Immediate Implant-Based Breast Reconstruction Using Variable Lower Pole Support

24

Michael Sheflan and Iain Brown

24.1 Introduction

Implant-based breast reconstruction continues to be the mainstay of the reconstructive repertoire and yet remains the greatest of all the reconstructive challenges. Although the use of an implant may appear to be the simplest and most straightforward option, this apparent simplicity belies subtle complexity, which must be overcome if a predictable, natural and reliable reconstruction is to be created.

Successful outcomes require:

24.1.1 Individualized Analysis, Planning and Selection

As with any other technique, implant-based breast reconstruction requires the careful analysis of the patient's specific tissue characteristics, biodimensional measurements and careful consideration of individual desires and expectations. In particular, the surgeon must

- Have an understanding and appreciation of the individual aesthetic components that contribute to the 'natural' breast form: a gradual upper pole, proportionate lower pole curvature, medial-to-lateral take-off and defined inframammary fold (IMF) and lateral mammary fold (LMF)
- Be able to select the correct implant to recreate the natural breast form.

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24.1.2 Creation of a Perfect Skin Envelope

The perfect reconstruction begins with the perfect mastectomy; an oncologically sound dissection does not need to compromise the viability or pattern of the resultant skin envelope. With careful planning and technical excellence, it is possible to preserve the optimal amount of healthy, well-perfused skin to drape the internal domain and produce a natural and predictable outcome.

24.1.3 Creation of a Stable Internal Domain

The standard complete submuscular pocket has several recognized limitations; most importantly it is difficult to produce natural ptosis or create a well-defined IMF. Even if an acceptable shape and volume can be achieved, the reconstruction is unlikely to age naturally. Deterioration of shape and increasing asymmetry are common and a result of instability between the pocket and the implant. Hence, there is often the need for the additional or maintenance procedure may be either to the reconstruction, the contralateral breast or both. Further surgical procedures may be avoided if a natural ptosis is achieved with the primary reconstruction.

The use of enhanced lower pole support to the upper subpectoral pocket with an acellular dermal matrix (ADM) or a deepithelialized lower pole (dermal) sling (LPS) can overcome many of these challenges. The creation of a precise, stable internal domain improves the likelihood of a lasting harmony between tissues and the implant; and hence a more reliable and predictable long-term outcome.

24.2 The Case for Lower Pole Support

24.2.1 Better Support of the Prosthesis

By creating a subpectoral pocket with an LPS or an ADM, one can position the implant device in such a way as to

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off-load pressure on the overlying soft tissues. Pectoral contraction is less likely to displace the implant superiorly, which could degrade the upper pole appearance. It is also less likely to allow lateral implant drift and a stepped cleavage when the patient lies supine.

24.2.2 Better Defined and Anchored Inframammary Fold

Whether the inframammary fold (IMF) is sutured, as with use of an ADM, or reinforced, when an LPS is used, the device is cradled above and anterior to the fixed IMF. This produces a more natural ptosis with the IMF hidden behind the lower breast curvature. As the tissues of pocket and skin envelope relax over time, a fixed IMF allows a natural increase in ptosis.

24.2.3 Better Defined and Anchored LMF

The lateral contour and overall breast shape is further defined by a smooth but nevertheless fixed LMF. Whether the LMF is created with accurate lateral suturing of the ADM, or precise sub-serratus anterior lateral pocket dissection (in the LPS technique), a smooth, natural and more predictable lateral curvature can be achieved.

24.2.4 More natural Medial-to-Lateral 'Take-Off'

For optimal cleavage and gradual medial 'take off', the implant must rest as low and medial as possible in the pocket created. Careful fixation of the ADM or LPS to the most medially divided fibres of the pectoral muscle allows the surgeon to control this unpredictable area of the pocket. It is also essential to have a device with the correct width and adequate lateral control to optimize the implant's medial position.

24.2.5 More possibility of Using a Fixed-Volume Versus Variable-Volume Anatomical Device

Even with an adequate, tension-free, healthy skin envelope, a traditional complete subpectoral pocket rarely allows implantation of the final desired volume in the first setting. In recent years, permanent shaped-adjustable (combined expander/implant) devices have improved outcomes [1–3]. However with the use of an ADM or LPS, it is usually possible to obtain a one-stage reconstruction with a definitive fixed-volume implant. If volume is not adequate, or there are concerns about skin envelope viability, then use of the LPS or ADM technique with a variable-volume implant (either as a one-stage expander/implant or as two-stage expander then implant) will produce a more natural breast than expansion of a standard complete submuscular pocket. Gradual expansion is done after an initial healing and relaxation phase to allow a more predictable descent to the final desired ptotic outcome.

24.2.6 Reduced Need for Contralateral Surgery

The use of an LPS or ADM creates a more natural final breast aesthetic than a traditional complete submuscular reconstruction. There is therefore a greater likelihood of achieving an initial match with the contralateral breast. Producing a stable long-term outcome will also improve the chances of maintaining symmetry, thus reducing the need for contralateral surgery later [4].

With lower pole support techniques it becomes possible to offer an implant-based reconstruction to women who, in the past, may have declined such a reconstruction because they were reluctant to have surgery to their contralateral (healthy) breast.

These techniques may also improve the options in hospitals or insurance-led healthcare systems where there are logistical or financial constraints on offering multiple, staged surgeries.

24.2.7 Better Harmony of Tissues and Device

In the author's experience, the use of an ADM or LPS creates a better harmony between the device and a patient's tissues, thus creating a stable internal domain; like a 'hand in a glove'. The ADM and LPS both cover about two-thirds of the implant, resulting in decreased compression of the soft tissues (pectoralis major and lower pole skin envelope). A stabler environment is therefore created, with a better distribution of pressure on, and exerted by, the implant. Using enhanced lower pole support has led to an observed reduction in our capsular contracture rates and reoperation rates.

A stabler internal domain allows better perfusion of all soft tissues (skin, muscle, capsule, LPS, ADM). It seems plausible, although as yet unproven, that optimized perfusion of soft tissue microcirculation may help to minimize acute radiotherapy-induced vasculitis (and fibrosis) and hence offer some protection against radiotherapy-induced complications.

24.3 The LPS or ACD?

24.3.1 Selection of the LPS Technique

The LPS technique is well suited to patients with large, ptotic breasts who desire a smaller volume and a more uplifted final breast. The technique involves a skin-reducing mastectomy using a Wise pattern, resulting in a section of excess lower pole skin which, once deepithelialized, provides autologous lower pole dermal support [5, 6].

A resultant safe and well-perfused skin envelope after mastectomy is essential for a good outcome in immediate reconstruction [7–9], but this is never better demonstrated than when using the LPS technique. Problems with skin envelope perfusion, ischaemia and necrosis with risk of infection and implant threat have discouraged some surgeons, mostly early in their learning curves, from perfecting the technique. However, with careful planning, precision technique and delicate tissue handling, it is possible to minimize these complications to acceptably low levels (see Sect. 1.7.1).

The likelihood of envelope necrosis or wound-healing complications is increased in certain scenarios. Patients with a history of obesity, smoking, diabetes, previous radiotherapy, and small vessel disease should be counselled on an increased risk of immediate postoperative complications or even reconstructive failure.

24.3.2 Selection of the ADM Technique

Patients with smaller, less ptotic breasts are unlikely to have sufficient surplus lower pole skin to create an adequate dermal sling and therefore require an ADM to provide lower pole dermal support.

There are several different types of ADM currently available and other innovative materials are already in the advanced stages of product development (Tables 24.1 and 24.2). The choice of ADM must take into account several factors:

- Immune reactivity, i.e. host adoption without inflammation
- Handling qualities
- Structural support ability
- Collagen matrix properties (no chemical cross-linking)
- Tissue incorporation and integration ability
- Tissue regeneration ability
- Cell revascularization ability.

ADMs are sourced from allogenic human cadaveric/bariatric dermis or from xenogenic tissues (porcine or bovine; dermis, pericardium, intestinal submucosa). They differ in thickness from less than 1 mm to over 4 mm, with the latter

Table 24.1 Comparison and summary of allograft acellular dermal matrices (ADM)

ADM	Year introduced	Supplier	Location	Material	Cross-linked	Sterilized (method)	Lyophilized	Hydration/ soak time	Refrigeration required	Shelf life (years)
AlloDerm	1994[a]	LifeCell	Branchburg, NJ, SA	Human dermis	No	No (aseptically processed)	Yes	10–40 min (2 steps)	Yes	2[a]
AlloMax		Davol (CR Bard) (processed by RTI Biologics)	Warwick, RI,USA	Human dermis	No	Yes (gamma irradiation)	No (supplied dehydrated)[2]	'Rapidly'	No	5
DermaMatrix	2005[a]	Synthes CMF (processed by MTF)	West Chester, PA, USA	Human dermis	No	No (aseptically processed)	Yes	3 min	No	3
DermaSpan	2011[b]	Biomet	Warsaw, IN, USA	Human dermis	No[b]	Yes (gamma irradiation)	Yes	15–45 min	No	2
FlexHD	2007[a]	Ethicon (J&J) (processed by MTF)		Human dermis	No[b]	No (aseptically processed)[a]	No	None	No[a]	3
Repriza	2010[b]	Specialty Surgical Products	Victor, MT, USA	Human dermis	No	Yes (irradiation)	No	None	No	2

Information from product sheets except as noted
[a] From [43]
[b] From [44]

Table 24.2 Comparison and summary of xenograft ADM

ADM	Year introduced	Supplier	Location	Material	Cross-linked	Sterilized (method)	Lyophilized	Hydration/ soak time	Refrigeration required	Shelf life (years)
Permacol	2000[b]	Covidien	Norwalk, CT, USA	Porcine dermis	Yes (HMDI)	Yes (gamma irradiation)	No (supplied moist)	None	No	3
Strattice	2008[a]	Lifecell	Branchburg, NJ, USA	Porcine dermis	No	Yes	No (supplied moist)	≥2 min	No	2[a]
SurgiMend	2006	TEI Biosciences	Boston, MA, USA	Bovine dermis	No	Yes (ethylene oxide)	Yes	60 s	No	3
Veritas	2001	Synovis	St. Paul, MN, USA	Bovine pericardium	No, propylene oxide capped amine technology	Yes (irradiation)	No	None	No	2[a]
XenMatrix	2006	Davol (CR Bard)	Warwick, RI, USA	Porcine dermis	No	Yes	No	None	No	5

Information from product sheets except as noted
HMDI—Hexamethylene Di-Isocyanate
[a] From [43]
[b] From [44]

best suited for cosmetic purposes, where bulking is desired, or for large ventral abdominal hernias, where strength is desired.

Whereas human ADMs typically come in various rectangular sizes, some xenogenic ADMs are provided in shapes more suited to the subsequent three-dimensional conformation a flat sheet will take when placed over an implant. Such shaping, as well as premade fenestrations, helps the ADM to conform to the implant without pleating or wrinkling.

Human cadaveric ADMs typically maintain greater intraoerative and postoperative stretch than do xenogenic ADMs. Care and thought must be given in anticipating the potential for gradual 'window-shading' of the ADM higher on the upper pole of an expander during filling when a human ADM is employed. When using a less extensible xenogenic ADM, one must anticipate further travel of the inferior margin of the pectoralis major muscle towards the IMF during expansion.

24.4 Technique and Surgical Considerations

24.4.1 The Perfect Skin-Sparing Mastectomy

The perfect breast reconstruction depends upon the perfect mastectomy. Although the planning, decision-making and technical execution of the reconstructive component are important, many of the short-term and long-term complications from immediate reconstruction are mostly related to a suboptimal mastectomy.

24.4.1.1 Who Should Perform the Mastectomy?

It is not important whether a general or a plastic surgeon performs the mastectomy, provided the surgeon has the appropriate training and skills to be able to safely find and then stay within the mastectomy plane.

24.4.1.2 Where Is the Mastectomy Plane?

The mastectomy plane lies between the subcutaneous fat and the superficial fascia of the breast, crossed by the ligaments of Cooper that travel through the subcutaneous fat to anchor in the dermis (Fig. 24.1a). There is a conventional view that the superficial fascial plane is not reliably present and thus the plane may not always be identifiable. This appears to be based on an often-quoted small observational study [10] of breast-reduction specimens. There is, however, a compelling embryological explanation for the constant presence of this fascia, even if patient factors (extremes of BMI) or surgical factors (poor or closed techniques) mean that it is not always visualized. The

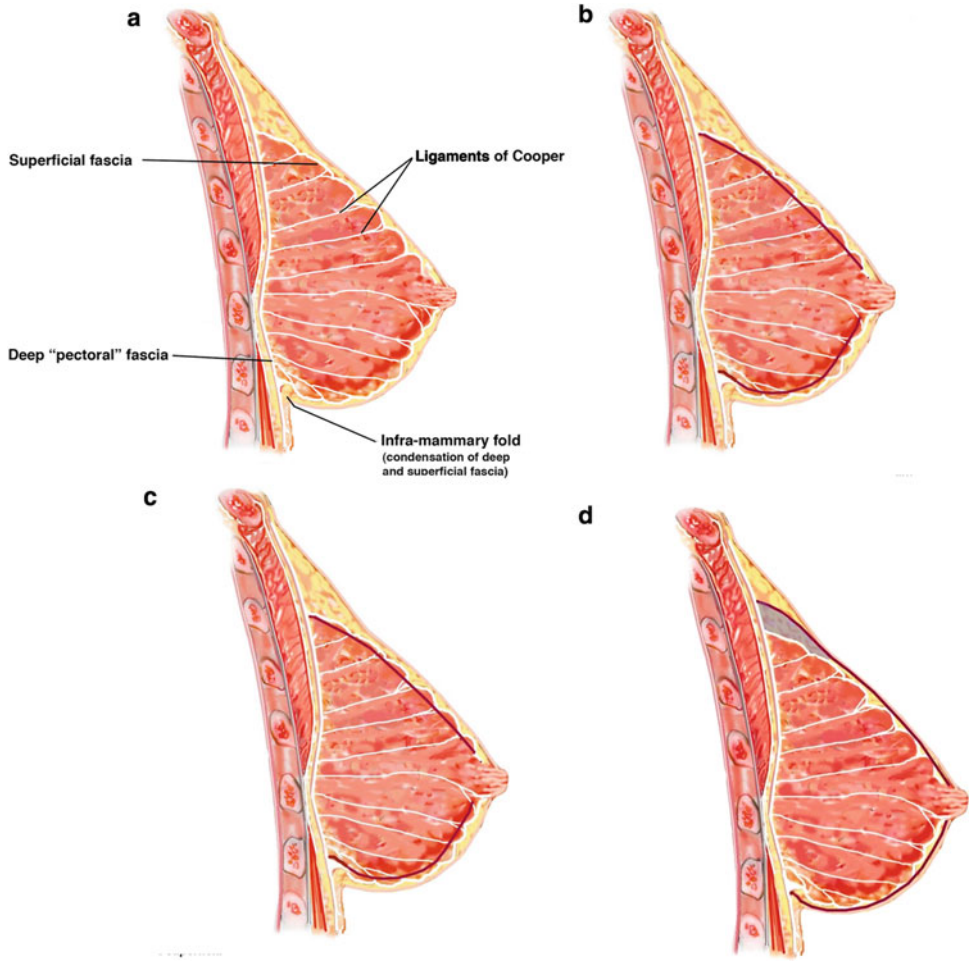

Fig. 24.1 Sagittal views of the breast demonstrating **a** fascial planes and ligamentous anatomy, **b** 'thin' skin flaps (increased risk of skin necrosis and unnecessary subcutaneous fat excision above the breast), **c** 'thick' skin flaps (increased risk of residual breast tissue and local recurrence) and **d** 'ideal' mastectomy plane over superficial fascia

superficial fascia is formed as a condensation from the sixth embryological week, when the primary ectodermal breast bud invaginates into the underlying mesenchyme [11].

Regardless of the technique and instruments used, achieving the correct dissection plane is essential for optimal oncological safety and viability of the skin envelope. A 'thin' or traumatized skin flap is more likely to have compromised perfusion. A 'thick' skin flap is more likely to carry residual breast tissue with an unnecessary increased risk of future disease or local recurrence (Fig. 24.1b, c). There are several well-designed studies that demonstrate residual breast tissue left on mastectomy skin flaps in up to 50 % of biopsies looked at [12–14]. Without evidence of intact superficial fascia on the mastectomy specimens removed, such studies should be interpreted with caution.

It should be remembered that the 'ideal' skin flap thickness is proportionate to a patients BMI and body habitus and is therefore 'patient-dependent' not 'surgeon-dependent'. It should be possible to aim for complete removal of the breast tissue, and breast surgeons should continue to strive for the cleanest possible dissection in the plane; i.e. over the fascia, with division of the ligaments of Cooper as close to dermal attachments as possible (Fig. 24.1d).

24.4.1.3 What Is the Best Technique for Performing Skin-Sparing Mastectomy?

Planning the mastectomy must take into account the three-dimensional shape of the envelope, the likely tension on the skin and the access that the incision will give, for both the least traumatic removal of the gland and the safest, most accurate insertion of the implant.

Once the optimal amount of skin (with or without nipple) for the best envelope and reconstruction has been decided upon, the joint surgical objectives are:

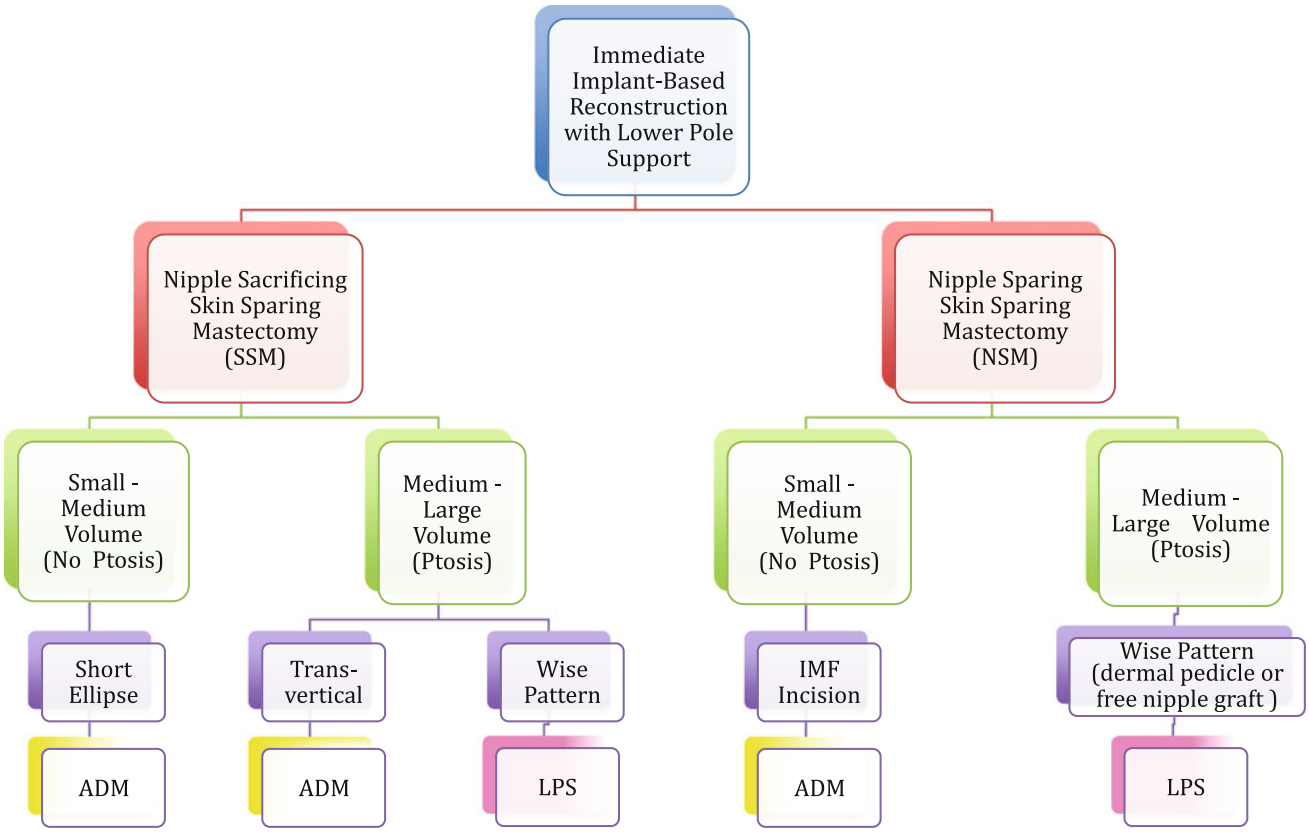

Fig. 24.2 Mastectomy and technique selection algorithm for implant-based reconstruction with lower pole support. *ADM* acellular dermal matrix, *IMF* inframammary fold, *LPS* lower pole derma sling

- To optimize oncological safety—removing all breast tissue whilst respecting the mastectomy plane and envelope landmarks
- To optimize envelope viability—not compromising the perfusion of the skin envelope.

There is no agreement, nor need there be, on the single best technique for performing skin sparing mastectomy. Some surgeons find infiltration helpful to develop the plane (with or without adrenaline). Alternatively a dry technique with direct visualization of the fascia and ligaments may be preferred. Scalpel, scissors, diathermy electrodissection, ultrasound, laser and argon all have their advocates. In selecting the technique for mastectomy, every surgeon must decide how best to reconcile the compromise among ease of dissection, speed, haemostasis and the development of complications such as seroma, haematoma and skin necrosis.

Finally, the appropriate selection of the technique and instruments to use for a specific mastectomy should be based not on a surgeon's routine preference, but after consideration of that patient's individual soft tissue characteristics and risk factors for skin necrosis (obesity, smoking status, etc.,).

24.4.2 Classification of Skin-Sparing Mastectomy with use of the ADM Technique

An algorithm for mastectomy and technique selection for implant-based reconstruction with lower pole support is show in Fig. 24.2.

24.4.2.1 Skin-Sparing Mastectomy in the Non-ptotic Breast: The Short Ellipse Incision

When the nipple is to be sacrificed, our preference is for a short ellipse including the nipple with an oblique orientation (Fig. 24.3a). The dimensions and exact orientation of the ellipse should take into account the desired final three-dimensional shape and volume of the breast. The incision may require a short 'lazy-S' lateral extension, so that it is large enough to allow safe access for mastectomy, accurate insetting of the ADM and access to the axilla if necessary. Excess skin should be excised with caution and after consideration of the characteristics of the skin envelope (elasticity, compliance, possible perfusion problems) as well as how to achieve a comfortable fit between the implant domain and the skin envelope. It is

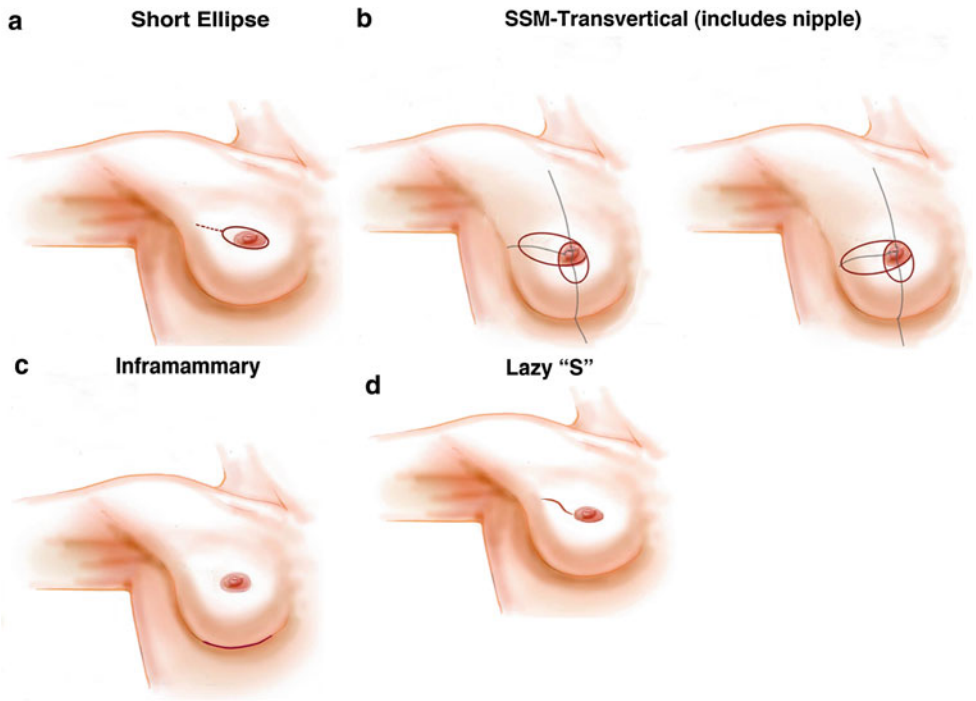

Fig. 24.3 Mastectomy incisions for use with the ADM technique: **a** short ellipse incision with or without 'lazy-S' lateral extension (skin sparing mastectomy); **b** transvertical incision (skin-reducing mastectomy); **c** inframammary incision (nipple-sparing mastectomy); **d** 'lazy-S' oblique lateral incision (nipple-sparing mastectomy)

always possible to modify and excise further if there is large skin excess when the envelope is redraped over the newly created mound. The oblique scar created is usually not conspicuous after nipple–areola reconstruction (Fig. 24.4).

24.4.2.2 Skin-Reducing Mastectomy in the Large or Ptotic Breast: The Transvertical Incision

If an ADM is to be used rather than an LPS, then our preference is for the transvertical approach (Fig. 24.3b), which combines two vectored skin excisions—the larger, horizontal one is placed lateral or oblique to the nipple–areola complex (NAC) and the shorter, vertical elliptical excision overlaps the former in the NAC area. The resultant skin envelope has a more pleasing final shape and a better positioned scar than if a longer, wider oblique or transverse ellipse is used. The transvertical approach avoids the potential ischaemia-related wound-healing problems encountered by some surgeons when using the Wise-pattern skin envelope (Figs. 24.5 and 24.6).

24.4.2.3 Nipple-Sparing Mastectomy in the Small to Moderate-Sized Breast: The Inframammary Incision

Traditional periareolar and circumareolar incisions have been shown in the best centres to have an increased risk of nipple–areola necrosis [15, 16]. Although it is possible to use an oblique orientated 'lazy-S' upper outer quadrant incision (Fig. 24.3d), our preference is for the use of an inframammary incision whenever possible (Fig. 24.3c). Although this is more technically challenging, there is less of a risk to nipple viability. The resultant access to the lower pole is ideal for the accurate insertion of the ADM and affords precise control and fixation of the IMF. It also produces a very favourable and 'hidden' scar (Figs. 24.7 and 24.8).

As mentioned earlier, the technique and instrumentation chosen for mastectomy through the IMF incision is less important than the surgeon's ability to produce a healthy, non-traumatized skin envelope and a well-perfused nipple. Where access is difficult, the use of a headlight and delicate use of retractors is essential. Great care must be taken by the surgeon and assistant to avoid mechanical crush of the lower pole skin. An endoscope may be useful in the large breast (video-assisted mastectomy) for direct visualization of the medial, superior and lateral extent of the envelope, thus minimizing retraction injury or damage to the important skin perforator vessels.

Although the risk of occult nipple involvement or future nipple disease is acceptably low, provided predictive criteria for further nipple disease are followed [17, 18], we still recommend a subareolar ductal biopsy in all cases of nipple preservation with intraoperative frozen section. This

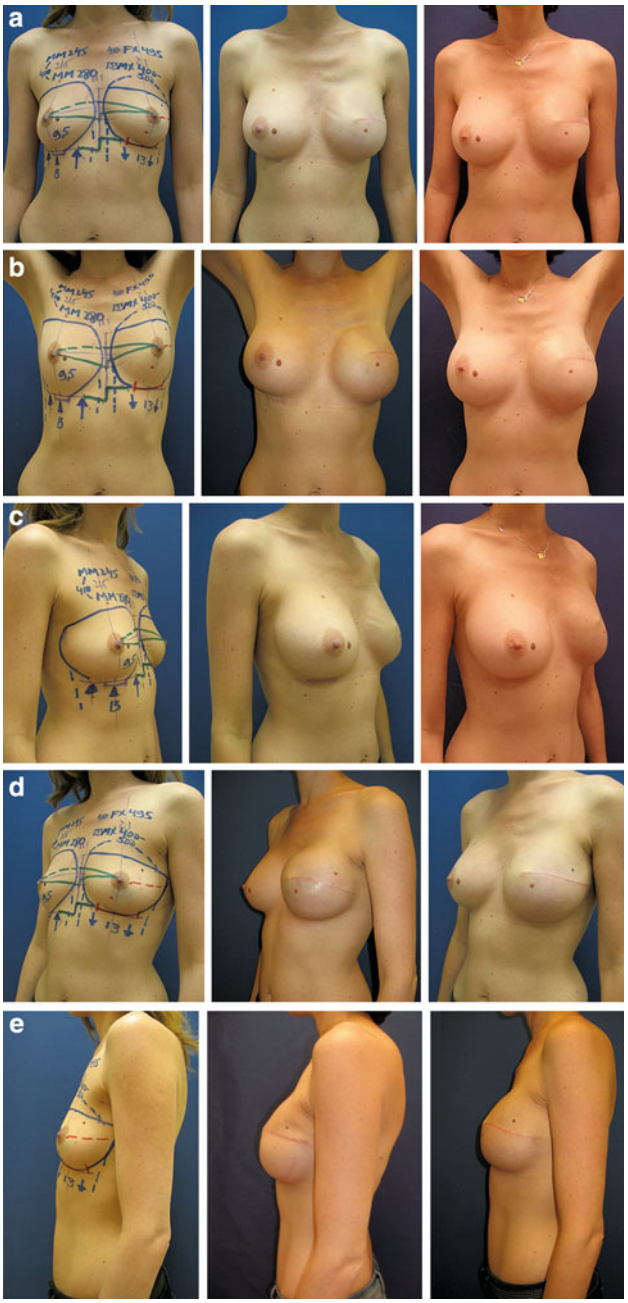

Fig. 24.4 Left skin-sparing mastectomy (270 g) with short elliptical oblique incision and two-stage reconstruction with an expander and ADM (Natrelle Style 133 MX500, Surgimend 10 cm × 15 cm) and then a definitive implant (Natrelle Style 410 MX550). Contralateral right dual-plane augmentation in the first stage (Natrelle Style 410 MM280). Preoperative and postoperative images demonstrating intermediate and final outcome following refinement with fat-grafting

requires close collaboration with an excellent histopathologist with a low false-negative rate for detecting occult disease on frozen section. Others may prefer to perform preoperative MRI, staged subareolar duct excision or subareolar vacuum-assisted biopsy prior to making a decision about the safety of nipple preservation. If the frozen section (or subsequent pathology report) demonstrates occult subareolar disease, then the nipple must be excised intraoperatively (or in a second procedure).

24.4.3 Classification of Skin-Reducing Mastectomy with the LPS Technique

An algorithm for mastectomy and technique selection for implant-based reconstruction with lower pole support is show in Fig. 24.2.

24.4.3.1 Skin-Reducing Mastectomy in the Large and Ptotic Breast: The Wise-Pattern Incision

A Wise pattern provides both excellent access for mastectomy and creates the surplus lower pole skin necessary to create the deepithelialized LPS and a natural ptosis (Fig. 24.9a). Great care must be taken to avoid tension on closure caused by excising the skin too widely, particularly at the T-junction. This can be prevented by intentionally leaving the vertical limbs 1–2 cm longer than for a standard Wise-pattern marking or wedging a skin dart into the T-junction. The vertical scar is subsequently concertinaed to below the height of the maximum projection of the breast mound (after the definitive implant volume is in place or the maximum temporary implant volume has been inserted into the expander).

The LPS is fixed internally to reinforce the IMF with interrupted absorbable sutures. This stops the IMF from drifting down under the weight of the implant; which then will rest in the dermal sling in front of the fixed IMF. A stable IMF facilitates an evolving but predictable natural ptosis (Figs. 24.10 and 24.11).

When the LPS is used, it should be remembered that unlike the relatively non-distensible ADM, the autologous LPS is stretchable. Even with a fixed IMF, one should avoid the use of excessively large implants, which may lead to 'overstretching' of the lower pole and a 'bottomed out' appearance over time.

24.4.3.2 Nipple-Sparing Mastectomy in the Ptotic Breast

A Wise-pattern skin reduction may be performed with preservation of the NAC on a superior or superior-medial dermal pedicle (Fig. 24.9b). The LPS may then be created and inset in the standard method. Nipple viability is increasingly at risk, the larger the skin envelope and the greater the elevation required to achieve its new position on the reconstructed breast mound. If more than 3–4 cm of elevation is required, and the patient wishes to keep her nipple, then a safer option is a free transplantation of the

Fig. 24.5 Skin-reducing mastectomy with transvertical incision and immediate implant and ADM reconstruction (Natrelle Style 410 FX615, Surgimend 10 cm × 20 cm). Preoperative and postoperative images: a 42-year-old woman with multifocal carcinoma in the right breast (872 g)

Fig. 24.6 Bilateral skin-reducing mastectomy with transvertical incisions and immediate implant and ADM reconstructions (Natrelle Style 410 FF335, Surgimend 10 cm × 15 cm). Preoperative and postoperative images: a 47-year-old, *BRCA1* gene carrier (right breast 295 g, left breast 315 g)

NAC as a full-thickness graft onto a deepithelialized recipient areolar bed. *This technique has been described for completeness of our algorithm, but should be approached with a degree of caution and should be performed only by surgeons familiar with skin-reducing mastectomy and acceptably low flap loss and other complication rates.*

24.5 Implant Selection

24.5.1 Fixed Volume Versus Variable Volume Versus Expander

In deciding whether to use a fixed-volume or a variable-volume adjustable implant, the surgeon must consider both the skin envelope and the pocket characteristics; either of these may conspire to restrict the initial volume of the device to be implanted.

24.5.1.1 Skin Envelope Tension/Viability Restricting Implant Volume

Skin envelope tension ought not to be a problem with careful preoperative planning and assessment of the tissue characteristics. However, there may be several reasons why the skin envelope may still prevent use of a definitive final fixed-volume implant:

- Previously irradiated skin (e.g. after local recurrence in the previously conserved but irradiated breast or after cancer with the need for risk-reducing mastectomy) may not initially accommodate the intended implant volume.
- If for oncological safety more skin needs to be excised at mastectomy than planned.
- The perfusion and hence viability of the skin envelope is uncertain after the mastectomy. This can be assessed more accurately using intraoperative full-field laser Doppler imaging technology (Sect. 1.7.1).

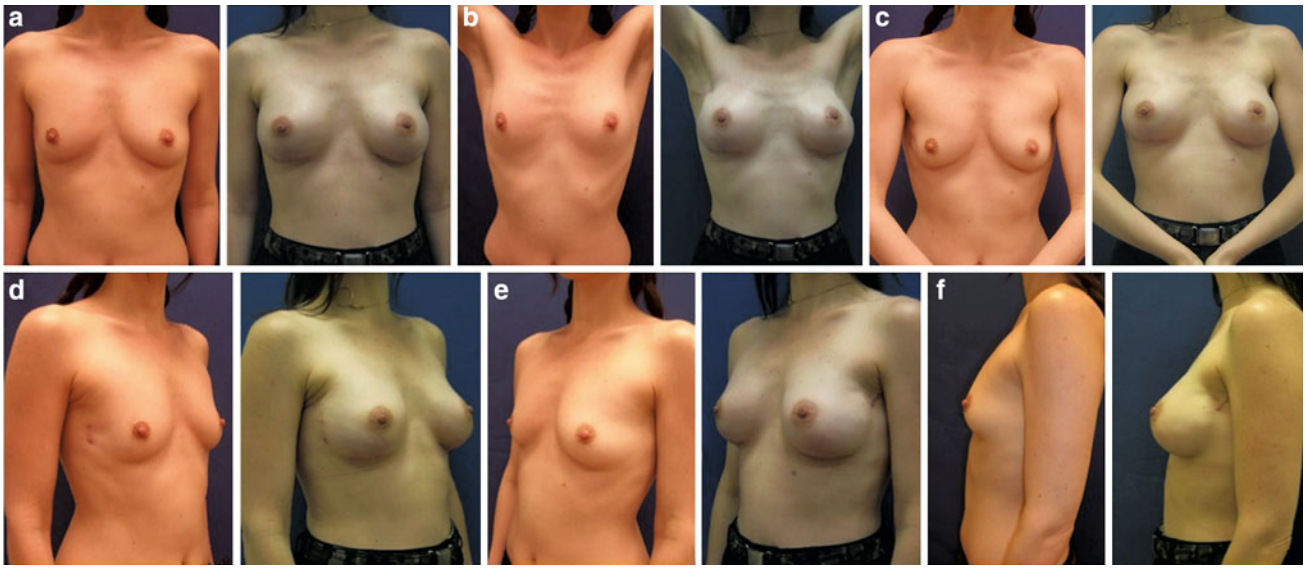

Fig. 24.7 Bilateral nipple-sparing mastectomy with inframammary incision and immediate implant and ADM reconstructions (Natrelle Style 410 MX325, Surgimend 10 cm × 15 cm). Preoperative and postoperative images: a 38-year-old, *BRCA1* gene carrier with carcinoma in the right breast (120 g) and risk-reducing mastectomy of the left breast (133 g)

Fig. 24.8 Nipple-sparing mastectomy with inframammary incisions and immediate implant and ADM reconstructions (Natrelle Style 410 FX410, Surgimend 10 cm × 15 cm). Preoperative and postoperative images: a 35-year-old woman requiring complete right mastectomy (350 g) after incomplete excision of carcinoma (wide excision 75 g)

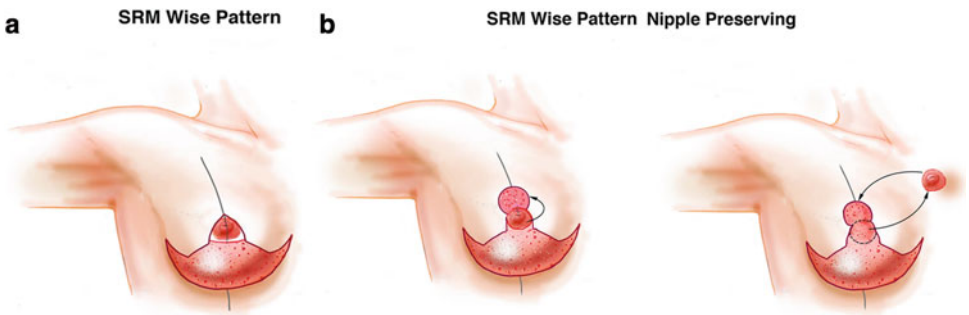

Fig. 24.9 Mastectomy incisions for use with the LPS technique: **a** Wise-pattern incision (skin-reducing mastectomy); **b** Wise-pattern incision, nipple-sparing on dermal pedicle or free graft (nipple-sparing mastectomy, skin-reducing mastectomy)

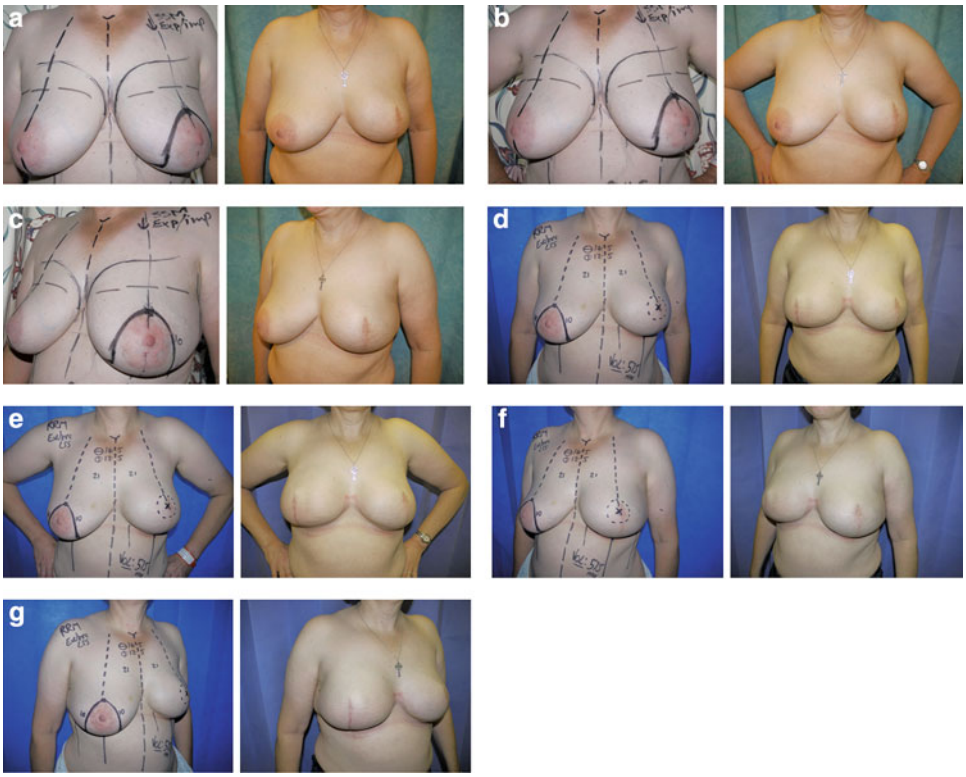

Fig. 24.10 Sequential bilateral skin-reducing mastectomy with a Wise-pattern incision and the LPS technique with adjustable-volume expander/implants (Natrelle Style 150 s—SH520). Preoperative and postoperative images: a 51-year-old woman after left mastectomy (630 g) for multifocal high-grade ductal carcinoma in situ followed by right mastectomy (675 g) for risk reduction 1 year later. Demonstration of reliability and reproducibility of outcomes

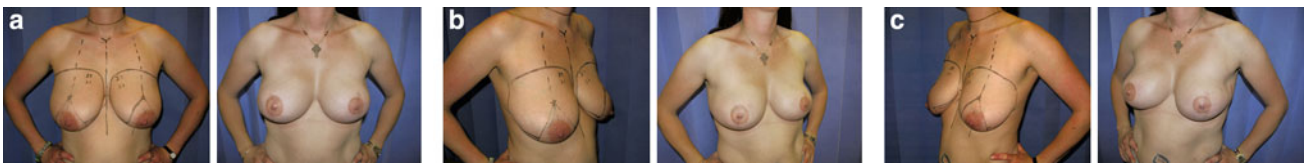

Fig. 24.11 Bilateral skin-reducing mastectomy with Wise pattern incisions and the LPS technique with adjustable-volume expander/implants (Natrelle Style 150 s—SH520). Preoperative and postoperative images: a 42-year-old *BRCA2* gene carrier undergoing bilateral risk-reducing mastectomy (right breast 610 g and left breast 595 g)

24.5.1.2 Pocket Characteristics Restricting Implant Volume

Intraoperatively, the composite pocket of the pectoralis major muscle and dermal support may also be found to prevent use of the final planned volume. Reasons for this may or may not be predictable preoperatively:

- Previously irradiated chest wall—progressive atrophic change and exaggerated fibrosis may lead to a reduced compliance of the pectoralis major muscle.
- Poor quality and adequacy of muscle.
- Traumatized or resected pectoralis major muscle following the skin-sparing mastectomy.

Use of a variable-volume device can partially overcome some of these problems. With the expander–implant devices currently available, e.g. Natrelle Style 150 (Allergan) or Becker 35 (Mentor), it may still be possible to offer a one-stage solution. Gradual expansion may then occur after the initial relaxation and healing phase as an outpatient procedure over the subsequent weeks.

In cases where it is deemed safer to have a minimal initial volume in the pocket (or to have the ability to completely remove any tension from the soft tissues if skin envelope viability is threatened), then a shaped tissue expander, such as the Natrelle Style 133 (Allergan), may be

used. Second-stage exchange to a permanent fixed-volume device would occur only once final expansion and the desired volume are settled upon.

24.5.2 Implant Selection/Dimension Assessment

24.5.2.1 Base Width

The defining dimension for a natural breast shape is the base width. The desired breast width may be assessed preoperatively in discussions with the patient and with demonstration of likely positions of cleavage medially and breast contour laterally. If allowance is made for overlying soft tissue, the estimated base width of the implantable device is approximately 1.0–1.5 cm (the average soft tissue pinch thickness) less than the desired breast width.

Intraoperatively, the final base width of the device can be measured more accurately by direct measurement of the pocket created. The author prefers to have a range of base widths available above and below the predicted preoperative implant width.

24.5.2.2 Implant Height

With the available matrices of shaped anatomical devices, there is a choice of available implant heights for any given base width. The implant height selected must take into account the preoperative biodimensional assessment of the patient's chest wall. An implant with greater height than the natural breast base height may prevent a 'step off' deformity in situations where excess chest wall subcutaneous tissue has been excised beyond the visible upper pole of the breast owing to an overenthusiastic mastectomy. The final height of the pocket can be rechecked intraoperatively before the final implant selection is made.

24.6 ADM-Based Lower Pole Support: Technical Points

24.6.1 ADM Insertion

After mastectomy, the pectoralis major muscle is divided from its origin inferiorly and medially (3 or 9 o'clock position, respectively). Posterolaterally, the pectoralis major muscle is freed from underlying pectoralis minor muscle (Fig. 24.12).

Depending on the choice of ADM, it may need to be cut to an appropriate curved shape. Our preference is for a semioval sheet of SurgiMend, a terminally sterilized bovine-derived ADM, which is fenestrated and measures 15 cm × 10 cm. It is large enough to provide lower pole support to most of the commonly used implant base widths. Additional sizes are available to accommodate patients as needed.

A common practice is hydration of ADMs in antibiotic cocktails as an added measure against microbial contaminants originating from the patient's skin or nipple. There are no studies to date evaluating whether this practice reduces complications. Immersion of ADMs in disinfecting agents (povidone-iodide, chlorhexidine, etc.) should be avoided as some such agents may concentrate in the ADMs and lead to chemical cytotoxicity. ADMs should be soaked in room-temperature fluids; hot saline from a warming oven can denature native dermal collagen and lead to a foreign body response and rejection. Many ADMs are supplied sterile, whereas some are aseptically processed and packaged with antibiotics that must be rinsed from the ADM by multiple saline soaks prior to use. This is to avoid the potential for 'red breast syndrome' or hypersensitivity reactions to antibiotics.

The superior edge of the ADM is sutured from medial to lateral, superiorly to the cut end of the muscle, using an absorbable, interrupted, and braided suture. Care should be taken to firmly anchor the material medially and to define the important medial IMF/cleavage area. The ADM must not be pulled too tight, but should be held gently to allow it to find its own tension-free position that best accommodates the lower ventral curvature of the implant. Once the ADM has been fixed medially, the use of an appropriate anatomical sizer in the developing pocket will allow more precise positioning and fixation of the ADM so it may fit 'like a hand in a glove' over the selected implant without wrinkling or pleating. Once the definitive sizer or implant is in position, the lateral most cut end of the pectoralis major muscle should be wedged downwards into a slit made in the ADM. This will put the muscle under moderate tension in a way that will prevent upwards 'window-shading' of the muscle.

24.6.2 LMF Definition

The ADM is then fixed laterally to the interface of the fascia over serratus anterior muscle. Even if the mastectomy has progressed beyond the intended LMF, the ADM should be fixed in a way that defines the lateral border of the intended internal domain and allows the lateral skin envelope to be draped comfortably over it. Lateral trimming of the ADM may be necessary if there is excess material. If the ADM is of insufficient width, then a composite ADM may be created with additional material as a full lateral patch. We have also had excellent uncomplicated results using separate strips of material to act as a lateral buttress.

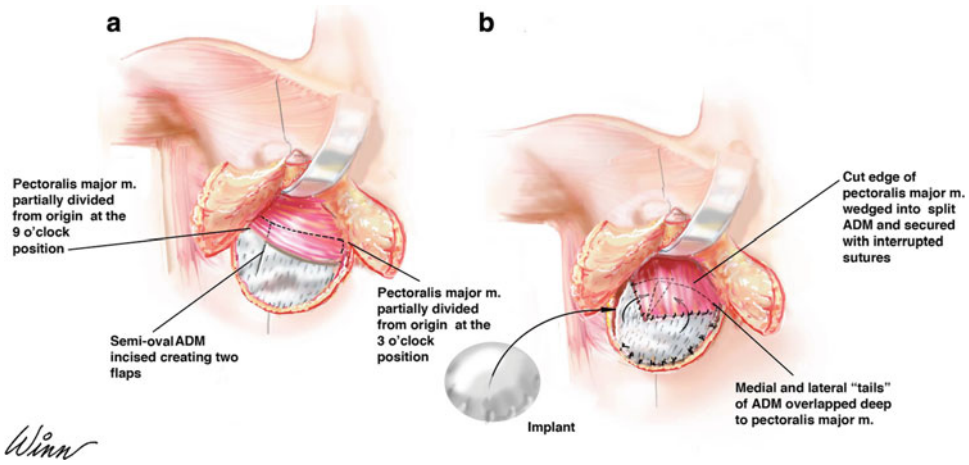

Fig. 24.12 ADM technique: technical points

24.6.3 IMF Definition

Lateral and medial fixation sutures are accurately inserted from the lower border of the ADM to the fascial condensation of the IMF. If the IMF has been breached or stretched during mastectomy, then the IMF can be reconstituted with these sutures.

24.6.4 Insertion of Definitive Implant Device

Depending on the mastectomy incision, the implant is inserted into the pocket via the most convenient route; either over the superior border of the ADM or under the inferior or lateral border. After removal of the sizer implant and insertion of drain(s), standard 'minimal handling' precautions are employed before the implant is inserted. Our preference is to insert the inferior (or superior) sutures accurately but without tying. Implant insertion under a curved retractor is then straightforward, and the final sutures may be tied with less risk of 'cutting out', which otherwise requires difficult, and potentially hazardous resuturing, in the presence of the implant.

24.7 Autologous LPS: Technical Points

24.7.1 Pocket Dissection

In contrast to the ADM technique, when using the autologous LPS, there is unlikely to be sufficient dermal material to support the implant laterally. For accurate lateral definition we use a sub-serratus anterior extension of the muscular pocket. The inferior division of the pectoralis origin is continued laterally in a horizontal line to the required pocket width through the fascia and costal digitations of the serratus anterior. The subserratus pocket is developed gradually upwards from the cut edge until the lateral pocket opens up to join the subpectoral dissection (Fig. 24.13).

Great care must be taken to elevate serratus digitations from the lateral ribs without breaching the intercostal musculature underneath or the often-flimsy serratus muscle at the lateral pectoral margin. If the serratus layer is attenuated, then a small lateral portion of adjacent pectoralis minor muscle maybe freed and transposed to reinforce the serratus layer ('lateral pectoral slide manoeuvre'). The reward for meticulous dissection laterally is a precise muscular pocket that will hold the entire upper portion of the implant and control the lateral border of the prosthesis without the need for lateral sutures. The lower cut border of the muscular pocket is then easily sutured to the dermal sling, with either a continuous suture or interrupted sutures, over the definitive implant or sizer.

24.7.2 The IMF

Even if the IMF is left intact after mastectomy, it is often stretched and somewhat displaced on the chest wall. It should be routinely reinforced at the desired position using interrupted absorbable sutures. This will prevent it from drifting inferiorly under the weight of the implant. When the implant is in position on the LPS, it is actually sitting in front of the newly fixed IMF. This facilitates an evolving natural ptosis on a stable IMF.

24.7.3 The 'Medial Corner'

When the LPS is used, there may be occasions when the dermal sling is deficient medially. The pectoralis major origin should still be divided in the same way as when using an ADM, but in this scenario it may not be possible to

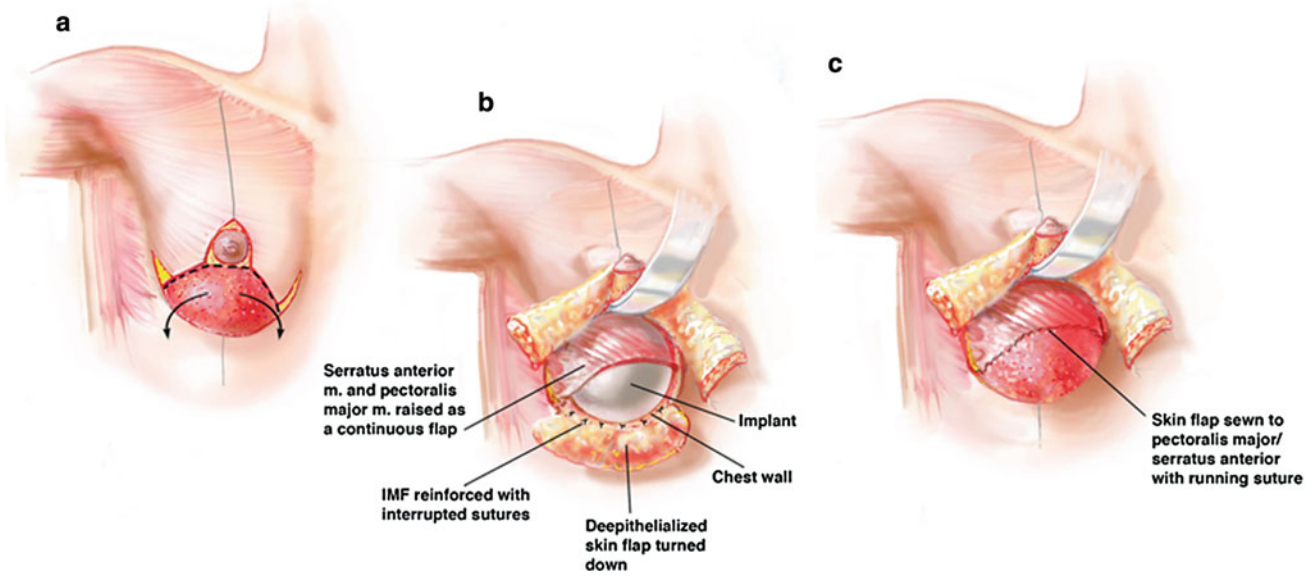

Fig. 24.13 LPS technique: technical points

oppose muscle to dermal sling over the implant in the medial corner of the pocket. In our experience, leaving the pocket open medially has not led to any complications, but our preference is still to use an ADM patch if there is any risk whatsoever of the implant lying immediately under the wound.

24.8 Minimizing Complications

As ADM use increases and newer materials become available, there is a growing body of literature to support safety and acceptable complication rates with the use of ADMs in implant reconstruction [19–25].

Some of the published meta-analyses however have shown increased rates of infection, seroma, haematoma and explantation compared with control subpectoral implant reconstructions [26, 27]. It is unsurprising that complications are commoner in patients who go on to have adjuvant chemotherapy and/or radiotherapy [28]. Other meta-analyses have not shown significant differences in complication rates compared with other methods of implant reconstruction and seem to concur with our assumption that this technique confers significant benefits in terms of cosmesis, reduced expander times, number of maintenance surgical procedures and a reduced overall time to completion of reconstruction [29, 30].

In our experience, although aesthetic results remain unquestionably better, complication rates when using lower pole support are comparable with standard subpectoral pocket based implant reconstructions for prolonged seroma, haematoma, implant infection, implant loss or device-related problems (rotation, rippling, edge palpability, port flipping or device failure). Our infective complications and implant loss occurred exclusively in the presence of seromas and skin necrosis or in a small proportion of those patients who had adjuvant chemotherapy, radiotherapy or both (Tables 24.3 and 24.4).

24.8.1 Skin Envelope Necrosis

To optimize perfusion and minimize the risk of skin envelope necrosis requires adherence to all of the technical points discussed so far. Excellent mastectomy technique requires careful patient assessment, accurate incision planning, meticulous tissue handling and tension-free draping and closure.

If the reconstructive team involves a general surgeon and a separate reconstructive surgeon, then close cooperation, joint planning and an agreed strategy are essential. Good communication with the anaesthetic team throughout the procedure is also important. To optimize skin perfusion, it is essential to ensure adequately monitored and stable haemodynamics as well as core temperature.

If, despite the best efforts, the skin envelope viability remains uncertain, then further intraoperative monitoring of skin perfusion can help inform decision-making regarding the need for further skin excision or whether to use a variable-volume device. Different strategies may be employed to assess skin envelope perfusion; intraoperative temperature or oximetry probes may not be reliable enough by the time an intraoperative decision has to be made and optical near-infrared spectroscopy, although a promising method for assessing global perfusion of skin flaps [31], is not yet

Table 24.3 Combined author's experience of implant breast reconstruction with lower pole support 2007–2011

	ADM experience (Surgimend), 341 immediate implant reconstructions, March 2001–July 2011 (Tel Aviv, Israel)	LPS experience, 102 immediate implant reconstructions, January 2007–January 2012 (Cornwall, UK)
Total skin-sparing mastectomy	341	102
Bilateral skin-sparing mastectomy	262 (131 patients)	50 (25 patients)
Unilateral skin-sparing mastectomy	79	52
Direct to implant (1-stage)	270	90
Tissue expander (2-stage)	71	12
Total radiotherapy	57	12
Preoperative radiotherapy	32 (9.4 %)	4 (3.9 %)
Postoperative radiotherapy	25 (7.3 %)	8 (7.8 %)
Total chemotherapy	62	10
Preoperative chemotherapy	43 (12.6 %)	0
Postoperative chemotherapy	19 (5.6 %)	10 (9.8 %)

LPS lower pole dermal sling

Table 24.4 Complications after implant-based reconstructions with lower pole support 2007–2011

	ADM experience (Surgimend), 341 immediate implant reconstructions, March 2001–July 2011 (Tel Aviv, Israel)	LPS experience, 102 immediate implant reconstructions, January 2007–January 2012 (Cornwall, UK)
Skin flap necrosis	18 (5.2 %)	10 (9.8 %)
Necrosis and infection	7 (2.0 %)	1 (1.0 %)
Infection (no necrosis)	1 (0.3 %)	4 (3.9 %) all after chemotherapy
Haematoma	7 (2.0 %)	5 (4.9 %)
Seroma	9 (2.6 %)	4 (3.9 %)
Failure (implant loss)	6 (1.75 %)	4 (3.9 %) all after chemotherapy
Capsule (grade 3–4)	7 (2.0 %) all after radiotherapy (7/57 = 12.3 % radiotherapy cases)	4 (3.9 %) all after radiotherapy (4/12 = 33.3 % radiotherapy cases)
Rotation	1 (0.3 %)	1 (1.0 %)

commercially available. Our preference is to use intraoperative full-field laser Doppler imaging technology to assess skin perfusion and viability. The laser signal illuminates an area of 7 cm × 7 cm of the skin envelope and is transmitted to a depth of up to 2 mm. The frequency shift caused by laser interaction with circulating red blood cells is used to calculate concentration, average speed and perfusion of the skin flaps, which is then displayed as a real-time perfusion colour map on the monitor. Poorly perfused skin should be excised.

If the planned closure with a fixed-volume prosthesis is no longer possible, or the tension is likely to be too great, then we recommend use of an adjustable-volume implant or expander.

24.8.2 Capsular Contracture

To some extent capsule formation is an inevitable consequence of implantation. Symptomatic and troublesome capsular contracture requiring intervention however can be minimized by adherence to recognized precautions—such as careful tissue handling and haemostasis, strict asepsis, the choice of ADM and the best-quality prosthesis.

Reducing capsular contracture risk still further demands the optimal balance and minimal tension between soft tissues, skin and the internal domain. The use of an ADM or LPS creates a less inflammatory, stabler internal domain, and in our experience this is an important reason why we continue to see evidence of reduced capsular contracture

rates with lower pole dermal support. Some of the recent meta-analyses and reviews of the early-published experience with ADMs appear to bear this out [32, 33].

24.8.3 Capsular Contracture Secondary to Radiotherapy

Whether radiotherapy is unexpectedly recommended after mastectomy and reconstruction (despite preoperative planning to the contrary) or a patient chooses to have an implant-based reconstruction with the knowledge that radiotherapy is to come, there is an inevitable increased risk of aesthetic compromise [34–36].

It is this that has led some to advocate avoidance of a definitive implant-based reconstruction in the face of radiotherapy, in favour of either delayed autologous reconstruction or a delayed–immediate reconstructive approach with temporary expanders during radiotherapy [37, 38]. Expansion during or after radiotherapy, even as part of a two-stage strategy, is not effective on its own to minimize radiation-induced aesthetic compromise [39].

Modern, individualized radiotherapy planning can go some way to ameliorating the unwanted effects of radiotherapy on the reconstructed breast; use of the three-dimensional treatment planning system for exact dose calculation, hyperfractionation of dose schedules and avoidance of specific skin boluses are all important advances in radiotherapy administration. A patient-specific approach to the intended treatment target, with particular attention to dose depth from the skin, assessment of surgical margins and a better understanding of tumour biology, has led to improvements in our implant-based reconstruction outcomes.

Use of lower dermal support seems to also improve outcomes in irradiated reconstructions. We believe this to be related, once again, to having established a better cushioning, padding, perfusion and harmony between soft tissues and a stable internal domain, as well as careful optimization of the health of the overlying skin envelope. Lower dermal support minimizes the tension within and exerted by the internal domain on the skin envelope. This ensures the best possible perfusion of skin and soft tissues in preparation for the radiotherapy. There is good evidence for enhanced fibroproliferation with radiotherapy in the presence of implants, and some important signalling pathways have been identified [40]. We hypothesize that in addition to this, collapsed small vessels (due to extra tension in skin, muscle and the developing capsule) may be more susceptible to radiotherapy-induced vasculitis, and hence subsequent fibrosis, than if the microcirculation is kept optimally perfused by minimizing tension within the soft tissues.

24.8.4 Acute and Chronic Pain

The reduced tension and stability of a subpectoral and ADM/LPS pocket, as compared with a full submuscular pocket, should lead to less immediate postoperative pain on early pectoral movement. There is the potential for increased discomfort from the subserratus lateral pocket dissection in the LPS technique and care must be taken not to traumatize underlying costal periosteum. The use of intercostal blocks and other regional local anaesthetic techniques can improve acute pain in the initial postoperative period.

As discussed earlier, the use of lower pole support techniques, specifically an ADM, seems to reduce the incidence of capsular contracture. We believe that this may then in turn lead to a reduction in development of chronic pain.

24.9 Refining Long-Term Results

Injection of autologous fat may be very effective as a secondary adjunct to improve outcomes in breast reconstruction generally [41] and in implant-based reconstructions specifically [42] by:

- Creating a more natural cleavage and upper pole take-off
- Smoothing out and filling uneven areas of the skin envelope where mastectomy flaps may have been taken too thin
- Improving contour/shape and transitional area irregularities
- Covering thin areas where there may be implant rippling or edge palpability
- Reducing radiotherapy-induced skin change and fibrous capsule formation.

The attendant risk to the underlying implant is small, but if soft tissues are thin and there is a significant risk of inadvertent intracapsular fat injection, simultaneous exchange for a new prosthesis may be appropriate.

Three-dimensional imaging (e.g. Vectra system) will demonstrate (and quantify) contour and volume discrepancies. Better objective and quantitative assessment can improve the quality of consultations and allow accurate planning for fat grafting refinement procedures.

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