Surgical techniques in breast cancer: an overview

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Abstract

Breast cancer is the most common female cancer and its incidence continues to increase. Ongoing advances in adjuvant treatments have resulted in declining mortality rates with increasing numbers of women surviving their breast cancer diagnosis. While the primary outcome of surgery remains oncological efficacy, the contemporary breast surgeon must consider the long-term aesthetic outcome of the procedure and the inevitable impact on body image and self-esteem. There has been a paradigm shift in breast surgery in the UK over the last 20 years with the widespread provision of oncoplastic breast surgery techniques now representing the standard of care. As the role of breast conserving surgery has been extended by therapeutic mammoplasty and the use of neoadjuvant treatments, mastectomy rates continue to decline. The widespread introduction of sentinel node biopsy has fostered an increasingly conservative approach to axillary surgery. Nationally, rates of immediate breast reconstruction following skin-sparing mastectomy continue to rise. Yet the National Mastectomy and Breast Reconstruction Audit highlighted the disparities in care and wide variation in practice that still exists in the UK. Whilst breast reconstruction is widely practiced, the adoption of the Oncoplastic Breast Surgery Best Practice Guidelines and engagement with long-term follow-up studies focusing on patient-reported outcome measures will hopefully result in a consistently high standard of care.

Keywords Breast implant; lipomodelling; mammoplasty; neoadjuvant; oncoplastic; reconstruction; surgery; techniques

Introduction

Breast cancer is the most common female cancer worldwide and in the UK. Though over the last 30 years there has been successive improvements in the adjuvant treatments of breast cancer, surgery remains the single most important modality in effecting its cure. With the 5-year overall survival rate for breast cancer exceeding 85% and the 10-year survival rate approaching 80% in the UK (http://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer/survival), the modern breast surgeon has to consider the long-term aesthetic outcome of breast surgery as well as the oncological effectiveness of the operation. In this chapter we will explore the advances in breast conservation surgery and the role of reconstructive surgery.

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Breast conservation surgery

Historically and up to the mid-1970s the surgical treatment of breast cancer was largely limited to mastectomy. From the mid-1970s a number of large randomized controlled trials (RCTs) comparing breast conservation surgery (BCS) with mastectomy demonstrated that, with the addition of whole breast radiotherapy, where a tumour had been completely excised from the breast with adequate margins, survival was equivalent.[1–3] However, these successive trials, which eventually included tumours up to 5 cm in size, showed that there was an increased rate of local recurrence following BCS (1% per annum compared to 0.5% per annum), but this was not translated to an inferior overall survival. More recent evidence supports at least equivalent loco-regional control following BCS.[4] Furthermore, there is growing evidence that BCS plus radiotherapy may offer a slight disease-free survival (DFS) advantage over simple mastectomy alone.[5,6]

Since the establishment of BCS its application within the management of breast cancer has been expanded by the adoption of oncoplastic techniques. Rather than the recommendation of mastectomy being made on absolute tumour size alone, it is now more appropriate to consider the ratio of the volume of the required excision to the total breast volume. In selected cases using some of the more complex oncoplastic approaches, tumour excision volume up to 50% of total breast volume can be managed with BCS. The randomized trial evidence of the oncological safety of BCS for tumours exceeding 5 cm is lacking but there is increasing evidence in some case series that this approach is acceptable. In his paper on the classification of oncoplastic breast surgery[7] Krishna B Clough describes two levels of oncoplastic procedures: level 1 procedures for tumour to breast ratios <20% requiring local glandular rearrangement and level 2 procedures for lesions between 20% and 50% where a therapeutic breast reduction (mammoplasty) may be required.

Oncoplastic breast surgery techniques, once the preserve of the specialized breast surgeon, should now be considered the standard approach to all breast conservation surgery. These basic principles are: incision placement and access to the tumour, glandular rearrangement to avoid local defect in breast contour, and steps to negate nipple displacement.

There are few situations where a tumour excision requires an incision placed on the cosmetically sensitive breast mound. The majority of breast cancers can be accessed via a circumareolar incision or an incision of the breast mound in the inframammary fold (IMF) or the lateral breast fold (Figure 1). The key to the success of these approaches is to use an incision of adequate length for the IMF or lateral incisions (a long sympathetically place incision is far superior to a short poorly placed one), and adequate elevation of the skin off the breast tissue in the mastectomy plane. This extensive superficial de-gloving of the breast allows not only excellent access for tumour excision, but also the mobilization of the surrounding breast tissue to reshape the breast.

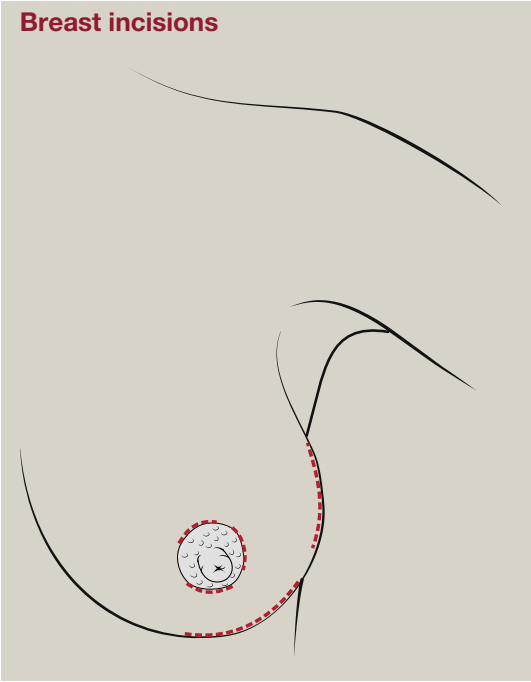


Figure 1

Once adequate exposure is achieved then the tumour should be excised in most cases as a full-thickness block extending from the mastectomy plane below the skin to the pre-pectoral fascia. In cases when the full thickness of the breast depth has not been excised, this should be noted at the time of the operation as it will need to be considered when the postoperative pathology is discussed at the multidisciplinary meeting. All breast conservation specimens should be orientated as agreed by local protocol to allow pathological assessment of radial margins. The excision cavity should be marked with titanium clips as in some cases the tumour bed may be targeted with a boost of radiotherapy and this facilitates CT planning of radiotherapy fields.

In cases where the tumour excision volume is less than 20% (level 1 procedures), the breast glandular tissue can then be rearranged to obliterate the excision cavity. This may well require some mobilization on the glandular tissue off the pre-pectoral fascia to allow a tension free closure of the cavity. This is usually not problematic but should be used cautiously in the sub-optimal patient (i.e. diabetics or smokers) or in patients with excessively fatty breast tissue to minimize the risk of fat necrosis. The diligent obliteration of the resection cavity is essential to reduce the incidence of local volume defects following adjuvant radiotherapy.

In some cases, especially in smaller breasted patients, careless resection of a tumour much smaller than 20% breast volume can lead to poor long-term aesthetic outcomes. Special consideration should be taken with tumours located in the upper inner quadrant of the breast where any defect in this cosmetically sensitive area is distressing to the patient, and to tumours of the lower pole where glandular excision can lead to a pronounced 'bird beak' deformity of the breast. In these cases a small therapeutic mammoplasty or mastopexy should be considered.

When the excision volume exceeds 20% of the breast, it is likely that in addition to the glandular resection, there will have to be an element of skin envelope reduction and relocation of the nipple areolar complex. To achieve this it is necessary to use a therapeutic mammoplasty. There are a multitude of techniques to perform a breast reduction. These were developed predominately as cosmetic plastic surgical operations but have been utilized to resect tumours from all locations within the breast. It is essential that the modern breast surgeon is familiar with a number of these operations to provide them with the tools to approach tumours of various sizes in all the breast quadrants.

Essentially, a therapeutic mammoplasty consists of an incision pattern to incorporate a skin envelope reduction, a glandular resection of the desired region of the breast and a dermoglandular pedicle to maintain the nipple areolar complex in its new position. The choice of method is dependent on the tumour location, the volume of resection required, the skin envelope reduction required and the desired new nipple areolar complex position.

Incision patterns include Wise pattern, vertical scar, round block (Benelli), bat wing and melon slice, to name a few. The nipple areolar complex may be maintained on a superior, superior medial, superior lateral, inferior of central mound pedicle. An extended or secondary pedicle may be required to fill a defect not included in the traditional mammoplasty pattern.

The obvious advantage of the therapeutic mammoplasty is the ability to excise relatively large tumours while minimizing the cosmetic defect. It is also suggested that there is reduced morbidity associated with the whole breast radiotherapy given to the excessively larger breast. It is therefore not unreasonable to consider a therapeutic mammoplasty for larger breasted women with relatively small tumours for this reason. This surgery carries higher complication rates than simple level 1 techniques predominantly in relation to wound healing, but there is no evidence that this causes a significant delay to a patient's adjuvant treatment.

When a therapeutic mammoplasty is performed, contralateral symmetrising surgery should be considered and it is reasonable to perform this simultaneously. With relatively small reductions it is reasonable to delay the symmetrising surgery until after the adjuvant radiotherapy as there is a degree of unpredictability of the response of the treated breast to radiotherapy and the asymmetry may not be excessive or troublesome to the patient (Figure 2).

There may be cases when the tumour-breast ratio, while not necessitating a mastectomy, exceeds the glandular volume available to fill the defect. These patients may be considered for breast volume replacement in the form of a local flap. These flaps are most commonly based upon the lateral chest wall vessels (LICAP/TDAP flaps) or the vessels of the upper abdominal wall (AICAP/MICAP) (Figure 3). These operations may be carried out in a single procedure or staged to ensure complete tumour excision before the volume replacement flap is performed.

One-third of breast malignancies in the UK are diagnosed as a result of the NHS Breast Screening Programme. To facilitate BCS the majority of these tumours require localization preoperatively as they are impalpable. This is traditionally achieved using the placement of a fine guidewire under image control on the day of surgery. Advances on the guide wire technique include the placement of a radioactive iodine-125 seed or alternatively a magnetic seed into the tumour in advance of the surgery. The

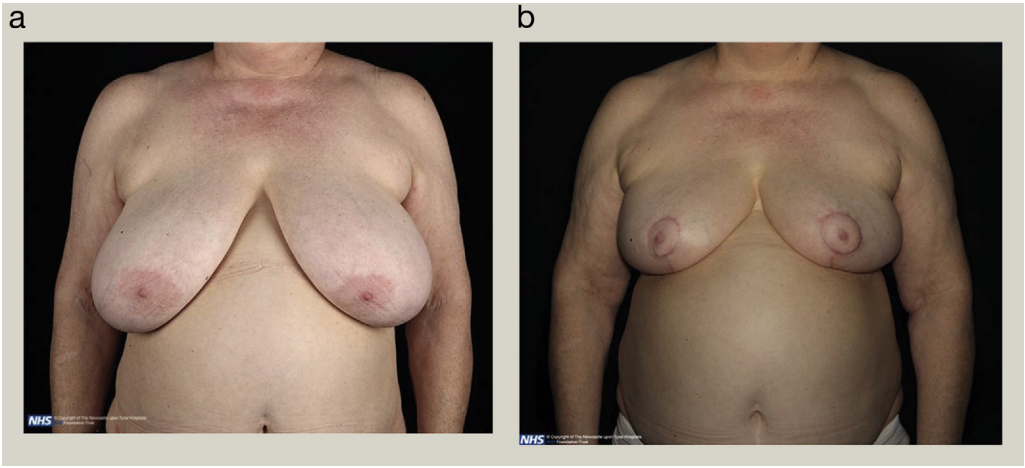


Figure 2 Therapeutic mammoplasty. **(a)** Preoperative; 40 mm multi-focal disease upper half of left breast. **(b)** Postoperative; left therapeutic mammoplasty and right breast reduction.

seed can then be accurately localized using either the gamma probe or magnetic probe and the excision performed with an X-ray of the specimen to confirm seed and tumour excision (Figure 4).

The development of various advanced techniques in breast conservation surgery has raised the possibility of resecting multiple tumours from a breast whilst leaving a cosmetically acceptable result. All the major randomized studies which established the oncological safety of breast conserving surgery excluded multi focal and multi centric breast cancers. There are, however, some increasingly large cohort studies that appear to demonstrate that if the excision of each tumour is adequate and adjuvant whole breast irradiation is used then recurrence rates are acceptably low. It does have to be recognized that multi-

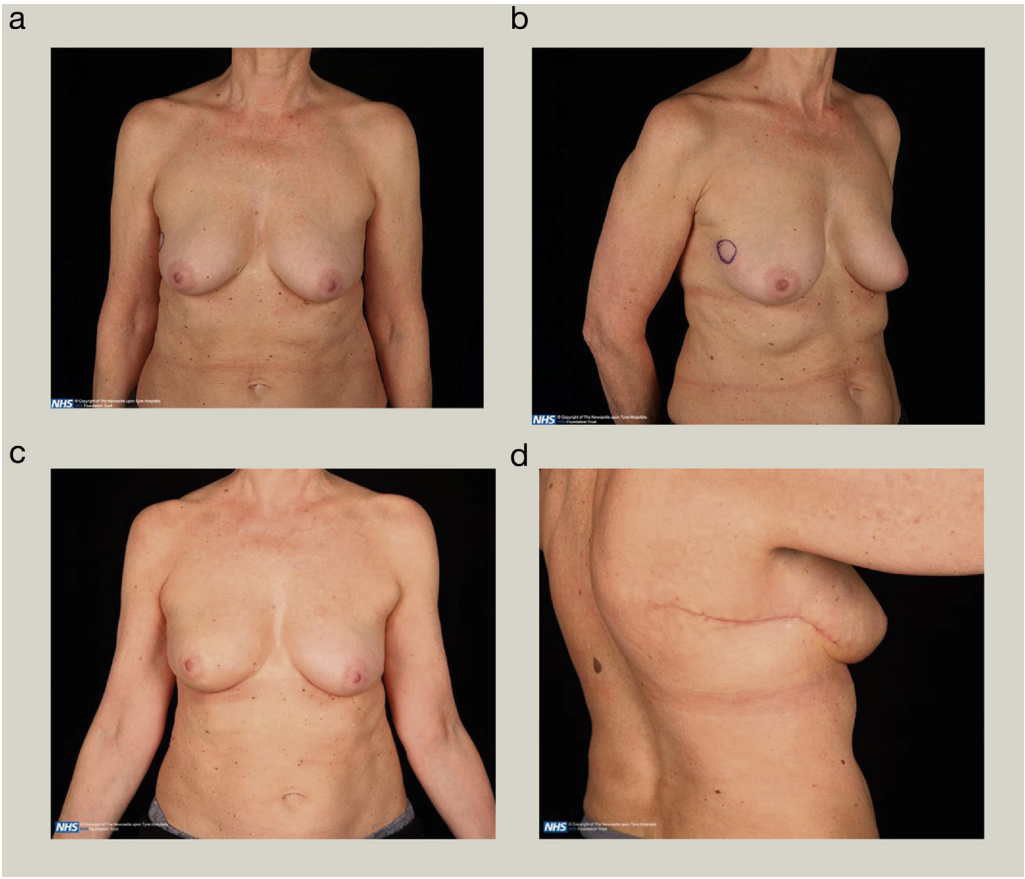


Figure 3 LICAP flap for partial breast reconstruction. **(a & b)** Preoperative; quadrantectomy required for 3 cm tumour of the right upper outer breast. **(c)** Postoperative; breast shape and volume maintained. **(d)** Donor site of LICAP flap.

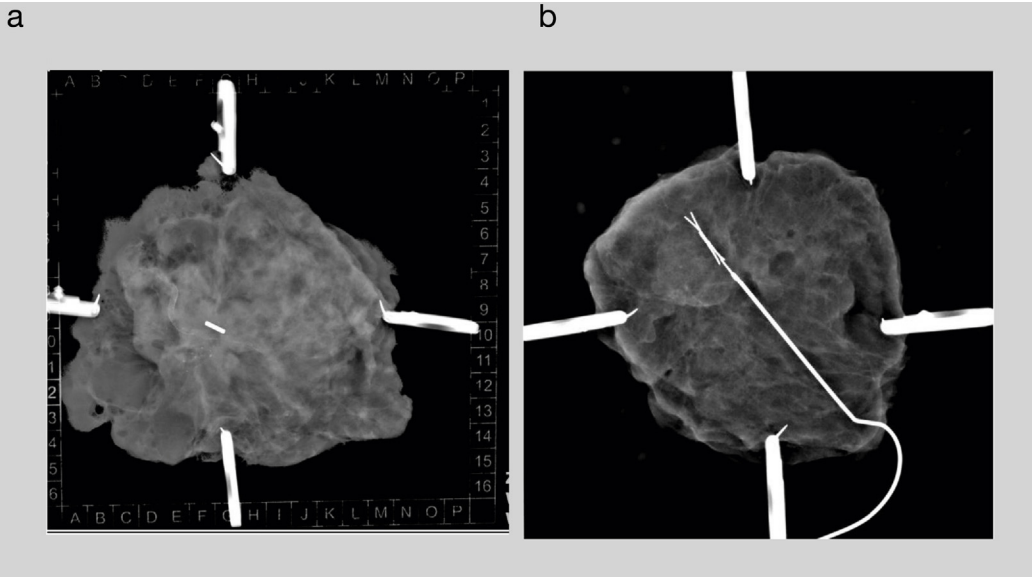


Figure 4 Impalpable tumours. **(a)** I^{125} Seed localized tumour. **(b)** Guidewire localized tumour.

focality of breast cancer is associated with a poorer outcome irrespective to the type of surgery performed.

As surgery for breast cancer evolved from the mastectomy era to BCS there has been a parallel evolution in the concept of adequacy of clear excision margins. Relatively recently it was routine to aim for microscopic excision margins in excess of 5 mm since it was thought that ever larger excision margins would decrease local tumour recurrence. Many clinicians thought that this was especially true in cases of unfavourable pathology such as high-grade or triple-negative disease. There have been two recent consensus statements on this issue, ASCO April 2014 and St Gallen Consensus 2017.[8,9] In both of the resulting statements it is suggested that 'no ink on invasive tumour' (i.e. microscopically clear margin is all that is required). This is irrespective of the tumour or patient type, and larger margins do not improve the outcome in poorer tumours. The St Gallen guidelines did recommend a 2 mm margin for DCIS with no invasive disease present. Current ABS guidelines recommend a 1 mm margin to both invasive cancer and DCIS. It is, however, recognized that microscopically involved margins are associated with an increased local recurrence rate.

The axilla, and its involvement or not with breast cancer, is still the most important independent prognostic indicator of survival. All patients diagnosed with a breast malignancy should have their axilla staged preoperatively with an USS plus tissue sampling with FNA or core biopsy.

Currently patients with a preoperative confirmed diagnosis of more than two malignant axillary nodes are directed to an axillary clearance. A standard approach is to perform a level 2 axillary clearance to the level of the superior boarder of pectoralis minor at the time of the primary breast surgery. This should contain at least ten lymph nodes.

Patients with an invasive cancer and preoperative stage negative axilla should have surgical staging of the axilla with a sentinel node biopsy. The sentinel node procedure is carried out following the injection of Tc99 into the subdermal lymphatic plexus, usually of the upper outer quadrant of the nipple areolar complex. The may be followed by an intraoperative injection of blue dye at the time of surgery. Up to four hot or blue nodes should be taken during the procedure and this may be via an axillary hair line incision or via the same incision for the breast operation if technically feasible. There are some novel techniques in development for the localization of the sentinel node, the most established is 'Sentimag', which involves replacing the Tc99 with a ferrous metal nano-colloid and then utilizing a magnetic detection probe.

Treatment of the positive sentinel node biopsy is discussed in *Management of breast cancer* on pages 157-163 of this issue.

Mastectomy

The 2015 UK NHS Breast Screening Programme Audit of screen-detected breast cancers reports an overall mastectomy rate of 21% in over 20,000 patients undergoing surgery.[10] While there remains significant variation in mastectomy rates between different screening units, the overall trend is of gradually declining mastectomy rates. Only 13% of patients with a small (<15 mm) invasive cancer underwent mastectomy, the lowest rate ever recorded (21% in 2000/01). Multiple factors have contributed to this change in practice including; widespread acceptance and availability of oncoplastic breast surgery (OPBS) techniques such as therapeutic mammoplasty, therefore extending the role of breast conserving treatment (BCT); the increasing use of neoadjuvant treatment to downsize cancers thereby facilitating BCT; improved access to adjuvant radiotherapy for patients in rural areas; and, ultimately, patient choice. Traditional surgical paradigms of central tumours, multi-centric tumours or those >4 cm requiring mandatory mastectomy are being increasingly challenged.

Absolute indications for mastectomy include;

- inflammatory cancers (T4d) following neo-adjuvant chemotherapy
- contraindication to radiotherapy, e.g. Li Fraumeni syndrome

- patient choice.

Relative contraindications for mastectomy include recurrent breast cancer following previous BCS radiotherapy.

While the NHSBSP 2009 guidelines recommend that patients with >40 mm or multi-centric non-invasive disease should usually undergo mastectomy,[11] the 2015 NHSBSP audit demonstrated only 88% of patients undergoing surgery for invasive cancers > 5 cm received mastectomy.

The Oncoplastic Breast Reconstruction (OBR) Guidelines published in November 2012 were developed by a multidisciplinary working group including patient representation in order to inform breast cancer multidisciplinary teams (MDTs) and champion 'best practice' in OPBS.[12] The guidelines were necessary due to the widespread delivery of OPBS throughout the UK in a relatively unregulated environment. This was set against the context of the findings of the National Mastectomy and Breast Reconstruction Audit (NMBRA), which aside from highlighting a broad range of new quality metrics and benchmarks of care in OPBS, also focussed attention on the disparities of care in relation to preoperative information, available reconstructive options, Patient-reported outcome measures (PROMs) and perioperative pain management.[13] These OBR guidelines proposed 25 quality criteria including 'OPBS is discussed in 100% of patients requiring a mastectomy'.

Techniques of mastectomy

Simple mastectomy: the psychosocial impact of simple mastectomy can be huge, with loss of confidence, body image and self-esteem commonly reported in the NMBRA. Simple mastectomy will typically leave a patient with significant asymmetry, yet with careful attention, a thoughtful simple mastectomy can still minimize the negative sequelae for that individual.

The patient should always be marked preoperatively in the standing or sitting position. Key landmarks to define include the patient midline and the 'footprint' of the breast. This 'footprint' represents the boundaries of dissection and these boundaries should be respected whether this is a simple or skin-sparing mastectomy (SSM). The inferior boundary is clearly identified as the inframammary fold, the lateral boundary is made obvious by asking the patient to lift their arm above their head. The medial and superior boundaries are made obvious by manually displacing the breast, and each boundary can be demarcated with a surgical skin marker. Whilst most surgeons would not mark a simple mastectomy in such detailed fashion, it is a useful technique to build confidence and discipline when progressing to the more complex techniques of SSM.

A simple mastectomy scar is ideally based in the IMF. This low-set, curved incision is relatively discrete and allows comfortable positioning of an external prosthesis. In those patients in whom delayed breast reconstruction (DBR) is a possibility, it offers the best starting point from which to achieve the optimal aesthetic result. A transverse crescentic or elliptical incision including the nipple–areolar complex (NAC) is based in the IMF. The upper incision often skirts just above the superior areolar border in order to maximize the length of the upper skin flap. The importance of preserving the medially placed intercostal perforators, particularly in the second intercostal space, cannot be overstated and is a key step in preserving upper skin flap vascularity. Clearly, excess tension in the wound closure should be avoided, and the scar should be raised above the IMF as appropriate. High-riding mastectomy scars should be avoided unless an upper pole cancer is clinically or radiologically involving the skin. A lateral 'J' extension curving superolaterally towards the posterior axillary line can be a useful way of reducing the bulk of fatty tissue in this area in more obese patients. While beyond the lateral boundary of the breast, this bulge of tissue becomes more obvious to patients once the breast has been removed and can irritate patients particularly in relation to getting their bra to fit. Another scar pattern to consider in obese patients with large breasts is the Wise pattern.

The ideal mastectomy must combine macroscopic removal of all breast tissue with preservation of the subdermal vascular plexus. Well vascularized skin flaps are essential. The plane between subcutaneous fat and breast parenchyma can be obvious with the use of gentle and targeted tissue retraction and counter-traction. This plane can also be frustratingly indistinct, particularly in the lower pole of the breast where the subcutaneous fat can become attenuated due to the effects of gravity, resulting in dense parenchyma in proximity to the subdermal plexus. Careful dissection, regardless of the cutting device used, is essential. This attention to detail applies to all types of mastectomy, regardless of complexity. Attention should always be given to the force of retraction employed by your assistant. While well-meaning, excess retraction, particularly in the context of SSM can have disastrous results for the patient.

Once the skin flaps have been raised and the 'footprint' delineated, the breast is dissected off the underling pectoralis major with care to preserve the pectoral fascia unless a posteriorly situated cancer is clinically invading the underlying muscle. In this situation a cuff of muscle should be excised en bloc. The mastectomy specimen should always be orientated with sutures according to local consensus. A dry-weight should be recorded in the operative notes, essential information for any delayed breast reconstruction (DBR). The specimen should either be sent immediately to the pathology laboratory as a fresh specimen or placed in a large specimen container so that it does not touch the sides containing at least double the specimen volume of tissue fixative. Inadequate tissue fixation can have a dramatic negative effect on the ability of the pathologist to provide an accurate histology report.

Sentinel node biopsy (SNB) or axillary clearance (AC), as previously discussed, can then be performed through the same incision. Two-layer wound closure is performed in a standard fashion using an absorbable suture.

Day-case mastectomy: the British Association of Day Surgery (BADS) advocates 15% of mastectomy patients should be discharged on the day of surgery, yet only a minority of breast units achieve this. This is despite a financial Best Practice Tariff incentive of £300 per case (£600 if SNB also performed). Certain flagship units perform around 70% of their mastectomies as day-cases, highlighting disparities in performance and patient experience.

Surgical and anaesthetic techniques are integral to the success of day-case mastectomy. Omitting the surgical drain removes one potential barrier to discharge. The use of internal tissue glues or quilting may help minimize seroma formation, obviating the

need for a drain. Planning list order and an organized and well-staffed day case unit are also key to success.

Regional local anaesthetic blocks can have a profound effect in reducing post-mastectomy pain, not only important for the immediate postoperative setting but also in mitigating chronic pain. These are typically performed by the anaesthetic team either with ultrasound control (para-vertebral block) or without (intra-pleural block) once the patient is fully anaesthetized.

Skin-sparing mastectomy (SSM): SSM involves complete excision of the breast parenchyma while retaining the skin envelope. If, for oncological reasons or patient choice, the nipple is to be sacrificed, a short elliptical incision including the nipple allows good access to perform the mastectomy. The entire NAC does not need to be excised, and indeed preserving some areola margin provides a good base for potential future nipple reconstruction. The incision is most commonly orientated vertically or horizontally (Figure 5). The horizontal incision can result in a 'boxier' looking result, but the incision should be individualized to the patient.

Access is more limited than a simple mastectomy and a surgical headlight or lit retractor is helpful if using diathermy under direct vision. Excessive retraction on the vulnerable skin flaps must be avoided at all costs. Some surgeons prefer to pre-infiltrate the retro-mammary space and Scarpa's fascia plane with a solution of local anaesthetic and adrenaline. This hydro-dissection then allows the dissection to be performed with scissors or the blade without direct vision of the plane itself. This certainly avoids excessive flap retraction and is generally a faster dissection than using diathermy under direct vision. Both techniques require considerable experience in simple mastectomy and the principles of respecting the 'footprint' of the breast are paramount.

SSM is only appropriate if that patient is undergoing immediate breast reconstruction (IBR) or immediate-delayed breast reconstruction (IDBR). Patient suitability for IBR will be discussed later.

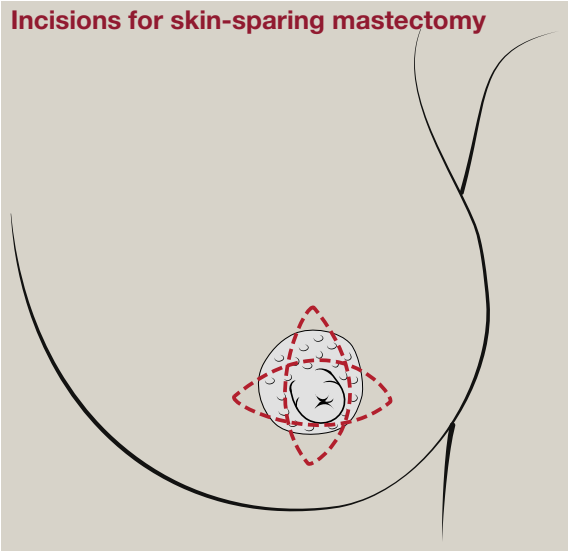


Figure 5

Ultimately, the oncological rigour of a SSM should be as sound as that for a simple mastectomy.

Local recurrence rates following OPBS should be no higher than for breast cancer surgery as a whole. ABS at BASO surgical guidelines for the management of breast cancer state that local recurrence rates should be less than 5% at 5 years with a target of less than 3% at 5 years.

As with much of OPBS, there is no RCT evidence comparing the safety of SSM or nipple-sparing mastectomy (NSM) with simple mastectomy. There is, however, a considerable body of retrospective evidence to suggest the safety of SSM in T1-2, multi-centric cancers and DCIS. More recently, a large US meta-analysis of nearly 5400 patients over a 10-year period confirmed comparable overall survival (OS) between patients undergoing SSM and simple mastectomy. However, local recurrence was 8.5% beyond 5 years.[14]

The majority of patients undergoing SSM or NSM will have a clinically and radiologically node-negative axilla preoperatively, therefore indicating SNB. SNB can generally be performed through the short elliptical incision. A separate short axillary hairline incision is occasionally required.

Nipple-sparing mastectomy: NSM implies complete preservation of the breast envelope. This is the ideal starting point from which to create a breast reconstruction as the scaffold of the breast is already in place. All patients require careful MDT discussion preoperatively to determine their suitability for NSM. There are no strict national guidelines to support this decision. An ideal candidate for NSM would be a patient with a small T1 invasive cancer, DCIS only, or a patient undergoing risk-reducing mastectomy (RRM). The disease should appear at least 2 cm away from the nipple on imaging. The mastectomy specimen should be clearly marked to indicate the ductal tissue underlying the nipple to aid the pathologist. The patient should be warned that if the disease extends to this surgical margin, subsequent NAC excision under local anaesthetic is likely to be recommended. Some units may percutaneously biopsy the retro-areolar space preoperatively to guide surgical planning. Intraoperative frozen section is of limited benefit. The patient needs to be warned that nipple preservation implies a tiny amount of ductal breast tissue will not be removed. In reality, if the nipple is adequately hollowed out the increased risk of local recurrence at the nipple is minimal.

NSM lends itself to a perimeter incision, either laterally (allowing access to the axilla) or in the IMF. A radial incision in the lateral breast is also appropriate but care should be taken not to extend too far around the areolar margin as this increases the risk of nipple necrosis (Figure 6).

SSM and/or NSM are most appropriate in a small–medium, non- or minimally ptotic breasts. Women with larger breasts will require some form of skin reduction in addition, such as a Wise pattern or vertical scar pattern. The basic principles of mastectomy should be applied regardless of mastectomy type.

Breast reconstruction

While the proportion of patients undergoing mastectomy in the UK continues to fall, the proportion of mastectomy patients

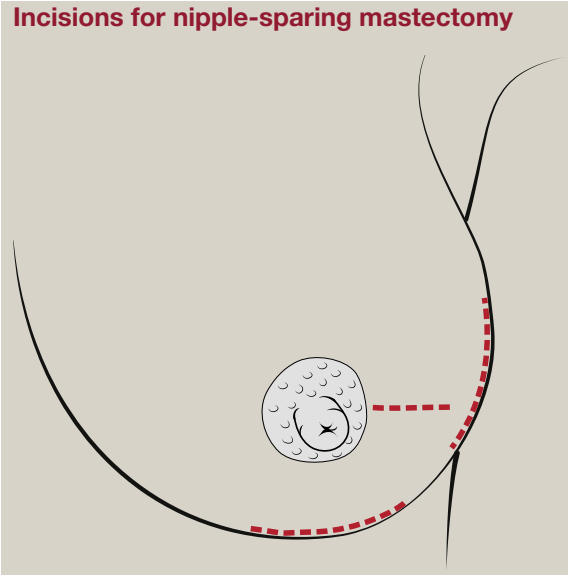


Figure 6

undergoing immediate breast reconstruction (IBR) continues to rise. The 2015 NHSBSP audit reported of the 20,039 patients who underwent surgery for breast cancer in 2013/14, 21% underwent mastectomy, of which 30% underwent IBR. While encouraging, this audit also confirms the wide variation in IBR rates between screening units nationally (0–59%). The OBR guidelines state that breast reconstruction should be discussed with 100% of patients undergoing mastectomy, yet clearly disparities in practice remain.

A successful breast reconstruction is determined by careful patient selection in a multidisciplinary environment. The reconstructive pathway must include detailed assessment of patient expectations including access to patient support groups/previously reconstructed patients. A well-informed patient has a higher chance of being satisfied with the outcome of their reconstruction. This is the ultimate judgment of reconstructive outcome. Patients must be made aware that breast reconstruction is a journey that may require multiple procedures both in the short and long term. The NMBRA highlighted the importance of Patient Reported Outcome Measures (PROMs) as a powerful tool to assess the quality of a reconstructive service. The NMBRA findings have underpinned many of the 25 key quality criteria set out in the OBR Guidelines (Box 1).

Age alone is no barrier to reconstruction, although overall fitness to undergo a longer procedure with a higher rate of potential postoperative complications is of paramount importance. Similarly, breast reconstruction in patients with metastatic disease may also be appropriate to improve their quality of life. All reconstructive cases should be discussed preoperatively in a multi-disciplinary environment, ideally a specific oncoplastic MDT with medical photography available (Table 1).

Immediate versus immediate-delayed versus delayed breast reconstruction (Tables 2 and 3)

Although preservation of the skin envelope is the preferred starting point for achieving the best objective reconstructive outcome, paradoxically, in the NMBRA, patients undergoing DBR reported generally higher satisfaction scores than those undergoing IBR. This may be related to their different levels of expectation. The key surgical concepts to consider are whether volume replacement alone is required (IBR) or both volume and skin replacement are required (DBR).

Immediate-delayed breast reconstruction (skin-banking) preserves the skin envelope ± NAC with the use of a temporary subcutaneous silicone implant or tissue expander. This concept of skin banking is generally employed in a patient with a small-medium breast in whom PMRT is anticipated. Accepting these patients are at higher risk of capsular contracture as a result of the radiotherapy, this can be addressed at the time of a definitive second-stage reconstruction 9–12 months following completion

Key quality criteria

OPBS is discussed with patients requiring a mastectomy

- NMBRA outcome: The risks and benefits of breast reconstruction was discussed with a surgeon or BCN in 61% of mastectomy only patients
- Target: OPBS is discussed in 100% of patients requiring a mastectomy

Medical photography (preoperative and postoperative) is part of the clinical record

- Target: Medical photography is offered in 100% of BR patients

Patients have access to a BCN or equivalent key worker with expertise in OPBS and psychological assessment and management

- Target: Access to a key worker with expertise in OPBS and psychological assessment and management is available in 90% of patients

Patients have their postoperative pain levels assessed and recorded

The Audit Commission recommends that less than 5% of patients should report severe postoperative pain

- NMBRA outcome: Severe pain was experienced by 6% of patients following mastectomy, 17% following IBR and 20% following DBR
- Target: Less than 5% of patients report severe pain within the first 24 hours

Postoperative complications, return to theatre and length of stay are documented in departmental BR database

- Target: There is a regular audit and discussion of all patients with postoperative complications

Patients' satisfaction with BR outcome is measured using standardized assessment tools

- NMBRA outcome: At 3 months 72% of patients reported satisfaction with information provision
- Target: Satisfaction with information provision is reported by 80% of patients at 3 months

Patients' satisfaction with BR outcome is measured using standard assessment tools

- NMBRA outcome: At 18 months over 90% of BR patients reported satisfaction with their appearance clothed, and over 60% unclothed
- Target: At 18 months, over 90% of BR patients report satisfaction with their appearance clothed

Box 1

Contraindications to breast reconstruction

Absolute	Relative
Inflammatory breast cancer	Indication for post-mastectomy radiotherapy (PMRT) Smoking Morbid obesity ASA III/IV/fitness for GA/multiple co-morbidities e.g. DM previous breast irradiation Need for axillary clearance

Table 1

of PMRT, typically with autologous tissue. While this approach is not generally intended as a definitive reconstruction, occasionally patients are very happy with this reconstruction alone and opt to decline further surgery. Caution must be applied in those patients who require axillary clearance as postoperative seroma rates and subsequent complications including implant extrusion are increased. However, immediate reconstruction is still achievable although it is preferable to separate the surgical cavities if possible.

Methods of breast reconstruction

Implant-based reconstruction: implant-based reconstruction is the most common method used in the UK. It is a versatile technique that avoids donor-site morbidity. It can be applied to most small, medium or large breasts either with or without skin reduction, and can be converted to an autologous reconstruction if there is an unsatisfactory outcome. It is important that patients are made aware of the high rates of revisionary surgery. The large US Core Study Implant Datasets report up to 50% revisionary surgery required within 6–8 years.[15] The implant reconstructed breast will not age in accordance with the contralateral natural breast, resulting in progressive asymmetry over time and the potential need for symmetrising surgery. Implant based reconstruction has a specific range of complications including infection and subsequent loss, capsular contracture, implant rupture and migration. The NMBRA reported surprisingly high implant loss rates at 3 months postoperatively of 9% following IBR and 7% following DBR. The OBR guidelines recommend that all implant-based reconstruction patients undergo MRSA and MSSA testing pre-operatively and receive a single dose of intravenous antibiotics at induction. Harvey et al. developed a checklist of actions to minimize early implant loss rates following a systematic review of the evidence.

Implant-based reconstruction can either be performed in one (direct to implant) or two stages. A two-stage approach utilizes a largely deflated tissue expander initially. Three to four weeks postoperatively this is gradually expanded (about 100 ml/week) until the desired volume is achieved. This tissue expander is then exchanged for a fixed volume implant.

A direct to implant approach utilizes either a fixed volume implant or an adjustable permanent expander. Good quality skin flaps are essential. In the larger, ptotic breast where skin reduction is necessary, an inferiorly based de-epithelialized dermal flap can be used for lower pole implant coverage, sutured to the inferior edge of a raised pectoralis major. The overlying Wise pattern skin flaps are then sutured in place (Figure 7).

Direct to implant reconstruction has undergone something of a revolution over the last decade due to the availability of biological acellular collagen matrices (ACM) or synthetic meshes that allow complete implant coverage at a single procedure without the morbidity of raising a complete submuscular pocket. This technique is ideal for a small–medium breast where skin reduction is not required. The upper half of the implant lies in a subpectoral pocket, the inferior edge of which is sutured to the selected scaffold material. The scaffold can then be used to control implant position and in particular avoid lateral migration of the implant (Figure 8). This trend has shifted further towards the completely pre-pectoral implant reconstruction. The implant

Advantages and disadvantages of immediate breast reconstruction (IBR)

Advantages	Disadvantages
Patient does not experience psychosocial effects of simple mastectomy alone Potentially single procedure Preserve skin envelope ± nipple Avoid need for tissue expansion Cost-effective	Risk of complications • May delay adjuvant treatment • Psychological blow if expectations not met Further adjustment surgery often needed Considerable time pressures of cancer waiting time targets • May effect patient choice • May limit reconstructive options available, particularly in units without microvascular surgery Patient may require unexpected radiotherapy/chemotherapy

Table 2

Advantages and disadvantages of delayed breast reconstruction (DBR)

Advantages	Disadvantages
Adjuvant treatments completed well in advance of reconstruction No risk of delay to adjuvant treatment More achievable expectations No time pressure from CWT	Need to replace skin • Skin expansion (unpredictable if had PMRT) • Import skin with autologous reconstruction Often two or more procedures Need to delay reconstruction post PMRT (>9 months) Patient has to live with simple mastectomy

Table 3

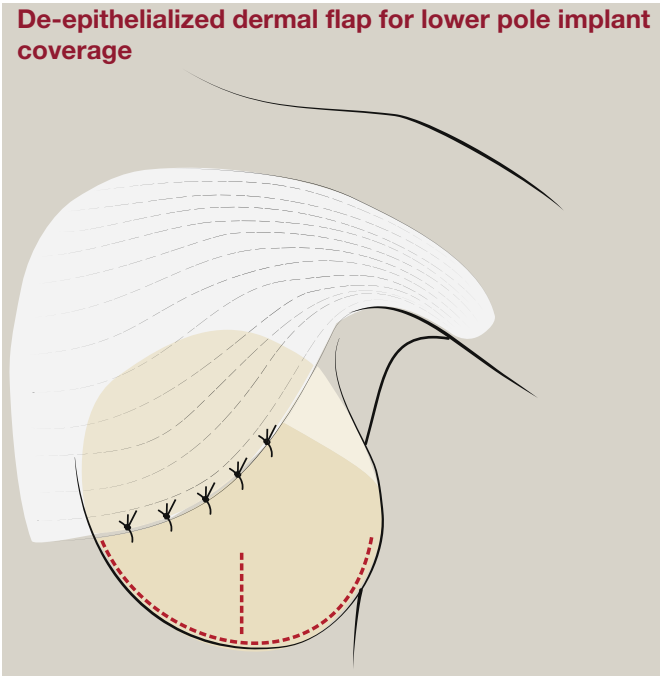


Figure 7

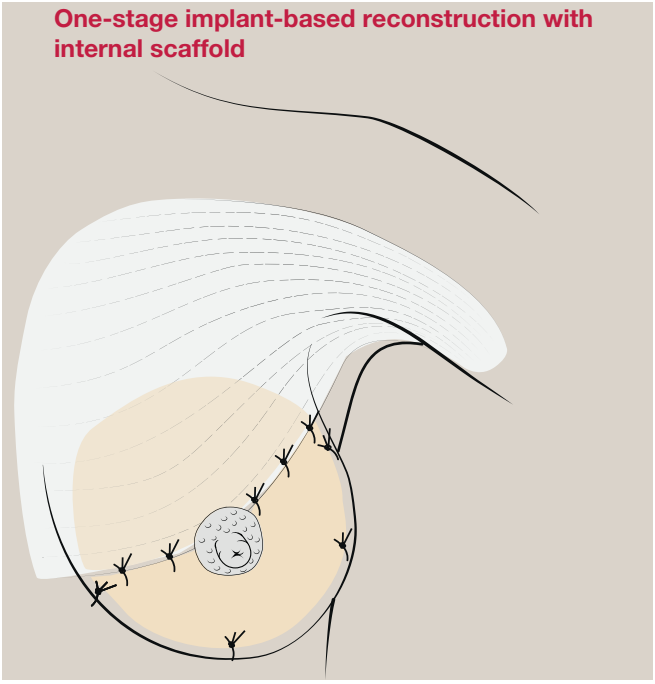


Figure 8

is secured in place in the subcutaneous plane using either an ACM or synthetic mesh. These can be pre-formed as an implant 'pocket' or shaped on the table according to surgeon preference. This avoids any disruption of pectoralis major, therefore avoiding loss of function, minimizing postoperative pain and avoiding 'animation' of the implant when the patient contracts the pec major muscle. There is less coverage of the implant in the cleavage area but any obvious rippling can subsequently be addressed with lipomodelling.

While there is some data to suggest reduced capsular contracture with certain ACMs, overall the data as to which scaffold material is superior is lacking. This has led to the development of the Implant-Based Reconstruction evAluation (iBRA) study, a UK wide collaborative project run by reconstructive surgeons in order to assess current practice, evaluate PROMs and generate new guidelines. Globally, iBRA is the largest prospective dataset of its kind. The results are quite damning in that we have failed to meet any of the pre-defined standards of patient outcome. Early implant loss rates have not improved since the NMBRA audit in 2011. There remains wide variation in patient outcome according to base unit. These variations in outcome will be addressed by the Get It Right First Time (GIRFT) programme in Breast Surgery that is commencing in 2018.

Autologous reconstruction: autologous reconstruction utilizes the patient's own natural tissue either as a transposed pedicle graft, e.g. latissimus dorsi (LD) flap, or as free tissue transfer requiring microvascular anastomosis. An autologous reconstruction is completely natural, provides the most like for like replacement for breast parenchyma and studies have shown the aesthetic results are much more durable than implant-based reconstruction over time. Changes in body weight are more likely to be reflected in the reconstructed autologous breast than an implant-based reconstruction. Autologous reconstruction avoids the use of implants, and therefore implant-related complications. Donor site morbidity, however, is a significant issue, as is the small but disastrous outcome of flap loss.

Latissimus dorsi flaps – the LD flap is a robust flap with a low (<1%) loss rate. It is a musculoadipocutaneous pedicled flap that is typically harvested through a bra-line incision in the lateral position, along relaxed skin tension lines. A simultaneous mastectomy can be performed with a second surgeon in the context of immediate reconstruction, thereby reducing operating time. The flap is harvested in the Scarpa's fascial plane, preserving the subdermal plexus to the back flaps. While an LD flap can be inset over an implant, an autologous 'extended' LD (ALD) flap avoids the use of implants by gaining extra flap volume with careful dissection of adjoining fatty areas (e.g. pre-scapular fat-pad). The flap is then transposed through a high axillary tunnel into the mastectomy pocket. Preservation of the proximal LD tendon owes to surgical preference. Dividing it offers greater mobility of the flap with less chance of postoperative flap twitching. However, preserving it offers greater security to the crucial supplying thoracodorsal pedicle vessels. Quilting the lower back skin flap has been shown to reduce seroma formation, which is a common sequel. Flap positioning and inset is crucial and is best performed in the supine, semi-sitting position once the patient has been turned, with both breasts prepped and exposed. Patients need to be counselled regarding postoperative shoulder weakness. However, studies show power returns to normal at around 1 year postoperatively.

Abdominal free flap reconstruction – abdominal free flap reconstruction requires microvascular expertise and is most safely performed in high-volume, specialized units who can demonstrate flap loss rates as low as 1–2%. A transverse ellipse

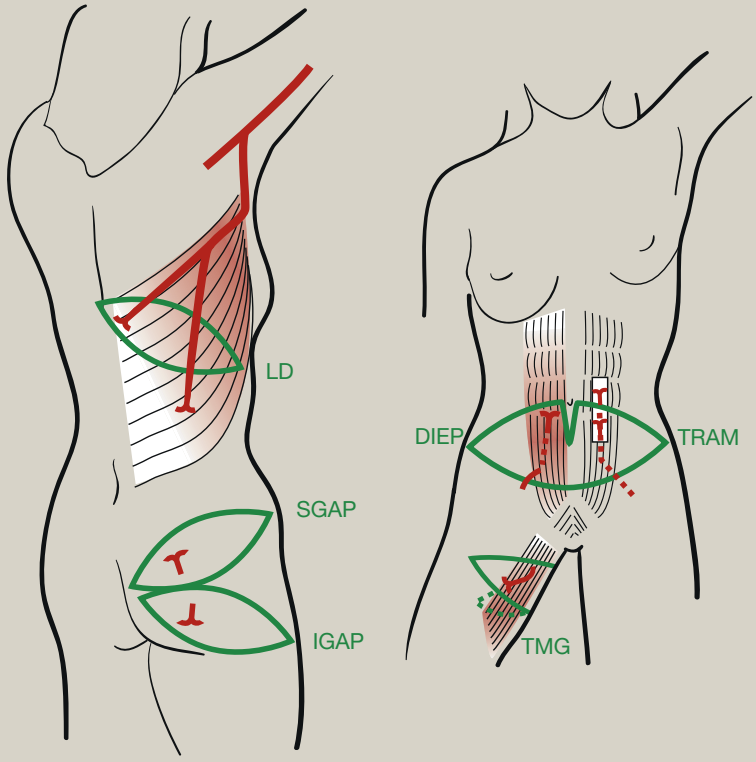
LD versus DIEP/TRAM

	LD	DIEP/TRAM
Operative duration	2.5–4 hours	4–6 hours
Length of stay	1–5 days	5–7 days
Flap loss rate	<1%	2–5%
Return to normal function	2 months	3 months
Specific complications	Shoulder weakness, flap twitching, back seroma	Abdominal weakness/hernia, seroma, loss of umbilicus

Table 4

of fat with overlying skin is harvested from the lower abdomen, leaving a long, low transverse incision. The umbilicus requires re-siting at abdominal closure. Flap design is based predominantly on the deep inferior epigastric vessels, which are usually the dominant circuit supplying the anterior abdominal wall. In around 10% of cases, the superficial inferior epigastric vessels predominate and these should not be divided until this has been excluded intraoperatively. An abdominal free flap is either performed as a deep inferior epigastric perforator flap (DIEP) or as a transverse rectus abdominis musculocutaneous flap (TRAM). While the DIEP is the gold standard technique owing to less disruption to rectus abdominis (RA) function, it requires the presence of a single (or a few, in proximity), good quality and calibre perforating artery and vein to be safely isolated without sacrificing the muscle. The TRAM flap, while sacrificing a degree of muscle (the full width of one of the RA), harvests multiple small perforators within a cuff of muscle which then converge in a larger calibre vessel downstream. A muscle-sparing TRAM (msTRAM) can be raised if a lateral portion of the rectus with its innovating nerves is preserved and kept in continuity. A preoperative CT angiogram can map out the vascular anatomy and greatly aid surgical planning. Nonetheless, the final decision

Diagrammatic representation of some common pedicled and free flaps



LD, latissimus dorsi; SGAP, superior gluteal artery perforator; IGAP, inferior gluteal artery perforator; DIEP, deep inferior epigastric perforator; TMG, transverse myocutaneous gracilis; TRAM, transverse rectus abdominis myocutaneous.

Figure 9

regarding DIEP or TRAM is made intra-operatively. Once safely harvested, the flap vessels are then anastomosed to the internal mammary system or the thoraco-dorsal system. The flap is then shaped and inset with great care (Table 4).

There are multiple other free flap options including superior gluteal artery perforator (SGAP), inferior gluteal artery perforator (IGAP), transverse musculocutanous gracilis (TUG) and greater omentum flaps (Figure 9).

Lipomodelling

Lipomodelling is a versatile technique whereby adipocytes are harvested from the patient's abdomen, buttocks or thighs and injected into the breast as a free graft. Lipomodelling has multiple applications including;

- improving contour defects following BCT
- increasing soft tissue cover over an Implant-based reconstruction
- boost autologous LD flap volume
- complete breast reconstruction e.g. Polands Syndrome
- rejuvenate radiotherapy affected skin
- soften scars
- lipoaugmentation.

The donor site is often infiltrated with a tumescent solution of Hartmann's solution and adrenaline. However, local anaesthetic and hyalase should be avoided as they increase graft loss. Local anaesthetic should be infiltrated following fat harvest. Careful fat harvest is performed with a blunt-tipped cannula under low pressure to minimize barotrauma. The harvested fat should ideally be washed and centrifuged to maximize graft survival, which is typically 60–70%. A variety of commercial systems are available, either with or without centrifuge. The fat is injected into the breast with a fine cannula in small aliquots in a lattice like pattern. Injecting the fat in multiple planes and directions avoids fat pooling and minimizes fat necrosis.

In addition to adipocytes, the graft also contains numerous stem cells and growth factors which play a key role in the rejuvenating qualities of lipomodelling. These additional factors have generated concern regarding the oncological safety of lipomodelling in a breast previously affected by breast cancer. Radiological concerns have centred on the challenges of mammographic follow-up of breast conservation patients who may develop fine fat necrosis as a result of lipomodelling. While large, single centre studies with long follow-up support the safety of lipomodelling in this group of patients, there is still a relative lack of data in the UK and wide variations in practice.[16]

In response the Association of Breast Surgeons (ABS) has produced guidelines on lipomodelling in order to try and standardize lipomodelling practice and to ensure adequate audit and follow-up to ensure patient safety.[17]

Nipple reconstruction

Nipple reconstruction can be performed at the time of IBR, yet most nipple reconstructions are delayed until the breast reconstruction has settled (3–6 months). Popular techniques include nipple-sharing which involves transferring around 50% of the normal contralateral nipple as a free graft to a small patch of de-epithelialized skin. There are numerous local skin flap patterns including the modified C–V flap (Figure 10). All of these

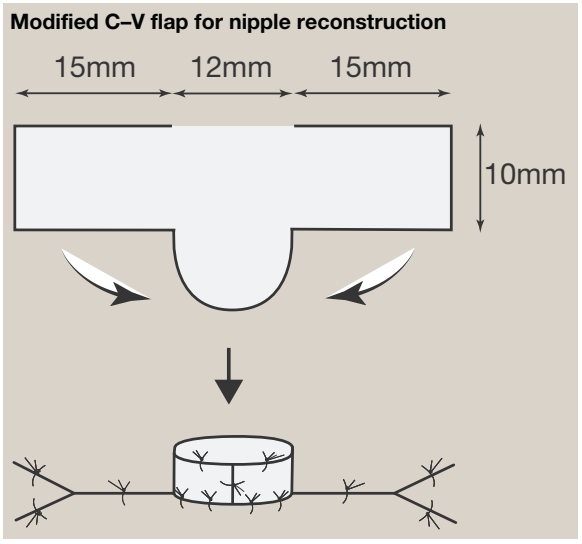


Figure 10

procedures can be performed under local anaesthesia and the risk of nipple necrosis is very small. While nipple projection can be lost over time, nipple reconstruction is important to bring a focal point to the reconstructed breast and a sense of completion for the patient. Nipple-areolar tattooing can be performed when the wounds have fully healed to mimic the areola. ◆

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