Review Article

The challenging patient in autologous breast reconstruction: obesity, breast ptosis and beyond

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Abstract: Autologous breast reconstruction has consistently demonstrated excellent patient satisfaction, ideal aesthetic results, and a low risk of complications. With the increasing incidence of breast cancer diagnoses and higher reconstruction rates, surgeons encounter a broader spectrum of patients. Obese patients undergoing breast reconstruction are more likely to experience a surgical complication. While free tissue transfer carries a higher donor site complication rate, implant-based reconstruction carries a higher loss of reconstruction in this population. Additionally, autologous reconstruction consistently demonstrates better patient-reported outcomes. Oncoplastic reconstruction is an oncologically safe alternative to free tissue transfer and implant reconstruction which reduces the risk of complications and the risk of delaying adjuvant therapy. Particularly in obese patients for whom radiation is indicated based on tumor size or nodal involvement, oncoplastic reconstruction is maximally beneficial. The Goldilocks mastectomy is yet another alternative to free tissue transfer or implant reconstruction which carries an acceptable risk profile, especially when augmentation with tissue expander or implant is delayed and performed at a second stage. In patients with breast ptosis undergoing skin-sparing mastectomy, vertical skin reduction allows an acceptable aesthetic result while minimizing the risk for mastectomy flap necrosis (MFN), especially in comparison to Wise pattern skin reduction. If a nipple-sparing mastectomy (NSM) is to be performed in the setting of breast ptosis, a nipple delay or a pre-mastectomy reduction/mastopexy is the safest and most conservative approach, but can alter the timeline for primary cancer resection and therefore is predominantly performed in patients with a genetic predisposition or those undergoing a prophylactic mastectomy. Patients with obesity, breast ptosis, advanced age, active smoking history, prior radiation therapy, or abdominal procedures can carry an increased risk of complications and present a challenge to plastic surgeons. We review the most recent literature published regarding reconstruction in these patient groups and seek to provide practical information to help inform clinical decision-making and operative execution.

Keywords: Autologous breast reconstruction; obesity; ptosis; surgical technique

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Introduction

Breast reconstruction is integral to breast cancer treatment and is increasingly offered following mastectomy. Reconstructive options are categorized into autologous and implant-based reconstructions. Autologous reconstruction has traditionally been known to utilize free tissue transfer, but more recently also incorporates techniques such as oncoplastic reconstruction and the Goldilocks mastectomy. Implant-based reconstruction involves reconstruction with a tissue expander followed by an exchange with a permanent implant. Breast reconstruction can be performed in an immediate or delayed fashion and combine both approaches. Over 137,000 breast reconstructions were performed in the United States in 2020 (1). According to projections by the National Cancer Institute, the incidence of breast cancer is projected to increase by 50% in the year 2030, resulting in 414,000 newly diagnosed cases per year (2).

With the increasing detection of breast cancer, providers will continue to encounter patients that pose a challenge, either due to difficult-to-reach aesthetic goals or comorbidities and history that increase the risk of complications. Unfortunately, complications can delay crucial adjuvant treatment, impact outcome, survival, quality of life, compromise aesthetic results, and have a significant negative psychosocial effect (3,4).

Our objective is to describe the latest surgical techniques and approach to breast reconstruction in challenging patients, including those with obesity, breast ptosis, and various other risk factors. Our review article incorporates a comprehensive review of the literature surrounding traditional autologous and implant-based reconstructions in these high-risk patient populations but also incorporates discussion regarding newer techniques including oncoplastic reconstruction, Goldilocks mastectomy, and fat augmented latissimus dorsi reconstruction. We aim to better inform the surgical decision-making process and optimize patient education by providing a comprehensive overview.

Obesity

Obesity remains an epidemic in the United States, affecting over 30% of all adults (5,6). The incidence of obesity among patients undergoing breast reconstruction is similar, between 27–28% (7,8). In a meta-analysis by Panayi and colleagues (9) identifying over 71,000 patients undergoing breast reconstruction, approximately 20,000 patients had a body mass index (BMI) over 30 kg/m^2. Patients with obesity were 2.3 times more likely to experience surgical complications, 2.9 times more likely to have medical complications, and had 1.9 times higher risk of reoperation. The most common complication was wound dehiscence and found to be 2.5 times more likely in obese women.

The World Health Organization (WHO) further classifies obese patients into three separate cohorts: class I (BMI 30.0–34.9 kg/m^2), class II (BMI 35.0–39.9 kg/m^2), and class III (BMI ≥40 kg/m^2). Fischer and colleagues (8) evaluated a National Surgical Quality Improvement Program (NSQIP) data set of almost 16,000 patients undergoing breast reconstruction and found that approximately 16% were class I, 7% were class II, and 4% were class III. Increasing obesity is associated with progressive perioperative morbidity in this subset of patients. Progressively higher BMIs were associated with higher rates of surgical, medical, and wound complications.

Almost 80% of patients with obesity undergo implant-based reconstruction (8). Autologous reconstruction, however, can provide a better aesthetic result that more closely resembles the natural breast and is proportional to the patient's body habitus. While autologous reconstruction carries a donor site complication profile, implant-based reconstruction carries a higher risk of loss of reconstruction in this cohort (10,11). In the obese population, Fischer and colleagues (12) demonstrated a higher overall success rate using free tissue transfer versus implant and a lower rate of unplanned surgical revisions and cost. Implant reconstruction demonstrated a higher rate of reconstructive failure, seroma, and unplanned operations. Autologous reconstruction has also consistently demonstrated improved patient satisfaction with the overall outcome, psychosocial well-being, and sexual well-being in the obese (13-15).

Alternative options

Innovation in breast reconstruction has provided additional reconstructive options as alternatives to implant-based or free tissue transfer in the obese population. When the complication profile is too high, there is a strong preference to avoid implants, or the patient is not a free flap candidate (i.e., due to prior abdominal surgery), these alternatives can be considered.

Oncoplastic reconstruction

Oncoplastic reconstruction allows oncologic resection while utilizing tissue rearrangement derived from mammaplasty techniques to reshape the breast to achieve an aesthetic outcome. It is a suitable option for proportionally small tumors. In one study, 75% of patients that underwent oncoplastic breast reconstruction had T1 or T2 tumors (16). The benefits of oncoplastic reconstruction compared to implant or autologous reconstruction include maximal preservation of as much of the native breast as possible and a single-stage surgical treatment while consistently maintaining equivalent local recurrence and survival rates (17).

In a study consisting of 408 patients, Tong and colleagues (17) evaluated oncoplastic reconstruction versus immediate breast reconstruction (with either implant or free flap) in the obese population. They found that the oncoplastic group experienced fewer complications requiring operative management (3.8% *vs.* 28.5%), fewer complications delaying adjuvant therapy (0.8% *vs.* 14.4%), and a lower incidence of hematoma and seroma formation (3.1% *vs.* 11.6%). Additionally, oncoplastic reconstruction was an independent protector against all major complications and complications that delayed adjuvant therapy. Obese patients undergoing oncoplastic reconstruction were 10 times less likely to have a complication requiring reoperation and 20 times less likely to delay adjuvant therapy than patients undergoing implant or autologous reconstruction (17). Particularly in obese patients for whom radiation is indicated based on their tumor size or lymph node involvement alone, oncoplastic reconstruction is a modality that could be maximally beneficial.

Goldilocks mastectomy

The Goldilocks mastectomy was initially described for challenging or high-risk patients for whom the complication profile to undergo traditional reconstruction was unacceptable. The technique employs a standard Wise pattern closure while preserving any residual mastectomy skin flap, de-epithelializing it, and using it to add volume and reconstruct an entirely autologous breast mound (18). This allows a single-stage operation without any distal donor sites while avoiding the use of implants. If oncologically appropriate, the nipple can be harvested as a free nipple graft and placed on the breast mound. Options to augment breast volume can be made at a later point if desired, i.e., delayed tissue expander or implant reconstruction, or fat grafting. In a 2023 study evaluating the Goldilocks-only mastectomy in a high-risk patient cohort with 82% of patients classified as obese and a mean BMI of 37, 7.2% developed a major complication requiring a return to the odds ratio (OR) and 10.8% of patients developed a minor complication treated conservatively. By an average follow-up of 9 months, 35% of patients had undergone a secondary reconstruction involving tissue expanders, implants, autologous reconstruction or fat grafting alone. The major complication rate in the delayed secondary reconstruction group was approximately 10% (19).

Alternatively, a Goldilocks mastectomy can be combined with an immediate pre-pectoral reconstruction utilizing an implant or tissue expander. The de-epithelialized inferior skin flap acts as a dermal sling and provides an additional layer of well-vascularized tissue over the prosthesis. In the largest series to date of 105 obese patients, Bustos and colleagues (20) compared Goldilocks mastectomy with and without immediate implant-based reconstruction and revealed a significant increase in minor complications [hazard ratio (HR) =2.83] and major complications (HR =2.26) in the cohort that underwent immediate implant-based reconstruction. Additionally, patients with a BMI of 35 kg/m^2 or greater were 3.4 times more likely to have major complications than those who underwent the Goldilocks-only procedure. Importantly, patient satisfaction among the entire cohort was not statistically significant between the two groups.

The stand-alone Goldilocks mastectomy, therefore, allows the high-risk obese patient a form of reconstruction with an acceptable risk profile and can serve as a bridging stage to secondary reconstruction with tissue expander, implant, autologous tissue, or fat grafting.

Latissimus dorsi

The pedicled latissimus dorsi provides an autologous alternative while avoiding the risks of free tissue transfer in the obese population. The flap can be harvested as traditionally described incorporating the entire muscle, in a muscle-sparing fashion, or as a perforator flap. A review of 277 patients undergoing latissimus dorsi flap breast reconstruction revealed no statistically significant differences in rates of seroma, hematoma, infection or skin necrosis of the donor site among the obese cohort (n=103). Patients who were reconstructed with a latissimus dorsi flap in conjunction with a tissue expander, however, did demonstrate an 11% increase in rate of flap-related complications compared to the flap only reconstruction (21). Placement of a tissue expander also negates the benefits of an autologous reconstruction and introduces the risks of capsular contracture, malposition, extrusion, and added risk of infection.

In an effort to maintain the benefits of an autologous reconstruction while augmenting volume, some studies have reported immediate fat grafting at the time of pedicled latissimus dorsi flap breast reconstruction (22-26). A 2020 study evaluated the use of this technique in the obese population. Novak and colleagues (22) compared free tissue transfer to latissimus dorsi flap with immediate fat grafting in 82 obese patients and 149 breasts. They found that the free tissue transfer group had a significantly higher rate of major complications (20.3% *vs.* 3.8%) that required a trip back to the operating room. There was no significant difference in minor complications between the two groups. Furthermore, the free tissue transfer group had a significantly higher rate of medical complications (10.6% *vs.* 0%). The latissimus flap with grafting cohort did not demonstrate any seromas—the authors attributed this to the use of progressive tension sutures in their closure (22). Authors in this study grafted an average of 186 mL's of fat to each reconstruction, however, the amount grafted varies in the literature ranging from 100 to over 500 mL (22-26).

The latissimus dorsi with immediate fat grafting therefore presents a reasonable autologous alternative to latissimus dorsi with implant or free tissue transfer which reduces risk of both surgical and medical complications, and operative duration in the high-risk obese population. A more conservative approach involves a latissimus-only reconstruction and fat grafting at a later stage. Larger prospective studies are needed to evaluate the use of this technique, its safety, and long-term outcomes.

Ptosis

Grade two or three ptosis presents a reconstructive challenge to the plastic surgeon. Eliminating the discrepancy between skin envelope surface area and flap volume while maintaining optimal perfusion is key in delivering an aesthetic result and minimizing the risk for complications such as mastectomy flap necrosis (MFN) or dehiscence.

In a skin-sparing mastectomy, the traditional transverse ellipse incorporates the nipple-areola complex, leaving behind long horizontal scars visible in the medial breast and can have a flattening effect. Alternatively, a skin-sparing mastectomy incorporating a non-elliptical, periareolar pattern similar to a periareolar mastopexy can result in flattening of the breast. Breast reduction incision patterns can provide an improved aesthetic result while allowing better projection and limiting scars in the upper and medial breast poles.

A vertical skin reduction requires a shorter incision, helps reduce the horizontal excess of the breast, improves projection, and has demonstrated a low risk of MFN (27-29). No MFN was reported in a study of 106 skin-sparing mastectomies using a vertical pattern skin reduction (27). The ability to perform symmetrizing procedures in the contralateral breast with matched incisions is an additional benefit of the vertical reduction. While the vertical reduction pattern improves blood supply, has lower rates of necrosis, and shorter scars, it is limited in reducing the skin envelope in the extremely ptotic breast.

The wise pattern most effectively and aesthetically reduces the skin envelope while maintaining projection and the conical shape of the breast. However, the high rate of mastectomy skin flap necrosis and T-point healing issues is unacceptable—as high as 30%. A Wise pattern de-epithelialization, as opposed to resection, has been described. However, it persists in high rates of MFN (20%) (30,31). In a direct comparison between Wise pattern and vertical skin reduction in autologous recon, the Wise pattern was associated with higher rates of MFN, more post-operative visits, and prolonged wound care (28).

Liu and colleagues (32) described a staged Wise pattern skin envelope reduction which involves a vertical reduction pattern at the time of mastectomy with gathering of redundant skin at the inframammary fold followed by a second stage horizontal excision along the inframammary fold. This technique affords ideal perfusion of skin flaps while achieving an ideal aesthetic with the Wise pattern.

Regardless of the elected technique, the incision should take into consideration the access required to perform the mastectomy and access to the recipient vessels, as excessive retraction can put undue pressure and add additional ischemic insult to mastectomy flaps.

Nipple-sparing mastectomy (NSM)

NSM is being offered to patients at an increasing rate, given expanding criteria and its well-documented oncologic safety (33-36). The superior aesthetic outcome, psychological benefits, and patient-reported satisfaction supports the increasing popularity of this technique (37,38).

The risk for ischemic complications in the setting of ptotic or hypertrophic, however, are well known. Specifically, breast volume, BMI, and ptosis are associated with nipple areolar complex necrosis in the setting of NSM (39-41). Additionally, increasing breast size and ptosis can create a discordance between the skin envelope and reconstructed breast volume leading to a poor cosmetic (41). A review of the American Society of Breast Surgeon's Nipple-Sparing Mastectomy registry demonstrated that of NSMs performed, only 15% were in patients with grade 2 ptosis and 3.9% in patients with grade III ptosis (42).

The objective of an NSM in the setting of ptosis or hypertrophy is to retain the NAC, reduce the skin envelope, reducing the perfusion stress on the skin flap and nipple. NSM can be performed as part of a multi-stage approach that involves either a delay or lift to reduce the risk of ischemic complications. For this reason, NSM in this cohort is often performed in the prophylactic setting or in a patient with a genetic predisposition, as additional interventions that cause delay may not be appropriate in an active breast cancer setting.

Single stage NSM

Performing a NSM in the hypertrophic or ptotic breast places significant stress on the mastectomy skin flaps and the nipple-areolar complex (NAC). The large surface area and the greater distance from source vessels with increasing breast size create a high risk for ischemic complications. Additionally, reconstruction in the hypertrophic or ptotic breast without skin reduction or nipple elevation produces discordance with flap volume, higher risk for nipple malposition, and, ultimately, a poor cosmetic result.

Performing a traditional Wise pattern reduction/mastopexy at the time of mastectomy would place unacceptable stress on the nipple and skin flap perfusion. Alternatively, a Wise pattern de-epithelialization rather than resection has been described—this involves de-epithelializing the Wise pattern and performing the mastectomy through a single limb (43). However, even with preservation of the dermal components within the Wise pattern, the risk for nipple necrosis remains high—12.5–13% (30,43).

NSM alone in this patient population, therefore, is rarely offered, particularly in the setting of prior radiation therapy or smoking history, unless a supplemental procedure is performed to lift the nipple and reduce the skin envelope or delay the nipple and allow ischemic conditioning prior to the mastectomy (44,45).

Nipple delay—ideal for patients with minimal to mild ptosis

In an effort to reduce the risk of necrosis of the NAC or mastectomy, delay procedures have been implemented to allow for pre-ischemic conditioning. This technique is a good option in patients with mild to minimal ptosis. It was first described in 2012 by Jensen and colleagues (46), who performed a nipple delay in a cohort of patients of whom several had grade 2 and 3 ptosis between 7–21 days prior to a NSM. In this cohort, no patients experienced any nipple necrosis. A subareolar biopsy is performed at the time of nipple delay, which allows examination by permanent sectioning prior to the mastectomy (46). Frozen section examination can have a chance of false-negative, ranging from 5.9–15.4% in the setting of NSM (47,48). Therefore, a nipple delay and an opportunity to examine subareolar tissue under a permanent section prior to NSM can reduce the risk of a false negative on frozen section.

In the same study, Jensen also describes a "hemi-batwing" procedure that can lift the nipple a few centimeters via resection of skin superior to a radial scar. The combination of nipple delay and preparation of a hemi-batwing excision prior to the NSM allows for it to be performed safely at the time of mastectomy.

Several studies have since evaluated the benefits of a delay procedure in the setting of a NSM. Miles and colleagues (49) found that delay was protective against ischemic complications (OR =0.28, P=0.007) and reduced the risk by 11%. Other studies have demonstrated no full-thickness necrosis in NAC after delay procedures (50-52). A systematic review of nipple delay procedures revealed a number of different techniques and incisions, a range of 1–6 weeks prior to mastectomy. No patients developed full-thickness nipple necrosis, and 8.9% developed partial necrosis. Of note, 6.9% had a positive subareolar biopsy necessitating excision of the nipple (53).

Delay procedures have an excellent safety profile; however, they do alter the timeline for primary cancer resection. While there is minimal impact of performing a nipple delay in the setting of a genetic predisposition or prophylactic mastectomy, in a patient with an active breast cancer timeliness in cancer treatment is prioritized.

Pre-mastectomy reduction/mastopexy > NSM—ideal for patients with moderate to severe ptosis or hypertrophy

Spear and colleagues (54) first published their experience with mastopexy or reduction in patients with grade 2/3 ptosis prior to performing NSM in 2012. Since then, several studies have utilized this staged approach with a complication profile similar to that of NSM in the non-ptotic or hypertrophied breast (44,55-58). Momeni and colleagues (58) had the largest study consisting of 61 patients undergoing pre-mastectomy reduction/mastopexy followed by autologous reconstruction with a 6.6% rate of nipple necrosis and a similar 6.6% rate of skin flap necrosis.

Post-mastectomy mastopexy

An alternative strategy that does not delay primary cancer resection involves performing a mastopexy after the NSM. Schneider and colleagues (59) described nipple-sparing mastectomies with autologous reconstruction performed in 34 breasts that were cup size C or greater, had a sternal notch to nipple distance of greater than 24 cm, and grade II and III ptosis. They observed one case of nipple necrosis in a patient with prior breast radiation (5%). Five patients (26%) underwent a subsequent mastopexy/reduction to tailor the skin envelope to the underlying free flap at an average of 6.6 months after the primary procedure. No patients were smokers or diabetics in this cohort.

DellaCroce and colleagues (60) conducted a similar study with 70 patients and 116 breasts who underwent NSM with autologous reconstruction followed by a secondary mastopexy on average 6.2 months after the primary procedure. There were 4 cases (3.4%) of partial MFN, 9 patients with partial incisional dehiscence (7.8%), and no NAC necrosis. Patients also reported high satisfaction with their results, including those with grade III and/or large breasts. The authors attest the lack of nipple necrosis to the ingrowth of vasculature from the underlying flap, which allows interruption of the skin at the time of the secondary mastopexy.

Autologous reconstruction allows this method to be considered. In the event of nipple necrosis at the time of NSM in the large or ptotic breast, the nipple can be excised in the post-operative period, and a primary closure with the surrounding skin can be performed.

Raghavan and colleagues (61) reported their experience in comparing tissue expander reconstructions and free flap reconstructions in NSM. Their study published in 2015 compared NSM with immediate free flap to NSM with tissue expander placement and noted that rates of NAC necrosis were 29% and 0%, respectively. The authors contribute to the decreased rate of necrosis due to the lighter weight of the tissue expander and minimization of pressure on the mastectomy flaps. Additionally, nipple projection and pigmentation were rated better with the intermediate tissue expander by blinded surgeons and residents.

Elderly

Approximately two-thirds of all solid tumors occur in patients over 65 years (62). According to the National Cancer Institute, over 40% of new breast cancer cases are diagnosed in women aged 65 years or older (63). As the elderly population continues to grow and advances in medicine allow for better control of comorbidities and increased cancer survival, we must recognize that the decision to undergo post-mastectomy reconstruction can significantly impact quality of life.

Women who decline breast reconstruction at this age commonly cite the fear of complications or feel that a prosthesis is adequate (64,65). Breast reconstruction is often not offered to the elderly due to the reluctance of clinicians, sometimes due to an inaccurate estimation of operative risk (66). An evaluation of the National Cancer Data Base indicated that age less than 50 years was the largest predictor of undergoing reconstruction, with 4.3 times greater likelihood than those over the age of 50 years. However, surgery is well tolerated in the elderly, with complication rates similar to that of a younger age group (64).

While older patients tend to have a greater number of comorbidities which is proportionately associated with a greater number of perioperative complications, age alone does not increase operative risk (65-68). All patients should be evaluated individually, with special attention to comorbidities and functional status (64).

Several studies evaluating surgical complications in the elderly indicate that patient frailty is more predictive than age. Roubaud and colleagues (69) provide an excellent review of existing frailty indices, indicating that a simplified 5-factor modified frailty index (mFI-5) is a simple and defective predictor of mortality and post-operative complications across surgical subspecialties. The mFI-5 takes into consideration functional status, diabetes, chronic obstructive pulmonary disease (COPD), congestive heart failure, and hypertension requiring medication (70). The mFI-5 has been utilized in the plastic surgery literature in patients undergoing pedicled flap reconstruction and demonstrated significant predictive capacity (71).

In evaluating reconstructive modalities, abundant literature has demonstrated that autologous reconstruction is superior to implant-related reconstruction, both from an aesthetic standpoint and with regard to complications (68,72-74). Despite concerns over the length and complexity of autologous reconstruction, it should not be withheld from elderly patients, given improved outcomes over implant-based reconstruction.

Additionally, reconstruction has a significant positive impact on social functioning and emotional well-being compared to elderly patients that did not undergo reconstruction (64). Older patients with breast reconstruction scored higher in overall quality of life than patients that did not undergo reconstruction (68).

In conclusion, breast reconstruction in the elderly is safe. Global evaluation of each individual should be performed, paying attention to acute and chronic medical conditions, nutritional status, function, and patient motivation and preference.

Smoking

Among active smokers, continuing to smoke after a cancer diagnosis has significant adverse effects on treatment effectiveness, overall survival, risk of second primary malignancy, and quality of life (75). With regards to reconstruction, smoking is strongly associated with an increased risk of MFN (11,76,77) and complications in both implant-based and autologous reconstruction (11,78-81). Loss of tissue expander to implant-based reconstruction in active smokers was 2.2× greater than that of non-smokers (11). In patients who are active smokers, autologous reconstruction does not imply loss of reconstruction (78).

Most notably, in autologous reconstruction, smoking increases the risk for wound complications at the abdominal donor site by over two-folds (81-83). Fortunately, smoking has not been associated with microsurgical complications or complete flap loss in large studies (84,85); however, it has been associated with an increased risk for partial flap loss (83,84).

Concerning the effect of smoking on fat necrosis, the literature is largely inconclusive (81,83,86). Mehrara (83) reviewed 1,195 autologous breast reconstructions and identified no increased risk of fat necrosis. However, this subset of patients, like in most autologous reconstruction studies, had a small number of active smokers (n=22) and, therefore, may not be sufficiently powered to demonstrate a difference. Khansa and colleagues (86), in a meta-analysis of fat necrosis in autologous abdominally-based breast reconstruction, noted that active smoking was associated with an increased risk of fat necrosis.

Smoking cessation can help reduce the risk of perioperative complications. Patients demonstrate increased motivation and interest in smoking cessation after a cancer diagnosis, even in patients with cancers that are not strongly related to smoking (75). In a pooled analysis of 6 randomized controlled trials, smoking cessation reduced overall risk by 41%, post-op wound healing complications by 52%, and surgical site infection (SSI) by 60%, with progressive reduction from 4 to 6 weeks (87). Studies have determined that smoking cessation for 4 weeks significantly impacts smoking-related complications and that longer periods of smoking are associated with reduced risk. Each week of cessation further contributes to risk reduction, and patients should be encouraged to refrain from smoking as long as possible prior to reconstruction (88-90).

The likelihood of smoking cessation doubles with nicotine replacement therapy (NRT) (91). No significant difference in complications or wound healing issues have been identified between abstinent smokers on NRT and abstinent smokers and placebo. This is most likely related to the significantly reduced levels of nicotine present in NRT compared to active smoking (88-92). While NRT specifically has yet to be studied in microsurgical reconstruction, there is well-documented benefit of achieving and maintaining abstinence without increasing the risk of complications.

Prior abdominal surgery/procedures

Amongst large reviews of consecutive patients undergoing abdominally based breast reconstruction, 38–52% have a prior abdominal incision (83-97). Prior surgery can potentially disrupt perforators, alter perfusion and lymphatic drainage of the abdominal skin, weaken fascia, and cause scar tissue that can complicate a dissection. Most large studies have demonstrated an increase in donor-site wound healing complications in patients with prior abdominal incisions (95-97). In the largest review of patients to date, Daly and colleagues (95) reported that patients with prior abdominal surgery were 1.8 times more likely to have donor site wound complications (OR =1.82, P=0.05) and had a 14% chance of having a donor site open wound.

Roostaeian and colleagues (96) noted delayed abdominal wound healing in the setting of prior open abdominal surgery compared to patients with no prior abdominal surgery (2.99% *vs.* 0.37%, P=0.04). The two groups had similar rates of hernia/bulge, hematoma, seroma, and infection. Additionally, prior abdominal surgery did not impact operative times.

Parrett and colleagues (97) noted that the prior abdominal surgery group had a higher rate of abdominal donor site complications compared to control (24% *vs.* 6.7%). The most common complications included abdominal breakdown (12%), seroma (6.4%), and abdominal laxity or bulge (5.1%).

While most studies have not identified any difference in flap-related complications, including partial or total flap loss (94,96-98), Daly and colleagues (95) noted an increased rate of fat necrosis ≥2 cm in patients with prior abdominal surgery (13.6% *vs.* 11.7%); however, the rates of fat necrosis are similar to general rates among this population, 14.4% in a large systematic review of autologous breast reconstruction (86). Interestingly, operative times between the two groups in multiple studies have not been significantly different (95-97). Additionally, pre-operative computed tomography angiography (CTA) did not affect operative times, perforator dissection, or the rate of complications (95). Practices for pre-operative imaging remain variable amongst institutions.

The most commonly encountered incisions in patients undergoing abdominally based autologous reconstruction are the low transverse incision, open appendectomy, laparoscopic incisions, and midline (93,94,96,98). Indications for prior incisions were most often obstetric and gynecological, with caesarian section and hysterectomy being the most common prior procedures performed (96). While some studies have found no differences in complications amongst incision types (94,97), others have identified an increased risk of donor site complications with the subcostal, midline, and Pfannenstiel incisions (97,99,100). Maneuvers to avoid these risks are limited undermining of the abdominal wall in the region of the scars and preserving as many perforators as possible (93).

The low transverse or Pfannenstiel scar is the most encountered prior abdominal incision. In a study by Kim and colleagues (101) comparing patients with a Pfannenstiel scar and those without, they noted increased communications between the superficial and deep inferior epigastric venous systems. The study also noted a lower rate of fat necrosis in patients with the Pfannenstiel incision, which is debated in other studies (94,97,98). Undermining of the lower abdomen and often division of the superficial epigastric vessels in a prior Pfannenstiel does result in a type of delay and preconditioning of the flap. Patients with a low transverse scar have demonstrated increased diameter of perforators than those without a scar (102). Studies evaluating a history of a low transverse scar have not identified a difference in complication rates (101-103).

Liposuction

Liposuction is one of the most performed cosmetic surgical procedures in the United States (1). A prior history of liposuction has traditionally been a relative contraindication due to concern for disruption of perforators and scarring that can complicate the dissection. A number of studies have evaluated pre-operative and post-operative doppler ultrasonography to determine the changes in the presence and number of perforators. While the data is inconsistent, the most recent studies have demonstrated that all preoperatively identified perforators can be identified in the same location post-operatively 6 months out without any major differences in diameter or blood flow (104-107). A 2022 systematic review of 11 studies and 55 abdominally-based free flaps, including transverse rectus abdominis myocutaneous (TRAMs), demonstrated no total flap loss, a partial flap loss or fat necrosis rate of 14.5%, and donor site complications in 4.6% of patients. These rates are similar to that of the general population of patients undergoing abdominally-based free flaps (86). Time from liposuction to reconstruction had a wide range, but the shortest interval was 1.3 years (108). Eight of the eleven studies reviewed performed pre-operative imaging, either CTA, magnetic resonance angiography (MRA), or Doppler ultrasonography. All patients that underwent imaging demonstrated adequate perforators and favorable anatomy; therefore, none were excluded from reconstruction. Furthermore, pre-operative imaging of any form did not result in a lower rate of complications—though this may have been a result of selection bias (108). Zavlin and colleagues (109) evaluated the effect of liposuction in a small cohort of deep inferior epigastric perforator (DIEP) patients and also noted no partial or total flap loss and an expected number of complications. It is important to note that liposuction techniques and technical factors such as tumescent used, cannula size, and amount aspirated can vary. Additionally, liposuction for fat grafting and suction-assisted liposuction for contouring should be considered differently.

In a meta-analysis of over 14,000 patients comparing abdominoplasty to lipoabdominoplasty, there was no significant difference in complications (104). Other studies have further investigated the impact of liposuction on perfusion with various modalities, including combined color Doppler ultrasonography, combined laser-doppler spectrophotometry, and SPY angiography and have determined minimal impact of perfusion on the raised abdominal flap (105,106,110,111). This data supports the robust perfusion of the abdomen in the setting of prior liposuction.

Radiation therapy

Post-mastectomy radiation therapy (PMRT) helps decrease local recurrence and increases overall survival (112). Radiation therapy, however, is associated with increased morbidity in breast reconstruction. The optimal timing and sequence of PMRT are highly debated in the literature and will be discussed in a separate portion of this special series.

It is important to note, however, that autologous reconstruction in the setting of prior radiation therapy can be associated with an increased risk of complications (113,114). Additionally, a 2016 guideline update expanded indications for PMRT and supported regional nodal irradiation (RNI) of internal mammary and supraclavicular lymph nodes in a wider range of patients (115). RNI improves the rate of disease-free survival, distant metastasis-free survival and reduces breast cancer mortality (116-118). As rates of RNI increase, we should expect to see more radiated internal mammary recipient vessels.

In a systematic review and meta-analysis of 29 articles and 1,500 flap reconstructions, Kelley and colleagues (114) compared flap reconstruction performed prior to radiation and flaps performed after radiation. The total flap loss rate was 4% in patients that were radiated prior to reconstruction and 1% in patients who received radiation afterward; however, the difference was not statistically significant.

Kaidar-Person and colleagues (119) evaluated the impact of RNI to the internal mammary nodes on delayed autologous reconstruction and noted no flap failures. However, one patient required conversion to thoracodorsal recipients because the vessels were of small caliber and unsuitable. RNI was not associated with the risk of complications; however, this was a small patient cohort.

Shechter and colleagues (120) compared PMRT to patients that underwent PMRT and RNI in the setting of delayed breast reconstruction. The flap loss rate in the PMRT + RNI group was 8.3% versus 0% in the PMRT-only group. This difference was not statistically significant; however, a flap loss rate of 8.3% was higher than the group's general autologous reconstruction cohort and greater than that demonstrated in the literature. Larger cohorts may be required to identify statistical significance.

Radiation has well-known effects on vessels, including intimal hyperplasia and adventitial fibrosis. Therefore, in the setting of delayed or immediate delayed reconstruction after PMRT and RNI should proceed with caution, particularly in the left chest where the caliber of the internal mammary vessels is smaller than that of the right (121,122).

Conclusions

In summary the aforementioned patient attributes can significantly impact patient outcomes, however, when properly managed, complications can be minimized. Obesity progressively increases the risk for surgical complications, however, autologous reconstruction remains the superior modality in comparison to implant-based reconstruction. Oncoplastic reconstructions are an excellent alternative to both autologous and implant-based reconstruction, demonstrating a better complication profile. In the setting of grade II or III breast ptosis, performing a staged operation with a pre-mastectomy mastopexy or reduction can help achieve harmony between skin envelope and reconstructed breast. In the setting of an active cancer a vertical skin reduction can safely be performed at the time of mastectomy to achieve an aesthetic result. If a nipple sparing mastectomy is being performed, a nipple delay can be considered, which also affords the opportunity for a subareolar nipple biopsy. The elderly should be offered autologous reconstruction after evaluating for comorbidities and frailty, as age alone is not a contraindication. Cancer diagnosis is an opportune time to counsel patients regarding smoking cessation given their increased motivation. Nicotine replacement therapies can be considered given their effectiveness in achieving and maintaining cessation with no identifiable impact on wound healing. Abdominally based reconstruction in the setting of prior abdominal surgery or liposuction are not associated with an increased risk of partial or total flap loss. Lastly, radiation therapy has untoward effects, and as the indications for RNI are expanded, surgeons should consider the impact it may have on internal mammary vasculature.

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