CME

A Safe and Efficient Technique for Pedicled TRAM Flap Breast Reconstruction

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Learning Objectives: After studying this article, the participant should be able to: 1. Understand the indications for a unilateral pedicled transverse rectus abdominis (TRAM) flap-based breast reconstruction. 2. Understand the different types and designs of pedicled TRAM flap used in both immediate and delayed breast reconstruction. 3. Understand the essential landmarks and relevant anatomy of the pedicled TRAM flap. 4. Understand the steps of raising the pedicled TRAM flap, the subcutaneous transfer, and the insetting of the flap on the chest wall. 5. Understand the nature of donor-site management and closure of the defect. 6. Develop a postoperative plan for continuing care and pain management.

Summary: This article focuses primarily on the unilateral, ipsilateral pedicled TRAM flap. Although the bilateral pedicled TRAM flap may be a reasonable option in some cases, they have been shown to have a significant impact on abdominal wall strength and integrity. Other types of autogenous flaps using the same lower abdominal tissue, such as a free muscle-sparing TRAM or a deep inferior epigastric flap, can be performed as a bilateral procedure with less impact on the abdominal wall. Breast reconstruction with a pedicled transverse rectus abdominis flap has persisted for decades as a reliable and safe form of autologous breast reconstruction leading to a natural and stable breast shape. *(Plast. Reconstr. Surg.* 151: 1022e, 2023.)

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One in eight American women will develop breast cancer during their lifetime.[1] Mastectomy alone can have a significant detrimental impact on the physical and mental well-being of breast cancer patients.[2,3] Breast reconstruction after mastectomy has been consistently shown to improve physical and mental health and quality of life of breast cancer survivors.[4] Autogenous breast reconstruction has the benefit of creating a more natural breast shape and feel than alloplastic reconstruction and provides superior long-term aesthetic results.[4] The lower abdomen is the most common donor site for autologous tissue transfer in breast reconstruction. Early descriptions of the use of an abdominally based flap for breast reconstruction raised on the rectus abdominis muscle can be traced back to the work of Drever in 1977, which were subsequently modified into a transverse design popularized for breast reconstruction by Hartrampf et al. in 1982.[5,6] Since its inception, multiple variations of the transverse rectus abdominis (TRAM) flap have been described, including pedicled, free, delayed, supercharged, and turbocharged flaps.[7] For three decades, pedicled TRAM flap reconstruction was the most common operation performed for autogenous breast reconstruction in the United States, to be surpassed by the deep inferior artery perforator free flap (DIEP) in 2012.[8] Nevertheless, pedicled TRAM flap reconstruction continues to be a reliable reconstructive option in the properly selected patient and in centers where microsurgery reconstruction is not available. Indications for the unilateral TRAM flap breast reconstruction may include when the recipient vessels for a microsurgical flap are absent or damaged secondary to radiation therapy to the

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internal mammary area or if the internal mammary was withheld for cardiac bypass reasons. The TRAM flap can be the ideal option when monitoring options in the postoperative period are limited or no stepdown/intensive care unit facility is available for recovery from a longer microvascular procedure. In terms of abdominal strength and integrity, most women do not miss one rectus muscle.[9] Understanding the surgical technique of performing a pedicled TRAM flap for breast reconstruction is valuable for practicing plastic and reconstructive surgeons.

PATIENT SELECTION

The preoperative assessment of the breast reconstruction patient is critical because the history and physical examination inform the selection of breast reconstruction. It is important to understand the breast cancer treatment plan. For an immediate TRAM flap, the plastic surgeon should work closely with the breast surgeon to understand whether a nipple-sparing or skin-sparing mastectomy can be performed. The contralateral breast should have an up-to-date workup and there should be no plan for future prophylactic mastectomy based on personal risk factors (eg, age, family history). This is the time to set clear expectations of a balancing procedure (augmentation or reduction). Postoperative radiation therapy is an important consideration. In this case, the surgeon may plan on constructing a slightly larger breast reconstruction in anticipation of post–radiation therapy volume loss or suggest delaying the reconstruction until adjuvant treatment is completed. In many cases, radiation therapy can have a deleterious effect on the aesthetic outcome of pedicled TRAM flap reconstruction whether administered before or after reconstruction.[9]

MEDICAL HISTORY

A thorough medical history is important to assess fitness for surgery. Comorbidities such as hypertension, obesity, coronary artery disease, vasculitis, and diabetes should be carefully considered but do not reflect absolute contraindications.[10] Patients who smoke tobacco should be counseled on the increased risks of mastectomy skin flap necrosis, fat necrosis, flap loss, wound dehiscence, and donor-site complications.[11,12] Patients should be encouraged to quit smoking for at least 4 weeks preceding surgery.[13]

Surgical history can inform the surgical team of any larger abdominal operations that may limit the abdominal site donor potential. Medication should be considered, including anticoagulants.

PHYSICAL EXAMINATION

Physical examination should include the breasts and abdomen. A surgeon will exam the footprint area of where the reconstructed breast will sit, the quality of the skin, and the location of scars on the breast. Before immediate reconstruction, lumpectomy scars and biopsy tracks must be noted, as some general surgeons will request reexcision at the time of surgery, which can result in skin loss in the bridging segments. The contralateral breast can be used as a guide to determine the quantity of tissue required from the donor abdomen, keeping in mind any desired balancing procedures. The abdomen is examined, with particular attention given to surgical scars, diastasis, and/or abdominal wall hernias. Paramedian abdominal incisions can damage the rectus abdominis muscles and/or blood supply, thus compromising TRAM and DIEP flap outcomes. The Kocher incision is a subcostal incision on the right side of the abdomen for open access to the gallbladder and biliary tree. If present, this would preclude the use of the right rectus muscle but may still allow consideration of a left rectus muscle-based contralateral TRAM flap. Multiple abdominal scars can jeopardize the blood supply to the remaining abdominal wall skin.[12] Perfusion of skin flaps across the midline or other scars can be poor, thus limiting the size of flap that can be harvested. Several additional procedures have been developed to increase the perfusion to the TRAM flap. The "delay procedure" is the ligation of the deep epigastric arterial and venous system initiated at least 14 days preceding the TRAM flap. This selectively converts the superior epigastric system from being the nondominant blood supply to the dominant blood supply and increases the blood flow reliability in patients with risk factors.[7,14] Supercharging or turbocharging may be considered in some situations where the perfusion is thought to be less reliable or possibly when, intraoperatively, the pedicle arterial venous blood supply is in question.[7] These are additional microvascular methods for immediately augmenting blood flow either from extrinsic local recipient vessels such as the ipsilateral thoracodorsal (supercharging) or deployment of intrinsic vessels within the flap vascular system, which can reroute the reverse flow into lower perfused areas, providing increased venous

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outflow.[7] Clear patient expectation management with regard to the outcome, risks, perioperative course, numbness of the reconstructed breast and abdominal donor site, and potential future procedures (balancing and/or nipple reconstruction) is a necessity.

SURFACE MARKINGS

The marking and design of the TRAM flap are performed with the patient in the standing position. The dimensions and parameters of the contralateral normal breast are transferred to the mastectomy site, including width, height, and axis of the breast in the midclavicular line (Fig. 1). [**See Video 1 (online)**, which displays preoperative markings for the TRAM flap in a unilateral breast reconstruction. The video emphasizes the importance of using the contralateral breast shape and contour as a guide to reconstructing the new breast and obtaining symmetry. The design of the TRAM flap on the lower abdomen is described, outlining the main features of capturing the periumbilical perforators. The video also shows the mastectomy scar being resected and placed in a vial to be sent for pathologic analysis, because the scar is one of the most common areas for recurrence.]

The TRAM flap is designed at the same location as the DIEP flap, where the upper border is just superior to the umbilicus and the inferior extent is based on the pinch test to ensure adequate primary closure. The width of the breast must equal the height of the flap at the midline of the hypogastrium. An in-depth understanding of chest wall and abdominal wall anatomy is critical for proper assessment and design of the flap to match the patient's deformity (Fig. 2).

ANATOMY

The unilateral, ipsilateral TRAM flap consists of a transverse island of lower abdominal skin and adipose tissue that is supplied by periumbilical perforators that are terminal branches of the superior epigastric vascular pedicle (once the deep inferior vascular pedicle has been ligated) (Fig. 2). The superior epigastric artery and its venae comitantes are the continuation of the internal mammary artery and veins (also known as the internal thoracic artery). The rectus muscle is a type III muscle in the Mathes and Nahai classification.[6] The superior epigastric artery and venae comitantes travel along the deep aspect of the rectus abdominis, muscle giving off perforators clustered in the periumbilical area midway

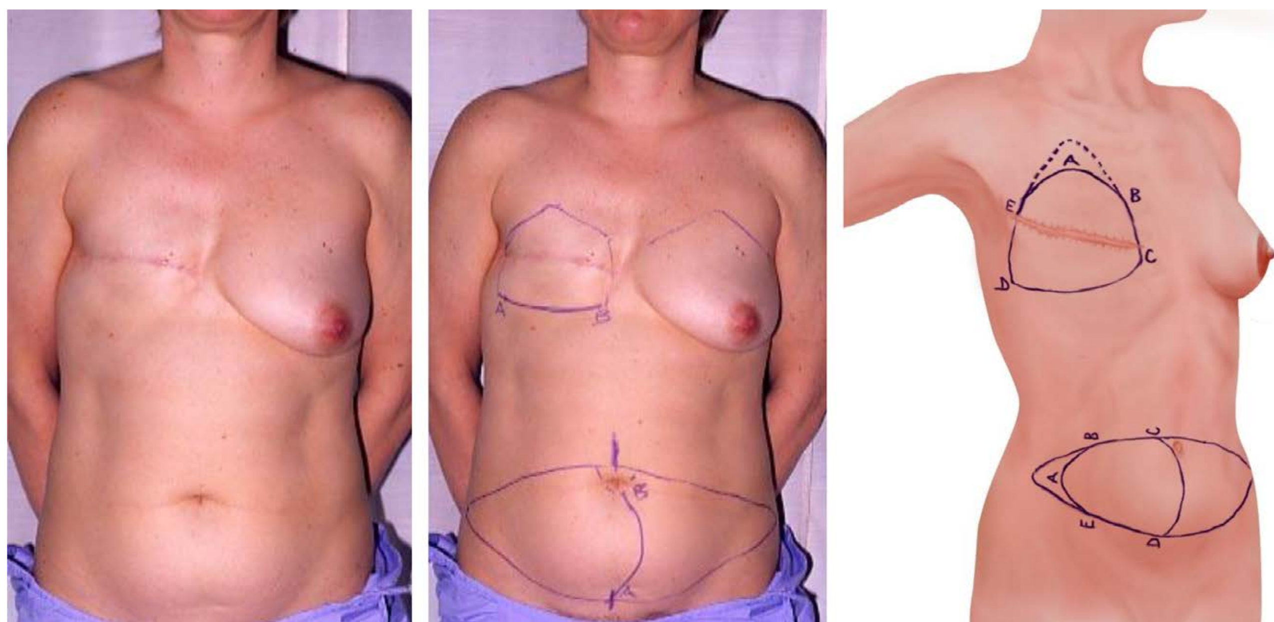

Fig. 1. The marking and design of the TRAM flap are performed with the patient in the standing position. The dimensions and parameters of the contralateral normal breast are transferred to the mastectomy site, including width, height, and axis of the breast in the midclavicular line. The TRAM flap is designed at the same location as the DIEP flap, where the upper border is just superior to the umbilicus and the inferior extent is based on the pinch test to ensure adequate primary closure. The width of the breast must equal the height of the flap at the midline of the hypogastrium.

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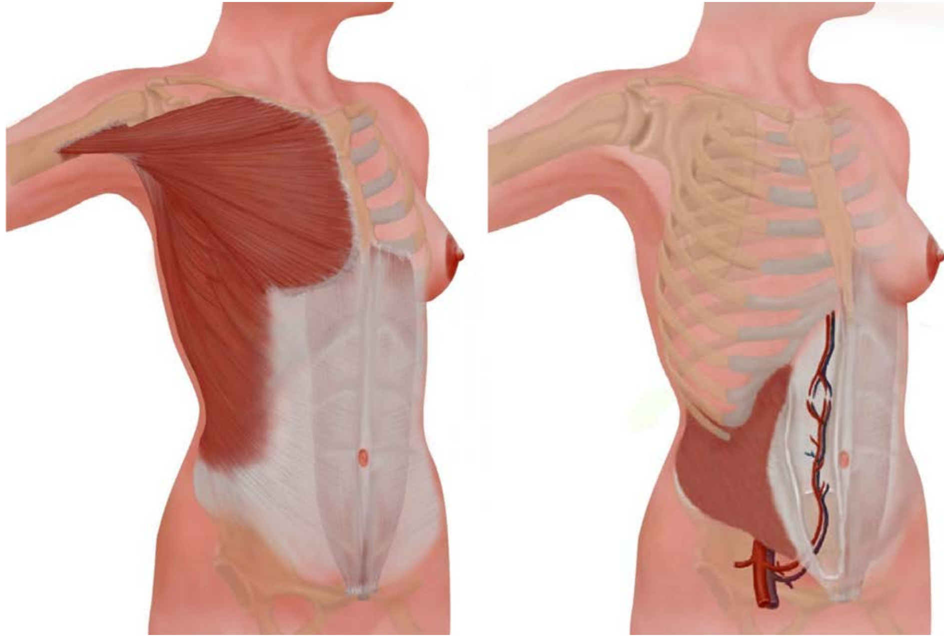

Fig. 2. The superior epigastric artery and its venae comitantes are the continuation of the internal mammary artery and veins (also known as the internal thoracic artery). The superior epigastric artery and venae comitantes travel along the deep aspect of the rectus abdominis muscle, giving off perforators clustered in the periumbilical area midway between the umbilicus and the pubic symphysis. The vascular pedicle connects with the terminal branches of the deep inferior epigastric artery.

between the umbilicus and the pubic symphysis. The vascular pedicle connects with the terminal branches of the deep inferior epigastric artery. Multiple minor segmental perforators come in laterally from the intercostal arteries and venae comitantes. As the TRAM flap uses the nondominant superior system, intravascular redistribution occurs in vascular choke zones located within the rectus muscle superior to the umbilicus. The reversal of the venous drainage can result in vascular congestion of the newly transposed TRAM flap in the immediate postoperative period. The congestion usually resolves within 24 hours but may limit the amount of abdominal wall tissue that can be harvested without developing fat or flap necrosis. Motor and sensory innervation enter the muscle from the seventh to the twelfth intercostal nerves. The most reliable areas of the lower abdominal flap based on a single pedicle have been divided into zones based on the reliability of adequate perfusion to the entire lower abdominal tissue area.[6] The best perfused area is directly over the perforators from the ipsilateral pedicle and the most reliable flap design is based on the ipsilateral tissue with a small amount, potentially, being safely perfused across the midline. The majority of the tissue across the midline on the contralateral side of the flap is considered less perfused with a greater chance of fat necrosis and skin loss.

ANESTHESIA AND OPERATIVE SETTING

The American Society of Anesthesiologists classification level should be documented. The TRAM flap is performed in a main operating room under general anesthesia. A combination of multimodal perioperative analgesia including intraoperative transversus abdominis plane blocks are used for pain control.[15] Perioperative antibiotics can be administered.

Operating Time

The total procedure takes up to 3 hours for a unilateral, ipsilateral delayed TRAM flap. The total operative time may increase if performed as an immediate procedure in combination with the breast cancer team. Patients in our hospital typically stay overnight (18-hour total stay).[15]

Operative Plan

Recipient-Site Preparation

If a delayed TRAM is performed, the old mastectomy scar may be excised and sent for

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pathologic examination. The superior flap is elevated to the upper breast marking. The skin over the lower footprint is incised to the level of the proposed inframammary fold (this step can be delayed until the end of the procedure if you are concerned that there is not enough donor skin). [**See Video 2 (online)**, which displays the preparation of the recipient site with elevation of the upper and lower flaps. The parameters of the medial and lateral extent of the reconstructed breast are identified and the importance of the placement of the inframammary fold is emphasized. The direction and location of the abdominal tunnel starting from the chest wall recipient site is also depicted.] The subcutaneous tunnel is created in the medial aspect of the mastectomy site and dissection can be started subcutaneously in an inferior direction, taking great care to avoid violating the rectus fascia, which can be prominent at the costal margin.

Donor-Site Preparation

The superior abdominal flap is incised down to the level of the rectus fascia. The superior abdominal flap is elevated to the xiphoid process medially and the costal margins laterally. A medial subcutaneous tunnel is created to connect the abdomen flap with the ipsilateral breast area, take care to leave the rectus fascia down. [**See Video 3 (online)**, which displays the execution of the upper transverse incision of the flap and the elevation of the upper abdominal tissue to the costal margin. Completion of the abdominal tunnel joining the chest wall recipient pocket is described, emphasizing the medial/central alignment and the ideal width of the tunnel.]

The inferior abdominal flap is now incised down to the rectus fascia. The umbilicus is freed circumferentially from the abdominal flap. The contralateral skin and subcutaneous tissue can be elevated off the rectus fascia from lateral to medial stopping just short of the midline. This process can help the surgeon identify, in advance, the dominant perforators so they are preserved on the ipsilateral side. Cautery is used to stimulate the ipsilateral rectus abdominis, which is marked with a pen. Cautery dissection continues through the rectus fascia superior and laterally to identify the lateral border of the rectus abdominis. This dissection is completed inferiorly, stopping at the inferior border of the abdominal flap. Typically, the inferior epigastric artery and venae comitantes can be visualized by retracting the lateral edge of the muscle pedicle and looking underneath on the posterior aspect of the rectus muscle from the lateral border. This is a simple way of determining that the arterial and venous system of the pedicle is in the central area of the rectus muscle and to avoid inadvertent damage during instrumentation. The same dissection through the rectus abdominis fascia is now completed from superomedially to the level of the umbilicus. The rectus abdominis muscle can now be transected inferiorly. The deep inferior epigastric artery and two venae comitantes are clipped on both sides before being ligated. Adequate perfusion to the flap is assessed after clipping and any compromised or unhealthy flap is discarded. The final attachment of the inferior and medial rectus abdominis muscle and fascia are elevated, leaving a cuff of fascia at the linea alba of at least 1 cm. [**See Video 3 (online)**. **See Video 4 (online)**, which displays the next step in the elevation of the lower abdominal tissue starting with the lower transverse incision and the release of the umbilicus from the main body of the flap. The contralateral side of the flap is raised, first taking care to identify the location of the periumbilical perforators as they are encountered and transferring their positions onto the ipsilateral flap with a marking pen. The ipsilateral flap is raised from lateral to medial to the lateral border of the rectus muscle. The video describes the elevation of the rectus muscle starting at the lateral border with the anterior fascia attached. The important anatomical features of the deep inferior epigastric vessels are illustrated.]

The cephalad dissection of the rectus sheath toward superiorly should be extended above the costal margin to allow for maximum excursion and folding of the pedicle as the flap is transferred through the tunnel. If the sheath is not fully released on both the medial and the lateral incisions, kinking or tethering of the pedicle can result, with potential decrease in blood flow.

Great care must be taken not to assume that the rectus muscles are always positioned in the midline. The position of the rectus muscles can be quite lateral in some patients who have a "diastasis" as the result of multiple pregnancies. The width of the rectus muscle will vary in patients. In some cases, it can be a very wide and robust muscle where it is reasonable to leave a lateral segment of muscle up to 1 cm in width. The advantage of retaining the lateral segment is that it contains the segmental nerves that insert and the different levels along the length of the rectus muscle. Leaving the nerves housed in muscle may prevent development of neuromas in the postoperative period. Although there is no indication that this strip of muscle is functional, it maintains the length of the

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muscle segments, including the lower portion of the rectus, which is still innervated. Maintaining the muscle length may prevent postoperative pain resulting from the uncontrolled contraction into the hypogastrium. If the rectus muscle is thin and less robust, we recommend taking the entire muscle. The main principle here is to provide adequate perfusion of the flap where leaving lateral or medial segments of muscle may compromise the arterial and venous network.

Now, the superiorly based TRAM flap is freed on the posterior surface to allow for adequate reach to the recipient ipsilateral breast on the chest. The full dissection of the subcutaneous tunnel from the abdominal area through to the recipient site on the chest wall must be carried out with several objectives in mind. The best position of the tunnel in relation to the inframammary fold is generally medial, allowing unrestricted passage of the flap pedicle as it turns over the costal margin. Kinking, twisting, and tension of the rectus muscle pedicle all must be avoided as much as possible. It is worthwhile to meticulously check the fully dissected tunnel for hemostasis before transferring the flap. Reversing the transfer procedure back through the subcutaneous tunnel may damage the blood supply. The flap is now passed through the subcutaneous tunnel, which should be large enough to avoid undue traction causing shearing on the bulk of the flap, which may damage the fragile perforator attachments from the muscle to the skin paddle of the flap. As described in the video segment, the most lateral point of the skin paddle is directed through the tunnel first, and a sponge may be used to gently grip the lateral point of the flap from the recipient site; by rocking the flap back and forth, the entire flap may be delivered on the chest wall. As a rule, the tunnel size should be approximately the width of the surgeon's hand (size 7.5 to 8.0 glove), ensuring that there is minimal pressure when passing the hand through the entire length of the passage. Once the flap has been fully transferred to the recipient site, it is important to check the position of the muscle pedicle again from the inferior aspect to check for appropriate flap rotation and a proper 90-degree turn of the pedicle. [**See Video 5 (online)**, which displays the additional details of raising the rectus muscle, taking care to note the position of the periumbilical perforators. The medial border of the rectus muscle is identified and incised, creating the rectus pedicle, which extends to the xiphoid process. At the distal extent of the muscle pedicle, the deep inferior epigastric vessels are located and ligated. The flap is now entirely raised and dependent on the rectus muscle pedicle superiorly through the superior epigastric system. It is now completely freed from caudal to cephalad. The video shows the transfer of the completely raised flap superiorly through the tunnel through to the chest wall. Important orientation aspects of the flap are described. Details for insetting of the flap in the mastectomy site are shown. The video continues with addressing the closure of the rectus fascia defect and the abdominal skin flap closure. The sequence of the different steps of final insetting of the flap are described.]

Insetting the Flap and Creation of the Breast Mound

The ultimate anterior projection of the flap is made up of (from superficial to deep) the abdominal flap epidermis and dermal layer, the adipose tissue and fascia, and the muscle pedicle. Proper attention to these different components during the insetting of the flap will maximize the reconstructive outcomes and symmetry. The lower abdominal skin and subcutaneous tissue are now perfused by means of the deep superior epigastric vascular pedicle contained within the rectus abdominis muscle. A horizontal strip of skin at the very base of the flap can be deepithelialized to assist in the insetting of the flap and can add additional elevation of the lower pole in the original mastectomy defect (Fig. 3).

In addition, the recipient-site inferior chest wall skin flap at the mastectomy can be deepithelialized to provide a stable platform that can add several centimeters to the anterior projection of the flap. Even when the site has been irradiated, the tissues here can be quite robust and act as a viable tissue layer. The deepithelialized mastectomy flap must be divided vertically to allow for the pedicle to sit at the base of the flap during insetting and not to add an extra twist to the pedicle (Fig. 4). The initial position of the flap is orientated with the thin (lateral) portion of the flap as the take-off of the superior pole of the breast in the infraclavicular area. The base of the flap is tacked at its greatest width to span the base of the breast defect and the best position for the flap (Fig. 5). The upper aspect of the flap is tucked under the chest wall skin at the superior point of the upper mastectomy skin flap. This new upper pole of the reconstructed breast will be deepithelialized but not before the abdominal closure is established because the mastectomy defect will enlarge slightly when the upper abdominal flap is dragged inferiorly (Fig. 6). Many surgeons will

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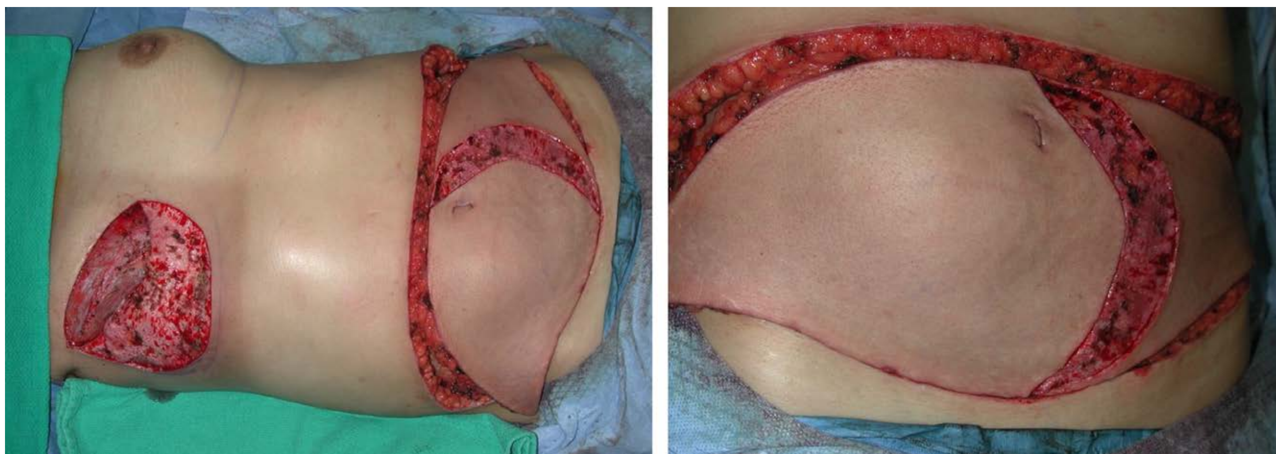

Fig. 3. The lower abdominal skin and subcutaneous tissue is now perfused by means of the deep superior epigastric vascular pedicle contained within the rectus abdominis muscle. A horizontal strip of skin at the very base of the flap can be deepithelialized to assist in the insetting of the flap and can add additional elevation of the lower pole in the original mastectomy defect.

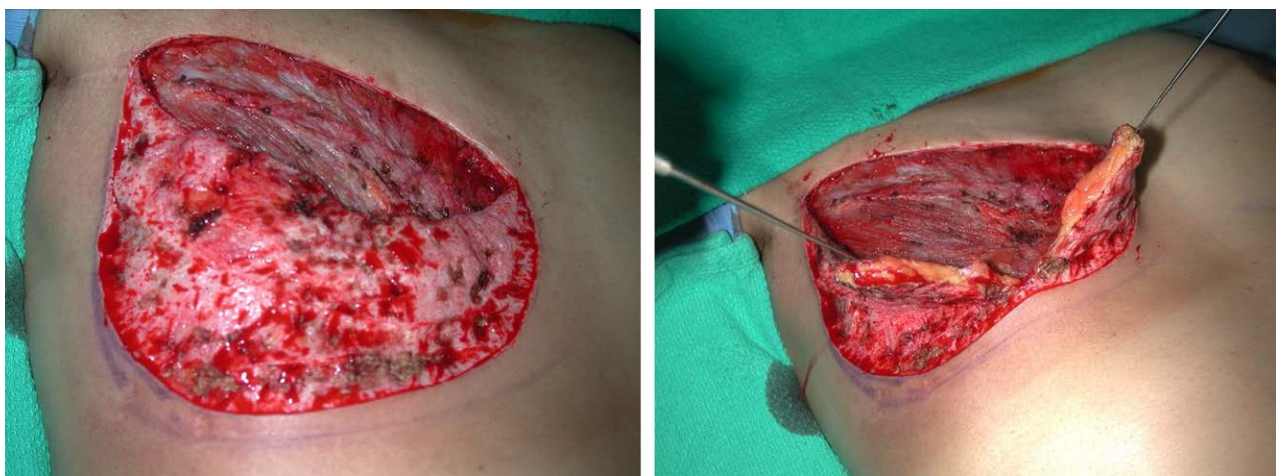

Fig. 4. The recipient-site inferior chest wall skin flap at the mastectomy can be deepithelialized to provide a stable platform that can add several centimeters to the anterior projection of the flap. Even when the site has been irradiated, the tissues here can be quite robust and act as a viable tissue layer. The deepithelialized mastectomy flap must be divided vertically (*left*) to allow for the pedicle to sit at the base of the flap during insetting and not to add an extra twist to the pedicle.

perform a release dart in the lateral aspect of the upper flap to allow for accommodation of the upper pole of the reconstructed breast. In this case, it was not required.

The final closure is performed with multiple layers of a 4-0 monofilament absorbable suture and Steri-Strips. A drain is left at the base of the flap and brought out through a separate incision and secured with a silk suture (Fig. 7). [**See Video 6 (online)**, which displays the details using photographs of the TRAM flap insetting and how to control projection of the breast mound. The different tissue components are listed, and the area of deepithelialization required is identified. The orientation of the skin paddle is shown and the insetting of both the inframammary fold and the superior pole of the breast mound illustrated in sequence. Final closure details are reviewed with photographs and voiceover.]

The postoperative regimen for monitoring of flap perfusion can vary between breast centers. The pedicled TRAM flap is based on the nondominant blood supply, and the realignment of perfusion through the superior epigastric vascular system can initially be sluggish. However, given that the patient's temperature and hemodynamic parameters are within normal limits generally, these flaps do well. Postoperative flap checks by surgical staff and nurses in the overnight stay are recommended. We order hourly flap checks until

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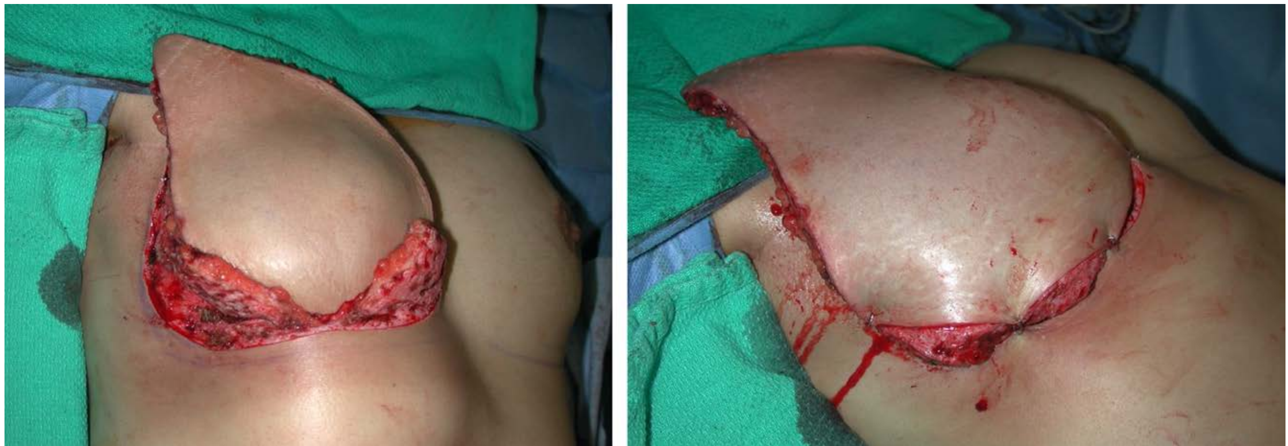

Fig. 5. The initial position of the flap is orientated with the thin (lateral) portion of the flap as the take-off of the superior pole of the breast in the infraclavicular area. The base of the flap is tacked at the greatest width to span the base of the breast defect and the best position for the flap.

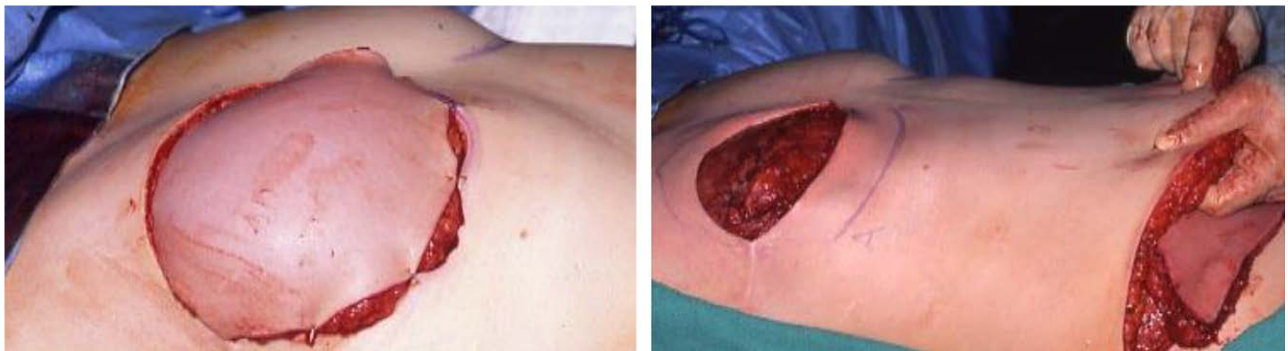

Fig. 6. The upper aspect of the flap is tucked under the chest wall skin at the superior point of the upper mastectomy skin flap. This new upper pole of the reconstructed breast will be deepithelialized, but not before the abdominal closure is established because the mastectomy defect will enlarge slightly when the upper abdominal flap is dragged inferiorly.

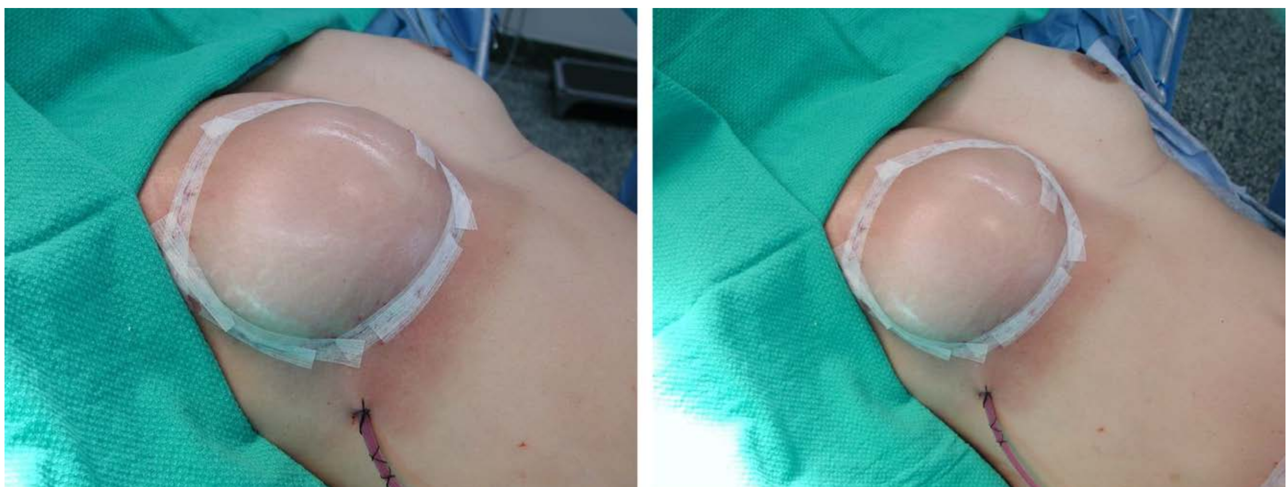

Fig. 7. The final closure is performed with 4-0 monofilament absorbable suture and Steri-Strips. A drain is left at the base of the flap and brought out through a separate incision and secured with a silk suture.

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midnight of the first day and then every 4 hours overnight. Adhering to an established monitoring protocol in your own institution is important, including checking color, temperature, and capillary return. If there is substantial decrease in flap perfusion in the immediate postoperative period, it may be related to abnormal pedicle folding or the presence of a hematoma. Monitoring methods such as handheld Doppler ultrasonography in a previously intraoperatively marked skin area directly over the pedicle may be helpful.

IPSILATERAL OR CONTRALATERAL PEDICLED TRAM FLAP

Complication rates are thought to be comparable for ipsilateral versus contralateral TRAM flaps, except that partial flap necrosis may be less in the ipsilateral method.[16,17] The ipsilateral TRAM flap breast reconstruction is our preferred method, if available; however, the contralateral pedicled TRAM flap may be a useful alternative in avoiding abdominal scars such as in the case of where an appendectomy scar may interfere with the ipsilateral design. In this case, the contralateral pedicle served as an excellent alternative (Fig. 8).

IMMEDIATE RECONSTRUCTION WITH THE PEDICLED TRAM FLAP

Experience with the ipsilateral TRAM flap has shown that it is very suitable and even has some advantages in immediate breast reconstruction, with preservation of the skin envelope. The longer pedicle length allows tension-free inset of well-vascularized tissue into the breast pocket, which is thought to lead to better positioning and shaping of the reconstructed breast, with minimal disruption of the inframammary fold.[16] The ipsilateral TRAM flap is a reliable flap option with low complication rates and shorter surgery time than microvascular alternative choices (Figs. 9 and 10).

ABDOMINAL DEFECT CLOSURE

Closure of the rectus fascia defect can be achieved by performing primary closure or by using permanent synthetic mesh, absorbable biosynthetic mesh, or acellular dermal matrix. We currently use a preset size of polypropylene mesh (2 × 12-inch) which has been washed with antibiotic irrigation solution and inlaid as an interpositional repair into the abdominal donor site to replace the rectus fascial defect created by harvesting the rectus muscle. The polypropylene mesh can stretch in vertical and horizontal directions and therefore provides a strong but flexible repair. We use mesh in every case, even if it appears possible to close the rectus fascia directly. Supplementation with mesh in the abdominal closure has been shown to demonstrate reduced hernia and bulge rates in the postoperative period beyond other closure techniques.[12,18] The mesh is secured medially along the linea alba and then laterally to the conjoint tendon with interrupted polypropylene sutures followed by a running closure. Bupivicaine is infiltrated as a transversus abdominis plane block into the rectus sheath unilaterally and along the costal margin. The abdomen is closed in multiple layers, first with a 3-0 monofilament suture at the level of the Scarpa fascia followed by a deep dermal and running subcuticular stitch in the superficial layer. Bilateral drains in the abdomen are secured with a 3-0 silk suture. The umbilicus is brought out through a new opening following abdominal closure at the level of the iliac crest and secured with 5-0 monofilament suture in an interrupted fashion with a running final closure. Steri-Strips, gauze around the drain sites followed with a light dressing, and then an abdominal binder are applied.

POSTOPERATIVE MANAGEMENT

A simple protocol for accelerated and streamlined postoperative recovery effectively reduces length of stay and patient care costs following TRAM flap breast reconstruction without compromising patient safety. A critical component to the success of our patient care protocol was following the 18 enhanced recovery after surgery perioperative recommendations.[9] The observed reduction in intraoperative and postoperative opioid use in women receiving multimodal analgesia in this study supports this as a mechanism for potentiating early discharge following pedicled TRAM flap breast reconstruction. Three drains are placed at the end of the unilateral TRAM flap procedure: one in the reconstructed breast and two in the abdomen (one above the umbilicus and one below). A wraparound binder is applied and worn by the patient day and night for 4 weeks to provide support and discourage seroma accumulation. Immediately in the postoperative period, we keep the patient flexed slightly with pillows under the knees. We avoid recommending wearing a bra postoperatively because of the potential constriction across the pedicle from the garment under the reconstructed breast. The remaining

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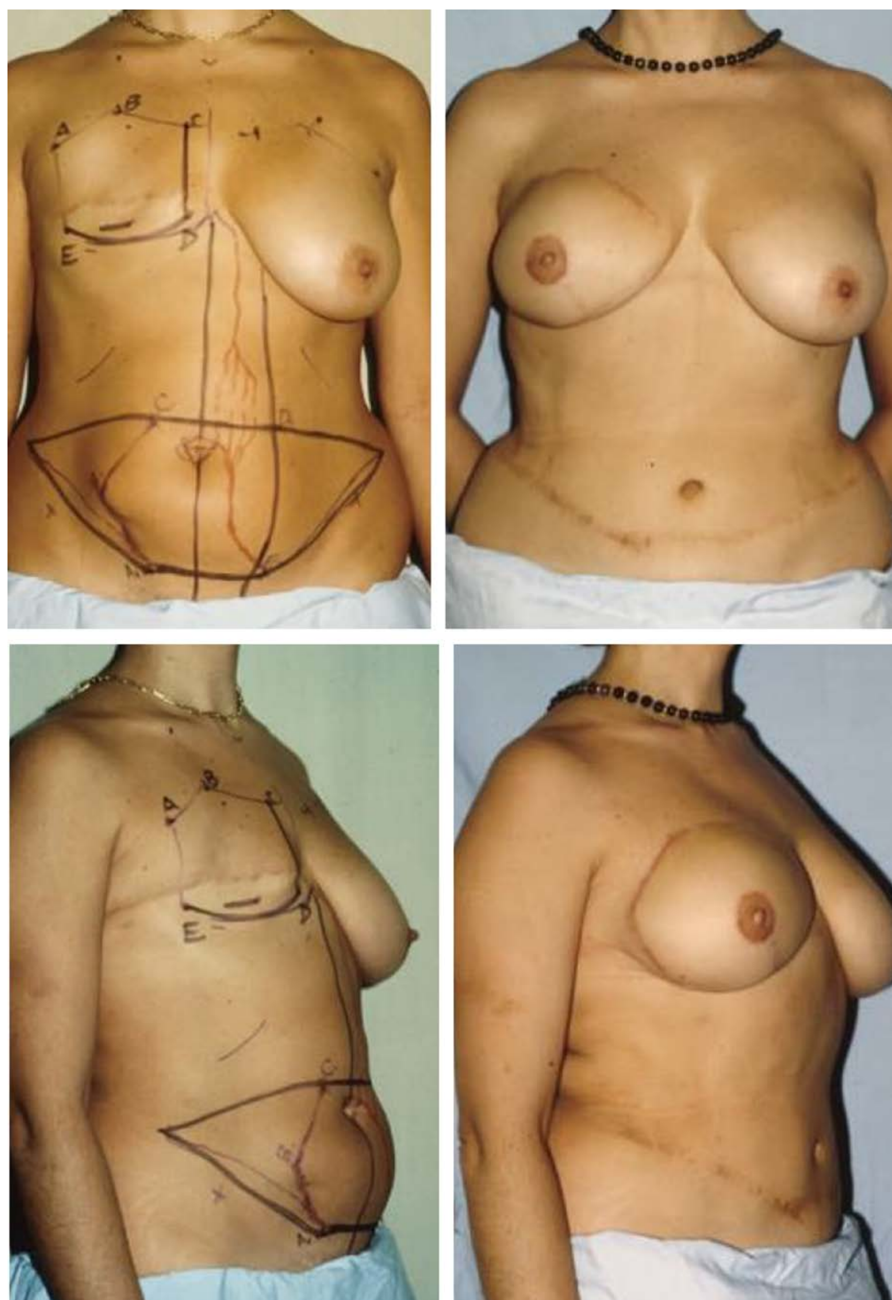

Fig. 8. The contralateral pedicled TRAM flap may be a useful alternative for avoiding abdominal scars, such as in cases where an appendectomy scar may interfere with the ipsilateral design. In this case, the before and after anterior and lateral views show how the contralateral pedicle served as an excellent alternative.

postoperative care and follow-up protocols are similar to other forms of autogenous breast reconstruction using the lower abdomen as the donor site.

COMPLICATIONS AND OUTCOMES

Complete flap loss is uncommon in pedicled TRAM flaps. Although the pedicled TRAM flap sacrifices a substantial portion of the rectus abdominis muscle and overlying fascia abdominal flexion, weakness in unilateral TRAM flap reconstructions is minimal and mitigated somewhat by compensatory rotational strength increase of the other abdominal muscles. Abdominal wall mesh or alternative biosynthetic and biomaterials can be used for the fascial defect repair to prevent the development of hernias.[19] The rates of donor-site

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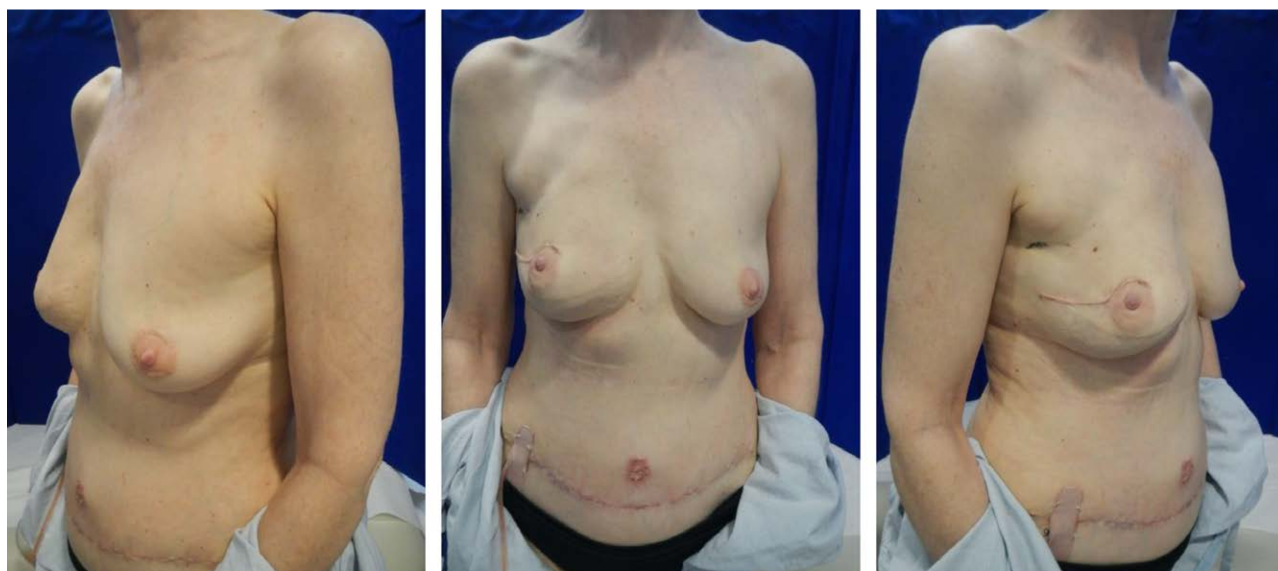

Fig. 9. This image shows the patient immediately after reconstruction with the ipsilateral TRAM flap, showing that it is very suitable and even has some advantages with preservation of the skin envelope. The longer pedicle length allows tension-free inset of well-vascularized tissue into the breast pocket, which can lead to better positioning and shaping of the reconstructed breast with minimal disruption of the inframammary fold.

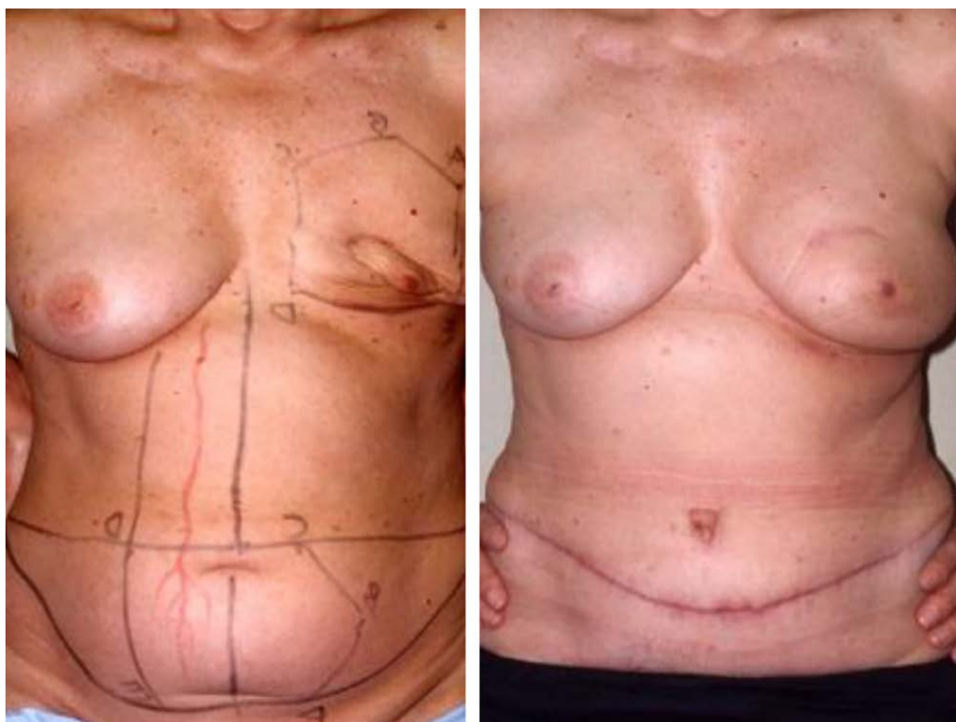

Fig. 10. This image shows the preoperative (*left*) and postoperative (*right*) views from a delayed reconstruction that preserved the skin envelope. The patient did not have radiation therapy, which allowed the skin to expand very quickly. This was a contralateral pedicle with a central mound modification to obtain projection and symmetry.

complications such as wound dehiscence, seroma, hematoma, and skin necrosis remain comparable between the various abdominally based autologous flaps.[10] Wound infection and dehiscence are the two most frequently reported donor-site complications, occurring in 17% and 13.8% of patients,

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respectively.[11] Risk factors for abdominal donor-site complications include obesity, diabetes, and active smoking.[12,13,20] The incidence of hernia and bulge following TRAM flap procedures varies greatly in the literature and has been reported between 3.5 and 9.9% in two recent large-scale reviews.[10,19] Both hernia and bulge formation may be affected by surgical technique, specifically, whether mesh is used during facial repair and abdominal closure. It is worth noting that patient-reported outcome scores for physical function and pain do not demonstrate any significant difference between the various abdominally based flap techniques (pedicled TRAM, free TRAM, DIEP, and superficial inferior epigastric artery flaps).[12] Breast satisfaction, upper body physical well-being, psychological well-being, and sexual well-being scores appear to be similar between abdominally based flap procedures.[20] Compared with unilateral TRAM flap reconstruction, bilateral TRAM flap reconstruction is associated with decreased overall satisfaction and increased abdominal wall symptoms.[20]

Breast-site complications such as hematoma, seroma, infection, wound healing issues, and mastectomy skin flap necrosis were found to occur in approximately 32% of patients at 2 years after reconstruction with a pedicled TRAM flap.[12] Of note, the rate of breast complications remains relatively consistent across the various abdominally based autologous techniques.[14] Risk factors for breast complications include higher body mass index and active smoking.[12] The rates of fat necrosis for DIEP and pedicled TRAM flaps have been reported to be 13.9% and 14.4%, respectively.[20] The incidence of partial and complete flap loss following pedicled TRAM remains low and has been reported to be 8.5% and 0.2%, respectively.[18,21,22] Postoperative thromboembolic events remain relatively rare. The incidence of pulmonary embolism following TRAM flap surgery is 1.6% according to one study.[21]

CONCLUSIONS

Multiple different autologous lower abdominal tissue–based procedures are currently used for autologous breast reconstruction. Deciding which type of abdominally based flap operation to perform requires assessment on a case-by-case basis and consideration of the needs of the individual patient and the surgeon's level of comfort with the different techniques. Patient selection criteria usually help determine which technique is used. The advantage of the free flap technique is improved blood supply to the skin island. The free flap, therefore, may be used in patients at higher risk for partial flap loss with the pedicled technique. Such high-risk patients include smokers, the obese, patients with significant medical comorbidities, and patients with prior abdominal surgery. Patients without these risk factors can be expected to achieve good results with either the pedicled or free flap technique.[23] Furthermore, with the addition of a vascular delay procedure, pedicled TRAM reconstructions can be safely performed even in some traditionally high-risk patients.[24,25] Breast reconstruction with a pedicled TRAM flap has persisted for decades as a reliable and safe form of autologous breast reconstruction leading to a natural and stable breast shape long term. Careful patient selection is important. Compared with free flap reconstruction, TRAM flaps have shorter anesthetic times and shorter length of stay in the hospital. The pedicled TRAM flap requires less sophisticated postoperative monitoring and can be performed efficiently in any hospital setting. The pedicled TRAM flap is a valid and safe option in the comprehensive management of breast cancer patients.

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