Monopedicled TRAM Flap

28

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28.1 Introduction

The transverse rectus abdominis myocutaneous (TRAM) flap revolutionized breast reconstruction, allowing surgeons to create a breast that is soft, warm, and with a good and long-lasting result [1]. Despite advances in free flap breast reconstruction, pedicled TRAM flap breast reconstruction remains an excellent option for unilateral breast reconstructions. Unlike microsurgical breast reconstruction, the pedicled TRAM flap does not require sophisticated postoperative monitoring and can be performed efficiently in any hospital setting.

28.2 History

Robbins [2] described the use of a vertical rectus abdominis flap for breast reconstruction in 1979. Drever [3], Dinner et al. [4] and Sakai et al. [5] refined variations on the use of vertical rectus abdominis myocutaneous flaps for breast reconstruction, but initially Hartrampf observed during abdominoplasty procedures that the lower abdomen could survive as an island of tissue as long as the attachments to the rectus abdominis muscle were kept intact. Hartrampf et al. [6–8] took the bold step of changing the skin island orientation to a transverse one across the midabdomen, making a larger volume of tissue available for breast reconstruction with a cosmetically desirable donor site, describing in 1982 the TRAM flap as the use of the excess skin and subcutaneous fat that is routinely discarded in an aesthetic abdominoplasty for breast reconstruction. From these beginnings, the TRAM flap was destined to become the gold standard procedure for breast reconstruction, and nowadays it remains a very good surgical option. Subsequently, several free flap options have developed as refinements of the original pedicled technique, including the free TRAM, muscle-sparing free TRAM, and perforator flaps.

28.3 Anatomy

The skin and fat of the lower abdomen is supplied by five major sources:

1. Superior epigastric vessels arising from the termination of the internal mammary vessels
2. Deep inferior epigastric vessels
3. Superficial inferior epigastric vessels
4. Intercostal segmental vessels
5. The superficial and deep circumflex iliac vessels.

The predominant blood supply of these area is from the deep inferior epigastric system [9–11]. The vessels from both epigastric systems perforate the rectus abdominis muscles on their deep surfaces and travel as single or duplicated vessels up and down the flap, ascending to the skin in two rows, a medial one and a lateral one (Fig. 28.1). This system is cranially connected with the superior epigastric vessels, and represents the unique vascular pedicle used when raising a pedicled TRAM flap, even if the eighth intercostal vessels can be incorporated into the pedicle to augment blood supply if necessary.

Rectus abdominis muscles can be vascularized by three different patterns:

1. Type I: single superior and inferior arterial supply (29 %).
2. Type II: double-branched system from each source artery (57 %)
3. Type III: triple-branched system from each vessel (14 %).

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Fig. 28.1 Corpse dissection of a transverse rectus abdominis myocutaneous (TRAM) flap: scissors are collocated behind the superior pedicle and the flap is rotated toward the chest. The inferior pedicle running posteriorly to the rectus abdominis muscle is clearly visible

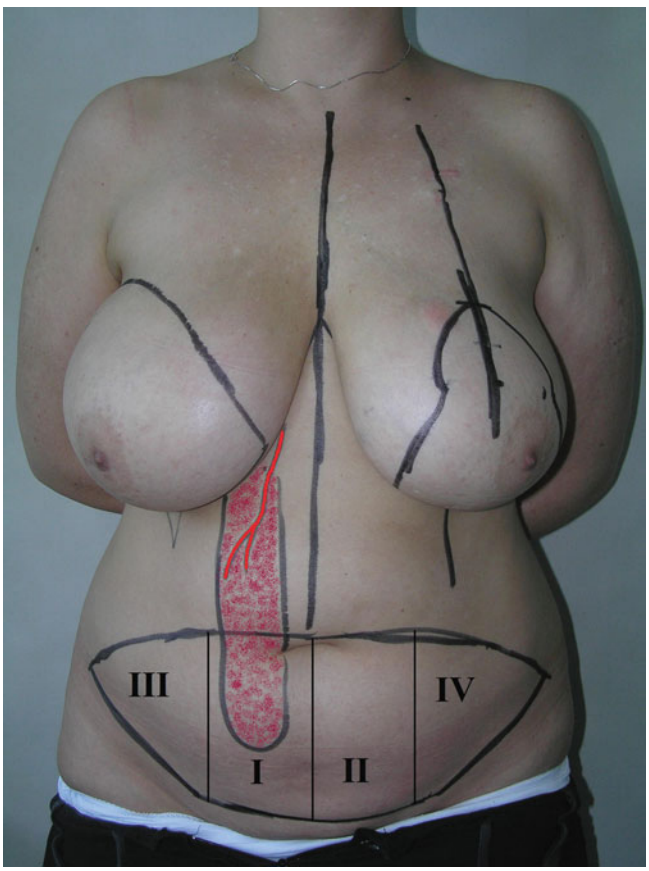

Fig. 28.2 TRAM flap vascular zone classification of Hartrampf

Symmetrical vascular pattern symmetry was described in only 2 % of patients.

Miller et al. [12] found that only 40–50 % of patients have macroscopic communication between the two systems, whereas 60 % of patients have choke vessels of microscopic caliber. The superior vessels pass into the muscle from the deep aspect of the costal margin and run inferiorly. The distal supply enters the posterolateral aspect of the muscle below the arcuate line and passes up to anastomose with the superior vessels in the periumbilical area. Major vascular supply is provided by the deep inferior vessel with venous drainage system supported by two large venae comitantes into the iliac vein. The inferior and the superior venous systems create an anastomotic web at the umbilical level. When a pedicled TRAM flap is raised, distal venous flow has to reverse and follow the drainage pattern of the superior veins, overcoming the venous valves within the choke system described by Moon and Taylor [11]. Arterial perforators arise in two rows aside the linea alba. The lateral row lies 2–3 cm within the lateral border of the rectus sheath, whereas the medial row lies 1–2 cm from the linea alba. These vessels differ significantly in both size and number; their caliber may vary up to several millimeters in diameter.

The anterior rectus sheath is tightly adherent to the muscle at the tendinous inscriptions. It is formed by two layers provided by external and internal oblique muscles in the lower rectus abdominis muscle and by a single layer in the upper rectus abdominis muscle. During flap elevation, it is possible to harvest a gentle strip of fascia within the muscle in order to keep it more resistant to tractions or to spare as much fascia as possible in order to provide a stabler closure of the door site [13]. A muscle-sparing technique can be used to leave a strips of muscle laterally and medially to assist in maintaining abdominal-wall strength, but it has been demonstrated that any muscular segment left loses neurovascular inputs [14, 15]. For these reasons nowadays the muscle-sparing pedicle TRAM flap can be considered obsolete. Two major vascular classifications exist for TRAM flap blood supply. The most classical description was introduced by Hartrampf (Fig. 28.2), who divided the supply into four zones:

1. Zone I: overlying the muscle pedicle
2. Zone II: lying across the midline, immediately adjacent to zone I
3. Zone III: lying lateral to zone I on the ipsilateral side
4. Zone IV: lying lateral to zone II on the contralateral side from the pedicle.

Zone I has been found to be the most reliable portion of the flap. The medial portion of zone III is the next most reliable portion of the flap, but its blood supply decreases close to the ipsilateral tip. The medial portion of zone II is

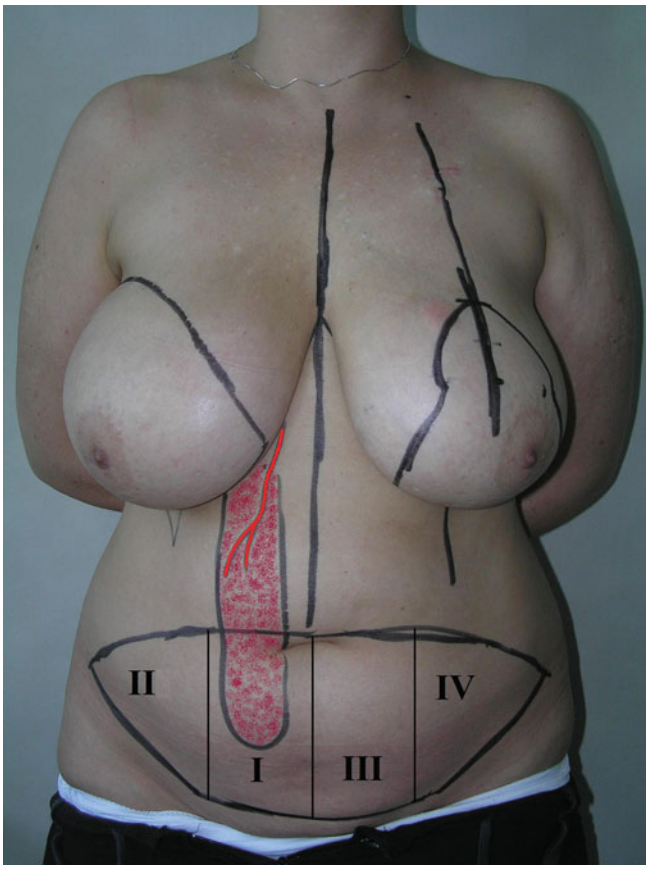

Fig. 28.3 TRAM flap vascular zone classification of Holm et al

also usually reliable, but the lateral part is less predictable. Finally, zone IV should always be considered as not vascularized and should be discarded routinely. Holm et al. [16] demonstrated that although zone I remains the most reliably perfused portion of the flap, any flow across the midline is more precarious than ipsilateral flow. So the classification of Holm et al. proposes that Hartrampf's zone III should be renamed zone II, and Hartrampf's zone II should be renamed zone III (Fig. 28.3).

Moon and Taylor [11] recommend surgical delay of the TRAM flap until 1 week before definitive elevation. The procedure focuses on ligation of the superficial and deep inferior epigastric systems in an outpatient setting. It increases arterial supply, but TRAM flap partial necrosis is often related to venous congestion rather than arterial inadequacy. A bigger flap can be raised with a bipedicled approach or as a free flap.

28.4 Surgical Technique

Appropriate patient selection is the key to achieving predictable results. Candidates for TRAM flap breast reconstruction must have sufficient lower abdominal tissue to achieve a successful reconstruction. Clinically, this can be evaluated by estimating the amount of superficial fat in the lower abdomen by squeezing the tissue between one's index finger and thumb (i.e., the "pinch test"). Patients with prior abdominal surgery should be carefully selected before undergoing TRAM flap reconstruction. A Pfannenstiel or McBurney incision is considered safe. The surgical technique for flap harvesting can be similar in immediate or delayed reconstruction. Preoperative markings consist in midline drawing (very effective in donor site closure to achieve a good symmetry and result) and cutaneous palette drawing. This is achieved by marking a suprapubic transverse straight or arcuate line from one inguinal fold to the other. Laterally, it continues upward in the inguinal fold or parallel to it up to the superior transverse mark. This line is drawn 1 or 2 cm above the navel and laterally it create an angle with the anterior superior iliac spine. Markings are variable in function of the amount of skin and fat available in the lower abdomen. Also inframammary folds are marked. Preoperative Doppler imaging is useful in order to find perforators but it is not mandatory. Recipient site markings are different in the case of immediate or delayed reconstruction. In immediate breast reconstruction, the breast undergoing mastectomy is marked with oncological patterns such as for Patey mastectomy, skin-sparing mastectomy, or nipple-sparing mastectomy.

In the case of delayed breast reconstruction, it is suggested to mark inframammary fold in the contralateral breast and to recreate the opposite one with the same footprint but 2 cm above: it will be lowered during the donor site closure by donor site suture tension. Skin between this marking and mastectomy scar should be removed in order to recreate a natural new inframammary fold but surrounding skin should be excised if there is radiodystropy. A tight mastectomy scar can also be cut in a Z-style incision to release skin tension is needed.

Perioperative assessment consists of heparin prophylaxis associated with pneumatic leg pumps. Blood transfusions can be required but should be prevented. The patient is positioned on a folding surgical bed.

Surgery starts by undermining the epigastric flap in a suprafascial plane. Skin is incised to the sheath with an upward 45° inclination in order to include as many perforators as possible and also in order to face the donor site skin flap with similar thickness (Fig. 28.4).

Rectus abdominis muscles are both individuated up to the rib arc and xiphoid. Rectus abdominis muscles and external oblique muscles are dissected on a suprafascial plane keeping a very thin layer of fat on the fascia in order to respect suprafascial vascularization as much as possible (Fig. 28.5).

Then, a tunnel is undermined to the breast. The tunnel should be large enough to let the surgeon's fist pass (Fig. 28.6). Before the flap dissection is continued, it is

Fig. 28.4 Elevating the epigastric skin flap. A 45° initial incision can produce several improvements, such as better skin vascularization and better donor site closure with a nice aesthetic result

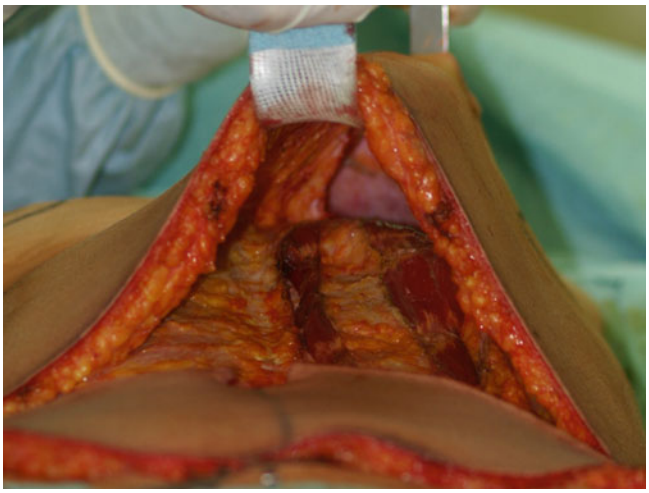

Fig. 28.6 A tunnel is undermined to transpose the flap to the chest. It should be large enough but it is suggested that dissection should not exceed the midline in order to respect the inframammary fold

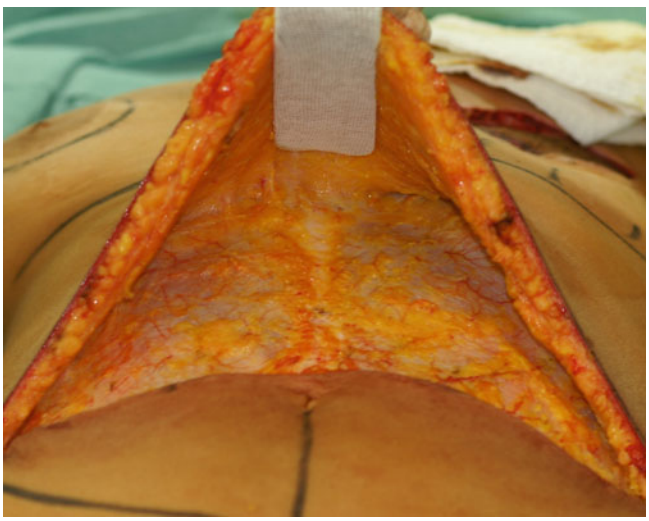

Fig. 28.5 Epigastric skin flap is elevated: the rectus abdominis muscles are both individuated up to the rib arc

Fig. 28.7 Checking donor site closure. The patient can be moved to a slightly sitting position but skin tension should be avoided

helpful to tilt the patient in order to check donor site closure (Fig. 28.7). In case of excessive skin tension, it is possible to modify the preoperative lower markings.

Flap dissection continues with suprafascial dissection of the TRAM flap skin island from lateral to medial, identifying perforators (Fig. 28.8). The choice of an ipsilateral or a contralateral pedicle is based on the availability of good perforators. If possible, it is suggested to harvest an ipsilateral pedicle because it has been described as having better perfusion [17] and also a better arch of rotation. Also an ipsilateral pedicle avoids having a muscle bulge in the xiphoid after flap rotation.

Once it has been decided which side is to be dissected, the rectus sheath is incised all along its length medially the lateral border and a few millimeters laterally to the perforators. The fascia is also incised 1 cm laterally to the medial border of the muscle down to the skin palette (Fig. 28.9).

Muscle is dissected from the fascia and intercostal segmental vessels and nerves are ligated (Fig. 28.10). Main vessels run just beneath muscle so it is suggested that the posterior fascia should be dissected by fat surrounding main vessels.

Then, the inferior pedicle is ligated and muscle is divided downward the pedicle insertion in the muscle, if possible upward the arctuate line (Fig. 28.11).

The rectus sheath can be now incised from the inside, a few millimeters from the linea alba, in order to spare as much sheath as possible so as to repair the fascial defect more easily. Then, muscle perfusion should be checked: in the case of bad perfusion, it will be still possible to harvest a bipedicled TRAM flap; in the case of good muscular perfusion, the navel is isolated and cutaneous palette is

Fig. 28.8 Lateral view of the skin island after dissection. Perforators are usually identified in a row

Fig. 28.9 Fascial dissection exposes rectus abdominis muscle

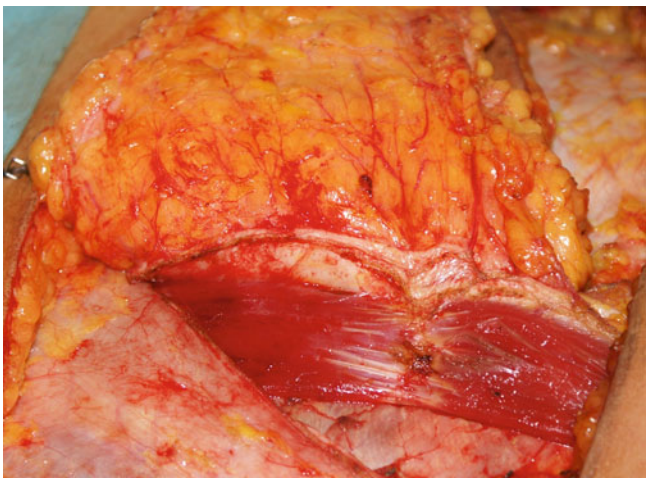

Fig. 28.10 Rectus abdominis muscle is exposed by surrounding aponeurosis

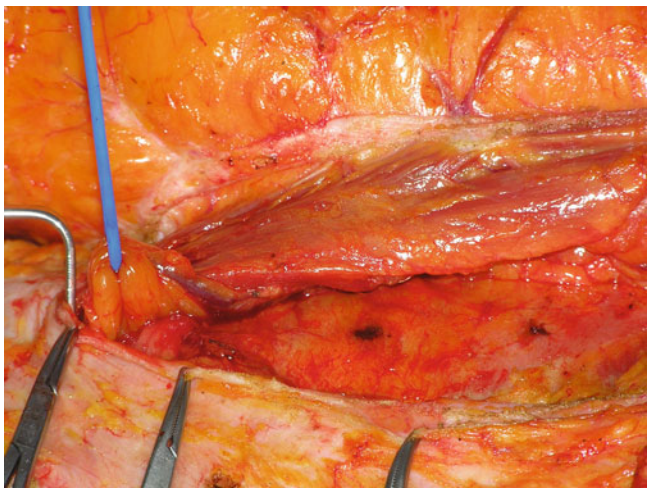

Fig. 28.11 Inferior pedicle is indentified (*blue marker*) and ligated before cutting the rectus abdominis muscle inferiorly

Fig. 28.12 TRAM flap skin island is congested after dissection. The skin color can be *reddish* or *bluish* and it is possible to identify the superficial vein net

Fig. 28.13 TRAM flap extremities are less perfused, so it'd better to be excised. It is clearly visible a venous bleeding

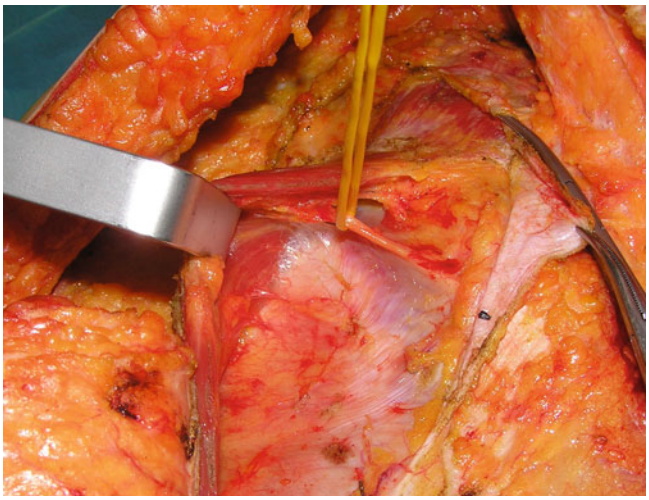

Fig. 28.14 The eighth intercostal nerve is isolated on the rib edge

dissected. Once the flap has been harvested, it can look congested but soon after it will achieve a well-perfused appearance (Fig. 28.12). This is a normal phenomenon, owing to the gradual opening of choke vessels that improves venous drain. Zone IV and partially zones II and III are resected and the flap is now ready to be transferred (Fig. 28.13).

It is essential to denervate the eighth intercostal nerve at the costal margin in order to avoid unpleasant muscle contraction after reconstruction (Fig. 28.14).

Fig. 28.16 Donor site closure with Prineo

28.5 Donor Site Repair and Closure

Competent rectus sheath closure is an essential procedure in any TRAM flap surgery because it should prevent the risk of hernia formation. It is essential to incorporate both the internal and the external oblique aponeuroses into the sheath closure [18]. We suggest incorporating a Mersilene mesh or an acellular matrix [19] in the closure, but some surgeons prefer not to use them, if not necessary, because of the risk of infection [20]. First, mesh is sutured to the medial edge of the remaining rectus fascia, then it is sutured laterally with single stitches transfixing external oblique muscle. Next, the lateral edge of remaining rectus fascia is sutured above the mesh in order to reinforce the closure (Fig. 28.15).

Before closure, the navel is repositioned in the midline, at the level of the ankle crease, defatting the epigastric flap. Quilting suture can avoid postoperative seroma formation

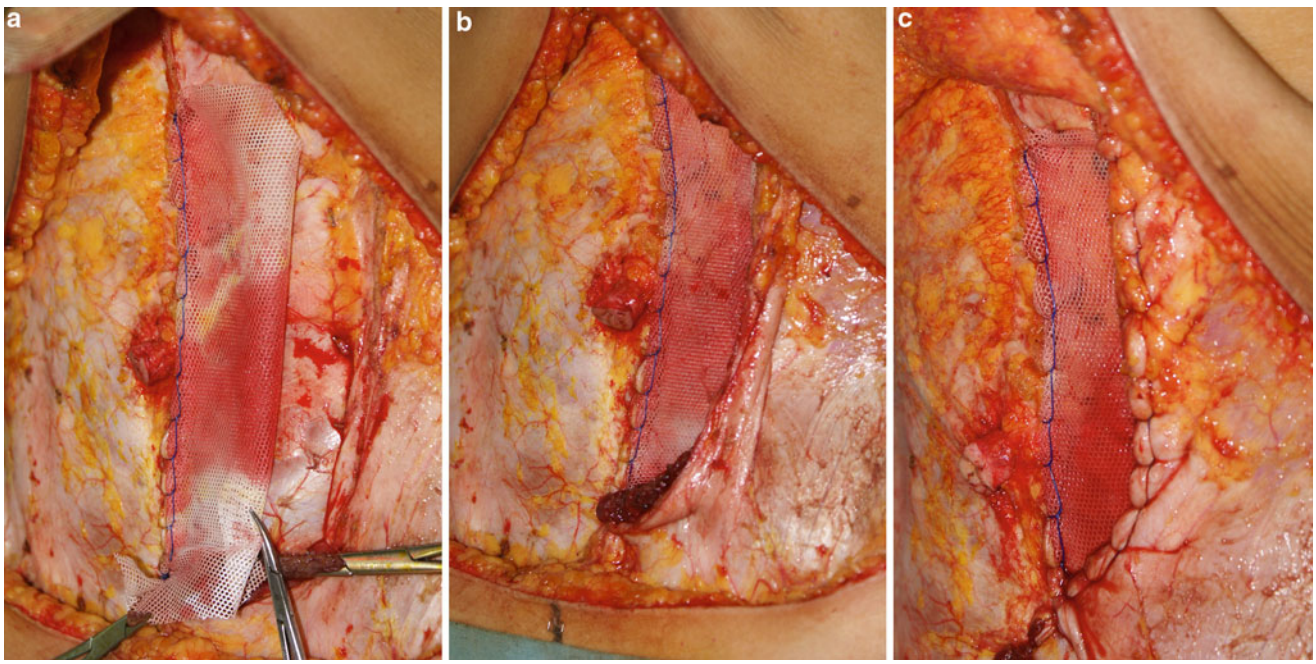

Fig. 28.15 Donor site repair with mesh. It is essential to suture the mesh to the residual rectus fascia in the midline, to fix it to the surrounding external oblique muscle compartment, and then to suture the rectus sheath edges to the mesh in a dual-layer approach

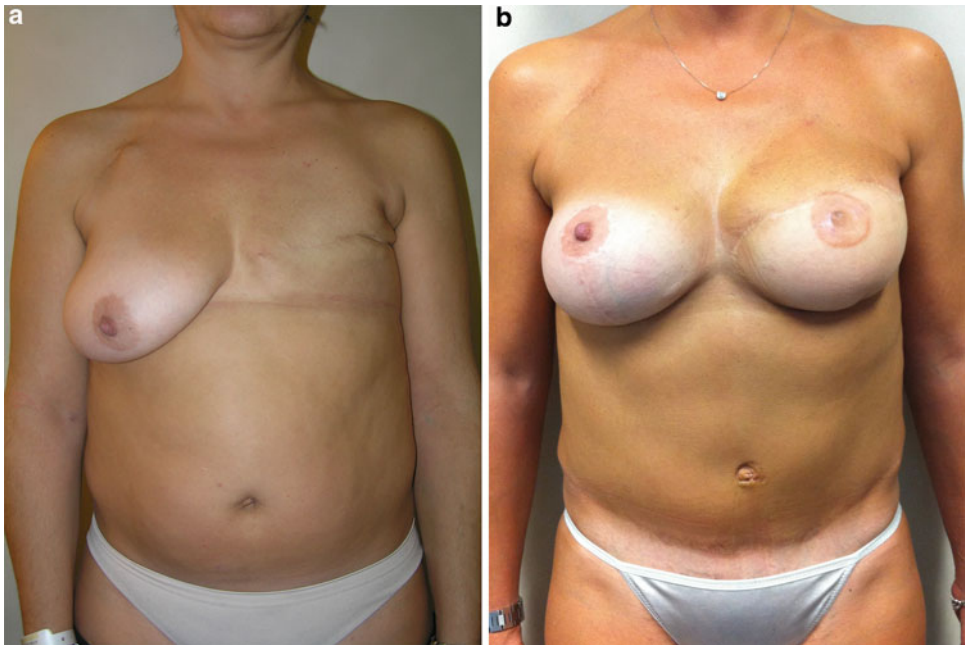

Fig. 28.17 TRAM flap and implant. A prosthesis is collocated under the pectoralis major muscle at the top and the rectus abdominis muscle at the bottom: intraoperative view of muscle suture

Table 28.1 Transverse rectus abdominis myocutaneous (TRAM) flap necrotic complication, European Institute of Oncology series 1994–2007

	Ipsilateral TRAM flap	Contralateral TRAM flap	Bipedicled TRAM flap	TRAM flap and implant
Partial necrosis (%)	12.22	14	3.26	7.89

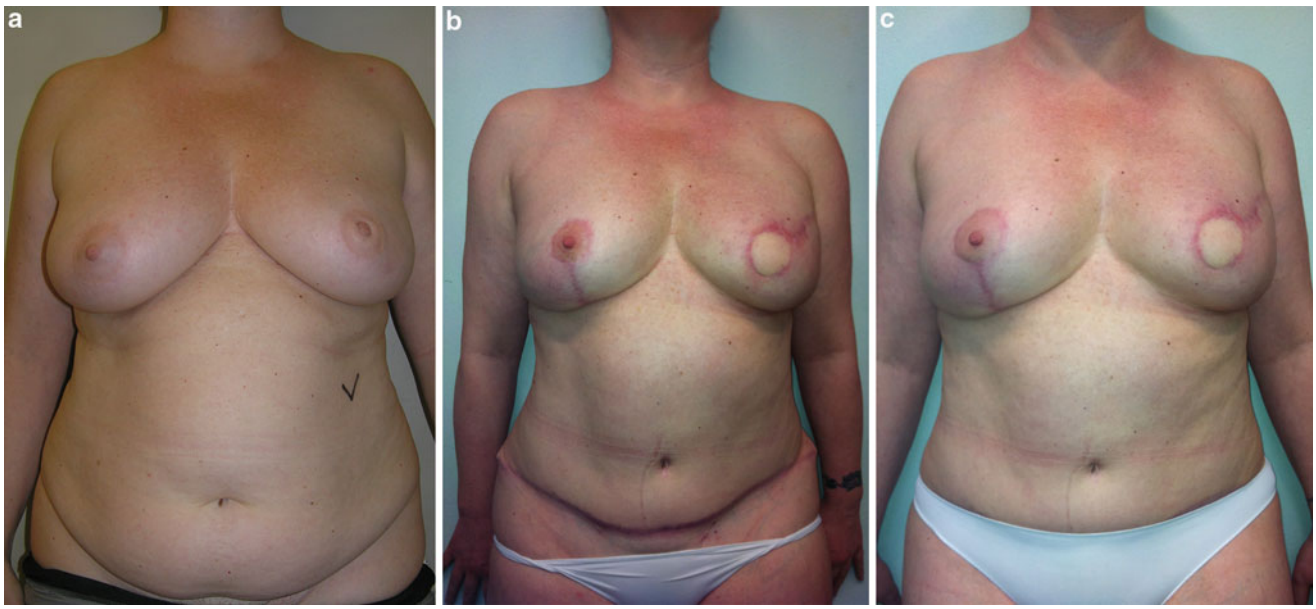

Fig. 28.18 Immediate left breast reconstruction with an ipsilateral pedicle TRAM flap after skin-sparing mastectomy: preoperative and postoperative images. Note that the abdominal scar can be easily hidden by panties

and also prevents tension in the abdominal triple-layer suture. Prineo is an automatic closure system that can be an effective and time-saving (Fig. 28.16). Note that donor site closure should be considered a very important phase of the procedure as good abdominal results are very important in demanding patients.

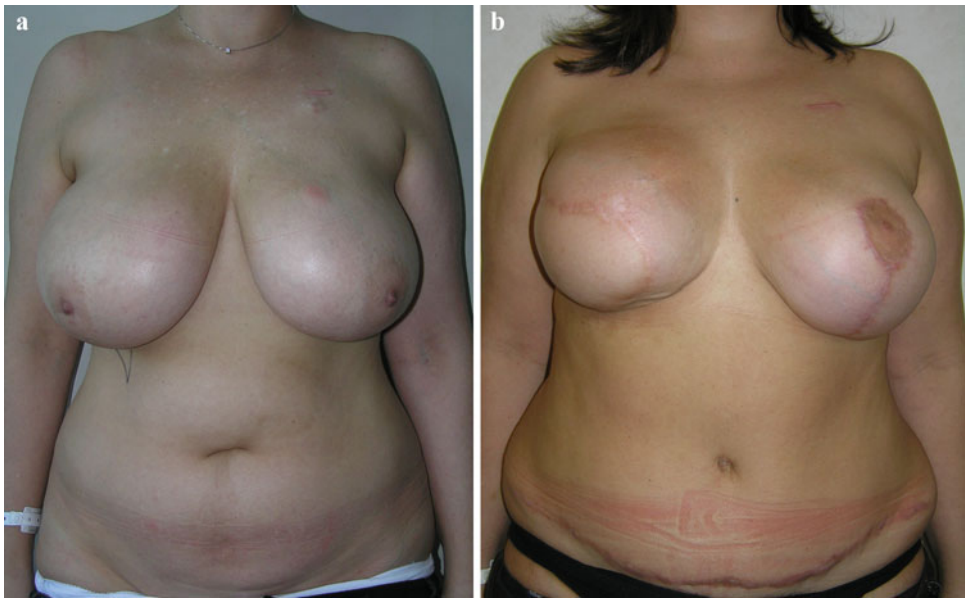

Fig. 28.19 Delayed left breast reconstruction with an ipsilateral TRAM flap: preoperative and postoperative images. Note the good symmetry but a lateral deviation of the navel and a little bulge to the side of it

28.6 Flap Remodeling

Once the flap had been harvested and transposed to the chest, the job is not yet completed: the following steps are probably the most important for patient satisfaction. We can distinguish different approaches in delayed or immediate reconstruction. In delayed reconstruction, scar should be excised and skin undermined in the whole breast footprint. It is important first of all to determine the new inframammary fold. It is possible to compare it with the contralateral side after donor site closure or to draw it in a line that will lie 1 or 2 cm above the contralateral inframmamary fold (that is because of the skin tension after donor site closure). A mastectomy scar can be a challenge because it can push the flap down to the chest wall with a retracted appearance. Mostly, the solution is to excise completely the retracted scar and also most of the inferior mastectomy skin flap. The skin paddle can be orientated in different ways, but the two principal suggestions are 180° and 90°. First, the skin paddle is fixed to the new inframammary fold and then the flap is put under mastectomy skin flaps after checking there is good bleeding all along the skin and fat margins. In the case of poor or venous bleeding, it is suggested to excise the less perfused area in order to avoid partial skin necrosis as much as possible. Contralateral symmetrization is often required. The volume should be compared to that of the contralateral breast (Fig. 28.17).

Once the symmetry has been achieved, the undermined flap skin is deepithelized and the flap can be sutured.

In the case of immediate breast reconstruction, breast reshaping is somewhat similar but it is easier in the case of nipple-sparing or skin sparing mastectomies, whereas the TRAM flap skin paddle is completely or almost totally deepithelized and then sutured to the chest wall, allowing easy remodeling like putting jelly in a mold. It is suggested to spare the original inframammary fold in order to keep the original ptotic appearance of the breast, creating a symmetrical result (Fig. 28.18).

28.7 TRAM Flap and Implant?

Somebody can identify a breast implant beneath a TRAM flap as an adulteration of a pure autologous reconstruction, but it is a very good indication in selected cases. It is indicated in cases such as the following:

- Patient requesting breast augmentation without the possibility to harvest a latissimus dorsi flap
- Patient refusing contralateral breast reduction
- Very large mastectomy or delayed breast reconstruction in patients with a wide radiodystrophic area to be excised
- Badly perfused flap.

If a bad blood supply is identified during dissection, it is suggested to harvest a bipedicled TRAM flap but, if the flap looks poorly perfused after transposition, the idea is to excise as much skin as needed. It does not matter how much volume you can lose because it can be replaced by an implant or an expander. In our series of patients with a TRAM flap and implant performed at the European Institute of Oncology, we obtained very good results in most cases (Fig. 28.19). A partial retropectoral pocket should be harvested, resecting pectoralis major muscle from rib and sternum insertions. In this way the implant can be collocated beyond the inferior free border of the pectoralis major muscle covering its upper pole and TRAM flap muscle

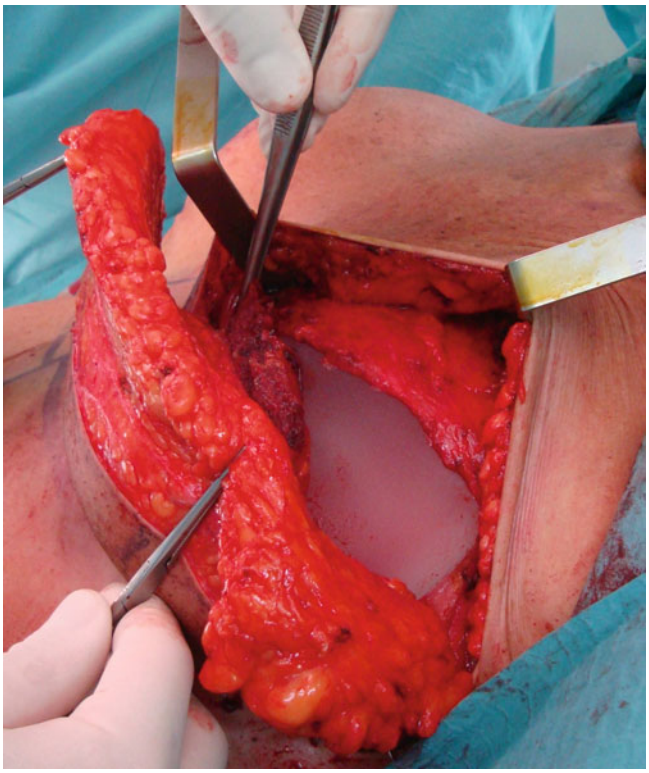

Fig. 28.20 Immediate breast reconstruction with a TRAM flap and implant: preoperative image and postoperative image after radiotherapy. In this case a mild capsular contraction can be observed

Fig. 28.21 Pregnancy after immediate reconstruction with a TRAM flap. This patient underwent cesarian delivery without complication for her or the newborn

covering the inferior one (Fig. 28.20). Delayed volume augmentation is still possible with an implant or fat grafting.

28.8 Complications

The major complications of delayed TRAM flap reconstruction include scarring, skin and fat necrosis, flap loss, hernia formation, deep venous thrombosis, asymmetry, abdominal tightness, and the psychosexual issues associated with breast reconstruction. Some degree of fat necrosis is common in any TRAM flap reconstruction whether free or pedicled. In our series we observed different rates of partial necrosis (requiring surgical debridement). Also, very rare total flap necrosis was observed (Table 28.1).

Donor site complications were observed but decreased as we improved the technique for donor site closure. In our series we observed an infection rate of 4.31 % and a rate of hernias or bulges of 4.15 % from 1996 to 2007 (Figs. 28.18, 28.19, 28.20).

28.9 TRAM Flap and Pregnancy

Despite the loss of muscle function after pedicled TRAM flap harvest, it is still possible for patients to conceive and carry a pregnancy to term as well as to achieve normal vaginal delivery [21]. Johnson et al. [22] described the successful vaginal delivery of monozygotic twins after bilateral pedicled TRAM flap reconstruction. Parodi et al. [23] caution against patients becoming pregnant within 12 months after TRAM flap surgery, reporting a single case of a woman becoming pregnant at 4 months postoperatively and developing a hernia. She delivered vaginally at term. We also observed some pregnancies after TRAM flap reconstruction without major diseases (Fig. 28.21).

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