Curr Breast Cancer Rep (2016) 8:105–111
DOI 10.1007/s12609-016-0210-y

The Optimal Approach to Post-Mastectomy and Post-Lumpectomy Breast Reconstruction

Merisa L. Piper[1] · **Hani Sbitany**[1,2]

Published online: 26 April 2016

Abstract The surgical management of breast cancer has changed dramatically over the past 30 years, attributed to improved chemotherapy regimens and a better understanding of tumor biology. There is now a greater emphasis on decreasing surgical morbidity and preserving the breast form. The evolution of oncoplastic surgery has enabled more patients to be candidates for breast-conserving therapy, and the preservation of the entire skin and nipple areolar complex with mastectomy has markedly improved esthetic and patient-reported outcomes. This review provides an overview of the reconstructive options for partial and complete mastectomy, as well as discusses several key factors which markedly influence outcomes.

Keywords Surgical management of breast cancer · Breast cancer · Oncoplastic surgery · Mastectomy · Breast reconstruction · Post-mastectomy breast reconstruction · Post-lumpectomy breast reconstruction · Review

This article is part of the Topical Collection on *Local-Regional Evaluation and Therapy*

✉ Hani Sbitany
Hani.Sbitany@ucsf.edu

[1] Division of Plastic and Reconstructive Surgery, Department of Surgery, University of California, San Francisco, San Francisco, CA, USA

[2] Division of Plastic Surgery, University of California, San Francisco, 505 Parnassus Avenue, Suite M593, San Francisco, CA 94143, USA

Introduction

Over the past 30 years, treatment of breast cancer has evolved dramatically. This can be attributed to a better understanding of tumor biology, improved adjuvant and neoadjuvant therapy, and refinements in surgical technique [1–4]. Many more women are now candidates for breast-conserving therapy (BCT) [5], and the surgical treatment of breast cancer is less radical, and more form preserving. The focus now is on decreasing morbidity and improving patient satisfaction, without compromising oncologic safety. Consequently, oncoplastic surgery developed, which combines plastic surgery techniques and oncologic surgery.

Oncoplastic breast surgery uses the remaining healthy breast tissue to reshape the breast immediately following partial mastectomy, in order to achieve the best possible esthetic outcome. Strategies may include local tissue rearrangement, local-regional flaps, mastopexy, and reduction mammoplasty. There is a growing body of evidence that women who undergo oncoplastic surgery have higher patient satisfaction, improved esthetic outcomes, and equivalent oncologic outcomes [6••, 7••, 8••, 9, 10••, 11].

In those women who require mastectomy, many modifications have been made on both the oncologic and reconstructive aspects of care. The most significant change to improve the overall esthetic result is the preservation of the skin envelope and entire nipple areola complex (NAC), coined as "nipple-sparing" or "total skin-sparing" mastectomy [12–15]. Preservation of all the external nipple skin and form has lead to greater patient satisfaction [16]. While implants remain the mainstay of reconstruction, autologous tissue reconstruction has gained popularity given its natural look, feel, and durability. Given the improved esthetic outcomes, more women are pursuing contralateral and bilateral prophylactic mastectomies [17••].

Despite the greater focus on esthetic outcomes, equivalent oncologic outcomes have been maintained [18••]. Radiation therapy plays a critical role in this finding [19] and also greatly influences reconstructive choices and outcomes. Radiation's effects on the soft tissue envelope endure for a patient's lifetime, and thus planning reconstruction is heavily dependent on the history, or prospect of, radiation. In this article, we will describe our reconstructive algorithm for partial mastectomy and mastectomy defects, and the key aspects which influence the decision-making process.

Partial Mastectomy Reconstruction

The key factors in determining whether a patient is a candidate for breast-conserving therapy is tumor size and location, breast size and shape, timing of radiation therapy, and tumor to breast size ratio [20, 21]. Reconstruction of partial mastectomy defects can be thought of in basic terms as either volume replacement or volume displacement [22]. Women with sufficient breast parenchyma and/or ptotic breasts often undergo reshaping procedures, while women with less breast tissue and minimal ptosis require displacement procedures [21]. Breast size and tumor to breast ratio are ultimately the most important factors in deciding which reconstructive method to use.

In women with moderate-large breasts, small-moderate tumors, and minimal ptosis, local tissue rearrangement following partial mastectomy can produce an excellent esthetic result [9, 22]. The skin and parenchyma adjacent to the partial mastectomy defect is shifted to fill the cavity left behind or to move the defect to a less noticeable area [23]. For this method to be effective, oncologic surgeons must be highly confident that they have achieved clear tumor margins. To do so, they often use additional modalities, such as intraoperative X-ray, to image the tumor specimen and visualize healthy breast tissue around the excised tumor.

Additional options for using local tissue for small defects include transposition or rotational soft tissue flaps [24], and for larger defects the latissimus dorsi flap. The latissimus dorsi is a robust flap that can include subcutaneous tissue and skin in addition to muscle, so it can correct most partial mastectomy defects [25, 26].

Women with large breasts or adequate breast volume but marked ptosis may benefit from various mastopexy (breast lift) techniques. The technique used depends on tumor location, breast size and shape, and surgeon experience. Superior pole tumors are best treated with a "batwing" mastopexy [23] or Benelli's "round block" technique [27]. In these procedures, patients are left with a discrete scar, and the recreated breast mound is well supported at the dermal and glandular levels. Lateral tumors are best treated with "donut" mastopexy [28] or radial-segmental lumpectomy [23]. The radial segmental lumpectomy removes full thickness skin and glandular tissue and then flaps are advanced to close the skin. Lower pole tumors are best treated with reduction-mastopexy, where the skin and subcutaneous tissue flaps are raised and advanced over the remaining breast tissue to lift the breast through the creation of a smaller breast pocket. The overall goals with all of these techniques are to reshape and lift the breast parenchyma, reposition the NAC, and tighten the skin envelope, thus creating a more esthetically-pleasing breast.

Reduction mammoplasty is now one of the most frequently used oncoplastic techniques in large-breasted women with grade II or III ptosis [29–31]. This technique relies upon excision of excess skin and parenchyma, following partial mastectomy, to reshape the breast mound and reposition the NAC. The incisions for the reduction are used to access and remove the tumor, and then once the partial mastectomy has been completed, the remaining breast parenchyma is shifted to recreate the breast mound. The most commonly used incisions are the Wise pattern [32] and vertical pattern [33, 34] techniques and are dictated by breast size and ptosis, and the quality of the skin envelope. The Wise pattern approach is versatile as it allows access to all areas of the breast and various pedicles can be used [35]. However, the ultimate durability is based on the skin, thus the breast parenchyma may settle more over time. The vertical scar technique has become more popular given the shorter skin incision, shorter pedicle, and straightforward resection [33–36], but fewer patients are candidates because less overall ptosis and better skin quality are required. The pedicle supporting the NAC is influenced by tumor location [37], and most frequently based on an inferior pedicle when a Wise pattern incision is used [32], and superomedial pedicle when a vertical incision is used [38].

Once the reduction has been performed in the breast with the tumor, the contralateral breast is reduced to match [39]. This technique has been shown to improve the overall cosmetic outcomes, and increase patient satisfaction [20,31,40,41]. Despite the significant tissue rearrangement that occurs, oncologic safety is not compromised [42••], in part because this technique allows for wider and more aggressive tumor resections. Thus, this technique has extended the option for BCT in many patients [7••, 8••, 31, 43]. Reduction mammoplasty has also been used as a strategy for reducing complications in women who will require radiation therapy [10••]. This technique enables more women to be candidates for BCT, thus avoiding the need for mastectomy and reconstruction altogether. Furthermore, this may be a safer technique when complete axillary dissection is required, relative to mastectomy and prosthetic reconstruction [44••].

Secondary lipofilling has gained popularity in the reconstruction of contour deformities following partial mastectomy. Fat is harvested via liposuction most commonly from the abdomen, flanks, and thighs, processed, and then injected to smooth out contour irregularities. Advantages of this technique include the use of autologous tissue, the ability to

improve skin quality, and the subtle contour changes that are possible [45–47]. However, concerns exist over the oncologic safety of lipofilling. There is fear that future imaging will be obscured or clouded, that the transferred cells may promote tumorigenesis [48], and that the cells that do not survive may become firm and calcified leading to increased patient morbidity [48–51]. These fears, however, have not been supported scientifically, and no increased oncologic risk has been shown [52–54]. Lipofilling remains widely used in the reconstruction of partial mastectomy defects [55••], as well as smoothing out contour irregularities in mastectomy flaps and providing more volume in autologous reconstruction. This technique also works in the post-radiation setting.

Mastectomy Reconstruction

Many women now have the option of undergoing nipple-sparing or total skin-sparing mastectomy. This technique preserves the entire skin envelope and nipple areolar complex externally, and removes all breast parenchyma including coring out the internal nipple tissue [12, 56]. When this technique initially developed, there were many limitations regarding who were candidates. However, women are potential candidates now as long as the tumor does not involve the NAC based on MRI and as long as there is no skin involvement following neoadjuvant chemotherapy. Even larger breasted patients can be staged first with a reduction mammoplasty, followed several months later by mastectomy with preservation of the NAC [57••, 58]. The preservation of the NAC has greatly improved the overall esthetic outcome and patient satisfaction [16], without compromising oncologic safety [59••].

The mainstay of post-mastectomy reconstruction is with implants [17••]. Most commonly, tissue expanders are placed at the time of mastectomy and slightly filled with saline. Acellular dermal matrix, which is a cadaveric collagen matrix, is frequently used as a sling to support the tissue expander and provide another layer of coverage and support. Acellular dermal matrix has been shown to decrease reconstructive complications in implant-based reconstruction in the setting of radiation therapy [18••, 60••, 61–65].

If patients are undergoing two-stage expander-implant reconstruction, most commonly the tissue expansion process begins 2 weeks after mastectomy and continues over several weeks to months. The tissue expander is exchanged for a permanent implant several months after the breast has reached the desired volume. Waiting for greater than 6 months has been shown to decrease reconstructive complications and expander-implant reconstructive failure [61]. Silicone implants are typically preferred over saline implants given their more natural look and feel [66••].

Some women are candidates for immediate reconstruction with a permanent implant at the time of mastectomy [62, 67••]. These techniques require a healthy breast skin envelope that can tolerate the stretch from the full size implant, during acute healing from the mastectomy. If this is not the case, the risk of breast skin flap necrosis is high.

Another variation on implant reconstruction is the "delayed-immediate" approach. This uses an inflated tissue expander to preserve the breast envelope and shape without putting excess tension on the tissues, and then once final pathology results are available, the expander is exchanged for a permanent implant if the patient does not require post-mastectomy radiotherapy (PMRT) [68]. Delayed reconstruction has fallen out of favor because the esthetic outcomes are less optimal, and no difference in complication rates or oncologic safety has been demonstrated. When reconstruction is delayed, it is very difficult to correct nipple malposition and retraction, and the skin envelope does not regain a normal breast contour.

The development of anaplastic large cell lymphoma in women with breast implants has made headlines recently. These tumors most often arise from the implant capsule, and the most common presenting sign is late seroma (median time to development 9 years). The underlying etiology is hypothesized to be multifactorial, but likely a chronic inflammatory response to the texturing of the silicone implant surface. To date, no cases of ALCL of the breast have been reported with smooth silicone implants. The management depends on the extent of disease, with tumor limited to the capsule treated by implant removal with total capsulectomies, and for extracapsular involvement the addition of multiagent chemotherapy with or without radiation [69].

Autologous reconstruction is the other primary option for reconstruction of post-mastectomy defects. The patient's own tissue is moved from one part of the body to the chest wall, and its blood supply is often re-established using microsurgery. The most common donor site is the abdomen, in the form of the deep inferior epigastric perforator flap (DIEP), the muscle-sparing transverse rectus abdominis myocutaneous flap (msTRAM), or the transverse rectus abdominis myocutaneous flap (TRAM). These flaps are reliable and usually provide enough tissue bulk to reconstruct the breast without requiring additional augmentation. Complete TRAM flaps, with harvest of the entire rectus abdominis muscle complex, can be rotated on their vascular pedicle, or can be transferred as free flaps, but put patients at a greater risk for developing abdominal hernias because both muscle and fascia are removed from the abdominal wall. The muscle-sparing TRAM flaps minimize the muscle and fascia removed, thus decreasing donor site morbidity. The DIEP flap further limits morbidity, with complete preservation of the innervated rectus abdominis muscle and fascia, but can be more technically challenging to perform.

Additional options for autologous reconstruction include the latissimus dorsi myocutaneous flap [70], flaps based on

the gluteus muscle and underlying gluteal artery perforator blood supply [71], flaps based on the gracilis muscle, and various perforator flaps. However, many of these flaps may not provide enough soft tissue and thus require augmentation with implants to achieve sufficient bulk. Secondary lipofilling is another option for adding some soft tissue bulk to autologous flaps, whereby adipose cells can be injected into the mastectomy flaps, as well as the autologous tissue flaps. While breast reconstruction with autologous tissue does require a longer operation and several days in an inpatient unit, reconstruction is often achieved with fewer operative procedures and less time to complete reconstruction than expander-implant reconstruction [70, 72••, 73]. It provides an excellent esthetic outcome and high overall patient satisfaction.

Modifications in the Setting of Radiation

The timing of reconstruction when PMRT is anticipated is controversial, both in prosthetic and autologous reconstruction. Some institutions advocate for irradiation once the tissue expander has been fully expanded, others partially deflate the expander prior to PMRT, and others wait until the permanent implant has been placed. With autologous reconstruction, some advocate for performing immediate autologous tissue reconstruction at the time of mastectomy, followed by PMRT. Others recommend delaying autologous reconstruction until after completion of PMRT. However, no randomized controlled trials have been performed to date to truly evaluate which protocol has the lowest complication rates and better esthetic outcomes.

We propose several modifications if PMRT is anticipated. Radiation's effects last a woman's lifetime, thus she will always have a compromised skin envelope and be at risk for implant loss [74••]. Autologous tissue fares better than implant-based reconstruction in the setting of radiation therapy because healthy, vascularized tissue is brought to an area of compromised tissue. Therefore, if a woman has adequate soft tissue to reconstruct the breast, we advocate autologous reconstruction. Another long-term negative effect of radiation therapy is fibrosis of blood vessels, which leads to higher levels of fat necrosis and flap fibrosis. We have found that augmenting both arterial inflow and venous outflow to DIEP flaps decreases the incidence of fat necrosis by enhancing perfusion [75••]. Thus, if radiation is anticipated, we attempt to augment both arterial and venous flow to the flap. An additional measure we take is working closely with our radiation oncologists with radiation planning and delivery. Our radiation oncologists use custom bolus to minimize radiation to the vascular pedicle in autologous reconstruction, and limit radiation to the skin and scar [76••]. We have found that the implementation of these modifications has led to improved esthetic outcomes and softer, less fibrotic breasts.

Conclusions

Dramatic improvements in the surgical management of breast cancer have been made over the last 30 years. Many more patients are now candidates for breast-conserving therapy attributed to improved chemotherapy regimens and the use of radiation therapy. Oncoplastic surgery, mastopexy, reduction mammoplasty, and lipofilling are methods used to minimize contour deformities and improve esthetic outcomes following partial mastectomy. For those women who require mastectomy, techniques are now much less morbid and the preservation of the entire skin envelope and NAC has markedly improved esthetic outcomes. Implant-based reconstruction remains the most commonly used technique, but autologous reconstruction has gained popularity given its natural feel and appearance, and ability to tolerate radiation therapy. Current research is directed towards improving outcomes in the setting of radiation therapy, investigating the oncologic safety of secondary lipofilling of the breast, and evaluating patient-reported outcomes.

Compliance with Ethical Standards

Conflict of Interest Merisa L. Piper declares that she has no conflict of interest.

Hani Sbitany is a member of the speaker's bureau of LifeCell Inc.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
•• Of major importance

1. Clarke M, Collins R, Darby S, Davies C, Elphinstone P, Evans E, et al. Effects of radiotherapy and of differences in the extent of surgery for early breast cancer on local recurrence and 15-year survival: an overview of the randomised trials. Lancet. 2005;366(9503):2087–106.
2. Clough KB, Lewis JS, Couturaud B, Fitoussi A, Nos C, Falcou MC. Oncoplastic techniques allow extensive resections for breast-conserving therapy of breast carcinomas. Ann Surg. 2003;237(1):26–34.
3. Fisher B, Anderson S, Bryant J, Margolese RG, Deutsch M, Fisher ER, et al. Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. N Engl J Med. 2002;347(16):1233–41.
4. Fisher B, Jeong JH, Anderson S, Bryant J, Fisher ER, Wolmark N. Twenty-five-year follow-up of a randomized trial comparing radical mastectomy, total mastectomy, and total mastectomy followed by irradiation. N Engl J Med. 2002;347(8):567–75.

5. Fisher B, Bryant J, Wolmark N, Mamounas E, Brown A, Fisher ER, et al. Effect of preoperative chemotherapy on the outcome of women with operable breast cancer. J Clin Oncol Off J Am Soc Clin Oncol. 1998;16(8):2672–85.
6.•• Hart AM, Pinell-White X, Egro FM, Losken A. The psychosexual impact of partial and total breast reconstruction: a prospective 1-year longitudinal study. Ann Plast Surg. 2014, **Prospective study exploring patient satisfaction and sexuality between two patient groups: mastectomy with immediate reconstruction, and lumpectomy with reduction mammoplasty. Found the two groups had similar overall satisfaction with sex life and body image, but the breast conserving therapy with reduction mammoplasty group had larger gains in body image perception**.
7.•• Losken A, Dugal CS, Styblo TM, Carlson GW. A meta-analysis comparing breast conservation therapy alone to the oncoplastic technique. Ann Plast Surg. 2014;72(2):145–9. **Metaanalysis comparing BCT alone, BCT with oncoplastic flap techniques, and BCT with oncoplastic reduction techniques. Found oncoplastic techniques with BCT decreased the positive margin rate and improved patient satisfaction**.
8.•• Losken A, Pinell-White X, Hart AM, Freitas AM, Carlson GW, Styblo TM. The oncoplastic reduction approach to breast conservation therapy: benefits for margin control. Aesthet Surg J / Am Soc Aesthet Plast Surg. 2014;34(8):1185. **Compared patients who underwent lumpectomy, and lumpectomy with oncoplastic reduction, by a single surgeon. Found oncoplastic reduction techniques resulted in fewer re-excisions and fewer positive margins**.
9. Chan SW, Cheung PS, Lam SH. Cosmetic outcome and percentage of breast volume excision in oncoplastic breast conserving surgery. World J Surg. 2010;34(7):1447–52.
10.•• Peled AW, Sbitany H, Foster RD, Esserman LJ. Oncoplastic mammoplasty as a strategy for reducing reconstructive complications associated with postmastectomy radiation therapy. Breast J. 2014;20(3):302–7. **This paper sought to evaluate whether neoadjuvant chemotherapy and oncoplastic mammoplasty had improved outcomes as compared to mastectomy and immediate reconstruction in patients who require XRT. Found that patients who underwent BCT and oncoplastic mammoplasty had fewer post-operative complications than patients who underwent mastectomy with immediate reconstruction in the setting of radiation therapy**.
11. Veiga DF, Veiga-Filho J, Ribeiro LM, Archangelo-Junior I, Mendes DA, Andrade VO, et al. Evaluations of aesthetic outcomes of oncoplastic surgery by surgeons of different gender and specialty: a prospective controlled study. Breast (Edinb Scotl). 2011;20(5):407–12.
12. Garwood ER, Moore D, Ewing C, Hwang ES, Alvarado M, Foster RD, et al. Total skin-sparing mastectomy: complications and local recurrence rates in 2 cohorts of patients. Ann Surg. 2009;249(1):26–32.
13. Chen CM, Disa JJ, Sacchini V, Pusic AL, Mehrara BJ, Garcia-Etienne CA, et al. Nipple-sparing mastectomy and immediate tissue expander/implant breast reconstruction. Plast Reconstr Surg. 2009;124(6):1772–80.
14. Spear SL, Hannan CM, Willey SC, Cocilovo C. Nipple-sparing mastectomy. Plast Reconstr Surg. 2009;123(6):1665–73.
15. Spear SL, Willey SC, Feldman ED, Cocilovo C, Sidawy M, Al-Attar A, et al. Nipple-sparing mastectomy for prophylactic and therapeutic indications. Plast Reconstr Surg. 2011;128(5):1005–14.
16. Peled AW, Duralde E, Foster RD, Fiscalini AS, Esserman LJ, Hwang ES, et al. Patient-reported outcomes and satisfaction after total skin-sparing mastectomy and immediate expander-implant reconstruction. Ann Plast Surg. 2014;72 Suppl 1:S48–52.
17.•• Cemal Y, Albornoz CR, Disa JJ, McCarthy CM, Mehrara BJ, Pusic AL, et al. A paradigm shift in U.S. breast reconstruction: part 2. The influence of changing mastectomy patterns on reconstructive rate and method. Plast Reconstr Surg. 2013;131(3):320e–6. **Used the NIS database to look at mastectomy and reconstruction trends from 1998–2008. Found contralateral and bilateral prophylactic mastectomy rates have increased, and implant use has increased for all mastectomy types**.
18.•• Wang F, Peled AW, Garwood E, Fiscalini AS, Sbitany H, Foster RD, et al. Total skin-sparing mastectomy and immediate breast reconstruction: an evolution of technique and assessment of outcomes. Ann Surg Oncol. 2014;21(10):3223–30. **Evaluation of all cases of total skin-sparing mastectomy with immediate reconstruction at a single institution demonstrated improved post-operative complication rates with greater experience, and no compromise in oncologic safety compared with skin-sparing mastectomy**.
19. Favourable and unfavourable effects on long-term survival of radiotherapy for early breast cancer: an overview of the randomised trials. Lancet. 2000;355(9217), 1757–1770.
20. Clough KB, Ihrai T, Oden S, Kaufman G, Massey E, Nos C. Oncoplastic surgery for breast cancer based on tumour location and a quadrant-per-quadrant atlas. Br J Surg. 2012;99(10):1389–95.
21. Losken A, Styblo TM, Carlson GW, Jones GE, Amerson BJ. Management algorithm and outcome evaluation of partial mastectomy defects treated using reduction or mastopexy techniques. Ann Plast Surg. 2007;59(3):235–42.
22. Losken A, Hamdi M. Partial breast reconstruction: current perspectives. Plast Reconstr Surg. 2009;124(3):722–36.
23. Anderson BO, Masetti R, Silverstein MJ. Oncoplastic approaches to partial mastectomy: an overview of volume-displacement techniques. Lancet Oncol. 2005;6(3):145–57.
24. Clough KB, Kroll SS, Audretsch W. An approach to the repair of partial mastectomy defects. Plast Reconstr Surg. 1999;104(2):409–20.
25. Papp C, Wechselberger G, Schoeller T. Autologous breast reconstruction after breast-conserving cancer surgery. Plast Reconstr Surg. 1998;102(6):1932–6. discussion 1937–8.
26. Slavin SA, Love SM, Sadowsky NL. Reconstruction of the radiated partial mastectomy defect with autogenous tissues. Plast Reconstr Surg. 1992;90(5):854–65. discussion 866–9.
27. Benelli L. A new periareolar mammaplasty: the "round block" technique. Aesthet Plast Surg. 1990;14(2):93–100.
28. Amanti C, Regolo L, Moscaroli A, Lo Russo M, Catracchia V. Total periareolar approach in breast-conserving surgery. [Approccio periareolare totale nella chirugia conservativa della mammella.]. Tumori. 2003;89(4 Suppl):169–72.
29. Macmillan RD, James R, Gale KL, McCulley SJ. Therapeutic mammaplasty. J Surg Oncol. 2014;110(1):90–5.
30. Newman LA, Kuerer HM, McNeese MD, Hunt KK, Gurtner GC, Vlastos GS, et al. Reduction mammoplasty improves breast conservation therapy in patients with macromastia. Am J Surg. 2001;181(3):215–20.
31. Spear SL, Pelletiere CV, Wolfe AJ, Tsangaris TN, Pennanen MF. Experience with reduction mammaplasty combined with breast conservation therapy in the treatment of breast cancer. Plast Reconstr Surg. 2003;111(3):1102–9.
32. Berry MG, Fitoussi AD, Curnier A, Couturaud B, Salmon RJ. Oncoplastic breast surgery: a review and systematic approach. J Plastic Reconstr Aesthet Surg. 2010;63(8):1233–43.
33. Hall-Findlay EJ. A simplified vertical reduction mammaplasty: shortening the learning curve. Plast Reconstr Surg. 1999;104(3):748–59. discussion 760–3.
34. Hall-Findlay EJ. Vertical breast reduction. Semin Plast Surg. 2004;18(3):211–24.
35. Lassus C. Breast reduction: evolution of a technique—a single vertical scar. Aesthet Plast Surg. 1987;11(2):107–12.

36. Lejour M. Vertical mammaplasty and liposuction of the breast. Plast Reconstr Surg. 1994;94(1):100–14.
37. Losken A, Elwood ET, Styblo TM, Bostwick 3rd J. The role of reduction mammaplasty in reconstructing partial mastectomy defects. Plast Reconstr Surg. 2002;109(3):968–75. Discussion 976–7.
38. Barnea Y, Inbal A, Barsuk D, Menes T, Zaretski A, Leshem D, et al. Oncoplastic reduction using the vertical scar superior-medial pedicle pattern technique for immediate partial breast reconstruction. Can J Surg J Can Chir. 2014;57(4):E134–40.
39. Kroll SS, Singletary SE. Repair of partial mastectomy defects. Clin Plast Surg. 1998;25(2):303–10.
40. Losken A, Pinell XA, Eskenazi B. The benefits of partial versus total breast reconstruction for women with macromastia. Plast Reconstr Surg. 2010;125(4):1051–6.
41. Chang E, Johnson N, Webber B, Booth J, Rahhal D, Gannett D, et al. Bilateral reduction mammoplasty in combination with lumpectomy for treatment of breast cancer in patients with macromastia. Am J Surg. 2004;187(5):647–50. discussion 650–1.
42.•• Piper M, Peled AW, Sbitany H, Foster RD, Esserman LJ, Price ER. Comparison of mammographic findings following oncoplastic mammoplasty and lumpectomy without reconstruction. Ann Surg Oncol. 2016;23(1):65–71. **Comparison of patients who underwent BCT with oncoplastic reduction mammoplasty to BCT alone found no significant difference in abnormal mammographic findings or biopsy rates despite the substantial tissue rearrangement that is performed**.
43. Chang EI, Peled AW, Foster RD, Lin C, Zeidler KR, Ewing CA, et al. Evaluating the feasibility of extended partial mastectomy and immediate reduction mammoplasty reconstruction as an alternative to mastectomy. Ann Surg. 2012;255(6):1151–7.
44.•• Wang F, Peled AW, Chin R, Fowble B, Alvarado M, Ewing C, et al. The impact of radiation therapy, lymph node dissection, and hormonal therapy on outcomes of tissue expander-implant exchange in prosthetic breast reconstruction. Plast Reconstr Surg. 2016;137(1):1–9. **An evaluation of all patients at a single institution who underwent total skin-sparing mastectomy with tissue expander-implant reconstruction found that axillary lymph node dissection increases the risk of implant loss compared with sentinel lymph node biopsy, regardless of radiation exposure**.
45. Coleman SR. Structural fat grafting: more than a permanent filler. Plast Reconstr Surg. 2006;118(3 Suppl):108S–20.
46. Illouz YG. Body contouring by lipolysis: a 5-year experience with over 3000 cases. Plast Reconstr Surg. 1983;72(5):591–7.
47. Rigotti G, Marchi A, Galiè M, Baroni G, Benati D, Krampera M, et al. Clinical treatment of radiotherapy tissue damage by lipoaspirate transplant: a healing process mediated by adipose-derived adult stem cells. Plast Reconstr Surg. 2007;119(5):1409–22.
48. Wang Y, Lehuédé C, Laurent V, Dirat B, Dauvillier S, Bochet L, et al. Adipose tissue and breast epithelial cells: a dangerous dynamic duo in breast cancer. Cancer Lett. 2012;324(2):142–51.
49. Wang C, Zhou Z, Yan Y, Zhao D, Chen F, Qiao Q. Clinical analyses of clustered microcalcifications after autologous fat injection for breast augmentation. Plast Reconstr Surg. 2011;127(4):1669–73.
50. Bertolini F. Contribution of endothelial precursors of adipose tissue to breast cancer: progression-link with fat graft for reconstructive surgery. Ann Endocrinol. 2013;74(2):106–7.
51. Pearl RA, Leedham SJ, Pacifico MD. The safety of autologous fat transfer in breast cancer: lessons from stem cell biology. J Plast Reconstr Aesthet Surg. 2012;65(3):283–8.
52. Coleman SR, Saboeiro AP. Fat grafting to the breast revisited: safety and efficacy. Plast Reconstr Surg. 2007;119(3):775–85. Discussion 786–7.
53. Rigotti G, Marchi A, Stringhini P, Baroni G, Galie M, Molino AM, et al. Determining the oncological risk of autologous lipoaspirate grafting for post-mastectomy breast reconstruction. Aesthet Plast Surg. 2010;34(4):475–80.
54. Delay E, Garson S, Tousson G, Sinna R. Fat injection to the breast: technique, results, and indications based on 880 procedures over 10 years. Aesthet Surg J / Am Soc Aesthet Plast Surg. 2009;29(5):360–76.
55.•• Kling RE, Mehrara BJ, Pusic AL, Young VL, Hume KM, Crotty CA, et al. Trends in autologous fat grafting to the breast: a national survey of the American Society of Plastic Surgeons. Plast Reconstr Surg. 2013;132(1):35–46. **Survey of plastic surgeons who are members of ASPS found that 62 % used fat grafting for breast reconstruction, and 28 % used it for aesthetic breast surgery, demonstrating the increasing prevalence of this technique**.
56. Wijayanayagam A, Kumar AS, Foster RD, Esserman LJ. Optimizing the total skin-sparing mastectomy. Arch Surg (Chicago, Ill: 1960). 2008;143(1):38–45. Discussion 45.
57.•• Alperovich M, Tanna N, Samra F, Blechman KM, Shapiro RL, Guth AA, et al. Nipple-sparing mastectomy in patients with a history of reduction mammaplasty or mastopexy: how safe is it? Plast Reconstr Surg. 2013;131(5):962–7. **Study of 13 breasts in 8 patients who underwent nipple-sparing mastectomy following reduction mammoplasty or mastopexy. There was no nipple loss and no subareolar positive biopsies, thus the authors concluded nipple-sparing mastectomy can be offered to patients who had a prior history of mammoplasty or mastopexy**.
58. Spear SL, Rottman SJ, Seiboth LA, Hannan CM. Breast reconstruction using a staged nipple-sparing mastectomy following mastopexy or reduction. Plast Reconstr Surg. 2012;129(3):572–81.
59.•• Piper M, Peled AW, Foster RD, Moore DH, Esserman LJ. Total skin-sparing mastectomy: a systematic review of oncologic outcomes and postoperative complications. Ann Plast Surg. 2013, **Systematic review assessing outcomes following total skin-sparing mastectomy identified 27 studies with a total of 3331 patients. Partial nipple necrosis found in 9.1 %, total NAC loss in 2 %, and overall local-regional cancer recurrence rate was 2.8 %. Concluded current data support TSSM without compromising therapeutic efficacy**.
60.•• Fowble B, Park C, Wang F, Peled A, Alvarado M, Ewing C. et al. Rates of reconstruction failure in patients undergoing immediate reconstruction with tissue expanders and/or implants and postmastectomy radiation therapy. Int J Radiat Oncol Biol Phys. 2015, **This study evaluates tissue expander-implant failure in the setting of post-mastectomy radiation therapy. Found TE/I failure rate was 18 %, and the strongest predictor of reconstructive failure was lack of total TE/I coverage with ADM or muscle at the time of radiation**.
61. Peled AW, Foster RD, Garwood ER, Moore DH, Ewing CA, Alvarado M, et al. The effects of acellular dermal matrix in expander-implant breast reconstruction after total skin-sparing mastectomy: results of a prospective practice improvement study. Plast Reconstr Surg. 2012;129(6):901e–8.
62. Salzberg CA, Ashikari AY, Koch RM, Chabner-Thompson E. An 8-year experience of direct-to-implant immediate breast reconstruction using human acellular dermal matrix (AlloDerm). Plast Reconstr Surg. 2011;127(2):514–24.
63. Sbitany H, Serletti JM. Acellular dermis-assisted prosthetic breast reconstruction: a systematic and critical review of efficacy and associated morbidity. Plast Reconstr Surg. 2011;128(6):1162–9.
64. Nahabedian MY. AlloDerm performance in the setting of prosthetic breast surgery, infection, and irradiation. Plast Reconstr Surg. 2009;124(6):1743–53.
65. Ward J, Cohen IK, Knaysi GA, Brown PW. Immediate breast reconstruction with tissue expansion. Plast Reconstr Surg. 1987;80(4):559–66.
66.•• Spear SL, Murphy DK, Allergan Silicone Breast Implant U.S. Core Clinical Study Group. Natrelle round silicone breast implants: core study results at 10 years. Plast Reconstr Surg. 2014;133(6):1354–61. **A 10-year study evaluating Allergan's Natrelle smooth and**

textured round silicone implants found high patient satisfaction and appropriate safety.

67.•• Colwell AS, Tessler O, Lin AM, Liao E, Winograd J, Cetrulo CL, et al. Breast reconstruction following nipple-sparing mastectomy: predictors of complications, reconstruction outcomes, and 5-year trends. Plast Reconstr Surg. 2014;133(3):496–506. **This single institution retrospective review evaluated 285 patients (500 mastectomies) who underwent nipple-sparing mastectomies over a 5-year period. They found body mass index, smoking, incision type, and preoperative radiation were predictors of complications**.

68. Cordeiro PG, Pusic AL, Disa JJ, McCormick B, VanZee K. Irradiation after immediate tissue expander/implant breast reconstruction: outcomes, complications, aesthetic results, and satisfaction among 156 patients. Plast Reconstr Surg. 2004;113(3):877–81.

69. Brody GS. Anaplastic large cell lymphoma occurring in women with breast implants: analysis of 173 cases. Plast Reconstr Surg. 2015;136(4):553e–4.

70. Kroll SS, Baldwin B. A comparison of outcomes using three different methods of breast reconstruction. Plast Reconstr Surg. 1992;90(3):455–62.

71. Kronowitz SJ. Redesigned gluteal artery perforator flap for breast reconstruction. Plast Reconstr Surg. 2008;121(3):728–34.

72.•• Fischer JP, Nelson JA, Cleveland E, Sieber B, Rohrbach JI, Serletti JM, et al. Breast reconstruction modality outcome study: a comparison of expander/implants and free flaps in select patients. Plast Reconstr Surg. 2013;131(5):928–34. **This study compared outcomes and cost between abdominally based autologous free flap and tissue expander-implant based breast reconstruction. They found that free flap reconstruction had faster time to complete reconstruction, lower rates of complications and failures, and fewer clinic visits**.

73. Yueh JH, Slavin SA, Adesiyun T, Nyame TT, Gautam S, Morris DJ, et al. Patient satisfaction in postmastectomy breast reconstruction: a comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques. Plast Reconstr Surg. 2010;125(6):1585–95.

74.•• Sbitany H, Wang F, Peled AW, Lentz R, Alvarado M, Ewing CA, et al. Immediate implant-based breast reconstruction following total skin-sparing mastectomy: defining the risk of preoperative and postoperative radiation therapy for surgical outcomes. Plast Reconstr Surg. 2014;134(3):396–404. **Evaluated effects of radiation of tissue expander-implant based breast reconstruction following total skin-sparing mastectomy. Found that both pre-operative and post-operative radiation had higher infection rates and more expander-implant loss, but no difference in NAC necrosis rates, than patients who did not undergo radiation**.

75.•• Piper ML, Lentz R, Evangelista M, Hansen S, Sbitany H. The "dual-plane" DIEP free flap: defining the effect of perfusion enhancement of clinical outcomes. American Society of Reconstructive Microsurgery Annual Meeting. Scottsdale, AZ, 2016. **In select patients undergoing DIEP flap breast reconstruction, rerouting the SIEA/SIEV system directly into the superior continuation of the deep vascular system pedicle leads to lower rates of fat necrosis that single-perforator "traditional" DIEP free flaps**.

76.•• Piper ML, Evangelista M, Amara D, Daar D, Foster RD, Fowble B, Sbitany H. A custom bolus approach to post-mastectomy radiation delivery following autologous breast reconstruction: an 8-year experience. American Society of Reconstructive Microsurgery Annual Meeting. Scottsdale, AZ. 2016. **In women undergoing immediate autologous tissue breast reconstruction who require post-mastectomy radiation therapy, custom bolus may be a favorable option. This technique allows more uniform dosing of the skin, limits radiation to the pedicle, and provides adequate radiation dose to prevent recurrence. Preliminary data indicates this technique may lead to fewer radiation-induced skin changes, less fibrosis, less volume loss, and fewer contour deformities**.