The Profunda Artery Perforator Flap: Investigating the Perforasome Using Three-Dimensional Computed Tomographic Angiography

Corrine Wong, M.D.
Purushottam Nagarkar, M.D.
Sumeet Teotia, M.D.
Nicholas T. Haddock, M.D.

Dallas, Texas

Background: The profunda artery perforator flap has been emerging as an alternative method of autologous breast reconstruction. This flap uses upper posterior thigh tissue. The profunda artery perforator perforasome is investigated using three-dimensional computed tomographic angiography.
Methods: Ten cadaveric thighs were dissected centered over the profunda artery perforator. The perforator was injected with contrast medium and the flap was then subjected to computed tomographic scanning using a GE Lightspeed 16-slice scanner. The three-dimensional images were viewed, and measurements were obtained using Aquarius software, including horizontal and vertical extensions of the flap and areas of perfusion. Clinical examples are presented.
Results: A profunda artery perforator (occasionally two) was consistently found in the upper medial thigh region, posterior to the gracilis muscle. The area of vascularity shown by the spread of contrast extends inferiorly beyond the usual lower border of the profunda artery perforator flap, which is usually 7 cm wide. In injected cadaveric flaps, the mean horizontal dimension was 16.7 cm and the mean vertical dimension was 16.5 cm. The mean area perfused was 8812 cm^2.
Conclusions: The profunda artery perforator flap is a vascularly sound flap, and is a good option for autologous breast reconstruction. Advantages include a reliable pedicle, no position changes required, and possibly an improved donor-site contour from a thigh lift. It is an excellent alternative to abdominally based free flaps and can also be used in conjunction with other flaps for further volume enhancement. (*Plast. Reconstr. Surg.* 136: 915, 2015.)

There are multiple options for free tissue transfer in autologous breast reconstruction, including abdominally based flaps (e.g., transverse rectus abdominis musculocutaneous,[1] muscle-sparing transverse rectus abdominis musculocutaneous,[2] superficial inferior epigastric artery, deep inferior epigastric perforator[3]), buttock-based flaps (e.g., superior gluteal artery perforator,[4] inferior gluteal artery perforator[5]), and thigh-based flaps (e.g., transverse upper gracilis,[6] anterolateral thigh[7]). Most commonly, the abdominally based flaps are used, as there is usually an abundance of donor tissue in that area, the pedicle is reliable and has adequate length, the patient can stay in the supine position, and postoperatively the patient can enjoy an improved abdominal contour. However, there are occasions when the abdominal donor site is contraindicated, has insufficient volume, or is simply rejected by the patient; thus, we look to other sites for donors.

The profunda artery perforator flap has emerged as a novel alternative in breast reconstruction.[8,9] This is based on the posterior thigh, posterior to the gracilis muscle. The width of the flap is based on the pinch test and ease of closing the donor site, usually approximately 7 cm. The scar is hidden in the gluteal crease. Although there have been a case series, cadaver study,[9]

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Fig. 1. One or two profunda artery perforators were consistently found in all of our specimens.

and radiologic investigations on the perforator anatomy,[10,11] there has not been a perfusion analysis of these flaps. Our aim was to investigate the perfusion of the profunda artery perforator using three-dimensional computed tomographic angiography.

MATERIALS AND METHODS

Ten circumferential thigh flaps were harvested from fresh adult female cadavers acquired through the Willed Body Program at the University of Texas Southwestern Medical Center. The upper borders of adipocutaneous flaps were the groin crease and gluteal crease. The lower margin was halfway down the length of the thigh. Circumferential elevation was made anterior and posterior from the mid–lateral thigh incision, thus placing the profunda artery perforators roughly in the center of the flaps. Specimen dissection was performed under loupe magnification. When more than one profunda artery perforator was encountered, the largest was selected and cannulated. These were injected with a dilute methylene blue solution to enable all vascular leaks to be identified and then sealed, through either bipolar diathermy or suture ligation. The flaps were then

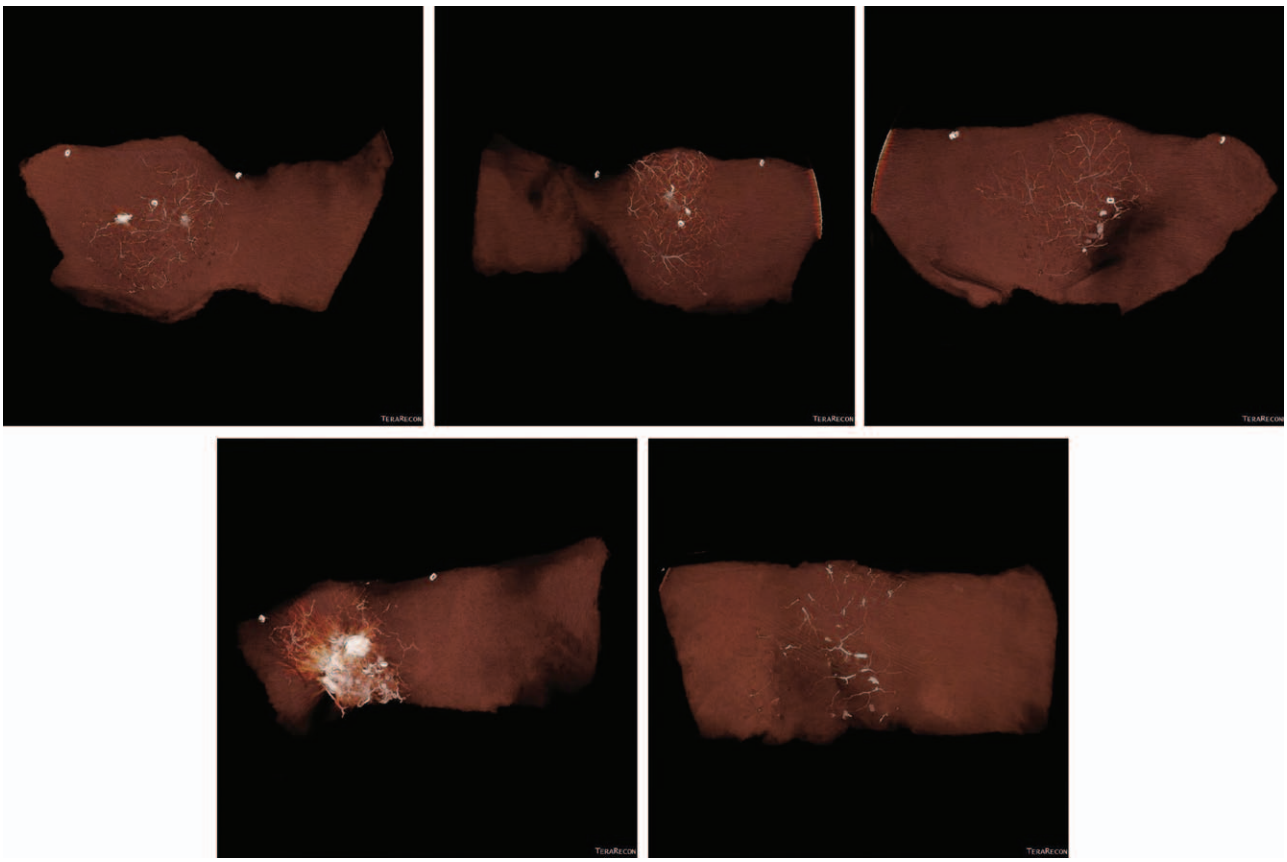

Fig. 2. Computed tomographic angiograms of flaps demonstrating areas of vascularity. Superior staples designate horizontal margins of flap (i.e., medial border of the adductor longus and lateral edge of the gluteal crease). Inferior staples are on the inferior border of the flap, giving it a width of 7 cm.

Table 1. Vertical and Horizontal Dimensions and Areas of Perfusion

Flap	Horizontal (mm)	Vertical (mm)	Area (mm^2)
1	103	116	2445
2	178	154	15,037
3	181	180	11,171
4	135	156	9090
5	199	162	9374
6	157	140	7678
7	162	188	8455
8	148	190	7119
9	201	182	8962
10	205	185	8786
Mean	166.9	165.3	8811.7

injected with a barium-gelatin mixture before computed tomographic scanning. Staples were used to delineate the usual borders of the profunda artery perforator flap (i.e., medial border of the adductor longus, lateral border of the gluteal fold, and 8 cm caudal to the gluteal crease).

Static Computed Tomographic Scanning

The barium-gelatin mixture was prepared by warming 100 ml of normal saline to 40°C, and adding 3 g of gelatin while stirring continuously. This is followed by slowly adding 40 g of barium sulphate. This solution is then injected into the investigated perforator artery/vein using the Harvard precision pump running at 1 ml/minute until the vascular tree is saturated (previously repaired leaks will start to leak and have to be recauterized). The flaps are then frozen for at least 24 hours before computed tomographic scanning.

Three-dimensional images were viewed using the TeraRecon Aquarius workstation (version 3.2.2.1; TeraRecon, Inc., Foster City, Calif.). The volume-rendering function allowed us to produce clear and accurate images of the simulated flaps. Measurements were obtained, including horizontal and vertical extensions of the flap and areas of perfusion.

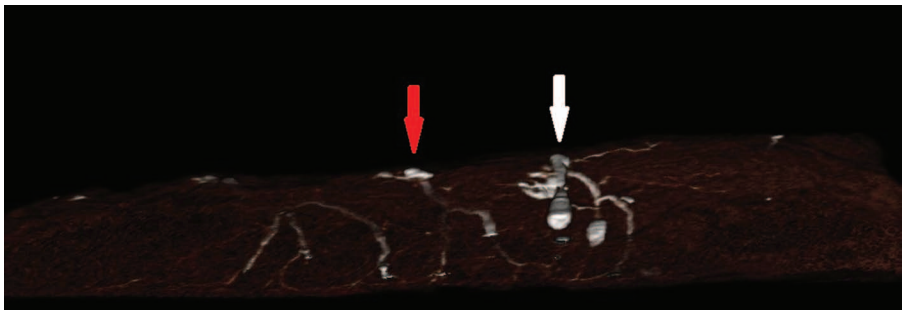

Fig. 3. Lateral view of computed tomographic angiogram demonstrating communication between perforators (*white* and *red arrows*) in the subdermal plexus.

Fig. 4. (*Left*) Preoperative photograph of a 29-year-old patient with right breast cancer. (*Right*) Postoperative photograph of the patient after bilateral mastectomies and reconstruction with bilateral profunda artery perforator flaps.

Fig. 5. Preoperative markings of the donor site.

RESULTS

A profunda artery perforator (occasionally two) was consistently found in the upper medial thigh region, posterior to the gracilis muscle (Fig. 1). The area of vascularity was shown by the spread of contrast in the flap. In all of the specimens, perfusion extended inferiorly beyond the usual lower border of the profunda artery perforator flap, which is usually 7 cm wide (Fig. 2). Table 1 gives the horizontal and vertical dimensions and the areas of perfusion. The mean horizontal dimension was 16.7 cm and the mean vertical dimension was 16.5 cm. The mean area perfused was 8812 mm^2. Figure 3, on lateral view, demonstrates the communication between perforators mostly in the subdermal plexus.

CASE REPORT

A 29-year-old woman with right breast cancer was treated with bilateral mastectomies and opted for autologous breast reconstruction. Examination of her abdomen revealed insufficient tissue volume; thus, her medial/posterior thighs were selected as the donor sites. Her markings and preoperative and postoperative photographs are shown in Figures 4 through 6.

DISCUSSION

Although a relatively new flap for breast reconstruction, the profunda artery perforator flap has so far shown clinical reliability[8] and consistency of location.[9,11] This study's goal was to investigate the spread of perfusion without prior flap incisions. Cadaveric perfusion is known to underestimate "real" perfusion under physiologic conditions[12–14]; thus, the dimensions demonstrated in this article are less than actual clinical perfusions. All of our flap perfusions were based on single-perforator injections for consistency, which may have reduced our areas of contrast spread.

The extent of inferior perfusion in all of our specimens went beyond the usual 7-cm width of the flap, which implies that a wider flap can potentially be harvested but would be limited by our ability

Fig. 6. (*Left*) Preoperative photograph of the donor site of the same patient. (*Right*) Postoperative photograph of the donor site.

to close the donor site. The horizontal extents of perfusion reached our staples, which were placed at the levels of the medial border of the adductor longus and the lateral border of the gluteal crease, which are our usual transverse landmarks in flap harvesting, so as to better hide the scar.

On lateral view, we observed that communication between perforators occurred in the subdermal plexus (Fig. 3). The phenomenon of recurrent flow through the subdermal plexus was first noted by Moon and Taylor in the transverse abdominal adipocutaneous paddle perfused by the deep superior epigastric artery,[15] and was seen by Alkureishi et al. in their study of the arterial anatomy of the anterolateral thigh flap in specimens following diaphanization.[16] This appears to be an important mechanism of flap perfusion and has been demonstrated in previous perfusion studies.[12,14,17,18]

The profunda artery perforator flap is a good alternative to abdominally based flaps for breast reconstruction. Although harvested from a similar region as the transverse upper gracilis flap, the profunda artery perforator flap offers further advantages such as greater volume, longer pedicle, and a less visible scar, and does not sacrifice muscle.[8] Another benefit is the improved contour of the medial thigh, as it gives the effect of a transverse thigh lift. In our institution, the profunda artery perforator flap is harvested in a frog-leg position and therefore does not require position change for breast inset.

CONCLUSIONS

The profunda artery perforator flap is a vascularly sound flap, with perfusion studies showing that it at least reaches our usual horizontal margins and always extends beyond our inferior flap width of 7 cm. It also has been shown to have reliable anatomy and a hidden scar location, and gives the added benefit of a thigh lift.

Nicholas T. Haddock, M.D.
University of Texas Southwestern
Department of Plastic Surgery
1801 Inwood
Dallas, Texas 75390
nicholas.haddock@utsouthwestern.edu

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