Review Article

The bioengineered prosthetic breast reconstruction: advancements, evidence, and outcomes

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Abstract: Recent advancements in prosthetic breast reconstruction have provided the foundation for the bioengineered breast. These advancements include improved mastectomy techniques, autologous fat grafting, acellular dermal matrices (ADMs), and improved devices. Device-based breast reconstruction has evolved from subcutaneous, partial or total subpectoral, and now to prepectoral placement of devices. The evidence demonstrating the safety and efficacy of the bioengineered breast continues to increase. This manuscript will review the fundamental components of the bioengineered breast and provide an update of the current evidence.

Keywords: Breast reconstruction; prepectoral; dual plane; acellular dermal matrix (ADM); tissue expander; breast implant; autologous fat graft; nipple sparing mastectomy (NSM)

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Introduction

2017 statistics complied by the American Society of Plastic Surgeons have demonstrated that of the 106,295 breast reconstructions performed, 86,979 (81.2%) were performed with prosthetic devices (1). The reasons for this include patient preference, improved mastectomy and reconstructive techniques, and improved outcomes (2). This paradigm shift is multifactorial and related to lifestyle choices, less invasive operations, a more rapid recovery, the ability to deliver excellent aesthetic outcomes.

It can be stated that reconstructive breast surgery is now an aesthetic operation. Patients and surgeons no longer find it acceptable to reconstruct just a breast mound. Current expectations are to reconstruct a breast that is naturally contoured and positioned and that provides optimal symmetry. Factors that have contributed to this paradigm shift include the use of acellular dermal matrix (ADM), nipple sparing mastectomy (NSM), fat grafting, better breast implants, and prepectoral reconstruction. This manuscript will review these factors in greater detail and discuss the evidence supporting these innovations.

NSM

Over the past decade, the rate of NSM for therapeutic indications has increased. In a recent review of 114,819 patients from the National Cancer Data Base, the incidence of NSM had increased from 2.9% to 8% between 2010 and 2013 (3). Traditional indications for NSM included tumors that were greater than 3 cm from the nipple areolar complex (NAC), less than 5 cm in size, and no angiolymphatic invasion (4,5). Current strategies have evolved such that margin status around the tumor is the primary determinant rather than distance from the NAC or tumor dimensions. Systematic reviews focused on NSM have demonstrated that complications occur in 11.2–22.3%, necrosis of the NAC occurs in 2.9–7%, and that local regional recurrence occurs in 1.8–2.3% of patients (5-7) (*Table 1*).

The oncologic aspects of NSM continue to be discussed and studied. In a recent systematic review of 29 studies, several observations with statistical significance were made (5). With regard to tumor size, the overall incidence of NAC involvement was 9.8% when the tumor was <2 cm, 13.3% for tumors ranging from 2–5 cm, and 31.8% for tumors

Table 1 Three systematic reviews are highlighted and focused on nipple sparing mastectomy (5-7)

Author	Year	No. of studies	Patients	Complication (%)	Necrosis (%)	Recurrence (%)	FU (mo)
Endara	2013	48	6,615	22	7	1.80	2–210
Mallon	2013	29	10,249	11.23	Full: 2.9; partial: 6.3	NAC: 0.9; skin: 4.2	Mean: 38.4
Headon	2016	73	12,385	22.30	5.90	2.38	Mean: 38

FU, follow-up; NAC, nipple areolar complex.

>5 cm (P<0.05). With regard to tumor location, the incidence of NAC involvement was 35.2% for central or retroareolar tumors and 9.7% for peripheral tumors (P<0.05). Multicentric tumors involved the NAC in 29.6% of cases, whereas solitary tumors had a 12.4% involvement (P<0.05). The incidence of NAC involvement in patients with a positive lymph node was 24.4%, whereas it was 10% in patients without lymph node involvement (P<0.05). Lymphovascular invasion resulted in NAC involvement in 35.6% of patients whereas it was only 12.4% without lymphovascular invasion (P<0.05). With regard to tumor type, the incidence of nipple involvement was 14.9% for invasive ductal carcinoma, 15.3% for ductal carcinoma in situ (DCIS), 17.2% for invasive lobular carcinoma, and 17.2% for invasive ductal carcinoma.

The technical aspects of NSM continue to evolve as breast and plastic surgeons strive to improve aesthetic outcomes while prioritizing oncologic safety (7,8). Perhaps the most important determinant of a good outcome following prosthetic breast reconstruction is the presence of well-perfused mastectomy skin flaps. When these flaps are too thin or widely undermined vascularity is usually compromised and the likelihood of skin necrosis, reconstructive failure and a poor outcome is increased (9). It is important for breast surgeons and plastic surgeons to communicate and ensure the delivery of an optimized mastectomy skin flap with the goal to preserve the subcutaneous layer and vascularity without compromising oncologic integrity.

The incisions for NSM include radial, lateral, periareolar and inframammary (7). The choice of incision is based on several factors including degree of ptosis, type of reconstruction, breast volume, as well as patient and surgeon preference (*Figure 1*). In a systematic review, rates of partial or total NAC necrosis were evaluated and demonstrated a necrosis rate of 8.83% for radial, 17.8% for periareolar and 9.09% for inframammary incisions (7). Transareolar incisions demonstrated the highest rate of delayed healing at 81.8% (6). Incisional approach had no effect on local regional recurrence rates.

In women with moderate mammary hypertrophy or with breast ptosis that desire NSM, various approaches have been described. Spear has described a staged approach whereby a reduction mammaplasty or mastopexy is performed as a first stage followed by a second stage NSM (10). In a woman with breast cancer, the first stage is essentially an oncoplastic operation whereby a partial mastectomy is performed followed by reduction or mastopexy. The timing for the second stage depends upon whether the procedure was for oncologic or prophylactic indications. If oncologic, it is recommended that the NSM be performed approximately 1 month later to avoid delays in treatment. If prophylactic, the NSM should occur 3 months or later. An alternative approach to reduction mammaplasty is the nipple delay procedure. This involves creating a vertical incision below the NAC followed by undermining of the NAC with disruption of the pectoral/intercostal perforators (11,12). This enables the peripheral vascularity to become the dominant blood supply to the NAC. The NSM is usually performed 2–3 weeks later.

ADM

The use of ADM is arguably one of the main advancements contributing to the rise in prosthetic breast reconstruction. Benefits include soft tissue support, elasticity, less scar, and device compartmentalization (13). Its ability to incorporate into the adjacent soft tissue by fibroblast infiltration and revascularization is the foundation for its success (*Figure 2*). Tissue incorporation is facilitated using human skin donors, creating fenestrations or perforations in the ADM that serve as zones of adherence, and achieving a hand-in-glove fit into the mastectomy space. ADM can be used for direct-to implant as well as 2-stage reconstruction. It can be used for prepectoral as well as partial subpectoral placement of devices. The role of ADM following partial subpectoral device placement is to stabilize the position of the pectoralis major muscle (*Figure 3*). Failure to do often results in

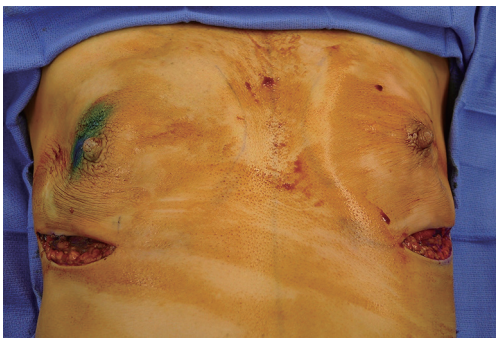

Figure 1 Nipple sparing mastectomy via the inframammary approach.

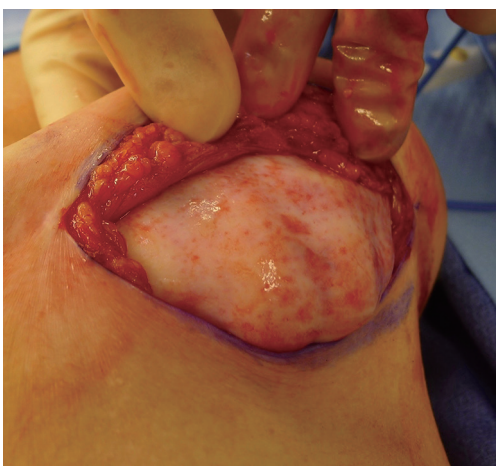

Figure 2 Intraoperative image demonstrating vascularized ADM. ADM, acellular dermal matrix.

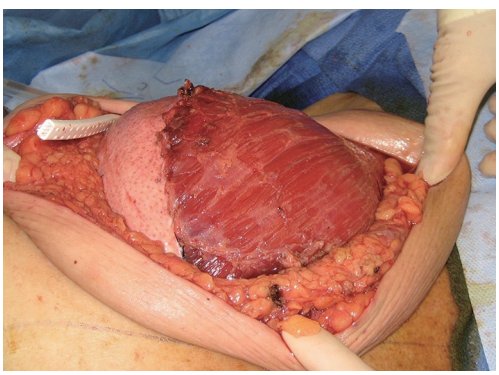

Figure 3 Dual plane reconstruction with the prosthetic device covered superiorly by the pectoralis major muscle and inferiorly with ADM. ADM, acellular dermal matrix.

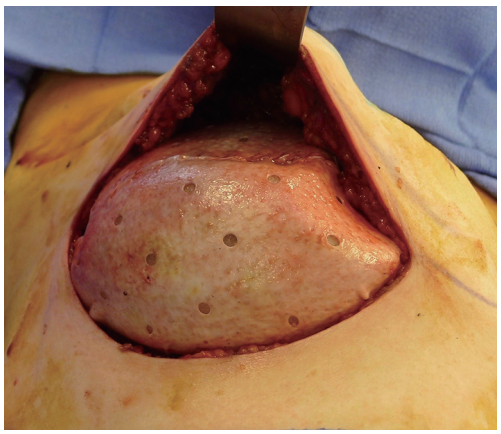

Figure 4 Prepectoral reconstruction with the device above the pectoralis major muscle and covered with ADM. ADM, acellular dermal matrix.

window-shading that is characterized by visibility of the inferior edge of the muscle during contraction. The role of ADM following prepectoral device placement is to provide tissue support and to compartmentalize the device on the chest wall (*Figure 4*). In both cases, ADM has the potential to minimize adverse inflammation and reduce the incidence of capsular contracture (14).

Perhaps one of the greatest benefits of ADM use is its ability to minimize scar formation around the implant thereby reducing the incidence of capsular contracture (14-19). Evidence for this comes from a variety of experimental and clinical studies focused on ADM performance (*Table 2*). Experimental studies in rabbits and primates comparing rates of capsule formation device implantation with and without ADM have demonstrated a lack of capsule formation in the ADM cohorts in contrast to thick capsule formation in the setting of no ADM (20,21). Histology of ADM following clinical use has demonstrated mild inflammation, collagen production, granulation and vascular proliferation (22). Native capsule on the other hand demonstrates abundant granulation, mild vascular proliferation, a moderate increase in collagen and inflammatory infiltrates (20). In another clinical study comparing outcomes in patients following prosthetic reconstruction with and without ADM, the incidence of capsular contracture was 3.80% in the setting of ADM and 19.40% without ADM (23) (*Table 3*). The association between inflammation and fibrosis in the setting of

Table 2 Capsular contracture rates from five studies (15-19)

Surgeon	Year	Patients	Breasts	Mean follow-up (months)	Capsular contracture (%)
Salzberg	2006	49	76	18	0
Breuing	2007	43	67	15.9	0
Zienowicz	2007	24	30	18	0
Spear	2008	43	58	18.1	2
Namnoum	2009	20	29	21	0

Table 3 Comparative data demonstrating a lower incidence of adverse events and higher aesthetic outcome using ADM (23)

Factor analyzed	Acellular dermis (+)	Acellular dermis (–)	P
Number of patients	208	129	
Complications	29.30%	40.30%	0.038
Capsular contracture	3.80%	19.40%	<0.001
Inframammary fold issues	8.20%	19.40%	0.002
Device displacement	1.90%	9.30%	0.002
Aesthetic score	3.26	2.87	<0.05

+, present; –, absent. ADM, acellular dermal matrix.

prosthetic devices is well known. Women with silicone gel implants that have capsular contracture are characterized with capsules with vascular proliferation as well as lymphocytic and mononuclear infiltrates (24).

The performance of ADM in the setting of radiation therapy has also been a topic of discussion. ADM has been demonstrated to revascularize and incorporate into the adjacent soft tissues in the setting of both pre and postoperative radiation, albeit at a slower rate (25). Experimental studies have demonstrated that capsules surrounding implants without ADM in the setting of radiation to be associated with prominent inflammatory infiltrates and pseudo-epithelial cells leading to prominent capsules whereas implants with ADM tend to have less cellular invasion and delayed or diminished pseudo-epithelial formation (26). ADM histology with and without radiation demonstrated no change in the relative proportion of cellularity, collagen content, elastin content, alpha smooth muscle actin and macrophage levels (27).

Clinical studies have demonstrated that infection rates following prosthetic reconstruction tend to be increased in the setting of radiation therapy but do not seem to vary based on the use of ADM (28). Studies have also examined the timing of radiation relative to prosthetic reconstruction with ADM. In most studies, complications are increased when radiation therapy precedes prosthetic reconstruction (28). The adverse effects of radiation therapy are unlikely to be altered by ADM (27). The effects of radiation are likely to be very similar when directed toward normal dermis or revascularized ADM.

Autologous fat grafting

The use of autologous fat grafting in the setting of prosthetic breast reconstruction has provided a valuable adjunct for plastic surgeons to correct contour and volume irregularities; however, it is not without controversy (29). Fat is metabolically active and consists of a diverse secretory cell population that includes cytokines, hormones, and growth factors (30-32). There are experimental studies suggesting that grafted fat may promote or accelerate cancer growth (33,34). In one such study, it was demonstrated that there was an increased potential for malignant transformation of progenitor cells in normal breast tissue in the presence of stromal vascular fraction (SVF) (33). In a similar study, it was found that human breast cancer cell viability increased from 45.5% to 95.5% in presence of adipose-derived mesenchymal stromal cells *in vitro* (34). Fortunately, clinical studies have not demonstrated malignant transformation or an increased in cancer recurrence in patients receiving autologous fat grafting (35,36). In one study, the biopsy rate after fat grafting was 7.4% without evidence of locoregional cancer recurrence (35). In another study, fat grafting after breast reconstruction did not adversely affect local tumor recurrence or survival on long-term follow-up (36). Although mammographic confusion following fat grafting is occasionally an issue, calcifications associated with fat grafting are characterized differently than calcifications associated with malignancy (37,38).

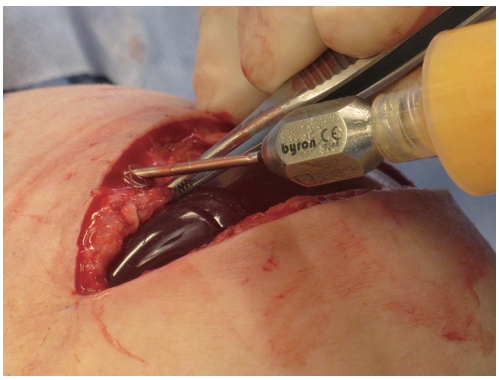

Figure 5 Fat grafting to the mastectomy skin flaps.

Table 4 Core data from the Allergan studies (47,48)

Factor analyzed	Anatomic		Round
	Reconstruction	Revision	Reconstruction
Number	225	68	98
Reoperation	54.60%	48.50%	71.50%
CC (grade 3, 4)	14.50%	26.80%	24.6
Malposition	5.70%	8%	2.30%
Infection	6.10%	8.50%	NR
Seroma	2.80%	6.20%	2.30%

CC, capsular contracture; NR, not reported.

In light of these issues the FDA has partnered with the American Society of Plastic Surgeons to maintain a proper use protocol that includes minimal manipulation of the harvested fat during the processing phase as well as injecting fat where fat normally resides. Minimal manipulation includes the avoiding strategies such as enzymatic processing of the fat to increase the stem cell population known as the SVF. Because of studies such as these, the FDA considers SVR a drug that does not fall into the category of tissue. Further studies evaluating the safety and efficacy of autologous fat grafting to the breast are in progress.

Based on the safety profile of grafted fat, this procedure is commonly offered to patients following mastectomy and reconstruction. Fat grafting is most commonly used for the correction of contour deformities, implant rippling, volume discrepancies and to improve the quality of radiated skin. The latter benefit is presumed related to the positive effect of stem cells in the lipoaspirate (39). Complications of autologous fat grafting include oil cysts formation, resorption, fat necrosis, microcalcifications, infection, nodularity, and contour abnormalities (30,40).

Techniques for fat aspiration, harvest, filtration, and transfer have varied amongst surgeons but all have demonstrated success in the majority of patients (*Figure 5*). The technique of fat grafting involves the aspiration of fat usually from the abdomen or thigh, removal of the excess fluids, oils and blood remnants, followed by fat injection in the desired area. In some patients, percutaneous aponeurectomy is necessary to disrupt the fibrous connections within the subcutaneous tissues, especially following radiation therapy (41). In some patients, especially those that have received prior radiation, several sessions of fat grafting may be required (39). Because the fat is transferred without a blood supply, revascularization is acquired from the recipient site resulting in retention; however, when revascularization is not achieved, resorption of fat will occur. Fat retention following lipofilling in the setting of mastectomy or reconstruction has been demonstrated to range from 40–60% and dependent upon previous radiation, prosthetic or autologous, and injection volume (42).

The concept of total breast reconstruction with fat grafting alone has been explored (43). External expansion system applied over the mastectomy site has been used to stretch the skin and improve the vascularity. The device is utilized for defined period of time to expand the space in which the fat will be injected and to improve the vascularity. The expansion and added vascularity creates an ideal environment for grafted fat to acquire vascularity and survive. This can be supplemented with an implant if needed.

Prosthetic devices

Prosthetic devices for breast reconstruction were first introduced in 1962 and have undergone significant modifications over the past 6 decades (44-46). Current devices can be filled with saline or silicone gel, have smooth or textured surfaces, and have a round or anatomic shape. The core studies have demonstrated that these devices are safe and effective with follow-up that ranges from 6–10 years (47-52). In all series, the reoperation rates tend to be higher than expected; however, reoperation does not imply device failure. In many cases, reoperation is performed electively and for aesthetic enhancement. *Tables 4-6* review the core study data from the three manufacturers of breast implants available in the USA.

Table 5 Core data from the Mentor studies (49-51)

Factor analyzed	Shaped implants		Round implants	
	Reconstruction	Revision	Reconstruction	Revision
Number	191	68	251	60
Reoperation	44.50%	45.40%	33.90%	36.20%
Capsular contracture	10.10%	16.40%	13.70%	25.20%
Malposition	5.10%	6.50%	1.70%	8.50%
Infection	1.60%	3.00%	6.10%	0.00%
Seroma	3.40%	4.60%	4.90%	1.70%

Table 6 Core data from the Sientra studies (52)

Factor analyzed	Primary reconstruction	Revision reconstruction
Patients/Implants	225/412	84/139
Round	87.60%	87.80%
Shaped	12.40%	12.30%
Reoperation	46.30%	56%
Malposition	5.30%	9%
Capsular contracture	12.80%	14.60%
Infection	5.10%	1.20%
Seroma	2.40%	1.20%

Prosthetic devices for reconstruction can be temporary, as in the case of tissue expanders, or permanent. Prosthetic breast reconstruction can be performed in 1 or 2 stages. Regardless of the stages, proper device selection is critical and optimized with biodimensional planning such that the device will closely match the footprint of the breast or mastectomy pocket. Two-stage reconstruction is performed using a tissue expander that is inserted into the post mastectomy space and filled with saline or air through an integrated port. Most tissues expanders are constant in terms of design and include a contoured shape, textured surface, suture tabs, and an integrated port. The suture tabs are to minimize the risk of device rotation of malposition (53). A recently introduced tissue expander that is remote-controlled, needle-free, and carbon dioxide-based that is now available and has been approved by the FDA (54). Tissue expanders are partially filled in the operating room and gradually filled over time to stretch the surrounding tissues with the goal of creating a natural breast mound. As with traditional expanders, these are removed and exchanged for a permanent implant following desired expansion.

There are a myriad of permanent implants available for prosthetic breast reconstruction. They vary in terms of size (100–800 cc), filler material (saline or silicone gel), surface (smooth or textured), and shape (round or anatomic). Current silicone gel devices are made with highly cohesive silicone gel that often results in less rippling and wrinkling. Shaped breast implants are able to maintain the natural contour profile of the device and result in a natural slope of the upper pole with less rippling and wrinkling. Current shaped implants have a textured surface that is presumed to provide better adherence to the surrounding soft tissue and to minimize implant rotation (55). There is clinical evidence demonstrating less capsular contracture with the use of textured surface devices (56). Shaped implants tend to increase projection along the lower pole of the breast and provide a gradual slope of the upper pole creating a natural breast shape. In general, shaped implants are useful when maximal control of the breast shape is necessary such as in patients with upper pole deficiency or a long torso (57). Round implants are available with smooth or textured surfaces and are sometimes preferred because they are softer than shaped devices and tend to move more like a natural breast.

When comparing silicone gel to saline implants, the majority of plastic surgeons and patients prefer silicone because they are soft and more closely resembles the natural breast. Some women however may not be comfortable with silicone gel breast implants based on reports from the early 1990s suggesting that they were associated with a myriad of problems such as chronic fatigue, connective tissue disorders, and altered immunity. Based on scientific evidence and numerous clinical studies, silicone gel breast implants have

been demonstrated to be safe and effective by the FDA as well as the Institute of Medicine and not associated with the development of any of these disorders (44).

Breast implant associated-anaplastic large cell lymphoma (BIA-ALCL) has recently emerged as a public concern and is associated with the use of textured surface breast implants. BIA-ALCL is extremely rare with a reported incidence that ranges from 1:1,000–30,000 patients (58-60). It typically manifests as a late swelling of the reconstructed breast do to a fluid collection or seroma with a predilection for textured surface devices. There is growing evidence that this may arise from a bacterial strain, Ralstonia, that tends to reside more commonly on the surface of macro-textured devices causing chronic inflammation and malignant transformation (59,60). The average time to onset is approximately 8 years. Diagnosis is via serology demonstrating anaplastic lymphoma kinase (ALK) negative and CD-30 positive. Treatment includes total capsulectomy and device removal.

Despite the safety and efficacy of breast implants, they do not last forever with an average life span of 10–15 years. Over time, device failure will become more likely due to rupture and/or capsular contracture that usually requires removal or replacement. It is recommended that women with silicone gel breast implants have MRI every 3–5 years to assess implant integrity and rule out silent rupture.

Prepectoral breast reconstruction

The innovations and advancements with prosthetic breast reconstruction are many and include the use of ADM, fat grafting, NSM, and better implants. These advancements have enabled surgeons to now place breast implants in the prepectoral space rather than under the pectoralis major muscle (61-64). Subcutaneous reconstruction was initially performed in the 1970's but abandoned because of the high complication rates that included skin necrosis (13.5%), device extrusion (6.7%), capsular contracture (56%), and explantation (28%) (65). Based on the initial failure of subcutaneous reconstruction, partial and total muscle coverage techniques became the standard. Despite the benefits of subpectoral device placement, shortcomings such as animation deformity with muscle contraction, pectoralis muscle spasm, and a generalized discomfort were common. The evolution to prepectoral placement was initiated with the abandonment of the Halstedian mastectomy principles that included aggressive mastectomy, thin flaps and wide undermining. Thus, the concept of the Bio-Engineered Breast has evolved as initially described by Dr. Maxwell based on these advancements that include nipple and skin sparing mastectomy, ADMs, autologous fat grafting, and improved prosthetic devices (61). The ability to place implants in the prepectoral space would not be possible if not for these innovations and advancements.

The benefits of pre-pectoral breast reconstruction are becoming well understood and can be explained based on anatomic and technical considerations (62-64). The pectoralis major muscle is no longer elevated or manipulated and as a consequence does not contribute to the pain, spasm and animation that was associated with partial subpectoral device placement. There is potential to reduce surgical and anesthesia time due to the simplicity of the technique. Most surgeons performing prepectoral reconstruction do so with the use of ADM to provide soft support. An addition benefit of ADM is to maintain low rates of capsular contracture. Capsular contracture rates using ADM tend to be less than capsular contracture rates without ADM (14,22). Long-term outcomes of prepectoral breast reconstruction are still lacking because the procedure is relatively new; however, outcomes with 2–3 years follow-up are encouraging (63,64,66,67). The principle limitation of prepectoral device placement is that adequate soft tissue support may be lacking in some cases; thus, proper patient selection is critical to minimize the risks of rippling, wrinkling and delayed healing. When adequate soft tissue support is lacking, delayed reconstruction is considered.

Prepectoral reconstruction in the setting of radiation therapy has become a major topic of discussion (68). When radiation therapy is delivered in the setting of a subpectoral or partial subpectoral device, it is common to observe skin tightening and elevation of the inframammary fold ranging from 1–4 cm. When radiation is delivered to devices in the prepectoral position, elevation of the inframammary fold is not observed or minimal. Theories explaining this observation suggest that the effects of radiation are more pronounced towards the pectoralis major muscle, especially when the inferior origin has been divided. The effect is manifested by contraction and foreshortening of the fibers of the pectoralis major resulting in the cephalad displacement of the prosthetic device.

The technique of prepectoral reconstruction is simple. Mastectomy skin flaps are assessed for thickness and perfusion. Direct to implant as well as tissue expander—implant can be performed and based on patient desire and surgeon comfort (69,70). Prepectoral reconstruction

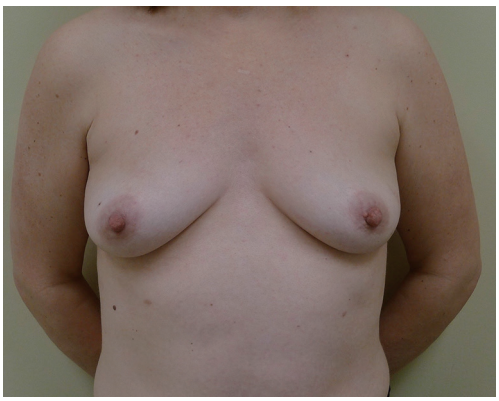

Figure 6 A preoperative image prior to right nipple-sparing mastectomy.

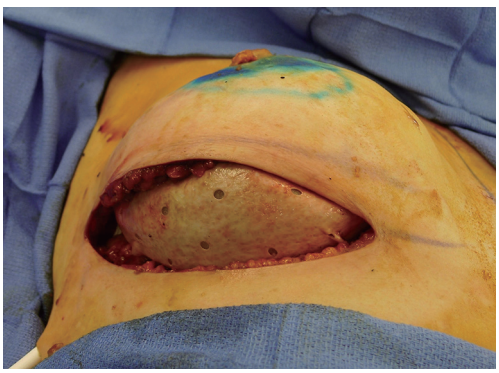

Figure 7 Intraoperative photograph of a prepectoral reconstruction using ADM. ADM, acellular dermal matrix.

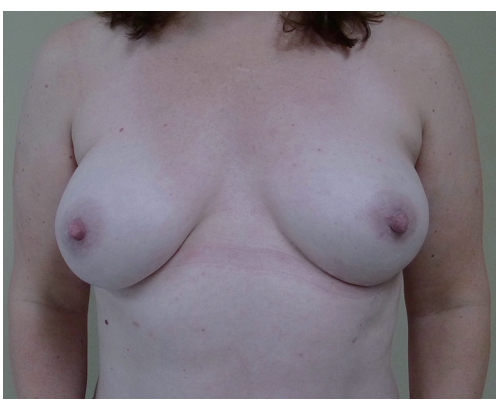

Figure 8 Postoperative following tissue expander removal and smooth round silicone gel breast implant placement at 6-month follow-up.

can be performed with or without ADM; however, ADM use is more common (71,72). ADM assembly can be performed using on or off label techniques according to FDA guidelines. Because ADM is indicated for soft tissue support, the on-label techniques are based on placing the ADM into the breast pocket first followed by the device second. With the off-label technique, the ADM is wrapped around the tissue expander or implant before insertion into the mastectomy defect. The ADM assembly can be designed as a 360° wrap or 180° around the device. *Figures 6-8* illustrate a patient following prepectoral reconstruction performed in two stages.

Recent clinical studies have supported the concept of prepectoral reconstruction and demonstrated the technique to be safe and effective. In a recent prospective multicenter study with data collected from 2014–2015 on 100 prepectoral breast reconstructions using Braxon dermal matrix, excellent outcomes were noted that included nipple necrosis or delayed healing occurred in 2% of patients at a mean follow-up of 17.9 months (73,74). In a retrospective review of 353 prepectoral reconstructions using ADM in 207 patients, Sigalove *et al.* demonstrated low rates of infection (4%), seroma (2%), and skin flap necrosis rate (2.5%) (63). In a retrospective review of 135 prepectoral reconstructions using ADM, Woo *et al.* demonstrated successful reconstruction in 96% of patients with minor complications occurring in 14% (64). Studies comparing outcomes between prepectoral and total muscle coverage techniques have demonstrated similar morbidities with regard to infection, superficial skin necrosis, and seroma (75) (*Table* 7). In addition, studies have confirmed that capsular contracture rates are lower when prepectoral reconstruction is performed with ADM (0%) compared to without ADM (12%) (76).

Summary

Prosthetic reconstruction has evolved and improved over the years based on the various innovations and advancements discussed. The use of ADM, autologous fat, improved mastectomy techniques, and improved devices remain the cornerstone of the bioengineered breast. The prepectoral concept represents the most recent advancement and may result in a paradigm shift with prosthetic breast reconstruction.

Table 7 A comparison of outcomes following prepectoral versus subpectoral device placement (75,76)

Author	Breasts	NSM (%)	SSM (%)	DTI (%)	TE (%)	BMI (kg/m^2)	FU (months)	CC (grade 3, 4) (%)	Infection (%)	Seroma (%)
Bernini										
Prepectoral	34	92	8	100	0	23	Median: 26	0	0	0
Subpectoral	39	85	15	100	0	23	Median: 25	12	6	0
Zhu – Saint-Cyr										
Prepectoral	50	42	58	0	100	27.8	Mean: 17.3	NR	2	10
Subpectoral	108	34	66	0	100	27.5	–	NR	3	2

NSM, nipple sparing mastectomy; SSM, skin sparing mastectomy; DTI, direct to implant; BMI, body mass index; FU, follow-up; CC, capsular contracture; NR, not reported.

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None.

Footnote

Conflicts of Interest: Dr. Nahabedian is a consultant for Allergan and Chief Surgical Office for PolarityTE.

Informed Consent: Informed consent has been obtained from the patients for publication of their figures.

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