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Breast Reconstruction: Review of Current Autologous and Implant-Based Techniques and Long-Term Oncologic Outcome

Breast Reconstruction

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Abstract

Implant-based reconstruction is the most common method of breast reconstruction. Autologous breast reconstruction is an indispensable option for breast reconstruction demanding keen microsurgical skills and robust anatomical understanding. The reconstructive choice is made by the patient after a discussion with the plastic surgeon covering all the available options. Advantages and disadvantages of each technique along with long-term oncologic outcome is reviewed.

Key Words: Breast Reconstruction; Mammaplasty; Breast Implant; Autologous Reconstruction; Oncologic Outcome; Breast Neoplasms

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Core Tip: Breast reconstruction can be achieved using autologous and implant-based techniques. Each method has its indications and contraindications accompanied by advantages and disadvantages. An astute plastic surgeon should have deep

understanding of the nuances of each technique when consulting patients about reconstructive breast options.

INTRODUCTION

Breast reconstruction aims to recreate the breast mound in postmastectomy patients. This can be achieved using autologous and implant-based techniques. Each method has its indications and contraindications along with advantages and disadvantages. The ultimate decision is made by the patient through an informed decision when all the options are fully explained. Here, we review implant-based and autologous reconstructive techniques along with oncologic outcomes.

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Implant-Based Reconstruction

The most common breast reconstruction method used by plastic surgeons is implant-based reconstruction which outpaced autologous techniques in early 21st century.[1] General advantages of implant-based reconstruction are shorter operative time, faster patient recovery and elimination of donor site morbidity. Disadvantages are capsular contracture, higher rate of infection, implant malposition, less natural feel, and breast implant illness. Complication rate and failure of implant-based reconstruction is significantly increased in patients undergoing adjuvant radiation therapy. Autologous techniques would usually remain an option after implant-based reconstruction.

Prosthetic reconstructions can be performed in one or two stages and in immediate or delayed fashion. Single-stage reconstruction is favored in healthy patients with smaller breasts. A useful adjunct is use of acellular dermal matrix which both provides better definition of the implant and maintains its position. Important risk factors for complications of prosthetic techniques are smoking, diabetes, obesity, and large breasts.[2-4]

Immediate vs Delayed Reconstruction

Immediate breast reconstruction preserves native skin envelop and breast borders. It minimizes trips to the operating room and improves aesthetic outcome and patient satisfaction by minimizing the negative psychological impact and improving the self-image.[5] On the other hand, delayed reconstruction is associated with fewer complications including flap necrosis, capsular contracture, and need for prosthetic removal. As a rule, immediate reconstruction is better for patients with less comorbidity, early-stage cancer, and lower body mass index (BMI). It is common practice to delay reconstruction in patients with questionable mastectomy flaps, when close tumor surveillance is needed, and in the setting of planned adjuvant therapy.[6]

Single- vs Two-Stage Reconstruction

Prosthetic reconstruction can be achieved *via* direct placement of permanent implant after mastectomy (single-stage) or placement of tissue expander and later exchange for a permanent implant (two-stage). Single-stage, a.k.a. direct-to-implant, approach has the advantage of eliminating the need for a second operation, reducing the risk of infection, and eliminating multiple office visits for device expansion. Smoking, diabetes, need for adjuvant radiation, and larger breast size are associated with increased risk of complications after single-stage reconstruction.[7] It is shown that two-stage reconstruction is associated with an overall decreased absolute rate of implant loss compared to one-stage reconstruction.[8]

Acellular dermal matrix (ADM) is used as an adjunct to prostatic reconstruction to help with defining the mastectomy space, support the soft tissue, and stabilize the implant.[9] It should be noted that ADM is not yet cleared by the US Food and Drug

Administration (FDA) for use in implant-based breast reconstruction and currently wide use of ADM is off-label.[10] ADM is shown to improve aesthetic outcome in both single- and two-stage reconstruction.[11] ADM use is associated with reduced rate of capsular contracture.[12] The downside of using ADM is increased risk of postoperative complications especially infection and seroma formation.[13]

Implant Selection

There are many options for size, texture, and shape for both expander and implants selection. Expander options are relatively more limited, and they are available in different heights, base width, projection, and capacity. Base width is the most important parameter which should match the width of the breast footprint on the chest wall. Implants, on the other hand, have more variety to choose from. They can be saline *vs* silicone, smooth *vs* texture, and round *vs* anatomic.

Although saline implants have a less rigorous surveillance protocol and are easier to detect when they are ruptured, they are associated with a higher rate of implant visibility and rippling. Silicone implants more closely resemble the native breast issue, but their rupture is harder to detect and can lead to capsular contracture. There are data suggesting that the rate of rupture and capsular contracture is slightly higher in silicone implants compared to saline implants.[14] On the other hand, it is shown that patients with silicone implants have higher satisfaction, and better psychological and sexual function compared to saline implants.[15]

Although it might be difficult to clinically differentiate between round and anatomic-shape implants, shaped implants may result in an improved upper pole shape and better volume.[16] One should keep in mind that most of shaped implants are textured which should be part of the discussion with the patient.

Implant Placement

Selection of the plane to place the implant is usually surgeon-dependent. Subpectoral position places the implant between the pectoralis major muscle and the chest wall, whereas the prepectoral position places the implant between the skin flap and the pectoralis major muscle.[17] Historically, prepectoral position was associated with higher complications including capsular contracture and implant exposure but with improvement in surgical techniques and use of ADM (currently off-label use) these complications are significantly reduced leading to regaining popularity of the prepectoral implant placement.[18] With subpectoral positioning of the implant, it is a common practice to create an ADM sling (currently off-label use) for the exposed part of the implant below the pectoralis major muscle (dual-plane or partial subpectoral).[19] Currently, subpectoral implant placement has outpaced the historically higher rate of capsular contracture with prepectoral implant placement and it is also associated with a higher rate of animation deformity.[17]

Quality of mastectomy flaps is the most important factor in the success of prepectoral implant placement.[20,21] Although it reduces the morbidity of subpectoral placement and animation deformity, it should never be performed in questionable mastectomy flaps.[22] In these situations, intraoperative Indocyanine Green (ICG) imaging can verify adequate blood supply to the mastectomy flaps. Active smoking, radiation to the field, and medical comorbidities also make prepectoral implant placement a less desirable option.[23] Tumor characteristics and location should be taken into account when choosing the appropriate plane for implant placement.[24,25]

Special Considerations

Need for adjuvant radiation complicates decision-making for prosthetic reconstruction techniques. Radiation is associated with increase rate of infection, flap necrosis, seroma, capsular contracture, and reconstructive failure.[26,27] Although some studies have shown no difference in the rate of complications between radiation of the expander *vs* the permanent implant in a two-stage reconstruction, the majority of available data have shown an increased rate of reconstructive failure following radiation of the permanent implant. Therefore, most plastic surgeons tend to increase the interval between completion of radiation and exchange to the permanent implant at about six-month interval.[28-30]

Timing for radiation in the two-stage reconstruction is usually around 8 wk after tissue expander placement.[28,29] Rapid expansion starts in about 2 wk after placement of the expander and expansion is usually completed by the 6th week to have the patient ready for radiation at the 8th week.[31] Variations in timing of radiation is described with acceptable outcomes.[32,33]

Complication rates of prostatic reconstruction of previously radiated breast can reach up to 50%.[34,35] Fibrosis and decrease vascularity does not respond well to expansion following radiation leading to three times increased risk of capsular contracture and reconstructive failure.[36] These risks appear to be slightly higher in post mastectomy radiation cases. Chemotherapy and hormonal therapy do not appear to increase the risk of complications following prosthetic reconstruction.[37,38]

Complications

Acute hematoma occurs in the first 24-48 h after surgery in up to 3% of implant-base reconstructions.[39] Surgical drains are not useful for evacuation of blood clots and any hematoma can increase the risk of mastectomy skin flap necrosis and lead to poor aesthetic outcome. Infection rate can reach up to 8% following prosthetic

reconstruction.[40] Capsular contracture can reach up to 13% in 3 years after prosthetic reconstruction and risk factors include radiation, hematoma, infection, and silicon rupture. The best way to prevent capsular contractor would be targeting the risk factors at the index operation.[41] Wound dehiscence is another complication (**Figure 1**). Although data supports the use of preoperative antibiotic use, there is not sufficient evidence supporting outpatient use of antibiotics to prevent infection.[42]

Oncologic Outcome

In a 10-year follow-up study in patients who underwent nipple-sparing mastectomy, in whom about 75% had implant-based reconstruction, not only the overall recurrence rate was low (3.33%) but also no demographic, tumor-specific or operative factor was found to be associated with increase recurrence.[43] This is a significant improvement from an earlier study on implant-based reconstruction after nipple-sparing mastectomy which showed a recurrence rate of 24%.[44] This is in part due to advancement in cancer treatment and better neoadjuvant and adjuvant treatments.

In a recent systematic review, locoregional recurrence was found to be 0-7.4% after a median 5-year follow-up and no increased risk of recurrence with reconstructive method.[45] In a 7-year median follow-up study, locoregional recurrence in patients with immediate breast reconstruction was found to be 3.5% and independent from the reconstructive method.[46] In another study of at least 60-month follow-up comparing smooth and textures implants, no significant difference was found between the two in terms of locoregional recurrence.[47]

Textured implants were historically used to reduce the rate of capsular contracture and provide a more stable implant position, but studies have shown a small increased risk of breast-implant-associated anaplastic large-cell lymphoma (BIA-ALCL) with the use of textured devices.[48-50] Companies such as Allergan voluntarily recalled some textured

implants (no new cases).[51] This led to FDA scrutiny of implants and in October 2021, patient decision checklist (PDC) was mandated as a condition for the sale of breast implants.[52] More recently, rare cases of breast implant capsule-associated squamous cell carcinoma (BICA-SCC) are reported which has a worse prognosis.[53] BICA-SCC can mimic BIA-ALCL but a similar diagnostic approach can be applied to distinguish between the two.[54] These should be discussed with the patient at the time of consult and during informed decision making for breast reconstruction. FDA recommends magnetic resonance imaging (MRI) to detect rupture at 3 years after implantation and then every 2 years.[55] More cohesive implants are now approved which are at an increased cohesion level compared to prior gel implants.[56]

Autologous Reconstruction

Despite the fact that the majority of patients undergo implant-base breast construction after mastectomy, autologous breast reconstruction is the only choice for certain patients and undoubtedly is an option after failure of implant-based reconstruction.[57,58] Patient-related and surgeon-related factors each play a role in the choice of reconstruction. Using autologous tissue reduces postoperative risk of infection, implant rupture, capsular contractor, and malposition. Furthermore, autologous technique is the preferred method in patients expecting to receive radiation therapy or with prior irradiated breast.[59-61]

Preoperative Evaluation

Thorough history and physical examination are essential parts of the preoperative evaluation. Patient's goals in terms of the reconstruction, and limitation of reconstructive options should be discussed in detail. Oncologic plan should be elucidated including neoadjuvant and adjuvant chemoradiation. Special attention should be paid to the tentative future donor site including prior surgeries, scars, skin quality, and infection. Although majority of patients prefer immediate reconstruction, when postmastectomy radiation is anticipated, delayed reconstruction is favored. Some microsurgeons elect to do preoperative imaging to elucidate vascular anatomy, yet many surgeons do not implement preoperative imaging and instead, use pencil Doppler intraoperatively to identify the location of the perforators.[62,63]

Pedicled Flaps

Latissimus Dorsi Flap

The latissimus dorsi (LD) myocutaneous flap is a well-establish pedicled flap for breast reconstruction. This flap is based on the thoracodorsal vessels, which arise from subscapular vessels that are branches of the axillary vessels (**Figure 2**). Medial and lateral branching of the vessels allows for muscle-sparing procedures. LD is a broad muscle that allows for a wide coverage with or without a skin paddle. The downside of using LD is that it does not typically providing sufficient volume which requires combination with prostheses. LD can also be used as a salvage option once other breast reconstruction options have failed.

Pedicled Transverse Rectus Abdominis Myocutaneous Flap

The pedicled transverse rectus abdominis myocutaneous (TRAM) flap uses lower abdominal fat and is based on the superior epigastric artery which is a continuation of the internal mammary artery (**Figure 3**). It is elevated with the ipsilateral rectus muscle

and tunneled into the mastectomy site. At times, delayed procedures should be performed by ligating the deep inferior epigastric artery so that choke vessels are recruited and superior epigastric vessels take over the perfusion of the pedicled TRAM flap.[64] Since harvesting this flap includes removal of the fascial coverage, closure requires implementation of mesh and there is an associated increased risk of incisional hernia in this patient population.[65]

Free Flaps

Commonly used free flaps are discussed below. Recipient vessels are usually internal mammary vessels, and as an alternative, thoracodorsal vessels can be used. End-to-end venous anastomosis are performed using vein couplers and end-to-end arterial anastomosis is typically handsewn using 8-0 to 10-0 nylon sutures.

Abdomen-Based Flaps

Abdomen-based free flaps are the most common free autologous flaps for breast construction. Besides extensive clinical experience, these flaps commonly have reliable vascular anatomy, long pedicles, reduced donor site morbidity, and sufficient soft tissue for breast reconstruction. Free flaps based on the deep inferior epigastric vessels (branches of external iliac artery) include free transfers rectus abdominis myocutaneous (TRAM), free muscle-sparing TRAM (ms-TRAM), and deep inferior epigastric perforator (DIEP). Free flap based on the superficial inferior epigastric vessels (branches of the femoral vessels) is the superficial inferior epigastric artery (SIEA) perforator flap (**Figure 4**). Less than 10% of abdominal-based flaps are superficially dominant.[66]

For patients undergoing immediate breast reconstruction, flap harvest can be performed at the same time of the mastectomy surgery. Flap design is usually inferior to the umbilicus in a lenticular fashion. Superficial inferior epigastric vessels are

isolated at the inferior aspect of the flap during flap elevation.[67] Most of the perforators needed for DIEP flap are within 10 cm from the umbilicus. Zones of perforation vary depending on the selected row of perforators.[68,69] For unilateral reconstruction, midline could be crossed to include the zone immediately adjacent to the midline, whereas this option is not available when using SIEA flaps.

The dominant perforator can be identified by temporarily clamping other perforators and assessing the flap while using ICG perfusion imaging. Once the appropriate perforators are selected, anterior rectus facia is opened, and intramuscular dissection of perforators is carried down to the level of deep inferior epigastric vessels. If a segment of muscle between the two rows of the perforators is also harvested, then ms-TRAM flap is created and with complete transaction of the rectus muscle without preserving continuity, a free TRAM flap is created. The vessels, which typically consist of two veins and one artery are ligated distal to takeoff from external iliac vessels.

Robotic-assisted DIEP flap breast reconstruction is drawing attention as a new and alternative way to harvest DIEP flaps to reduce the risk of abdominal wall herniation, bulging, motor weakness and chronic pain.[70] It is associated with improved visualization, dexterity, ergonomics, and more importantly decreases the size of facial incision to reduce the above-mentioned complication.[71] If the length of the intra-muscular section of the pedicle is more than 5 cm, then it is unclear if robotic-assisted DIEP would reduce the rate of complications compared to the conventional DIEP approach.[72] This method would require pre-operative vascular imaging for appropriate planning and the microsurgeon needs to be additionally trained for robotic surgery.

Medial Thigh Flaps

Medial thigh flaps incorporate gracilis muscle and is an option for construction in patients with prior abdominoplasty or those with insufficient abdominal tissue.[73] This

flap is based on the medial circumflex femoral artery which is a branch of the profunda femoris artery (**Figure 5**). The skin paddle can be oriented transversely in transverse upper gracilis (TUG) flap, vertically in vertical upper gracilis (VUG) flap or as a combination of both. This flap is better for patients with small- to moderate-sized breasts and the flap artery is usually smaller than the recipient artery.

Posterior Thigh Flaps

Posterior thigh skin and adipose tissue can be used for breast reconstruction based on the profunda artery perforator (PAP) flap (**Figure 6**). PAP flap provides longer pedicles compared to medial thigh flaps[74]. This flap is designed as a horizontal ellipse with the superior incision below the gluteal crease. PAP flap can be harvested in prone position, though, to facilitate two-team approach, PAP flap is elevated in the lithotomy position.

Gluteal Artery Perforator Flaps

Another option for patients who cannot have abdomen-based flaps is superior or inferior gluteal artery perforator flaps (SGAP or IGAP). The superior gluteal artery exists the pelvis above the piriformis muscle and inferior gluteal artery exits the pelvis below the piriformis muscle.[75] Patients are either positioned laterally or prone which requires positional change intraoperatively to inset the flap. Although GAP flaps provide adequate amount of adipose tissue for breast reconstruction, they often have relatively short pedicle lengths.

The decision making about the choice of the autologous flap is based on several factors. First and foremost is the patient's choice which happens after providing adequate information so that the patient can make an informed decision.[76] Anatomical considerations are critical in the decision making about the choice of the flap. DIEP flaps are harvested in the same position and can allow two teams to work at the same

time.[77] It also provides a reliable pedicle of enough length closely matching the recipient vessels.[78] Donor site comorbidities are acceptable for DIEP flaps. Other choices of free flaps, that are discussed above, have shortcomings in one or more of these factors such as providing short length of pedicle, need for repositioning in the OR and increased donor site comorbidities.[79] This is why currently DIEP flaps are the most favorable free flaps for breast reconstruction.[80]

Postoperative Care and Complications

Post operative protocol can differ from surgeon-to-surgeon and institution-to-institution. Typically, postoperatively, flaps are kept warm and are evaluated every hour for at least the first 24-48 h. Examination consists of clinical exam, capillary refill, warmth, color, and pencil Doppler exam if no implantable Doppler is used. It is common practice to prescribe aspirin as an anti-platelet agent and to place the patients on venous thromboembolism prophylaxis. During the first 48 h, vascular compromise due to vessel positioning, hematoma, thrombus formation and compression can be devastating leading to flap loss. Early vascular compromise equals reoperation for flap salvage.

Other postoperative complications include partial flap loss (**Figure 7**), fat necrosis, infections (**Figure 8**), wound dehiscence, hematoma (**Figure 9**), and seroma formation. Donor site complications include infections, seroma, hematoma, wound dehiscence, necrosis, and hernia formation. It is shown that frailty is a reliable predictor of postoperative complications in autologous reconstruction.[81]

Oncologic Outcome

Boyed *et al* performed a 10-year follow-up study on a cohort of patients in whom about 25% had autologous breast reconstruction and found no association between increased

recurrence and operation.[43] No significant difference is found in terms of locoregional recurrence of cancer between implant-based and autologous reconstruction.[82,83] Low locoregional recurrence rate (3.5%) after immediate autologous breast reconstruction is shown in another study by Wu *et al* with a median follow-up of 7-year.[46]

CONCLUSION

Plastic surgeons have an armamentarium of implant-based and autologous reconstructive options to manage patients with breast cancer which should be tailormade for each individual patient. Both options have favorable long-term oncologic outcomes.

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