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Implant-Based Breast Reconstruction Cutting Edge and Controversies

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Abstract
Purpose of Review In recent years, the field of breast reconstruction has undergone dramatic changes that have given reconstructive plastic surgeons tools to rebuild more natural breasts
Recent findings Improved outcomes are in part attributable to improved mastectomy techniques with nipple preservation and efforts to preserve well-perfused mastectomy skin flaps. There have also been tremendous advancements in technology and supplemental fat grafting which have greatly enhanced cosmetic results.
Summary The present review provides data from the authors' experience and outlines important components of successful implant-based breast reconstruction and highlight the evolution of this process. Many novel, innovative techniques and advancements in implant design aim to refine patient outcomes and experience. Reconstructive plastic surgeons must be aware of the unique benefits and risks inherent in each technique, device, companion tools, and cancer treatment strategies to help guide their patients toward a successful, aesthetic reconstruction that meets their expectations and wishes.

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Introduction

Based on the latest statistics from the *American Society of Plastic Surgeons* (ASPS), more than 100,000 breast reconstructions are performed annually in the USA. Of these, almost 70% underwent 2-stage reconstruction using a tissue expander (TE), while 13% had direct-to-implant (DTI), and 18% were autologous, predominantly with a DIEP flap. In recent years, the majority of reconstructions were performed bilaterally, approximately two-thirds, while 34% were carried out unilaterally [1]. The increase in the number of bilateral reconstructions can be attributed in part to (1) more widespread and earlier detection; (2) incorporation of genetic mapping in prevention protocols; (3) greater public education on breast reconstruction options; and (4) better results with advances in surgical oncological, radiation therapy, and reconstructive techniques [2, 3].

The ideal modality of breast reconstruction after mastectomy is still a point of debate and will differ from patient to patient and the surgeon's expertise. Nowadays, implant-based breast reconstruction is the leading reconstructive method in the USA as in many countries including Argentina [4, 5]. While it is not entirely clear, changes in oncologic practice, increased number of bilateral mastectomies, and patient and physician preference may have contributed to the expansion in implant use [6]. For example, surgical treatment for breast cancer has moved from radical mastectomies and two-stage subpectoral

breast reconstruction to more conservative mastectomies with preservation of both the skin and the areola-nipple complex and prepectoral reconstructions with direct-to-implant placement. This change has been reported to achieve more aesthetic results and faster recovery in cancer patients.

In this review, we will explore implant-based breast reconstruction, its controversies, and hot topics to provide an overview of the most up-to-date data in the cutting edge of breast reconstruction.

Changes in Mastectomy Patterns: Evolution of Skin Incisions

Skin-Sparing Versus Nipple-Sparing Mastectomy

In recent years, surgical treatment for breast cancer has changed from the traditional Halstedian mastectomy to more conservative resections. However, in the current era of breast cancer treatment, the use of the skin-sparing and even the nipple-sparing approach have been found to have equivalent long-term outcomes with equivalent survival and disease-free recurrence [5, 7].

Given the increasing popularity of the skin-sparing and nipple-sparing technique, patient expectations and optimizing cosmetic outcomes in breast reconstruction have also increased [8]. Preserving the native breast skin is critical in achieving the most aesthetic result, and a number of technologies have emerged, designed to maximize mastectomy skin flap survival. The earliest skin-sparing mastectomies were performed through a long horizontal incision, but since its introduction, the approach has migrated toward shorter oblique incisions. In nipple-sparing mastectomies, the authors prefer an incision in the inframammary fold (IMF). Although it is more technically challenging, the incision is well concealed and achieves superior aesthetic results.

Other surgeons advocate for the use of the midlateral incision at the level of the nipple-areola complex, which allows easier access to the upper pole and limits the trauma to the inferior skin flap. However, certain patients with large, ptotic breasts do not qualify for a midlateral or inframammary incision and require a skin-reducing, Wise-pattern mastectomy. In this setting, careful consideration is necessary to preserve the vascular perfusion to the nipple-areola complex in these patients which is based solely on the wide dermal-subcutaneous pedicle. Alternatively, one can consider revascularization as a free nipple graft, but this is generally not performed in the setting of breast cancer. Following appropriate oncologic guidelines and principles, studies have not found a significant difference in complications between the mastectomy types.

Direct-to-Implant Versus Two-stage

While a two-stage approach is more commonly performed where a tissue expander is placed at the time of the mastectomy, the ability to proceed with a single, direct-to-implant operation has also demonstrated promising results. Implant-based reconstruction can be accomplished in a single-stage DTI when the final implant is placed at the time of the mastectomy; however, important technical factors should be considered to minimize complications. When reconstruction is performed in two stages with a TE, the expander can be exchanged to the final implant in a second surgical procedure, or alternatively, with autologous tissue which often provides the most durable, natural result.

Outcomes in direct-to-implant reconstruction continue to be defined. Previous single-stage reconstructions were associated with a higher incidence of adverse events and reoperations because of mastectomy skin necrosis, device malposition, and asymmetry [7–9]. Over the years, advancements in technology including the increasing popularity of using acellular dermal matrix to augment coverage of prosthetic devices, and improved mastectomy techniques have enabled plastic surgeons to perform single-stage reconstruction more predictably and without significant complications [10, 11].

Using the National Surgical Quality Improvement Program (NSQIP) database, Wink et al. demonstrated that DTI can indeed be performed safely with a 9% incidence of 30-day major surgical complications. They also found that obese patients, active smokers and cases with a prolonged operative time had a greater risk for the occurrence of a major surgical complication [12••]. Comparatively, Fischer et al. published a larger study with 14,585 patients and showed significantly increased complications.[13] Ultimately, the most critical component to successful DTI procedures is the health and vascularity of the mastectomy skin flap. It is most frequently performed in nipple-sparing procedures and on patients who are otherwise healthy, with relatively symmetric breasts and volume less than 900 cc. [14] In a cost-utility perspective, Krishnan et al. established equivalent safety profiles in these cohorts and demonstrated that single-stage implant breast reconstruction was the best strategy with proper patient selection [15] (Fig. 1).

Despite some promising results with single-stage DTI breast reconstruction, current statistics from the ASPS demonstrate that two-stage expander-implant breast reconstruction is the most frequent used modality in the setting of prosthetic breast reconstruction [4]. In 2018 Cordeiro and McCarthy reported a large series of TE reconstructions delineating the overall low risk of early

complications in 1221 patients with a rate of 5.8% and loss rate of 2.8% [16].

Both reconstructions may be a successful strategy when used in appropriately selected patients. Studies have demonstrated delayed two-stage reconstruction is safer than DTI in high-risk patients including those that use tobacco products, have poorly controlled diabetes mellitus, have had prior breast irradiation, have very thin mastectomy skin flaps, or who are morbidly obese. Despite the added costs, intraoperative tissue angiography can be a useful adjunct for assessing mastectomy flap viability and aiding in intraoperative decision-making in DTI.

We strongly believe that the ideal patients for single-stage immediate implant reconstruction are those with small or moderate breasts and who aim to have the same or less volume. We suggest two-stage reconstruction in those patients who desire more volume in small or moderate sized breasts, require skin-reducing Wise-pattern mastectomy, or who have resections that alter the anatomy of the breast, like traditional mastectomies or skin-sparing mastectomies (Figs. 2 and 3).

Evolution of Soft Tissue Support: Total Muscle, Dual Plane or Prepectoral?

The subpectoral technique provides well-vascularized muscle coverage of a tissue expander or implant, decreasing the high complication rate that plagued the initial prepectoral or subcutaneous reconstruction era where breast implants were plagued with high implant rippling, capsular contracture, implant exposure, and mastectomy skin flap necrosis [8–10]. In the total muscle coverage technique, the pectoralis major muscle covers the majority of the device, and the serratus anterior muscle or fascia covers the lateral aspect. It provides a well-vascularized pocket for the device, which is protective in cases

Fig. 1 A 47-year-old patient with right breast cancer who was also found to have a deleterious genetic mutation who wanted to preserve her natural volume and shape (above). She underwent bilateral nipple-sparing mastectomy with one-stage direct-to-implant reconstruction using 475 cc medium height, moderate plus projection, shaped implants through an inframammary fold incision (*below*). She had no fat grafting and no ADM was used

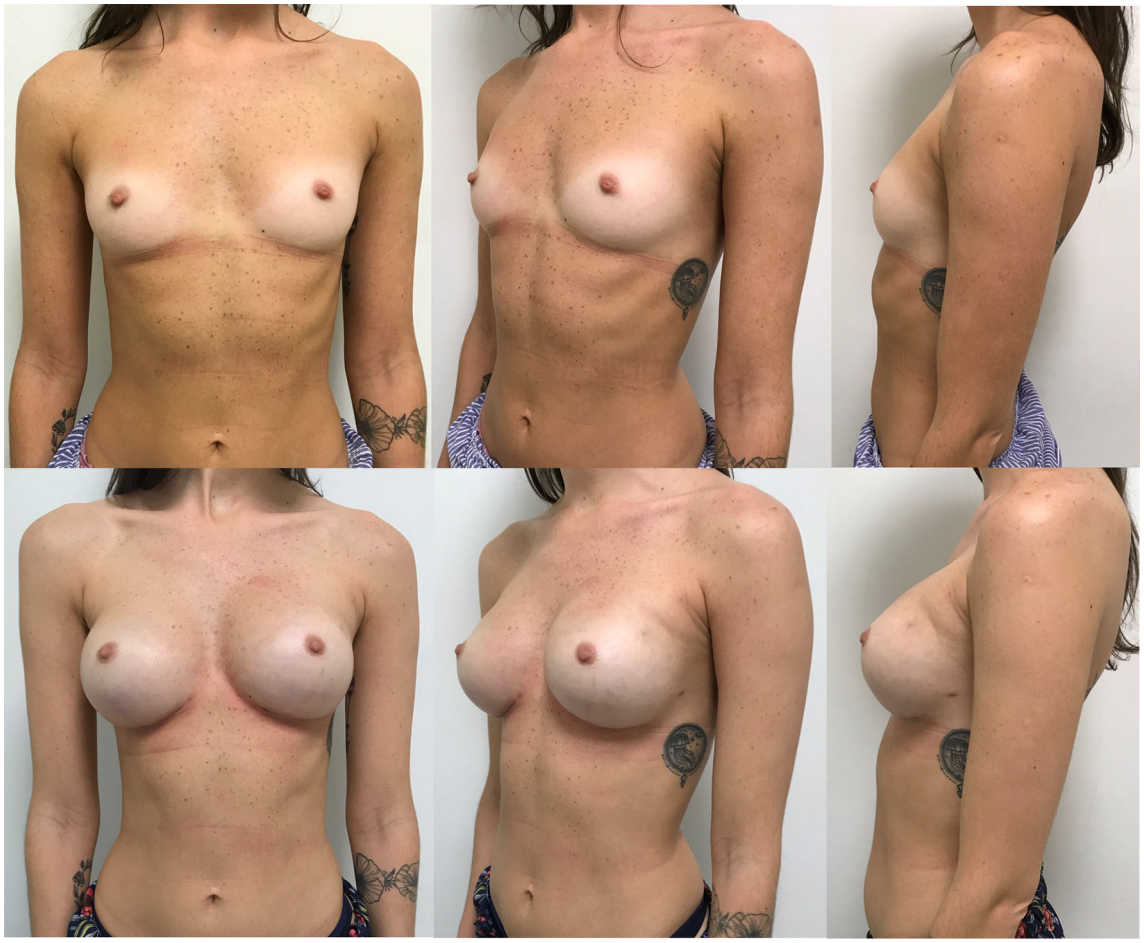

Fig. 2 A 29-year-old woman who was anticipated to undergo bilateral nipple-sparing mastectomies and was also interested enhancement in size of her breasts (above). She underwent bilateral nipple-sparing mastectomy using an inframammary fold incision and prepectoral 300 cc, medium height, variable projecting expanders without supplemental coverage using ADM. She had exchange to medium height, high projection 345 cc shaped implants and 60 cc of fat transfer to bilateral upper poles of the reconstruction (below)

of mastectomy flap necrosis or wound breakdown [17, 18] (Fig. 4).

In the search of means to improve the results, the dual plane was described, releasing the inferior and lateral edge of the pectoralis major. To provide coverage of the device and maintain the position of the muscle, most reconstructive surgeons have adopted the use acellular dermal matrix (ADM) or other biologic meshes to provide an inferior sling to cover the inferior pole. Proponents of the ADM believe its use allows for more initial fill reducing the number of expansions, better definition of the IMF, improved positioning of the device, and reduced capsular contracture rates, but others are not friends of these scaffolds and prefer to fix the edge of the muscle to the flap of the mastectomy. In some circumstances, ADM is simply not available or is prohibitively expensive.

Surgeons who criticize partial or total muscle coverage techniques believe using the pectoralis major has significant drawbacks including animation deformity, pectoral muscle disruption, and pain due to chest wall irritation, and muscle spasm. Another limitation of partial or total pectoral muscle coverage is that optimal placement of the device is limited by the medial origin of the pectoralis major muscle along the sternal border [19].

As the quality of mastectomy skin flaps began to improve, which is likely multi-factorial with increased experience and comfort in performing nipple-sparing mastectomies as well as the emergence of indocyanine green (ICG) angiography to evaluate tissue perfusion and, consequently, skin and nipple viability, we have witnessed a rebirth of prepectoral subcutaneous implants. However, with the resurgence of the prepectoral placement of tissue expanders and implants, the need for ADM has also grown exponentially. In the authors' opinion, the ideal candidates for prepectoral reconstruction include patients with a body mass index less than 35 kg/m^2, patients with mild to moderate breast volume, nonsmokers, patients with minimal ptosis, patients having prophylactic mastectomy, and

Fig. 3 A 43-year-old patient with a right breast cancer who presents with significant breast ptosis but was interested in maintaining her current breast volume. (above) A skin-reducing, Wise-pattern mastectomy was performed and immediate reconstruction using a two-stage expander-implant approach was performed. The 350 medium height expander was placed in a dual plane with a lower dermal flap and a bilateral free nipple grafts. She underwent exchange to medium height, high projection 390 cc shaped implants with 40 cc of fat transfer to the upper pole of each breast (below)

patients with central breast tumors [19–22]. The decision whether it is best to perform single- or two-stage reconstruction using prepectoral placement depends on the perfusion and thickness of the mastectomy skin flaps [23, 24]. Rancati et al. reported on the use of digital mammography to evaluate soft tissue coverage and the benefit decision-making for Argentine patients undergoing implant-based breast reconstruction [25].

In prepectoral reconstructions implants may be supported by soft tissue alone or with a scaffold. Different approaches have been described using ADM for anterior coverage alone or as a wrap. Despite its widespread use, the US Federal Drug Administration considers the use of ADM in breast reconstruction off-label use of the material. The complication rates of the subpectoral and prepectoral techniques are similar, but the early results with prepectoral placement are promising [26–28]. The prepectoral technique has been increasing in popularity as it not only avoids distorting animation, but also may decrease surgeon operative time. However, there are also significant disadvantages such as superior pole implant visibility, that may require fat grafting, rippling and the high costs of the material. With this technique, the implant tends to lie lower on the chest wall when compared with subpectoral implants, and therefore mimics a more ptotic breast which may be more symmetric to the contralateral breast [14]. In 2020 Safran et al. presented the largest single-surgeon, DTI prepectoral cohort in the literature and showed that surgical complications did not differ in terms of acellular dermal matrix use, incision selection, and use of postmastectomy radiation therapy and that strict patient exclusion criteria may not be required. There may an

Fig. 4 A 52-year-old patient with a left breast cancer who underwent a skin-sparing mastectomy and placement of a tissue expander in a dual plane with muscle coverage of the upper pole only without ADM. During the second operation, the patient underwent exchange for an anatomic shaped implant with a contralateral augmentation for symmetry. The patient subsequently underwent nipple areolar reconstruction and tattooing

associations between major complications and acellular dermal matrix use, and between minor complications and postmastectomy radiation therapy [29].

Acellular Dermal Matrix and Scaffolds

The most popular and one of the fastest growing industries is the use of biologic meshes or acellular dermal matrices (ADM) which are essentially skin products harvested from humans as allografts or animal xenografts [30, 31]. The concept of these products is to provide support and total coverage of the expander or implant to minimize any pressure on the mastectomy skin flaps that can precipitate skin necrosis. Other benefits to the use of these products were previously noted. Multiple studies have examined outcomes in implant-based reconstructions using total submuscular coverage versus use of scaffolds. Acellular dermis has been an increasingly popular adjunct to traditional expander reconstruction with benefits including improved inframammary control, decreased incidence of migration, greater intraoperative fill, improved cosmetic and amelioration of contracture. In 2011 Kim et al. presented a meta-analysis demonstrating that human ADM seems to be associated with a higher complication profile than submuscular reconstruction [32]. However, a more recent meta-analysis demonstrated the increased complications associated with ADM may have been overstated, and the risks are outweighed by the benefits [33]. In 2020, Manrique implemented both patient-reported outcomes (BREAST-Q) and professional evaluation by blinded plastic surgeons (Aesthetic Item Scale), and concluded that acellular dermal matrix is not always required during two-stage prepectoral implant-based breast reconstruction for good aesthetic results [34•].

However, the use of ADM is not without potential disadvantages. A number of studies have examined the utility of these products, but most are limited due to industry bias and conflicts of interest or are derived from large databases which do not account for surgeon technique and experience [35]. Nonetheless, studies have demonstrated an increase in infection and seroma rates with the use of these products [36, 37]. Aside from these complications which can have serious consequences for the patient and final cosmetic result, these products tend to be very expensive, sometimes prohibitively so for many patients.

Differences in outcomes reported in these large-scale studies may be influenced by the lack of well-controlled studies. Other scaffolds more nascent in the field, such as polyglactin 910 mesh, appear to be potentially safe, effective, and less expensive alternative to ADMs, but evidence is limited and prospective studies are needed to further define its efficacy [38]. When used judiciously, scaffolds play an important role in alloplastic breast reconstruction, specifically in cases of insufficient muscle coverage or in settings where the implant pocket must be enlarged to match a larger overlying skin envelope, such as single-stage reconstruction or nipple-sparing mastectomy and prepectoral reconstruction [39•].

For many centers around the world, access to these products presents considerable obstacles and significant costs that preclude their use in many health systems. We believe that managing the patient's anatomy can achieve similar results to those obtained using an ADM or other scaffold. In our experience, we do not believe the advantages supersede the costs and risks in two-stage expander reconstruction since the fixation of the expanders and the

formation of a capsule provides adequate support and control of the pocket as well creating a plane for in the future to perform fat grafting. We believe the greatest benefit of these products are in mastectomies with skin redundancy and prepectoral implant reconstructions, where the implant can worsen the pre-existing breast ptosis. Under these circumstances, we believe the ADM or scaffold functions to provide an internal support for the breast, but the benefit in reducing capsular contracture rates remains to be defined in future studies.

Evolution of Tissue Expanders

There have been tremendous advances in the engineering tissue expanders over the years. Advances in tissue expander design have included the texture of the devices to improve the quality of the capsule and the development of fixation tabs to prevent malposition of the expander. An integrated valve has eliminated malfunctioning of the remote valve, and an enlarged buffer zone to prevent inadvertent puncture of the expander during inflation. Further, newer devices have been engineered to focus on lower pole, maximizing projection and expansion for a more natural shape.

Shortcomings of traditional tissue expansion devices include the need for frequent office visits, inherent risk of infection with percutaneous needle introduction for device filling, and a lack of patient autonomy. Various devices, such as osmotic tissue expanders and patient-controlled externalized tissue expanders, have been designed with an aim of circumventing these issues. However, each has distinct disadvantages, including lack of control over expansion forces and infection, respectively. More recently, patient-controlled remote carbon dioxide tissue expanders, specifically designed for use in breast reconstruction, have been introduced. The advantages of patient and physician convenience for this device are offset by disadvantages of device bulk, permeation, and cost. Despite the initial appeal with the concept, these expanders have not been universally adopted.

With increasing concerns of breast implant-associated anaplastic large cell lymphoma (BIA-ALCL) and its association with textured devices, predominantly breast implants, new smooth-walled tabbed expanders have resurfaced hoping the new generation of smooth expanders do not have the quality problems of capsular contracture and malposition previously found with earlier designs.

Types of Implants

Breast implants can be divided into smooth round, textured round, and anatomical ones which are textured, but can also be classified based on the fill: saline, silicone, or cohesive gel. Multiple studies have examined comparative outcomes and demonstrated concerns regarding bottoming out, superior pole contour deformities, rippling, and/or lateral malposition with smooth round implants [40, 41]. However, numerous design modifications have subsequently been made to round devices to minimize these issues. The first modification includes an increased fill ratio using the same gel, to help minimize rippling. The second modification is a more cohesive silicone gel implant that also resists rippling and limits difficulties with implant rupture and gel bleed. However, these implants can flip in the anterior/posterior position which creates an obvious contour deformity with loss of projection.

Cohesive shaped anatomical implants offer a stiffer gel to help minimize rippling, but patients may feel the gel is too firm to mimic a natural breast. Newer gel formulations retain the benefits of cohesive gels but have a softer more natural feel. Shaped implants have a more natural result, particularly in the prepectoral position compared to round implants and may have an advantage with postmastectomy radiation therapy. Other disadvantages for some patients include a risk of rotation and lack of upper pole projection. The main disadvantage includes the risk of BIA-ALCL, which is a rare low-grade lymphoma associated exclusively with textured implants [42]. Although uncommon, the risk of BIA-ALCL has led many surgeons around the world to offer only the smooth round implants. However, comparison of patents with round or shaped implants reported equivalent 2-year patient-reported satisfaction rates [28].

The decision for which implants to use should be based on each patient's anatomy, expectations on achieving the most optimal aesthetic and durable results. Advancements in breast implant technology aim to maximize more natural feeling implants, to minimize complications like contracture rates, and certainly to avoid causing BI-ALCL or any other type of disease.

IBR and Radiotherapy: A Plausible Combination?

Radiation therapy is crucial in the treatment of breast cancer, but it causes significant short and long-term sequelae to the surrounding tissue, which progressively leads to dermal thickening and chest muscle fibrosis and atrophy that lead to significant challenges for the reconstructive surgeon [43]. Radiation in breast cancer patients can occur in two different settings. Some patients have had

radiation prior to their mastectomy because of treatment following breast conservation. Others who have more aggressive or advanced disease will receive postmastectomy radiotherapy (PMRT). While radiation has been administered in both circumstances, radiation is not equivalent between these two groups of patients. Further, it is important to remember that radiation protocols vary greatly from one institution to another. The protocols often differ in terms of timing and radiation dose, which can make comparison difficult as radiation has dose-dependent effects.

Premastectomy Radiotherapy

Patients presenting for reconstruction who have received prior radiation therapy come from two scenarios: (1) patients requiring salvage mastectomy after conservative surgery, (2) true delayed reconstruction after mastectomy and PMRT [44]. While the radiation differs between the two groups, previous radiation introduces significant risks for implant reconstructive failure and higher complication rates leading many to pursue autologous reconstruction in this scenario which is also the authors' recommendations. However, studies have demonstrated acceptable risks employing an implant-based reconstruction in patients with prior radiation.

Postmastectomy Radiotherapy

When postoperative radiation therapy is indicated, the debate arises over the timing of reconstruction, particularly whether to irradiate the expander or the implant. Many studies have shown that PMRT to be a relative contraindication to IBR due to associated higher complication rates such as capsular contracture and complete reconstructive failure [45, 46, 47••]. In a review by Nava et al., delayed autologous tissue breast reconstruction had superior outcomes compared to immediate autologous tissue-based or implant-based reconstructions when PMRT was required [48]. Lam et al. reported a 12-year study which included 671 patients and concluded that two-stage delayed prosthetic breast reconstruction had a low failure rate comparable with the immediate option [49]. Cordeiro et al. found higher rates of complications when radiating the expander compared to radiating an implant; however, patients with a radiated implant suffered a lower aesthetic result and higher rates of capsular contracture [50].

Meta-analyses and recent prospective studies suggest no significant difference in the timing of radiation [47••, 51]. A current multicenter prospective study from 11 centers suggests that radiation timing (before or after exchange) had no significant effect on complication risks or on most patient-reported outcomes in immediate expander/implant reconstruction. While patients who underwent radiation after exchange of their expanders to permanent implants reported lower levels of anxiety, depression, and fatigue, these differences were not clinically significant [52].

Certain radiotherapy centers prefer to irradiate the tissue expander rather than the implant and suggest deflating the expander to irradiate the internal mammary lymphatics and thus reduce mediastinal morbidity. Some studies have demonstrated a benefit in disease-free survival without benefits in overall survival, but future studies are needed as the indications for postmastectomy radiation therapy are expanding. In our experience, we prefer to irradiate the expander and, 3 or 4 months later perform two lipofilling sessions every 3 months and then replace the expander with the implant. We consider that the irradiated tissue is repaired with lipofilling, improving aesthetic results and reducing capsular contracture.

Currently, a multidisciplinary approach between reconstructive surgeons and radiation oncologists have resulted in targeted radiation regimens with the aim of minimizing complications in prosthesis-based breast reconstruction [46]. The increasing popularity with fat grafting has also revolutionized implant reconstruction and changed the paradigm in breast reconstruction. While there is extensive ongoing research, to date there is a paucity of high quality evidence in regarding use of implants in PMRT, and the authors still advocate autologous tissue as our preferred option in reconstruction following radiation [47]. Thus, the timing of PMRT relative to expander/implant exchange should be based on oncologic, not reconstructive, considerations.

Implants and Fat Grafting

Fat grafting for breast reconstruction can be divided into small volume, large volume and mega volume procedures [53]. Small volume (< 100 cc) is often used for correction of contour irregularities. Kanchwala et al. classified these deformities into 3 groups: step-off deformities, intrinsic defects, and extrinsic defects. Step-off deformities are generally caused by an over-aggressive superior pole mastectomy excision particularly in thinner patients, an inadequate amount reconstructive tissue in the upper pole, or a combination of both. The selection of implants can also impact step-off deformities and is less often seen in anatomic implants. Intrinsic defects are caused by fat necrosis in autologous flap reconstructions or rippling following implant-based reconstruction, and extrinsic defects are caused by radiation, extensive scarring or post-lumpectomy defects [54].

Aside from its biocompatible filler properties, fat grafting has been shown to have tissue reparative properties. The beneficial effects of transferred fat on irradiated tissues have been demonstrated in various clinical contexts, and the observed benefits are attributed to adipose-derived mesenchymal stem cells that interrupt the radiation-induced cycle of fibrosis and facilitating development of a microvascular bed created by an adequate ratio of adipocytes to capillaries [55–58].

Large volume, 100 to 300 cc, requires a more careful technique, especially harvesting, purification, and placement of the fat are all critical in providing successful outcomes. Small to large volume has been used to increase operative success on both retromuscular and prepectoral reconstructions, with the aim of improving the upper pole of the breast, camouflaging the upper edge of the implants and reducing the intermammary distance. The majority of mega volume (greater than 300 cc/breast) fat transfer breast reconstruction is still performed in combination with implants or flaps. Composite breast reconstruction utilizing tissue expanders and implants, in combination with large or mega volume fat grafting, is becoming the gold standard treatment for mastectomy reconstruction.

Total breast reconstruction using total autologous fat is still uncommon but has been reported [59]. In 2012, Del Vecchio [60] introduced the concept of simultaneous implant exchange with fat (SIEF) for management of implant complications. Multiple publications already demonstrated the benefit of this approach allowing reconstructive plastic surgeons to reconstruct the breast with various sessions of fat grafting and offers patients an excellent alternative to an implant or for patients who are not candidates for reconstruction with a flap.

As with any surgical procedure, there are potential complications with fat grafting which vary greatly in the literature and range from 8-12% [59, 61, 62], the most common of which are fat necrosis and cyst formation, mostly related to overfilling, which should be avoided. The great majority of cases can be solved in the office without the need of surgery under general anesthesia. Larger areas of fat necrosis can be removed with liposuction or needle band release, then later re-grafted to correct any defects [53]. In 2019, Nava et al. conducted a panel of experts that concluded that higher quality studies are necessary to support procedural standardization and to definitively confirm the oncological safety of fat grafting following breast cancer surgery in particular in patients with a deleterious BRCA-mutation [63•].

Key Points to Improve Results in Delayed Breast Reconstruction

Unfortunately, there are a large number of patients who have had a mastectomy who do not have access to a reconstructive surgeon or are focused on the oncologic treatment and have lost the opportunity for immediate reconstruction. In these patients where the mastectomy, lack of reconstruction, and potentially radiation alter the anatomy, reconstruction becomes even more challenging, having to recreate the lower pole, soft tissue envelope, and inframammary fold. (Fig. 5)

In the authors' humble opinion, some potential points to consider in implant-based reconstruction may aid in achieving superior results and limiting complications. While the concepts and approaches do demonstrate a need for more research, the data and evidence presented does provide support for our algorithm in prosthesis-based breast reconstruction.

1. Improve soft tissue coverage, if necessary, with fat grafting, particularly in irradiated patients which will improve the tissue quality. During the expander exchange for the permanent implant, perform capsulotomies in several directions to allow greater laxity and expansion of the tissue.
2. Placement of the expander should be determined according to the quality of the skin and soft tissue. If the pocket and the inframammary fold remain following the mastectomy, the expander can be placed very simply into the pocket, but if the anatomy is distorted following the resection, we often place the expander in a lower position, and thus tissue from the abdomen is recruited to later recreate the lower pole. Regarding the plane, if the patient was previously irradiated, we prefer to place the expander in a prepectoral position after the mastectomy to avoid the risk of muscle contracture, but again caution should be used when using a device in the setting of prior radiation.
3. Replace the expander with the definitive prosthesis after a minimum 6 months in patients with prior radiation, and during this procedure, we are very aggressive with the capsule to achieve relaxation of the cavity, so we recommend not to over-expand the expander. Following release of the capsule, a larger implant can be placed without difficulty that is little larger than the expanded volume.
4. Internal recreation of the inframammary fold using permanent sutures from the dermis of the skin flap to the posterior capsule.

Fig. 5 All of these patients had total mastectomies performed without reconstruction (above). Delayed reconstructions were performed in all cases using a staged approach. During the first stage, patients were treated with autologous fat grafting, followed by placement of a tissue expander below the native inframammary fold to recruit the abdominal soft tissue. Following expansion, in the second stage, the expanded upper abdominal tissue was used to reconstruct the lower pole, recreating the inframammary fold, with multiple capsulotomies and additional lipofilling to reconstruct an entire breast. In all patients except the first case on the left, a contralateral implant was also placed (below)

Enhanced Recovery After Surgery: It Is Possible in IBR?

Emerging evidence suggests that one effective strategy for reducing postoperative complications may be the adoption of an enhanced recovery after surgery (ERAS) program. ERAS is a collective, standardized, evidence-based preoperative, intraoperative, and postoperative multidisciplinary protocol involving the collaboration of several specialties and focuses on engaging patients and their families in their care and ensuring that uniform bundled care is delivered with the primary goal of reducing the length of hospital stay [64, 65, 66••]. For women undergoing implant-based breast reconstruction, recent studies have demonstrated benefits including reduced length of stay and better quality of recovery, with no differences in complication rates or emergency room visits [67].

An important goal on ERAS protocol is to reduce the contribution of opioids to the postoperative analgesic regimen, to reduce side effects of nausea, vomiting and constipation, effectively increasing mobilization of patients following surgery. Early mobilization improves muscle strength and reduces pulmonary embolism, pneumonia, and decubitus ulcers. Moreover, it is important to limit postoperative ileus allowing early initiation of oral or enteral diet within 24 hours of surgery, associated with improved wound healing, reduced infection, and reduced hospital stay [67]. Furthermore, home support and early psychotherapy help to improve physical and emotional recovery after mastectomy and axillary dissection. Postoperative physical rehabilitation programs in breast cancer patients improve mobility, reduce pain, and improve quality of life [68, 69].

As plastic surgeons, we were also able to transfer our experience in cosmetic breast surgery into reconstructive surgery. Following the guidelines defined by Tebbets [70, 71], we began to apply them also in reconstructive surgery using ERAS protocols. It is the surgeon's responsibility to adapt to the changes in the management of patients and motivate them to mobilize earlier, reducing the pain and restrictions, while limiting complications following breast reconstruction. The knowledge and experience gained from one patient can then be translated into the management of future patients and starts with the initial preoperative consultation where educating patients will decrease patient anxiety which in turn transforms the vicious cycle of fear of surgery and the postoperative

recovery to a virtuous cycle that enhances the patient's experience and proactively engages them in the recovery process.

Conclusions

Implant-based techniques are the most common methods of breast reconstruction worldwide for both immediate and delayed reconstruction. Advancements in implant technology and supplement techniques should be discussed thoroughly with patients as well as technical aspects including device selection, timing, and need for revision surgery to meet patients' objectives and expectations. As plastic surgeons, we must be technically prepared to face an increase in bilateral mastectomies in light of genetic studies, advancement and sophistication of oncoplastic techniques, evolution of implants, and the improved educational access for patients.

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Compliance with Ethical Guidelines

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

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