10 mL of gadofosveset trisodium, a blood pool MRI contrast agent. It is a gadolinium chelate that reversibly binds to serum albumin with approximately 90% binding fraction, and effectively stays within the blood pool with a relatively long redistribution half-life of 28 minutes. It has high T1 relaxivity so that a fourfold lower molecular dose compared with other gadolinium chelates confers greater vascular enhancement. This low dose virtually eliminates the risk of nephrogenic systemic fibrosis. Zou et al have demonstrated that gadofosveset improves vessel-to-muscle contrast ratio and vessel sharpness, mainly due to preferential enhancement of vessels compared with muscle derived from blood pool distribution of gadofosveset. Using this blood pool contrast agent permits high-resolution abdomen, buttock, and upper thigh imaging in a single MRI examination to assess all available donor sites for perforator flap breast reconstruction (i.e., DIEP, SIEA, profunda femoral artery perforator [PAP], SGAP, IGAP, TUG, and lumbar artery perforator flap).

**Magnetic Resonance Angiography Technique**

Patients remove all clothing including undergarments to avoid skin and subcutaneous fat distortion from elastic bands or metal artifacts. Vitamin E capsules are placed as reference points at the top of the buttock crease and on any surgical scars. The surface landmark, patient positioning, and anatomic coverage used for different types of PFs are described in Table 1. After acquiring a three plane localizer, axial, and coronal T2-weighted single shot fast spine echo images are acquired to screen for unexpected pathology and to help characterize any lesions detected on postgadolinium scans. As most of these patients have history of breast cancer, unsuspected metastatic disease may be detected: 4% of cases in our experience. These sequences are also helpful to confirm the central position of umbilicus in prone position. A transverse pre- and postcontrast arterial phase three-dimensional liver acquisition with volume acquisition (3D LAVA) sequence is acquired with imaging parameters of: TR/TE/flip = 3.9/1.9/15, bandwidth = 125 kHz, slice thickness = 3 mm reconstructed at 1.5 mm intervals using twofold zero interpolation (ZIP2), matrix = 512 × 128 to 256, parallel acceleration factor = 2. Precontrast imaging is important to determine adequacy of fat suppression. Central frequency and shim field of view can be adjusted as necessary to ensure effective fat suppression over the subcutaneous tissues of interest if Dixon fat/water separation is not available. If Dixon fat/water separation is available, for example, LAVA flex, then the echo times should be set to as close to in and out of phase as possible. The arterial phase imaging is bolus tracked by automated triggering (smartprep) or MR-fluoroscopy and scanning is initiated.
super
plane LAVA is acquired with an acquisition matrix of 512 dimensions. Thereafter, a lower resolution coronal and sagittal voxel dimension and 0.9 minutes acquisition duration with 0.9 acquired with free breathing and typically requires 3 to 5 ports and also serve as a reference for the plastic surgeons. It is encoding is set to the right-left direction. This is the primary 3 mm reconstructed at 1.5 mm intervals using ZIP2. Phase parallel acceleration factor of 2 to evaluate internal organs.

after arrival of contrast in the abdominal aorta with breath holding on inspiration. A standard 10 mL volume of blood pool MRI contrast agent followed by 20 mL of normal saline is injected at a rate of 1 mL/s. Hand injecting is preferred especially if there is a tenuous intravenous, because approximately one-third of patients may experience some sensation at the injection site or in the pelvis related to the ionic gadofosveset. A nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection. The K-space is mapped sequentially with the help of a nearby comforting person performing the injection also helps the patient to hold still during the arterial phase of the injection.

First, the planned donor site is imaged, followed by a single high spatial resolution equilibrium phase imaging of other potential donor sites using free breathing 3D LAVA sequence described above. A typical complete perforator flap MR examination, including abdomen, buttocks and upper thigh, takes approximately 45 minutes.

Postprocessing and Image Interpretation
After screening axial and coronal single shot fast spine echo images for unexpected pathologies, the arterial phase images are reviewed to determine number of perforators available and to look for any enhancing lesions. High spatial resolution equilibrium phase images are used for final perforator evaluation, as perforators are best visualized on these images. The equilibrium phase series is loaded on a computer workstation (GE Advantage Windows 4.4, GE Healthcare). Coronal, sagittal, and surface rendered reformatted images are generated (Fig. 2). The user identifies the reference point and each candidate perforator artery. It is important to note that with blood pool MRA images; there is both venous and arterial enhancement. Thus, “perforator” is generally referred to the artery–vein bundle. The diameter and exit site of each perforator where they pierce superficial fascia and enter into subcutaneous fat is noted. The superficial/inferior and right/left distance of each perforator exit site relative to the reference point is calculated. The intramuscular course and length of each perforator is measured to predict vascular pedicle length. Finally, a predicted flap volume is calculated on the same workstation assuming an elliptical geometry and the full abdominal subcutaneous fat thickness on a slice-by-slice basis (Fig. 7).

### Table 1: Landmark, patient position, anatomic coverage, and specific comments for various types of perforator flaps

<table>
<thead>
<tr>
<th>Flap</th>
<th>Landmark</th>
<th>Position</th>
<th>Coverage</th>
<th>Report should include</th>
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<tbody>
<tr>
<td>DIEP/SIEA</td>
<td>Umbilicus for both SI and RL coordinates</td>
<td>Prone</td>
<td>5 cm above umbilicus to pubic symphysis, ensuring coverage of origins of DIEA and SIEA</td>
<td>DIEA and SIEA branching pattern</td>
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<tr>
<td></td>
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<td>Identification of SIEV, its diameter and communication with deep venous system</td>
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<td></td>
<td>Horizontal distance of SIEV from midline, 10 cm and 12 cm inferior to umbilicus</td>
</tr>
<tr>
<td>SGAP/IGAP</td>
<td>Top of midline gluteal crease for SI coordinates and manual tracing along the gluteal surface from midline for RL coordinates</td>
<td>Prone</td>
<td>5 cm above top of midline gluteal crease to complete buttocks inferiorly</td>
<td>Gluteal fat pad thickness measured at top of crease, inferior gluteal crease and a midpoint</td>
</tr>
<tr>
<td>PAP</td>
<td>Inferior gluteal crease for SI coordinates and straight line along medial border of thigh for RL coordinates</td>
<td>Prone</td>
<td>Midgluteal region to 12 cm below inferior gluteal crease</td>
<td>Posterior thigh fat pad thickness</td>
</tr>
<tr>
<td>TUGP</td>
<td>Pubic symphysis for both SI and RL coordinates</td>
<td>Supine</td>
<td>Pubic symphysis to 15 cm below it</td>
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</table>

Abbreviations: DIEA, deep inferior epigastric artery; DIEP, deep inferior epigastric perforator flap; IGAP, inferior artery perforator flap; SDAP, superior deep artery perforator flap; SDAP, superior deep artery perforator flap; SIEA, superficial inferior epigastric artery; TDAP, thoracodorsal artery perforator flap; TUGP, transverse upper gracilis perforator.
Coordinates identifying the location of the perforating arteries on the axial images are superimposed and displayed on volume-rendered 3D reconstructed image and coronal 3D minimum intensity projection image (Fig. 2). These images and coordinates are invaluable for the plastic surgeon to locate the perforator arteries during preoperative surface making and intraoperatively. Anatomic detail that needs to be reported specific to the type of perforator flap of interest is given in Table 1.

### Results

In our practice, anterior abdominal wall tissue is the most commonly used donor site for perforator flap breast reconstruction and DIEP are the most commonly used vascular pedicle. In our experience, there are always at least three to four good DIEP perforators on either side of the abdomen, usually; the left side perforators are larger in caliber than the right side perforators.

In patients with insufficient anterior abdominal wall fat or distorted vascular anatomy due to previous abdominal surgery, the thigh and buttock are the next most commonly used donor sites. A thigh flap, based on the PAP flap has become the second most used flap in our institution. At present, the ratio of PAP flap to gluteal flaps (SGAP/IGAP) performed at our institute is 9:1, indicating an increasing surgical preference for the posterior thigh harvest site. Dissection is easier for PAP flaps, it produces a longer pedicle, and there is a favorable cosmetic result achieved by tucking the PAP harvest site scar into the buttock crease.

Usually there are at least one to two good PAP perforators on either medial thigh. Medial perforators have a generous length and can be dissected with supine frog-leg positioning so the patient does not need to be flipped over in the operating room between harvesting at the donor site and performing the breast reconstruction (Fig. 8). Lateral perforators may be larger in caliber but are rarely used because their close proximity to the femur requires dissection off the periostium which can be challenging.

In our experience, MRA is not reliable for the assessment of SIEA. Only in 10% of the MRA studies, SIEA is visualized and is usually small in diameter making microsurgical anastomosis with internal mammary artery (IMA) difficult and prone to thrombosis. In addition, it is located on the inferior edge of the flap and may not well perfuse the more medial or central fat on the abdomen potentially leading to fat necrosis with possible loss of areas of the flap. Therefore, the SIEA flap is only used when DIEP vessels are not available in our practice.

MRA imaging also screens for metastatic disease which was found in 4% of our patients on a retrospective analysis done on 120 patients at Weill Cornell Medical College from October 2011 to November 2012. The T2-weighted and contrast enhanced T1-weighted sequences are useful for detection and characterization of metastatic lesions.

### Discussion

Preoperative perforator flap donor site imaging facilitates developing a surgical strategy and backup plans beforehand, thereby decreasing operative time, reducing intraoperative complications, and improving outcomes. It provides an opportunity to select the best available perforator and plan the flap design accordingly. At present, various imaging modalities are available for preoperative imaging for perforator flap breast reconstruction. Advantages and disadvantages of each are described in Table 2. Although, CTA is widely used for imaging perforator arteries, recent concerns over CTA radiation exposures, which can be as high as 70 mSv for perforator CTA, have led to reductions in CTA dose and a corresponding reduction in CTA image quality. Several studies have established comparable accuracy of MRA and CTA in preoperative perforator artery imaging. MRA does not involve exposure to ionizing radiation or potentially nephrotoxic iodinated contrast agents. Moreover, MRA of donor sites using gadofoveset trisodium, a blood pool contrast agent provides opportunity to scan multiple donor sites in single study. At present, MRA is limited in the assessment of SIEA anatomy. However, the newer MRI techniques such as high temporal resolution LAVA spiral and two-point Dixon for fat and water separation (LAVA Flex, GE Healthcare) appear promising and may improve assessment of SIEA anatomy in the future.

A noncontrast MRA can also be performed and has been shown superior to CT for preoperative imaging of breast reconstruction with DIEP flaps as described by Masia et al. In their study of 56 patients, preoperative noncontrast MRI showed no false-positive or false-negative results with 100% predictive value in selection of the most appropriate dominant DIEA perforator.

The cost for radiological examination varies from center to center. The Manhattan Medicare reimbursement for CTA abdomen and pelvis with and without contrast is $582.
and MRA abdomen and pelvis with and without contrast is about one-third more. However, in our experience a good quality MRA of abdomen and pelvis using blood pool contrast agent provides high contrast and high spatial resolution imaging of multiple donor site in a single MRA examination. Therefore, in some cases when the anatomy of initially imaged donor site is unfavorable or due to lack of good perforator, it avoids a second visit to the hospital for a second examination.

**Factors Considered while Selecting Optimal Perforator Vessel**

The foremost factors determining the optimal perforator are vessel diameter, site of vessel entry into the planned flap, and its arborization pattern within the adipocutaneous tissue. A larger diameter, central location on the proposed flap, and a pattern of arborization that suggests adequate perfusion of the tissue to be transferred is

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**Fig. 8** Thick slab axial high-resolution equilibrium phase LAVA through posterior thigh region (A, B) demonstrate, a good caliber medial intramuscular profunda femoral artery perforator (A, arrow) and a lateral septocutaneous profunda femoral artery perforator (B, arrow) with good subcutaneous fat arborization pattern. A medial profunda perforator is preferred over lateral one. Corresponding (C) sagittal and (D) coronal reformatted images showing position of the perforators (arrow) with respect to underlying PFA and FA. (E) A 3D volume-rendered image demonstrating surface display of perforator position with respect to landmark, inferior gluteal crease. 3D, three-dimensional; FA, femoral artery; LAVA, liver acquisition with volume acquisition; PFA, profunda femoral artery.
favorable. A perforator that is > 1 mm in diameter and located in an area favorable for flap harvest is desirable (►Fig. 2). On MRI obtained during the blood pool phase of the contrast agent injection, the artery and vein are indistinguishable so the perforator diameter measurement corresponds to the artery/vein bundle. The vessel course is also important but considered a secondary factor in perforator selection. Among two vessels of similar caliber and arborization patterns, the vessel that can be dissected more easily with least trauma to muscle is selected. Generally, several perforators on each side need to be identified and reported by the radiologist because the best perforators may be damaged or appear differently at surgery, necessitating the availability of backup perforators. A septocutaneous perforator is a perforator that travels around the muscle. An intramuscular perforator traverses the muscle. Perforators with short intramuscular course or a septocutaneous course are preferred because dissection is easier and quicker with minimal muscle trauma (►Fig. 2). A long or tortuous intramuscular course makes dissection tedious.

Table 2 Advantages and disadvantages of various modalities used for preoperative imaging of perforator flap arteries

<table>
<thead>
<tr>
<th>Modality</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Unidirectional Doppler</td>
<td>• Portable</td>
<td>• Time-consuming and low accuracy</td>
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<td></td>
<td>• Simple to use</td>
<td>• High interobserver variability</td>
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<td></td>
<td>• Useful tool for intraoperative evaluation to document and follow the flow</td>
<td>• No information about vessel diameter, anatomic course, and can detect only</td>
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<td></td>
<td>of a chosen perforator during dissection</td>
<td>vessels &gt; 1.5 mm in diameter</td>
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<td></td>
<td>• No IV contrast</td>
<td>• Inability to distinguish perforators that arise from the superficial or</td>
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<td></td>
<td>• Overall low cost</td>
<td>deep system accurately</td>
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<tr>
<td></td>
<td>• No radiation</td>
<td>• Failure to locate perforators that do not exit fascia perpendicularly</td>
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<tr>
<td>Color duplex ultrasonography</td>
<td>• Detects vessel diameter, velocity and anatomic course</td>
<td>• Require highly trained technicians with good knowledge of perforator</td>
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<tr>
<td></td>
<td>• No IV contrast</td>
<td>anatomy</td>
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<tr>
<td></td>
<td>• Overall low cost</td>
<td>• Time-consuming and require patient to be one position for long time</td>
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<tr>
<td></td>
<td>• No radiation</td>
<td>• Cannot produce images that surgeons can independently review and understand</td>
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<tr>
<td>CTA</td>
<td>• Current gold standard</td>
<td>• Ionizing radiation exposure</td>
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<td></td>
<td>• Quick and easy to perform</td>
<td>• Risk of nephrotoxicity with contrast even in patient with normal renal</td>
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<tr>
<td></td>
<td>• Less dependent on body habitues</td>
<td>function</td>
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<td></td>
<td>• Accurate documentation of vessel diameter, location, and course</td>
<td>• Longer scan time</td>
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<td></td>
<td>• Provide high-spatial resolution 2D and 3D image which surgeons can view</td>
<td>• Need for MR contrast agent</td>
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<tr>
<td></td>
<td>easily and independently</td>
<td>• Contraindicated in patients with severe claustrophobia, pacemaker</td>
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<tr>
<td>MRA (becoming increasingly</td>
<td>• Safer MRI blood pool contrast agent</td>
<td>• Greater muscle to vessel contrast and fat suppression, which enables</td>
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<td>popular)</td>
<td>• No exposure to ionizing radiation</td>
<td>visualization of small caliber vessels</td>
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<tr>
<td></td>
<td>• Accurate documentation of vessel diameter, location, and course</td>
<td>• Provides high-spatial resolution 2D and 3D image which surgeons can view</td>
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<td></td>
<td>• Large field of view with ability to image multiple donor site in a</td>
<td>easily and independently</td>
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<td>single study</td>
<td>• Greater muscle to vessel contrast and fat suppression, which enables</td>
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<td>• Multiple acquisitions in single scan images of both arteries and veins</td>
<td>visualization of small caliber vessels</td>
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<td>• Greater muscle to vessel contrast and fat suppression, which enables</td>
<td>• Provides high-spatial resolution 2D and 3D image which surgeons can view</td>
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<td>visualization of small caliber vessels</td>
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<td>easily and independently</td>
<td>visualization of small caliber vessels</td>
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Abbreviations: 2D, two-dimensional; 3D, three-dimensional; CTA, computed tomography angiography; IV, intravenous; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging.
and increases potential for injury to the muscle and/or perforator.

The available pedicle length is yet another factor to consider. The vessel is dissected until its origin from a major artery (e.g., external iliac artery, profunda femoral artery). Adequate vascular pedicle length and caliber facilitates tension free microanastomosis with the IMA. A pedicle length of at least 6 cm is favored.

In conclusion, MRA is an invaluable tool for preoperative imaging of perforator flap arteries for breast reconstruction. Knowledge of relevant anatomy and protocols for acquiring MRA, postprocessing, and interpretation of MRA images can help to improve surgical planning, reduce operative time and postoperative complications.

References


