Breast Reconstruction with Tissue Expander and Definitive Implant Replacement

Thomas H.S. Fysh and R. Rainsbury

35.1   Introduction

For patients who are not suitable candidates for autologous breast reconstruction, the traditional approach has been a staged procedure, by first expanding the skin and chest wall musculature over a period of weeks and then exchanging the expander for a fixed volume implant. While this was conventionally a delayed procedure to be carried out once adjuvant treatments were completed, it is now routinely used in the immediate setting [1].

The use of silicone implants for breast augmentation was described as long ago as the early 1960s, but it was another decade before Snyderman published the technique for a rudimentary, single-stage immediate implant-based reconstruction [2, 3]. It was not until 1982 that Radovan first described formal tissue expansion after mastectomy followed by exchange for a fixed volume silicone implant [4]. Since then, the steady advances that have been made in implant technology and dermal substitutes, as well as the rising demand for reconstructive and oncoplastic breast surgery, have served to increase the popularity and improve the outcomes associated with two-stage, expander-based breast reconstruction.

35.2   The Rationale for the Two-Stage Breast Reconstruction

Each reconstructive option has its attractions, but while the aesthetic outcomes of implant-based reconstruction may be inferior to tissue-based techniques, high-quality series and national audits nonetheless report rising patient demand and high levels of satisfaction following this approach [5, 6].

T.H.S. Fysh (✉)
Consultant Oncoplastic, Breast and General Surgeon, The Medical Specialist Group, Alexandra House, Les Frieteaux, St Martin's, GY1 3EX, Guernsey

R. Rainsbury, BSc, MS, FRCS
Consultant Surgeon, Winchester Breast Unit, Royal Hampshire County Hospital, Winchester, SO22 5DG, UK
e-mail: rrainsbury@aol.com

Two-stage implant-based breast reconstruction is, in many respects, the simplest of options. As such, it has found favour where other approaches cannot be considered, either because of operative risk, resource limitations or patient preference.

35.3   Patient Selection and Relative Contraindications

Given that the maximum volume achievable in two-stage breast reconstruction is around 650 ml, the ideal patient is usually of slim to normal habitus or only mildly overweight. The pectoralis should be innervated and functioning, and the skin flaps should be healthy. Although contralateral symmetrising surgery is usually straightforward, it may be difficult to achieve significant ptosis with this approach, and some patients will go on to have a mastopexy or reduction either at the time of their reconstruction or later on.

Patients undergoing immediate breast reconstruction will usually be suitable for either a 'direct-to-implant' approach or an autologous tissue-based reconstruction with or without an implant. A two-stage approach, however, provides the patient and surgeon with more flexibility, and there are many examples of situations when it is an attractive option.

While the initial surgery is relatively simple and low risk, patients who choose to undergo two-stage breast reconstruction must be advised that they are likely to require adjustments or revision of their reconstruction at a later stage. Leading manufacturers of cohesive gel implants generally advise that after 10–15 years, more than half the number of implants will have been replaced. Furthermore, several high-volume case series have shown that almost half of patients who have a planned 'two-stage' breast reconstruction actually go on to have three or more procedures [7, 8]. It is also clear from these and other reports that patients who have postmastectomy radiotherapy are particularly at risk of complications and have poor aesthetic outcomes. But while radiotherapy is often regarded as a contraindication to implant-based breast reconstruction, this view is currently being questioned as discussed below.

35.4 The Operative Approach

35.4.1 Marking Up

With the patient standing up, her feet a comfortable distance apart and her shoulders relaxed with arms by the side, the midline is marked, starting at the sternal notch. The breast meridian is marked on the normal side, as is the inframammary fold (IMF), with its most dependent point marked in the midline. The planned IMF is then marked on the operative side, with the most dependent part marking the intersection of the planned new breast meridian. The upper and lateral borders are matched with the normal side, and so a new breast 'footprint' is marked and the base width noted. Some manufacturers provide transparent plastic templates for this purpose. The skinfold thickness is taken away from the base width to give an expander base-width measurement. The exact choice of the expander will depend on the manufacturer and familiarity with use, but in general, the choice of devices is smaller than that of the fixed volume implants. The height of the device is only relevant in anatomically shaped 'adjustable implants', which are usually more expensive than 'true' tissue expanders and used in situations where they are unlikely to be exchanged (their use is discussed below). As a rule, we suggest ordering two expanders of the measured base width, two of the size above and two of the size below, which allows for size discrepancy and accidental contamination or damage.

35.4.2 Antisepsis Measures

- Screening for methicillin-resistant and methicillin-sensitive *Staphylococcus aureus* (MRSA and MSSA).
- When screening is positive, implement a clearance regimen (e.g. nasal mupirocin and chlorhexidine body washes) for 5 days before surgery.
- Where possible, a 'clean air' theatre is used (e.g. laminar flow).
- Passage of staff in and out of theatres is restricted.
- Single dose of IV antibiotics should be administered on induction according to local policies, to reduce the risk of post-operative infection, and repeated in procedures lasting more than 4 h.
- The skin should be prepared with a single wash of 2% chlorhexidine in a 70% solution of isopropyl alcohol and allowed to dry. Povidone Iodine is less effective [9].
- The pocket is prepared as much as possible prior to implantation, even with the use of an ADM.
- All operating staff put on a second pair of gloves prior to opening the expander (or wear two pairs, taking the outer pair off at this stage).

- The authors favour a 'minimal or no touch' technique, whereby the expander is opened immediately before implantation and bathed in a betadine/antibiotic mixture [10] or aqueous chlorhexidine. High-quality evidence confirming that this measure reduces implant loss is lacking and there is some concern that betadine may cause local tissue trauma, increasing capsule formation; some favour saline washes only.
- Contact between the skin and the implant should be avoided.
- Time between implantation and skin closure should be minimal; consultants should determine how much time to allow trainees with this in mind since operating time is directly related to surgical site infection rates.
- The pocket is thoroughly washed prior to implantation, with special attention given to removing loose fat and necrotic tissue, which could provide a nidus for infection.
- The use of special devices such as plastic sleeves to deliver the prosthesis into the pocket is largely untested, but is conceptually attractive as they allow for a true 'no touch' approach.

35.4.3 Intraoperative Technique

The procedure is undertaken under general or regional anaesthesia such as paravertebral blockade and sedation, with the patient in the supine position and arm abducted.

In the delayed setting, the incision is made usually via the previous mastectomy wound, but there is the opportunity to redefine the new IMF if necessary at this stage. Alternatively, this can be considered at the time of implant exchange. The techniques for redefining the IMF are described below; this is generally more important in patients who have undergone chest wall radiotherapy, since nonirradiated skin should expand without difficulty. It is preferable to excise as much irradiation-damaged and scarred skin as possible at this stage.

In the 'immediate reconstruction' setting, the mastectomy is most commonly performed using a skin-*reducing* pattern, since a total skin-*sparing* approach is usually more appropriate for a 'direct-to-implant' reconstruction. While it is technically possible to retain the nipple in a skin-reducing pattern, the vasculature of the nipple-areola complex is extremely precarious, and patients must be advised of the greater risk of ischaemic complications, especially when adjuvant therapies may be required. The template for the skin-reducing approach is a modified 'Wise' pattern, whereby the T junction is raised a little and the angle of the apex made more acute than for a breast reduction. As such, the final incision takes on more of a 'Mercedes' sign appearance than the classic 'inverted T'. The surgeon's aim is to be able to drape
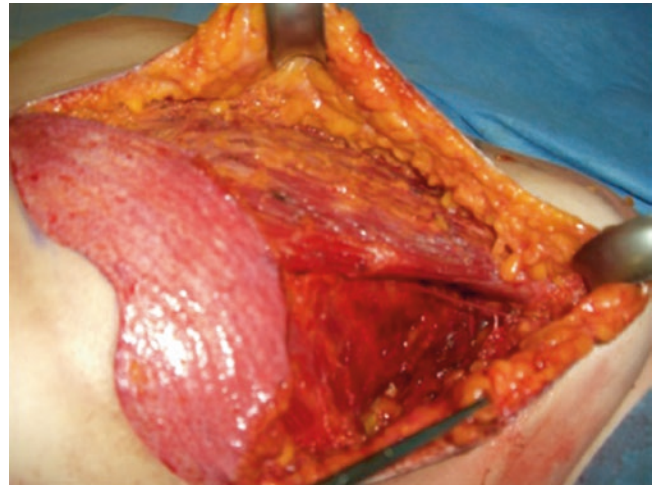
the skin over the reconstruction 'mound' such that it is not under tension but in such a way that it remains 'smoothed out'. In both the immediate and delayed setting, the skin is elevated from the chest wall musculature about 1–2 cm beyond the superior and lateral boundaries of the planned breast 'footprint'. Care should be taken to preserve the perforating intercostal branches medially, and some surgeons like to mark these preoperatively using a handheld Doppler device.

The pectoralis major is then elevated and detached from the chest wall at its costosternal origin as far as the level of the planned maximum breast projection (usually the fourth intercostal space). It is crucial NOT to over-dissect the submuscular pocket superiorly or laterally. It is all too easy and tempting to do so, since this is a natural tissue plane, but the expander will follow the path of least resistance once in situ and will tend to migrate in this direction.

In its lower pole, the expander must be covered either with an ADM and/or chest wall fascia/musculature. Using the former approach, the IMF and lateral border can be easily defined by carefully suturing the lower border of the ADM to the anterior rectus sheath inferiorly and to the serratus fascia laterally; indeed this is the main reason for using an ADM in this context. Since the ADM itself cannot be expanded, a small a piece as possible should be used and attached to the pectoralis muscle with interrupted absorbable sutures. At the time of implant exchange, the incorporated ADM can be incised radially to improve its compliance and shape. When using the skin-reducing approach, the lower pole breast skin can be de-epithelialised, forming an 'inferior dermal' or 'lipodermal' sling. This avoids the cost and risks associated with ADMs and is sutured to the pectoralis to provide implant cover (Figs. 35.1, 35.2, 35.3 and 35.4).

Fig. 35.2 The de-epithelialised inferior sling is sutured to pec major superiorly and serratus laterally to form the expander pocket. The skin is draped over the top without undue tension

Fig. 35.3 Early post-operative appearances (bilateral procedure), Becker™ adjustable implants 70% filled

Fig. 35.1 Mark-up for skin-reducing mastectomy and inferior lipodermal sling with Becker™. *Inferior shaded area* is de-epithelialised and skin template cut quite loosely compared to a cosmetic breast reduction

Fig. 35.4 Three months post-operative left skin-reducing mastectomy and lipodermal sling with Becker fully inflated (with prior right augmentation mastopexy many years ago). This patient unexpectedly required postmastectomy radiotherapy and the implant extruded 12 months later

It is the authors' preference to use a single suction drain at closure, which can be fed into the expander pocket and through the skin via the mastectomy pocket. It is important for any dead space to be drained long enough for the ADM or lipodermal sling to incorporate into the skin envelope. Typically, this means the drain is left for 1–2 weeks. As with any immediate reconstruction, it is preferable to stage the axilla beforehand or intraoperatively. This not only avoids unnecessary early reoperation, risking exposure of the expander, but may also influence the timing and type of any reconstruction. There is a lack of evidence to demonstrate that skin necrosis rates are higher when accessing the axilla via the mastectomy incision. Some surgeons prefer to minimise traction and trauma to the skin envelope by accessing the axilla through a small separate incision, thereby keeping the axillary and mastectomy pockets separate. If required, the use of high-intensity illumination and careful exposure with atraumatic retractors can provide excellent axillary access even through a small circular mastectomy incision.

35.5 Radiotherapy in Two-Stage Implant-Based Breast Reconstruction

It has long been held that postmastectomy radiotherapy is a relative contraindication to two-stage implant-based breast reconstruction. Ideally, it would be preferable to replace the irradiated skin with fresh tissue from elsewhere. Sometimes, however, this may not be an option because patients are not willing or able to consider autologous reconstruction. When two-stage implant-based breast reconstruction is undertaken either after chest wall radiotherapy or before planned chest wall radiotherapy, it must be on the understanding that the rates of all complications, including reoperation, implant extrusion and reconstructive failure, are much greater, often quoted as high as 50% [7, 11]

35.5.1 Patients with Planned Radiotherapy

In the immediate setting, it may be appropriate to use a two-staged approach to implant-based reconstruction in patients for whom the adjuvant treatments are unclear. This is sometimes referred to as 'skin-banking' or a 'delayed-immediate' approach. Common reasons for adopting this approach include:

- When it is unclear preoperatively whether or not patients will require or accept postmastectomy radiotherapy. Few would disagree that it is preferable to avoid any implant-based breast reconstruction when radiotherapy is being considered. The value of 'skin banking' is this context is questionable since healthy skin can usually be transferred along with an autologous flap later, and so the simpler

approach of a well-executed, IMF-based mastectomy is often the preferred option.
- For patients who have not yet decided what kind of definitive reconstruction they would like, but who will not accept being flat chested at any point.
- For patients who need cancer surgery soon and do not want to be flat chested, but who can wait for definitive reconstruction for other reasons, such as buying time to stop smoking, attending important personal engagements or when there is lack of access to specialist services.
- For patients who have had a previous augmentation and who need the existing implant to be removed as part of their cancer surgery. In these patients, the implant pocket (or parts of it) can usefully be retained, but often needs to be expanded to make up for the volume lost to the mastectomy.

35.5.2 Adjustable Implants Versus Tissue Expanders

Most tissue expanders are constructed from a solid state silicone shell surrounding a saline chamber that is accessed via an integrated metallic port on the anterior surface of the device. Most ports have a magnetic location system, which allows the clinician to cannulate the port transcutaneously without sonography. They are relatively cheap but are not designed to be left in situ. Moreover, the integrated port means that they are often unsuitable for patients likely to require MRI scanning or radiotherapy.

Adjustable implants such as the Becker™ expander series (Mentor, Johnson and Johnson) can provide an elegant solution for patients who are suitable for implant-based reconstruction but who are not suitable for either the "direct-to-implant" approach or in whom a two-staged "exchange approach" may not ultimately be necessary. These implants contain a variable volume of cohesive silicone gel (between 25% and 50%, depending on the type) with an adjustable inner saline chamber accessed via a remote subcutaneous injection port. Typically the port is removed under local anaesthetic, once the final volume has been achieved, and the adjustable implant is left in situ without being exchanged. These gel/saline implants are more expensive than traditional saline expanders or fixed volume gel-filled implants, and so their use should reflect the likelihood that they will remain in situ. In one case series reporting the outcome of >300 Becker™, 74% remained in situ >5 years following implantation, avoiding the cost and morbidity of exchange for a fixed volume device [12]. Examples of patients who might be suitable for an adjustable implant include:

1. Those for whom postmastectomy radiotherapy is dependent on histopathology findings, but may not be necessary.

2. Those who require contralateral reduction simultaneously. Since shape and volume match in such patients is difficult to predict, final adjustments may be needed.
3. Patients in more remote communities where access to a large implant bank is not possible.
4. Patient groups with poorer-quality skin flaps, but who would otherwise be suitable for the 'direct-to-implant' approach (such as the growing number of older patients requesting breast reconstruction). In such women, the pressure on the skin can be easily reduced if necessary without exposing the patient to further surgery (Figs. 35.5 and 35.6).

Fig. 35.5 78 year old with prior left mastectomy requesting reconstruction (preoperative). A single operation was desirable, and so a Becker™ adjustable prosthesis was used with a non-biological ADM (TiLOOP™)

Fig. 35.6 Three months post-operative. Left delayed Becker™/ADM reconstruction in older patient. She underwent a single operation lasting approximately 1 h. She had good symmetry in a bra and declined contralateral reduction/mastopexy

5. Women with a very small (100–150 cc), somewhat flat breast mound who choose implant-based reconstruction but decline contralateral augmentation. The use of a slightly underinflated small (150–200 cc) Becker™ expander will achieve a breast shape which is as close as possible to the remaining breast. The base width is wider than a gel implant of equivalent volume, and the somewhat unnatural projection associated with smaller fixed volume implants can be avoided.
6. Patients undergoing bilateral immediate or delayed reconstruction after risk-reducing mastectomy who are uncertain about the most appropriate final volume. Becker™ provides considerable flexibility in relation to both volume and projection while avoiding the inconvenience and risks of subsequent exchange.

35.5.3 Timing of Radiotherapy in the 'Delayed-Immediate' Approach

For patients awaiting radiotherapy and not requiring chemotherapy, the expander is inflated fairly rapidly 2–3 weeks after surgery, provided wound healing is normal. This is usually straightforward because these patients do not require very much (if any) true skin expansion in the early stages due to the skin-sparing approach of the mastectomy. The aim is ultimately to 'overexpand' the skin envelope in order to pre-empt the fibrosing effects of radiotherapy. Most manufacturers of tissue expanders favour overexpansion and exchange to a fixed volume implant prior to radiotherapy. Overexpansion volumes are given in the manufacturers' leaflets, and while the actual tolerance tends to be well in excess of the advised overfill volume, most advocate an overfill of about 20% of the intended final volume.

Given that it is desirable to deliver postmastectomy radiotherapy within 4–6 weeks of surgery, this approach can lead to delays in order to accommodate hospitalisation and healing times. Although long delays can worsen outcomes, excellent loco-regional control is still achieved when radiotherapy is delivered within 8 weeks of surgery [13, 14]. Delay is seldom a problem since most patients with a disease profile warranting postmastectomy radiotherapy will also require post-operative chemotherapy. In this situation, expansion is carried out during chemotherapy, and exchange is carried out 3 weeks after the last cycle of chemotherapy and 3 weeks before the start of radiotherapy. These timing issues will become more common as the use of neoadjuvant chemotherapy continues to rise.

An alternative strategy is to delay implant exchange until *after* completion of radiotherapy. This may seem to be an attractive approach, as operative scheduling is simplified and irradiation of the final implant is avoided.

Recent evidence suggests however that this approach is associated with poorer outcomes, including high rates of capsular contracture and reconstruction failure and is best avoided [15].

35.5.4 Patients with Prior Chest Wall Radiotherapy

When patients present with an irradiated chest wall, but who have otherwise completed their adjuvant treatment, the basic approach to the reconstruction differs to that in nonirradiated patients. Only rarely will such patients end up having an implant-based reconstruction, and it is fair to say that these patients are extremely challenging. Most are suitable candidates for an autologous reconstruction, combined with an implant/expander or subsequent lipofilling if further volume is required, or an external prosthesis should be considered. For those wanting an implant-based reconstruction, several issues arise:

- The irradiated skin is less elastic, and the underlying pectoralis is often somewhat fibrotic, rigid and resistant to stretching. These factors combine to make expansion a much more challenging and time-consuming process. The number of expansions required will usually be greater, in smaller increments (e.g. 50 ml per expansion), with longer periods between each expansion.
- It is wise to be modest in terms of the final reconstruction volume. Attempting to use a large volume expander may preferentially depress the chest wall, causing a 'saucer' deformity of the rib cage, rather than expanding the skin. This can happen with smaller expanders too and should be anticipated and suspected in those patients who fail to achieve satisfactory projection despite numerous expansions.
- The expander will tend to migrate upwards or laterally towards the axilla, following the plane of least resistance. It is crucial to avoid over-dissection of the pocket in the first instance, although migration may still occur during the phase of overinflation (Figs. 35.7, 35.8, 35.9 and 35.10).
- Subcutaneous autologous fat grafting to improve the quality of irradiation-damaged skin has been shown to improve patient-reported outcomes in this context [16]. This may need to be repeated until visible improvement takes place, prior to delayed reconstruction.
- Nonirradiated skin will tend to expand preferentially compared to irradiated skin. Accurate placement of the tissue expander directly beneath the irradiated mastectomy flaps is important to avoid the creation of a 'double bubble' breast mound, due to differentially greater expansion of the unirradiated peripheral tissues.

Fig. 35.7 50 year old requesting delayed reconstruction 5 years post-mastectomy and chest wall radiotherapy and axillary clearance

Fig. 35.8 Pt in Fig. 35.7, 4 weeks postoperatively. A planned LD was aborted intraoperatively, since the LD pedicle was destroyed by previous surgery and radiotherapy. An expander was inserted with and inferior non-biological ADM (TiLoop™) and filled with 60 ml initially

- Irradiated skin and muscle is unlikely to yield sufficiently to provide good projection even after expansion. This can be addressed in a number of ways
  - At the time of exchange to a permanent implant, a good volume of skin and subcutaneous fat can be recruited from the abdominal wall by dissecting beyond the IMF often as far as the umbilicus, in the plane of abdominal wall fascia. This 'abdominal advancement flap' can then be advanced into the lower pole of the new breast mound. It can then be secured in place with a line of sutures including the anterior rectus sheath and positioned to define the new inframammary fold. The imported, unirradiated abdominal tissue is then draped over the lower pole, providing ptosis and enhancing projection.

Fig. 35.9 Pt in Fig. 35.7. As expansion continues, the expander migrates along the path of elastic resistance, superolaterally. The radiotherapy damaged skin fails to expand

Fig. 35.10 Pt in Fig. 35.7. Upon exchange, an attempt to redefine the IMF by advancing abdominal wall tissue is only partially successful. The patient went on to have symmetrising reduction, however, and no longer needs an external prosthesis

– At the time of expander placement and again at the time of exchange for an implant, the irradiated skin and fascia can be relaxed through multiple radial and horizontal 'capsulotomy' incisions, carried out from within the cavity (stopping before the dermis is reached). It is also safe to perform multiple capsulotomies following ADM-based procedures, as the dermal substitute should be fully incorporated into the surrounding tissues by the time of exchange.

- Because of resistance of irradiated chest wall tissues to expansion, clear definition and firm fixation of the IMF is crucial. This can be achieved in a number of ways.
  – At the time of expander placement, an ADM can be used to define the IMF, bearing in mind that the use of an ADM in this setting is associated with higher rates of infection and loss of both ADM and implant. The ADM will not expand itself and so in addition to fixation to the anterior rectus sheath and serratus fascia, it must be sutured to the lateral border of the pectoralis muscle with interrupted sutures; it may help to further shape it with radial incisions to encourage future expansion. Similarly, careful fixation of the ADM inferiorly prevents the expander from migrating downwards. This will not guarantee a well-defined IMF particularly in larger patients, or in those who have had an incomplete mastectomy leading to thick flaps.
  – At the time of replacement of an expander with a permanent implant, the IMF may require further definition. This can be achieved from within the implant pocket, and, here, the author's preference is to use several heavy PDS sutures to anchor the IMF from the deep dermis to the chest wall along a pre-drawn line corresponding to the level of the intended IMF. Forming the new IMF is facilitated by advancing the abdominal wall as described above, particularly when the soft tissues over the lower pole are tight and attenuated.
  – An alternative approach is to redefine the IMF by entering the implant cavity via an incision placed along the line of the planned IMF. A crescent of skin is then de-epithelialised, such that the full-thickness 'access' incision is in its centre. The upper part of this de-epithelialised crescent is then tacked to the chest wall with heavy interrupted PDS sutures. The abdominal wall is advanced to the same level and in a similar way is also tacked to the chest wall with heavy PDS sutures, since it will now be under some tension. The exact mark-up of the de-epithelialised section will vary and depend on skin laxity, thickness of the abdominal wall and degree of projection to be achieved after expansion. Contrary to traditional teaching, the authors have not found that fashioning these parallel 'tramline' incisions carries a risk of ischaemia, as long as the original mastectomy incision is mature, preceding the inframammary fold incision by at least 6 months.
- Patients with a with previously irradiated chest wall should be warned that, more than any other patient undergoing breast reconstruction, the likelihood of requiring further unplanned operations (for any reason, including repeated adjustments, implant exchange and revisional surgery) is very high [12].

35.6 Summary

Two-stage implant-based breast reconstruction is an attractive, relatively uncomplicated option, particularly for those women who are not suitable for other forms of breast reconstruction. Its appeal lies in its simplicity, low morbidity, short hospital stay and rapid recovery. Women should be informed that these shorter-term gains need to be considered carefully alongside the more favourable longer-term aesthetic outcomes associated with autologous tissue-based techniques. They should also understand that although the initial surgical episode is usually uncomplicated, they are likely to require long-term maintenance, with revision and possibly conversion of their reconstruction in the years which lie ahead.

References

1. Jagsi R, Jiang J, Momoh AO et al (2014) Trends and variation in use of breast reconstruction in patients with breast cancer undergoing mastectomy in the United States. J Clin Oncol 32(9):919–926
2. Snyderman RK, Guthrie RH (1971) Reconstruction of the female breast following radical mastectomy. Plast Reconstr Surg 47(6): 565–567
3. Cronin TD, Brauer RO (1971) Augmentation mammaplasty. Surg Clin North Am 51(2):441–452
4. Radovan C (1982) Breast reconstruction after mastectomy using the temporary expander. Plast Reconstr Surg 69(2):195–208
5. Spear SL, Majidian A (1998) Immediate breast reconstruction in two stages using textured, integrated-valve tissue expanders and breast implants: a retrospective review of 171 consecutive breast reconstructions from 1989 to 1996. Plast Reconstr Surg 101(1):53–63
6. Jeevan R, Browne J, Meulen JVD et al (2010) National mastectomy and breast reconstruction audit: Part 3. Health Quality Improvement Partnership, United Kingdom
7. Collis N, Sharpe DT (2000) Breast reconstruction by tissue expansion. A retrospective technical review of 197 two-stage delayed reconstructions following mastectomy for malignant breast disease in 189 patients. J Plast Reconstr Aesthet Surg 53(1):37–41
8. Castelló Lganemas OJBJR (2000) Immediate breast reconstruction in two stages using anatomical tissue expansion. Scand J Plast Reconstr Surg Hand Surg 34(2):167–171
9. Noorani A, Rabey N, Walsh SR et al (2010) Systematic review and meta-analysis of preoperative antisepsis with chlorhexidine versus povidone–iodine in clean-contaminated surgery. Br J Surg 97(11):1614–1620
10. Burkhardt BR, Dempsey PD, Schnur PL et al (1986) Capsular contracture: a prospective study of the effect of local antibacterial agents. Plast Reconstr Surg 77(6):919–932
11. Krueger EA, Wilkins EG, Strawderman M et al (2001) Complications and patient satisfaction following expander/implant breast reconstruction with and without radiotherapy. Int J Radiat Oncol Biol Phys 49(3):713–721
12. Goh SCJ, Thorne AL, Williams G et al (2011) Breast reconstruction using permanent BeckerTM expander implants: an 18 year experience. Breast 21(6):764–768
13. Whelan TJ, Julian J, Wright J et al (2000) Does locoregional radiation therapy improve survival in breast cancer? A meta-analysis. J Clin Oncol 18(6):1220–1229
14. Metz JM, Schultz DJ, Fox K et al (1999) Long-term outcome after postmastectomy radiation therapy for breast cancer patients at high risk for local-regional recurrence. Cancer J 5(2):77
15. Nava MB, Pennati AE, Lozza L et al (2011) Outcome of different timings of radiotherapy in implant-based breast reconstructions. Plast Reconstr Surg 128(2):353–359
16. Serra-Renom JM, Muñoz-Olmo JL, Serra-Mestre JM (2010) Fat grafting in postmastectomy breast reconstruction with expanders and prostheses in patients who have received radiotherapy: formation of new subcutaneous tissue. Plast Reconstr Surg 125(1):12–18