Immediate breast reconstruction after mastectomy for cancer

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Background: Immediate breast reconstruction after mastectomy has increased over the past decade following the unequivocal demonstration of its oncological safety and the availability of reliable methods of reconstruction. Broadly, it is undertaken in the treatment of breast cancer, after prophylactic mastectomy in high-risk patients, and in the management of treatment failure after breast-conserving surgery and radiotherapy. Immediate breast reconstruction can be achieved reliably with a variety of autogenous tissue techniques or prosthetic devices. Careful discussion and evaluation remain vital in choosing the correct technique for the individual patient.

Methods: This review is based primarily on an English language Medline search with secondary references obtained from key articles.

Results and conclusion: Immediate breast reconstruction is a safe and acceptable procedure after mastectomy for cancer; there is no evidence that it has untoward oncological consequences. In the appropriate patient it can be achieved effectively with either prosthetic or autogenous tissue reconstruction. Patient selection is important in order to optimize results, minimize complications and improve quality of life, while simultaneously treating the malignancy. Close cooperation and collaboration between the oncological breast and reconstructive surgeons is desirable in order to achieve these objectives.

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Introduction

In the UK, breast cancer is the commonest malignancy in women with around 26 000 new cases diagnosed annually\(^1\). About 40 per cent of these patients require mastectomy because of diffuse multifocal disease, tumour size or site, concern about the desirability of radiotherapy, or merely strong patient preference for mastectomy. Additionally, a number of women initially undergoing breast-conserving surgery later have a mastectomy because of incomplete resection margins or local recurrence. Breast reconstruction may, therefore, be required in a significant proportion of all patients with breast cancer. Breast reconstruction after mastectomy has become popular over the past 20 years for several reasons. The evolution of safe and predictable reconstructive techniques has been coupled with an increased availability of plastic surgical expertise. Simultaneously, there has been heightened patient awareness of, and demand for, the various reconstructive options, and widespread recognition by surgeons and oncologists of the psychological benefits of reconstruction.

Historically, almost all breast reconstructions were delayed for months or years after mastectomy. It was feared that immediate breast reconstruction would compromise adjuvant treatment and that such therapy would increase the risk of postoperative complications. There was further concern that it would mask locoregional recurrence and render treatment of such disease difficult. However, there are several obvious benefits such as the potential for a single operation and period of hospitalization, better psychological adjustment to the loss of the breast, and better aesthetic results. Drawbacks include the increased length of procedure, difficult logistics (between ablative and reconstructive surgeons) and more complex surgery.

Not all candidates are suitable for immediate breast reconstruction, for instance those with significant cardiopulmonary or other systemic disease. The surgical risk factors for individual operations, for example the transverse rectus abdominis myocutaneous (TRAM) flap, are well understood and include chronic obstructive airway disease, severe cardiovascular disease, uncontrolled hypertension, morbid obesity, insulin-dependent diabetes mellitus and
general debility. Oncologically, patients with diffuse metastatic disease are not candidates for breast reconstruction, but those with locally advanced or aggressive cancers may undergo successful reconstruction.

This article reviews the literature on immediate breast reconstruction after mastectomy and provides a pragmatic approach for the oncological breast and reconstructive surgeon.

**Techniques of immediate reconstruction**

Modern breast reconstruction techniques have evolved steadily since the introduction of the silicone gel-filled implant in the early 1960s. Today they comprise the use of prosthetic materials, autogenous tissue or a combination of the two. Because of the variable needs of individual patients, the reconstructive surgeon must be able to provide all options to patients. In general the aesthetic results from autogenous tissue reconstruction are superior to those of prosthetic reconstruction. The latter may involve a simple breast implant, a tissue expander followed by an implant, or a permanent expander-implant or an adjustable prosthesis. Autogenous tissue for immediate breast reconstruction can be supplied by the TRAM flap, latissimus dorsi (LD) myocutaneous flap, and the lateral transverse thigh flap. Prostheses and autogenous tissue are not mutually exclusive, however, and expanders or implants are often used in combination with LD flaps, or occasionally with TRAM flaps.

**Prosthetic reconstruction (Figs 1–5)**

**Implant reconstruction**

Primary implant reconstruction was commonly performed in the 1980s but its popularity has waned. Today its role is limited to patients with small volume requirement (A/B cup size or volume below 400 ml) who have adequate soft tissue coverage, especially skin. This stringent requirement occurs most often in delayed reconstruction or immediate reconstruction with short healthy skin flaps or with the aid of a LD flap. The ideal patient is a young non-smoker with good chest wall musculature.

Notwithstanding the above, the insertion of a gel- or saline-filled prosthesis under the pectoralis major–serratus anterior musculofascial complex is undoubtedly the simplest method of immediate reconstruction. The placement of a gel-filled prosthesis subcutaneously under mastectomy flaps should be of only historical interest because of the high incidence of flap necrosis, wound dehiscence, implant extrusion, infection and peri-implant capsular contrac-
delayed placement of the tissue expander was preferred in an attempt to decrease local complications\textsuperscript{58,59}, but immediate tissue expander reconstruction after mastectomy is now well established\textsuperscript{45,21–25}. The ideal candidates for immediate reconstruction are those with smaller, minimally ptotic breasts, and those having immediate bilateral reconstruction when radiotherapy is not anticipated. Following placement of the expander in the submuscular pocket at the time of mastectomy, expansion is carried out at intervals of 1 week on an outpatient basis. The volume at which the breast mound looks equal to the contralateral breast is noted (to guide the choice of size of the permanent implant). The expander is then overinflated to about 150–200 per cent of the desired final breast volume\textsuperscript{12,57,60,61}. Subsequent volume reduction results in a more naturally shaped breast\textsuperscript{15,16,59} and may result in a lower incidence of capsular contraction\textsuperscript{57}. 

![Fig. 1 Mentor Contour Profile anatomical tissue expander with integrated valve](image1)

![Fig. 2 McGhan anatomical expandable implant style 150 with permanent remote fill tube and injection port](image2)

![Fig. 3 Mentor Siltex Becker 50 expander–implant with fill tube and injection port](image3)

![Fig. 4 Mentor Spectrum postoperatively adjustable expander–implant with fill tube](image4)

![Fig. 5 McGhan anatomical cohesive gel breast implant demonstrating the semisolid gel](image5)
Although completion of expansion usually takes 6–8 weeks, expander-to-implant exchange is usually delayed for some months after achieving the desired size. This delay may not be necessary as Foo et al.\textsuperscript{42,43}, in a prospective randomized controlled trial comparing the insertion of the definitive prosthesis at 2 weeks and 6 months after completion of expansion, found no difference in adverse capsular contracture rates (24 \textit{versus} 26 per cent). To achieve maximum symmetry in tissue expander reconstruction may require significant alteration of the contralateral breast by mastopexy, reduction or augmentation. Nipple-areolar reconstruction is also usually undertaken at this second stage. In summary, the indications for immediate breast reconstruction by tissue expansion include: (a) patients with small volume requirements (small, preferably non-patchy breasts); (b) patients who have not been irradiated previously or in whom no postoperative radiotherapy is anticipated; (c) bilateral reconstructions as it is easy to achieve symmetry with any technique; and (d) patients who are unfit or unwilling to undergo major surgical procedures for reconstruction.

The main advantages of breast reconstruction by tissue expansion are its simplicity, and shorter operating, hospitalization and recovery times. The main drawbacks are difficulty in achieving ptosis\textsuperscript{42,43}, projection in the nipple area, lack of natural consistency especially with saline implants, and an almost 30 per cent incidence of adverse capsular contracture\textsuperscript{16,60,62,64,65}. The incidence of capsular contracture has, however, been dramatically decreased with the use of textured-surface expanders\textsuperscript{53,66,67} and implants\textsuperscript{53,54}. Breast implant rupture with time, common in second-generation gel prostheses\textsuperscript{68}, is not a major issue with the new-generation implants.

The most devastating complication of tissue expander breast reconstruction is exposure and extrusion of the prosthesis which inevitably leads to a failed reconstruction. Historically, the reported rates of implant loss were as high as 30–50 per cent\textsuperscript{11,12,16,29,30,41,45,69,70}. It results from wound dehiscence secondary to mastectomy skin flap necrosis, infection, erosion of the overlying skin and tissues by a fold in the expander, poor soft tissue coverage, and expanding irradiated tissue\textsuperscript{71}. The recent advances that have simplified breast reconstruction by tissue expansion and made it more predictable are the use of textured-surface\textsuperscript{53,66,67} and anatomical breast-shaped expanders with integrated injection ports\textsuperscript{11,71–74}.

**Adjustable implant reconstruction**

In order to avoid the need for a second stage in expander–implant reconstruction, permanent expander–implants were developed\textsuperscript{14,16,61}. The Becker expander/mammary prosthesis (Mentor Medical Systems, Wantage, Oxford, UK) and the Mcghan style 150 expandable breast implant (Inner Medical, Wokingham, UK) have an adjustable saline-filled inner lumen surrounded by a silicone gel outer lumen (25–50 per cent of the nominal implant size). The gel renders the implants more natural-feeling while the saline compartment allows volume adjustment. More recently Mentor Medical Systems has developed the Spectrum postoperatively adjustable prosthesis which is entirely saline filled (i.e. with no gel component) and is being used increasingly in the USA. The indications for adjustable implant reconstruction are similar to those for simple prosthetic reconstruction. The ideal candidates are those with: (a) anticipated or actual skin deficiency at mastectomy which precludes simple implant reconstruction; (b) contralateral ptosis that cannot be matched with a simple permanent implant (the overexpansion followed by deflation to the ideal volume achieves a good cosmetic result); and (c) large chest wall diameters with moderate obesity and hypertrophy or ptosis not severe enough to warrant mastopexy or breast reduction.

**Autogenous tissue reconstruction**

Immediate reconstruction using autologous tissue yields the most durable and natural-appearing results with the greatest consistency\textsuperscript{75}. It has several general advantages.

1. A large volume of the patient’s own tissue is available.
2. No prosthesis is required, obviating problems such as infection, extrusion, malposition and capsular contracture.
3. It is suitable for patients who do not want implants.
4. It offers unrivalled versatility, including creation of excellent ptosis and fill of the infraclavicular hollow and anterior axillary fold.
5. These tissues can withstand postoperative radiotherapy and can also be used in previously irradiated patients undergoing completion mastectomy for recurrence.
6. The excellent vascularity of the tissues leads to improved wound healing.

The autogenous tissues available in decreasing order of frequency of use are the TRAM, LD, superior gluteal, inferior gluteal, lateral transverse thigh and Taylor–Rubens peri-iliac flaps.

**Transverse rectus abdominis myocutaneous flap (Fig. 6)**

The TRAM flap, the most widely used autogenous tissue, was first described by Hartrampf \textit{et al.}\textsuperscript{18} in 1982 in Atlanta.
Conventionally, it relies on the blood flow through the deep superior epigastric pedicle within the rectus abdominis muscles to supply a horizontal ellipse of overlying abdominal wall skin and fat. The TRAM flap can be raised either as a conventional pedicled flap (based on the deep superior epigastric vessels) or as a microvascular free flap (based on the larger deep inferior epigastric vessels). Pedicled TRAM flaps can be ipsilateral or contralateral, unpiediced or bipediced, unilateral or bilateral, surgically delayed or immediate. Free TRAM flaps can utilize the full width of the muscle\textsuperscript{19,76}, be partial muscle sparing\textsuperscript{77,78} or, more recently, be total muscle-sparing perforator flaps\textsuperscript{79-84}.

The TRAM flap has become established as the ‘gold standard’ for breast reconstruction\textsuperscript{75,85}. It gives the most natural-looking breast with the most natural feel, and is associated with the fewest complications compared with all other reconstructive techniques\textsuperscript{4,86}. It also has excellent reliability and donor site cosmesis and so may be used preferentially unless there are compelling reasons not to do so. Its specific advantages are: (a) availability of a large volume of well vascularized autogenous tissue; (b) ability to withstand postoperative radiotherapy; (c) utility in sites of previous irradiation or tight chest wall skin; (d) good piosis (versatility in balancing the opposite breast even in the presence of piosis or a large contralateral breast); and (e) concomitant beneficial reduction of excess abdominal tissue (‘tummy tuck’) and the highly favourable donor site scar.

Contraindications include patients who do not want or cannot withstand a major operation, elderly patients, and the lack of adequate tissue from the abdomen such that implants are needed. Adverse risk factors include weight more than 25 per cent over the ideal, smoking, diabetes mellitus, autoimmune disease, psychological problems, abdominal scars and an inexperienced surgeon\textsuperscript{87}. Disadvantages of the TRAM flap include: (a) a major operation requiring exacting training and technique of the surgeon\textsuperscript{117}; (b) a longer operation (3–8 h depending on the variant) and longer hospital stay (5–10 days) compared with prosthetic or other reconstructions\textsuperscript{3}; (c) risk of partial or total flap loss; (d) increased possibility of blood transfusion\textsuperscript{1}; (e) risk of abdominal wall hernia and bulges; (f) frequent need for prosthetic mesh reinforcement of the abdominal wall; (g) a long transverse abdominal scar; and (h) increased general complications of major surgery such as deep vein thrombosis, pneumonia and adult respiratory distress syndrome\textsuperscript{87}. Significant complications may occur with the TRAM flap\textsuperscript{87} and their incidence is increased dramatically by obesity\textsuperscript{66,88}, especially if more than 25 per cent above the ideal body-weight, smoking\textsuperscript{89}, underlying systemic disease (diabetes, collagen vascular disease, hypertension), previous abdominal surgery and scars, and prior irradiation\textsuperscript{87,90}.

There are a number of options in TRAM flap technique designed to maximize its success and consistency while minimizing morbidity\textsuperscript{91,92}. The two main variants are the conventional (pedicled) and the free flap, with the latter relying on microvascular tissue transfer. In general, the free flap is preferred to the pedicled variant because of its reduced risk of localized fat necrosis and partial flap loss, owing to its more reliable blood supply\textsuperscript{77,93}.

**Single-pedicled TRAM flap**

This is indicated in patients who are non-smokers, not obese, with no peripheral vascular disease or diabetes mellitus. It is generally reserved for those aged below 60 years and, ideally, with a small-to-moderate volume requirement. It is also a good choice for bilateral reconstruction when a hemi-TRAM flap is used for each side.

**Double-pedicled TRAM flap\textsuperscript{91,94}**

The use of two rectus muscle pedicles increases the blood flow to the overlying skin and fat, thereby increasing the reliability and size of the flap. Its indications are limited because of the morbidity associated with abdominal wall damage and the effect on cardiorespiratory function. Because of its effect on the abdominal wall, young women are unsuitable for this procedure; it is also better avoided in the elderly because of compromise of respiratory function. It is used primarily to augment the circulation in obese patients, smokers, diabetics, and in those with peripheral vascular disease, chest wall irradiation and other microvascular risk factors. It is especially useful for patients in...
whom a large amount of tissue is needed on the chest wall, for example those with previous irradiation, inflammatory carcinoma, chest wall spread or recurrence. It is also useful in patients with midline scars from previous surgery. It is very controversial, however, with some claiming that it amounts to medical malpractice to use such a flap and others justifying it on grounds of reliability.

**Conventional TRAM flap with preoperative surgical delay**

In the surgically delayed TRAM flap, the dominant deep inferior epigastric pedicle is ligated or divided, thus increasing the blood flow through the deep superior epigastric vessels. This has the effect of increasing the viable dimensions of the pedicled flap, and decreasing flap necrosis in the high-risk patient. It also decreases the need for double-pedicled TRAM flaps and reduces venous congestion within the flap. It is indicated in high-risk patients who do not want a free flap, or when the reconstructive surgeon has no microsurgical skill or equipment. Specific indications for preoperative TRAM flap delay are: (a) smoker; (b) greater than 20 per cent of ideal body-weight (obese patients with abdominal pannus); (c) history of chest wall irradiation; (d) diabetes mellitus; (e) hypertension or cardiovascular disease; (f) patients with high volume requirements; and (g) autoimmune disease.

Although it is a simple and effective technique, it nevertheless carries some morbidity. It is often associated with asymptomatic localized seromas; infection, dehiscence and hernia are rare. The standard technique involves ligation and division of the ipsilateral deep and superficial inferior epigastric vessels. Sometimes the deep inferior and superior epigastric vessels on both sides are divided either through two separate incisions or one extended suprapubic incision. Classically this is undertaken 2-3 weeks before flap elevation, although 3 days may be all that is really needed to increase viability and reliability.

**Mid-abdominal TRAM flap**

In this variant, the horizontal location of the abdominal ellipse is moved up towards the mid or even upper abdomen in order to increase the blood flow to the overlying skin and fat. It exploits the concentration of the musculocutaneous perforating vessels in the periumbilical region and the location of the choke vessels just above the umbilicus. It has not achieved widespread use, perhaps because of the highly visible scar and the availability of other reliable TRAM flap variants. The mid-abdominal TRAM flap may avoid fascial closure below the umbilicus and so decrease the risk of weakness of the abdominal wall.

‘**Supercharged’ pedicled TRAM flap**

This involves reconnection of the opposite deep or superficial inferior epigastric vessels by microvascular anastomoses to recipient vessels in the axilla, while maintaining the other pedicle based superiority. Its main use is to rescue ‘struggling’ flaps, especially those with venous congestion as sometimes occurs in borderline high-risk patients undergoing immediate conventional TRAM flap reconstruction.

**Turbocharged** pedicled TRAM flap

In this variant the two deep inferior epigastric vessels are joined to each other by microvascular anastomosis as a loop to increase the circulation to the side contralateral to the pedicle. Its main use is to augment the blood flow of single-pedicled TRAM flaps in patients with lower midline abdominal scars.

**Free TRAM flap**

First described in 1979 by Holmstrom, the inferiorly based free TRAM flap relies on the more robust deep inferior epigastric vessels. It thus has better vascularity and less risk of ischaemia to its peripheral zones (and consequently less fat necrosis and partial flap loss) than the pedicled TRAM flap. It is the preferred TRAM flap technique in many centres.

This flap reliably carries a larger amount of skin and subcutaneous fat than the conventional TRAM flap. It is therefore desirable when large volumes of tissue are required and delay or bipedicled techniques are not feasible or desirable. It is the TRAM flap of choice in patients with risk factors (obesity, smoking, diabetes, peripheral vascular, autoimmune, and cardiovascular disease), and is ideal for those who have abdominal scars, especially upper abdominal scars. Its drawbacks are added theatre time, increased difficulty in performance and the possibility of total flap failure. The chances of total flap failure are 5–6 per cent, with a re-exploration rate of 10–15 per cent. With increasing experience of the operating team, these values should decrease to 1 and 3 per cent respectively. Although one of its key indications is cigarette smoking, patients who smoke have an increased risk of partial flap and fat necrosis, pneumonia and atelectasis. Ideally they should stop smoking several weeks before surgery and for 6 weeks thereafter. However, to avoid delay in cancer treatment, immediate free TRAM flap breast reconstruction is routinely undertaken even in those who continue to smoke up to the day of operation.
Free TRAM flaps may be used for both unilateral and bilateral reconstructions, and the former may be ipsilateral or contralateral. In immediate reconstruction, the choice of which side to base the vessels on depends largely on the recipient vessels for the microvascular anastomoses. Usually the vessels in the axilla (thoracodorsal or circumflex scapular) are preferred for microvascular anastomoses because they have been exposed by the breast surgeon during axillary dissection; the contralateral flap vessels are then preferred. If no axillary dissection is planned, either the internal mammary or axillary vessels may be used, depending on the preference and experience of the surgeon.\(^{87,110–112}\)

Comparisons with pedicled TRAM flaps show distinct advantages in favour of the free flap. Schusterman et al.\(^{106}\) reported 7 per cent partial flap loss or fat necrosis for the latter versus 13–41 per cent for pedicled flaps\(^{3,18,66,77,88,90,104,105,113,114}\). Fat necrosis is a common occurrence in pedicled flaps, with an incidence 10–50 per cent. This manifests as subcutaneous firmness which often causes anxiety in patients and surgeons in view of its differential diagnosis as recurrent cancer. There is also less rectus muscle and fascia harvested with free flaps and so a reduced incidence of abdominal wall bulges and hernias\(^{77,106}\). there is less functional muscle weakness\(^{115}\). The incidence of abdominal wall hernia after free flap reconstruction is 3–6 per cent\(^{77,106}\) compared with 12 per cent for pedicled flaps\(^{66,105,113}\). Free TRAM flaps avoid the bulge in the epigastrum that is often caused by tunnelling of pedicled flaps. In immediate breast reconstruction Elliott et al.\(^{104}\) found shorter hospital stays and a decreased incidence of fat necrosis with free flaps. However, in sharp contrast to all of the above, one study has shown no significant difference in outcome and complications between 53 pedicled and 72 free flaps after a 20-month follow-up\(^{116}\).

**Free deep inferior epigastric perforator flap**

The deep inferior epigastric perforator (DIEP) flap is the latest innovation in TRAM flap breast reconstruction which, in contradistinction to all the above variants, preserves the whole of the rectus muscle and sheath\(^{79,81,84}\). This flap is composed only of the essential parts required for reconstruction, i.e. skin and fat. It is based on one, two or three perforators of the deep inferior epigastric vessels. Vascularity is not compromised and the incidence of fat necrosis is no different from that of the standard free TRAM flaps\(^{80,83,84}\). The advantages of perforator flaps in general, and of DIEP flaps in particular, are the avoidance of muscle sacrifice, hernias and bulges, and decreased postoperative pain and hospital stay. It also avoids a tight fascial closure and the use of synthetic mesh. The former reduces pain and allows the patient to be mobilized on the first postoperative day with only oral analgesia\(^{80,117}\).

The operation involves a tedious and somewhat nerve-racking dissection that typically adds 1–3 h to the free TRAM flap harvest\(^{82}\). Despite current enthusiasm for this procedure to the extent that it is the main or only TRAM flap procedure undertaken in pioneering centres\(^{83,82,84}\), the indications are still being refined. It should, however, be the procedure of choice in: (a) young women (less than 55 years) requiring free TRAM flap breast reconstruction as they will benefit from an intact and previously unviolated abdominal wall for many years of their remaining life; (b) those who may later become pregnant and distend the abdomen (prevents hernia formation) even though pregnancy can be successful after pedicled TRAM flap surgery\(^{118}\); (c) athletic patients for whom abdominal wall integrity is important; and (d) those having simultaneous bilateral breast reconstruction, because the avoidance of sacrifice of the anterior rectus sheath and the rectus abdominis muscle significantly decreases donor site morbidity.

**Latissimus dorsi musculocutaneous flap (Fig. 7)**

The LD musculocutaneous flap was previously widely used for coverage of mastectomy defects. More recently it has regained popularity with advances in tissue expander and implant design\(^{51,52,54,55}\), the description of the total autologous LD breast reconstruction technique\(^{86,119–123}\) and endoscopic techniques of harvest\(^{124}\).

The flap is based on the thoracodorsal vessels and it may be transposed anteriorly for breast reconstruction as a musculocutaneous flap with a variable skin paddle, a muscle flap (unusual even for immediate reconstruction) or as an extended completely autogenous flap with overlying fat. Initially developed to provide cover for breast implants, it can provide enough soft tissue on its own to reconstruct small to moderately sized breast defects. Indications in immediate breast reconstruction include: (a) coverage of an expander–implant reconstruction (main use); (b) patients with skin insufficiency after mastectomy but who have insufficient lower abdominal tissue or are medically unfit for a TRAM flap; (c) previously irradiated patients undergoing completion mastectomy; and (d) reconstruction in patients who have already undergone an abdominoplasty or a TRAM flap procedure for the contralateral breast.

In immediate reconstruction following skin-sparing mastectomy the skin requirement is small or none, thereby allowing most or all of the LD skin paddle to be de-epithelialized and buried for increased projection. It is also an excellent option for salvaging partial TRAM flap necrosis in which debridement has left the patient with a distorted reconstructed breast\(^{125}\).
Fig. 7 Latissimus dorsi flap skin paddle utilizing a natural skin fold and demonstrating the angle of the scapula, surface marking of the latissimus dorsi muscle and its arterial supply

**Standard latissimus dorsi myocutaneous flap**

This is the commonest type of LD flap. The skin paddle on the back may be variously sited or oriented depending on the mastectomy defect. The oblique (superolateral to inferomedial) skin paddle column has the best blood supply as it is centred over the anterolateral border of the muscle. It is the easiest to design, raise and inset. The resultant low oblique scar can be easily hidden. This low oblique orientation ideally suits the chest requirements of modified radical mastectomy as the skin island and muscle both need to be located inferiorly. The transverse (horizontal) skin paddle column results in a higher transverse scar that can be easily hidden in the bra-line, unlike the preceding type. Patient input in the choice of scar is important. This design is ideal for radical mastectomy defects in which muscle replacement of the pectoralis major is required. It also places the scar inconspicuously in the bra-line. The oblique (superomedial to inferolateral) skin paddle (skin crease) is more appropriate for patients undergoing skin-sparing mastectomy because the orientation at flap inset is not a problem. The scar sits along the crease line producing the best cosmetic donor site. The excess skin is de-epithelialized and buried under the skin-sparing mastectomy skin flaps. In this situation, where little skin is required, the scar on the back can be reduced dramatically by endoscopically-assisted LD flap harvest.

**Extended total autogenous latissimus dorsi myocutaneous flap**

In this variety, most or all of the fat overlying the whole of the LD muscle is used to increase the bulk of the flap and so form a larger breast. In its classical form the harvest is at the level of Scarpa’s fascia. Another form, to increase further the bulk, involves a harvest at subdermal level. Significant obesity is one of the key indications for the autogenous LD musculocutaneous flap. Although obese patients have more than enough TRAM tissue, they are at high risk of abdominal wall complications and partial TRAM flap loss. Additionally, the obese have adequate thickness of fat on the back. The pedicled LD flap can be rapidly and safely harvested but it is important to leave enough subdermal or subcutaneous fat under the back skin to avoid skin flap necrosis. There is an increased incidence of seroma formation in obese patients but this is short lived and can be treated simply by aspiration.

The skin paddle in the total autogenous technique for immediate breast reconstruction can be a small straight ellipse that is oriented according to the patient’s preferred back donor site. The total autogenous technique is especially suitable for immediate reconstruction because the excess muscle and fat, which are folded underneath the skin paddle, contribute to the breast volume and this increased amount of tissue can be buried under the chest wall flaps to obtain projection ptosis. Although simpler than the TRAM flap and with a shorter recovery time, the volume obtained is often not as large. The final result is not as natural, and the donor site and contour deformity are not as well tolerated. The autogenous LD flap may be combined with an implant in extremely thin patients lacking adequate tissue at any other donor site. An expander technique is preferable because of the greater flexibility in choosing the final implant size and second-stage adjustment of the breast mound.

**Muscle flap**

In immediate breast reconstruction, the pure muscle flap alone is feasible only for skin-sparing mastectomy or subcutaneous mastectomy where no extra skin is required. It is especially amenable to endoscopic harvest, thereby avoiding large back scars. Its commonest use is to provide muscle coverage for an implant or expander. The advantages of the LD flap are its reliable robust blood supply, associated with the versatility of the skin paddle orientation, and the ease and speed with which it can be performed. The hardy blood supply allows it to be used safely in patients who are high-risk candidates for a pedicled TRAM flap. It involves a much smaller operation than the TRAM flap and gives predictable results with few complications. The scar on the back may be minimized with endoscopic techniques or counterincisions in the axilla.

The drawbacks of the LD flap of specific relevance to immediate reconstruction relate to the donor site, the flap and the (often associated) prosthesis. The commonest postoperative complication is seroma formation at the back.
donor site and this often requires repeated aspiration before it settles. Its reported incidence ranges from 9 to 33 per cent\(^{123,126-129}\). Significant flap necrosis is rare and is nearly always associated with recognized or unrecognized injury to the vascular pedicle\(^{126,130,131}\). Partial flap necrosis occurs in up to 7 per cent of cases, but is more common in the extended total autogenous variant, or when the skin paddle is placed too distally over the aponeurotic part.\(^{22,121,123,126,127,131}\) Capsular contracture in association with combined LD flap and silicone gel breast implant reconstruction was historically common (up to 40 per cent)\(^{126,127,132,133}\). When the LD flap is used with saline-for-gel substitution and prosthetic surface texturing, significant capsular contracture is unusual.\(^{126,134}\) Slippage of the expander or implant through the axilla and into the back is rare but is more likely to occur in immediate reconstruction because of the wide communication between the mastectomy, axillary dissection and back donor sites.\(^{126}\) It can be prevented by suturing the LD muscle to the lateral chest wall.

**Other autogenous tissue techniques**

Although these all require microvascular surgical transfer, they are important secondary choices. Because of the uniform requirement for microsurgical expertise and the excellent results obtained from TRAM and LD flap reconstruction, their use is restricted to patients seeking autogenous tissue reconstruction who: (a) have insufficient abdominal or back tissue; (b) do not want scars on the back or abdomen; (c) have had numerous previous abdominal or chest wall operations precluding the use of TRAM or LD flaps; (d) have previously used the TRAM flap for an earlier unilateral breast reconstruction or an abdominoplasty; and (e) have had a failed pedicled or free TRAM flap.

**Superior gluteal free flap**

The gluteus maximus myocutaneous free flap for breast reconstruction was first introduced in 1983 by Shaw\(^{110,113}\). The superior gluteal free flap is based on the superior gluteal artery and vein. Although a large amount of vascularized fat and overlying skin can be reliably moved to the chest wall to create a new breast, its size depends on the size of the patient’s buttocks. The donor site is well hidden and matches the opposite side quite well in individual cases.

**Inferior gluteal free flap**

The inferior gluteal free flap\(^{23,24,136}\) is preferred to the superior version because of its longer vascular pedicle, which is easier to dissect, and because even in the thin patient it has more available tissue. The natural breast contour and shape obtained stem from its thickness, consistency and the large amounts of fat and skin available. It has excellent vascularity and only a small amount of muscle is needed to provide musculocutaneous perforators for the much larger overlying skin and fat island. Its drawbacks include the need for microsurgery, repositioning during the operation and (frequently) the need for vein grafts to establish microastomoses on the chest wall. It also requires a more difficult dissection than free TRAM flap harvest. The inferior gluteal donor site scar can sometimes be painful. Sciatica may result from taking too much muscle with the flap, thereby leaving the sciatic nerve devoid of a suitable pad. Seroma is also frequent at the donor site.

**Gluteal perforator free flaps**

Both the superior and inferior gluteal flaps can be raised as perforator flaps, totally preserving the muscles and utilizing only the skin and fat.\(^{117}\) The superior gluteal perforator flap has been used successfully for immediate reconstruction.

**Lateral transverse thigh flap**

The lateral transverse thigh flap uses skin and fat from the upper lateral thigh based on the lateral circumflex femoral vessel blood flow into the tensor fascia lata muscle.\(^{17,25}\) It may be utilized either unilaterally or bilaterally. In the latter, the two transfers may be performed simultaneously or staged from a few days to a month apart. Its disadvantages are the more visible scar on the lateral thigh compared with TRAM or gluteal flap scars, the need for microsurgery, and donor site seromas which can be persistent.\(^{17}\) It also creates a contour deformity in the upper thigh. As for the Taylor–Rubens flap, the unilateral donor site usually requires a balancing procedure on the opposite side; this may be achieved with liposuction.

**Taylor–Rubens peri-iliac free flap**

This consists of the skin and soft tissue portion of the deep circumflex iliac artery flap described by Taylor \(et\ al\). in 1979\(^{137,138}\). Its indications are the same as for the other non-TRAM, non-LD, autogenous tissue reconstructions. It is an ideal alternative when the TRAM flap is not available because the patient has previously undergone a TRAM flap procedure or abdominoplasty. Another specific indication is in patients in whom there is insufficient lower abdominal fat, but adequate fat in the flank and peri-iliac crest area. Its
main drawback is the violation of the integrity of the lateral abdominal wall and the possibility of flank herniation if the donor site is not closed properly.

Inframammary fold

The inframammary fold is a key landmark in defining the breast contour and it is very important that it is not destroyed during mastectomy. Marking its position, such that it is clearly visible during operation, helps to avoid its unnecessary violation. However, if it is destroyed it may be recreated during surgery before insertion of the prosthesis using the internal suturing technique, carefully avoiding inadvertent exteriorization of the sutures (an infection risk). Other techniques of recreating the inframammary fold are more appropriate for delayed reconstruction or expander-to-implant exchange; such detail is beyond the scope of this review.

Aesthetic, oncological and psychological considerations

Skin-sparing mastectomy

Skin-sparing mastectomy was introduced in 1991 by Toth and Lappert. It entails the careful preoperative planning of mastectomy skin incisions with the express aim of maximizing skin preservation in order to facilitate reconstruction of the breast mound and enhance its aesthetics. It removes the breast, nipple–areolar complex, previous biopsy incisions (if feasible) and skin overlying superficial tumours. The use of skin-sparing incisions does not increase the complication rate or compromise local disease control. Kroll et al., for instance, reported only one local recurrence after a 2-year follow-up of 100 patients with breast cancer treated by skin-sparing mastectomy and immediate reconstruction.

Preoperative and perioperative communication and cooperation between the oncological surgeon and the reconstructive surgeon is vital to ensure success of skin-sparing techniques. The reconstructive advantages are that preservation of the native skin reduces the amount of tissue transfer required, while preservation of the inframammary fold and native skin envelope facilitates breast shaping during reconstruction and reduces the extent of balancing surgery on the contralateral breast needed to achieve symmetry. In addition, the periareolar incisions are inconspicuous. It is technically more demanding and time consuming than a modified radical mastectomy. The skin flaps must be handled gently to avoid ischaemic complications and the procedure should be used with caution in smokers or those who have had chest wall irradiation. A recent review of the Emory University experience of 331 cases of skin-sparing mastectomy described a 10 per cent incidence of native skin flap necrosis. In practice, most skin-sparing mastectomies are followed by autogenous tissue reconstruction, especially with the TRAM flap. When tissue expander reconstruction is used, it is often possible to close the circular periareolar incision completely with a purse-string suture.

Oncological considerations

Breast reconstruction after mastectomy was traditionally performed as a delayed procedure because it was feared that immediate reconstruction would delay or increase the complications following adjuvant treatment, such as radiotherapy or chemotherapy. An additional concern was that the presence of a reconstructed breast might delay or interfere with the diagnosis of local recurrence. The incidence of local recurrence following mastectomy and immediate reconstruction of all types ranges from 0 to 11 per cent. Several of the relevant studies compared patients who had reconstruction with those who did not have immediate reconstruction, and no significant difference in local recurrence was detected once the groups had been corrected for tumour size, grade and node positivity. It is well documented that the majority of local recurrences are located in the skin flaps following mastectomy. Slavin et al. reported that all local recurrences following reconstruction were detected on follow-up clinical examination, and that no delay in diagnosis was due to the reconstructed breast. Furthermore, the presence of a reconstruction did not compromise the treatment of recurrence. Women undergoing immediate breast reconstruction have similar survival rates to women who do not have reconstruction. Furthermore, there is no significant difference in survival between patients who undergo immediate or delayed reconstruction.

Immediate reconstruction does not delay the administration of adjuvant radiotherapy or chemotherapy. It has been suggested by some that early complications of reconstruction might delay chemotherapy, but others have found that this is not so. Rosen et al., for instance, found no delay in administering adjuvant chemotherapy in 23 patients following reconstruction with either tissue expansion or myocutaneous flaps. In a non-randomized comparison of pedicled and free TRAM flaps, Schusterman et al. found a non-significant trend towards less delay in chemotherapy in patients who had free TRAM flaps. Significant additional morbidity with delay of chemotherapy has not been noted with either breast implants or autogenous tissue.
The morbidity associated with reconstruction may be increased by the various adjuvant therapies for breast cancer, and the cosmetic results may be worse than in those not subjected to adjuvant treatment. This is especially so with radiotherapy and prosthetic reconstruction. Dickson and Sharpe found a significantly increased risk of capsular contracture in prosthetic recipients who had postoperative radiotherapy. This has been confirmed independently by others. Barreau-Pouhaer et al. reported an increased risk of implant failure in patients undergoing postoperative radiotherapy where ‘failure’ was defined as implant removal. Expanding irradiated tissues is more difficult and painful, and the final reconstructed breast is often too small and hard, without natural ptosis. Patients who undergo adjuvant chemotherapy and radiotherapy also have worse cosmetic results than those not subjected to adjuvant treatment. The effect of radiation on reconstruction performed using myocutaneous flaps has been the subject of recent attention. Hunt et al. found no significant increase in complications following TRAM flap reconstruction and radiotherapy in a group of 19 patients. Zimmerman et al. studied 21 patients who had free TRAM flap reconstruction followed by radiotherapy. They found no flap-related complications, and the cosmetic results were rated good to excellent by 90 per cent of the patients. In contrast, the Emory University group found radiation changes in ten of 19 TRAM flaps subjected to postreconstruction radiotherapy and six of these patients consequently required surgery to the flap. In general, however, TRAM flaps tend to tolerate irradiation well and so, if radiotherapy is required, it is sensible to avoid prosthetic reconstruction and preferentially resort to autogenous reconstruction.

Contralateral breast

When the reconstructed breast cannot match its partner, reduction mammoplasty and mastopexy are routinely undertaken to improve symmetry; this is done at the time of mastectomy and immediate breast reconstruction. This allows greater flexibility for second-stage revision and should reduce the overall cost of breast reconstruction. The breast reduction technique should avoid fat necrosis or excessive internal scarring. Liposuction of the breast during the reduction should be avoided because of the possibility of inducing macrolcification. Occasionally breast augmentation to achieve symmetry is indicated. While mastopexy and reduction cause some alteration of the mammographic image of the normal breast, such change does not generally interfere with surveillance. In contrast, augmentation mammoplasty (especially subglandular placement) changes the ability to interpret postoperative mammograms and implant displacement mammography techniques are required.

Immediate nipple reconstruction

Creating a nipple–areolar complex is an integral part of breast reconstruction. It enhances the final cosmetic result, creates a more realistic and more natural-looking reconstructed breast, and significantly increases patient satisfaction. There are numerous techniques for nipple reconstruction. Free grafts of tissue may be taken from the contralateral nipple (nipple sharing), ear lobe, labia minora or toe pulp.

Nipple sharing allows a perfect match of colour and texture, but may overly reduce and distort the otherwise normal donor nipple, and reduce its sensation, while producing only slight projection of the new nipple. It is reserved for patients willing to sacrifice 50 per cent of the height of a prominent nipple on the normal breast. Worldwide, the commonest method of nipple reconstruction is the use of local flap techniques based on the new breast mound such as the skate/quadrapod, modified skate, mushroom, star, C–V, S, maltese cross and other flaps. The choice of technique is largely dependent on the experience of the surgeon. It is important to remember that, with time, almost all flap techniques lose more than 50 per cent of their size in terms of projection.

Immediate nipple reconstruction is feasible but requires well vascularized autogenous tissue such as the free TRAM flap or the total autogenous LD flap. It involves creating a central ‘dog ear’, i.e. leaving excess tissue on the flap at the proposed location of the nipple. At present it cannot be recommended because exact nipple location is difficult. In addition, it may compromise the blood supply to the breast flap or to the nipple flap.

Immediate areolar reconstruction with a skin graft from the inner thigh, labia minora, opposite areolar or trunk dog ears has now been superseded by later intradermal tattooing of the skin that surrounds the newly reconstructed nipple. This is carried out 2–3 months after nipple reconstruction. Areolar sharing, unless it is carried out at the time of a planned contralateral breast reduction, can significantly distort the otherwise normal-looking nipple–areolar complex. Although tattooing of the nipple–areolar complex can be undertaken before nipple reconstruction, it is mostly undertaken afterwards, as popularized by Spear et al. Artificial nipples may be used; although they look realistic they have not gained popularity with patients.
Psychological considerations

Although this is a complex subject, it is well recognized that early breast reconstruction significantly reduces the psychological morbidity of mastectomy. There are many psychological effects of mastectomy. Notable among these are feelings of mutilation and altered body image, diminished self-worth, loss of a sense of femininity, and decrease in sexual attractiveness and function. Anxiety, depression, hopelessness, guilt, shame, fear of recurrence and abandonment. Most difficulties in the long term, however, relate to body image and sexual functioning.

It is anticipated that immediate reconstruction will spare women the pain of disfigurement and loss that accompanies mastectomy. Women undergoing immediate reconstruction not only have high levels of satisfaction with the surgical results, but also significantly less psychosocial morbidity than those undergoing mastectomy alone. They are less depressed, and experience less impairment of their sense of femininity, self-esteem and sexual attractiveness than their peers who delayed or did not seek reconstruction. They also tend to accept the new breast as an integral part of their body. They have significantly less ‘distress’ in recalling the surgery, are less likely to be ‘repulsed’ by their own naked appearance, and have more freedom to dress than women who do not have reconstruction. However, there may be a selection bias in these results in that patients who want and demand immediate breast reconstruction may be a self-selected and well-motivated group who therefore show the most benefit.

The psychological benefits of immediate breast reconstruction are greater than those of delayed reconstruction and compare favourably with breast conservation therapy in psychosocial outcome. In one comparison of immediate versus delayed breast reconstruction, there was lower postoperative psychological morbidity in the former. In an uncontrolled study, Noone et al. found improved self-image and less psychological turmoil following immediate reconstruction. In another non-randomized study, Dean et al. demonstrated significant psychological advantages to immediate reconstruction compared with delayed reconstruction. Schain found that women who underwent immediate or early reconstruction (less than 1 year after mastectomy) had significantly less recalled distress regarding the mastectomy than women who had a delayed reconstruction. Patients seeking reconstruction after mastectomy are primarily motivated by a desire for wholeness. Handel et al. examined the reasons why women did not have reconstruction following mastectomy, and found that advanced age, concern about complications from more extensive surgery, uncertainty about the outcome and anxiety about the effect of reconstruction on breast cancer all deterred women from reconstruction. Marital status, need for adjuvant therapy, or personal experience of poor results from reconstruction did not influence decision-making. More recently, Rosenqvist et al. found high levels of patient satisfaction following immediate reconstruction, although they point out that high levels of preoperative information and psychological support were necessary.

However, the advantages of breast reconstruction may not be universal. It was suggested in one early study that the initial differences in adjustment between reconstructed and non-reconstructed patients might be minimal and disappear with time. Similarly, Rolland suggested that satisfaction with the technical aspects of the reconstructive outcome might be slightly lower among those reconstructed patients. This large prospective study of women’s response to reconstruction found that the greater the time since mastectomy, the greater the patient’s satisfaction with the overall results of the reconstruction.

Health economics

This area is poorly addressed in the literature. In a direct comparison of costs to hospitals, delayed breast reconstruction was 62 per cent more expensive to perform than immediate breast reconstruction after completion of the entire reconstruction process, including nipple–areolar reconstruction. Although the initial costs of prothetic reconstruction are lower than those of autogenous tissue reconstruction, with time the costs of the former increase significantly for a number of reasons. The prime reason is the need for revisional surgery with prothetic surgery. Tissue expanders need to be exchanged for permanent implants, capsular contracture needs reoperation plus implant exchange, and deflated or ruptured implants need replacement. A study comparing the cost of TRAM flaps and prothetic reconstructions found that the long-term cost of TRAM flap reconstruction did not increase as much as that of implant-based reconstruction and was cumulatively lower than that of tissue-expander implants. This differential cost is likely to increase with time.

Conclusion

Immediate breast reconstruction is a safe and acceptable procedure after mastectomy for cancer. There is no evidence that it has oncologically untoward consequences. In the appropriate patient it can be achieved effectively with either prothetic or autogenous tissue, but careful patient selection is important to optimize results and minimize...
complications. Careful counselling of the patient about available options and the need for future revisional surgery, particularly with prosthetic reconstruction, is important. Ideally, the oncological and reconstructive surgeons should discuss and plan surgery together, and communicate closely during the operation (especially in skin-sparing mastectomy and autogenous reconstruction). Although autogenous tissue techniques give the best aesthetic and most natural results, they are a more significant surgical undertaking. Finally, it should be appreciated that recent innovations in expander and implant design have made the results of prosthetic reconstruction more predictable.

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