An Algorithmic Approach to Prepectoral Direct-to-Implant Breast Reconstruction: Version 2.0

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Although the modern plastic surgeon strives to be the vanguard of postmastectomy breast reconstruction, prepectoral direct-to-implant breast reconstruction bids us to confront our notions of a disadvantaged, hazardous subcutaneous plane and reconsider prepectoral implant placement with fresh perspective. Its early adoption has been by those surgeons undaunted by its precarious past, recognizing that although prepectoral implant placement now represents...

Background: Prepectoral direct-to-implant breast reconstruction has historically been fraught with complications, including flap necrosis, implant extrusion, and capsular contracture, along with high rates of operative revisions. This may result from a number of factors, including the lack of an algorithmic approach, failure to predict postoperative migration of the implant, use of improper implants, and unsuitable patient selection. Over the past 5 years, the authors have gained significant experience in prepectoral breast reconstruction as they have transitioned their direct-to-implant technique.

Methods: Using video, technical aspects for achieving superior results are demonstrated, including suture technique, application of acellular dermal matrix, creation of the implant pocket, implant selection and placement, and postoperative dressings. Video is used to highlight technical aspects to yield consistent, predictable results using the anterior tenting technique.

Results: A systematic review of prepectoral direct-to-implant breast reconstruction was conducted to amalgamate the experience of the authors and others with regard to technique, material, and outcomes.

Conclusions: Prepectoral direct-to-implant breast reconstruction represents a significant paradigm shift in postmastectomy breast reconstruction and warrants reconsideration. Prepectoral direct-to-implant breast reconstruction provides the potential benefits of a single-stage operation, elimination of dynamic deformity, enhanced aesthetic outcomes, and increased patient satisfaction. Although early evidence suggests an increased incidence of complications, our experience and that of others demonstrate favorable outcomes with version 2.0 of prepectoral direct-to-implant breast reconstruction. As the body of literature encompassing a modern approach to prepectoral direct-to-implant breast reconstruction grows, greater appreciation for operative technique, candidate selection, and implant choice may accelerate its adoption and mitigate past concerns. (Plast. Reconstr. Surg. 143: 1311, 2019.)

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SURGICAL TECHNIQUE

The prepectoral direct-to-implant method of reconstruction is most commonly used following nipple-sparing mastectomy; however, skin-sparing mastectomy does not preclude use of the technique. Following completion of the mastectomy, adequacy of perfusion is assessed with a fluorescence imaging system (SPY; Stryker, Inc., Kalamazoo, Mich.), and is also carried out during other key portions of the operation. In our protocol, we limit prepectoral direct-to-implant breast reconstruction to a relative perfusion of 30 percent or greater. If inadequate perfusion is encountered, the reconstruction is then tailored to the intraoperative findings; most often, this results in dual-plane or full muscle coverage and tissue expander placement. (See Video, Supplemental Digital Content 1, which demonstrates the authors’ method of prepectoral direct-to-implant breast reconstruction, available in the “Related Videos” section of the full-text article on PRSJOURNAL.com or, for Ovid users, at http://links.lww.com/PRS/D393.)

If initial perfusion assessment is acceptable, a sizer is then placed into the mastectomy pocket and adjusted until optimal volume is achieved with the patient sitting in the upright position on the operating table. Reassessment of mastectomy flap perfusion with the sizer in place is recommended. For prepectoral direct-to-implant reconstruction, we favor use of round, high-fill cohesive gel implants (Natrelle Style SRX/SSX/SCX; Allergan, Inc., Dublin, Ireland). Recently, we have

Video. Supplemental Digital Content 1, which demonstrates the authors’ method of prepectoral direct-to-implant breast reconstruction, is available in the “Related Videos” section of the full-text article on PRSJOURNAL.com or, for Ovid users, at http://links.lww.com/PRS/D393.
preferred implants of higher levels of cohesivity as a preventative measure against potential upper pole rippling. The perimeter of the mastectomy pocket is marked slightly smaller than the desired implant to ensure a tight pocket. The creation of a tight pocket is necessary, anticipating the stretch/relaxation of the acellular dermal matrix postoperatively. A 16 × 20-cm sheet of perforated acellular dermal matrix (AlloDerm; LifeCell/Allergan Medical Inc., Madison, N.J.) is tailored to cover the anterior surface of the sizer/implant and sutured circumferentially with a combination of 2-0 Vicryl (Ethicon, Inc., Somerville, N.J.) interrupted suture (superiorly) and 2-0 polydioxanone running suture (laterally and medially) along the markings in the mastectomy pocket, with the inferior border left open for implant insertion. Orientation of the acellular dermal matrix facilitates inset, and an inferior cuff of acellular dermal matrix allows for pocket adjustment to achieve symmetry. The chest is prepared again with povidone-iodine and sterile paper drapes, gloves are changed, and the implant is placed into the pocket with a Keller Funnel (Allergan). The inferior border is tacked down and the patient is again sat upright on the table to confirm positioning and make any necessary adjustments to ensure symmetry. The inferior border is then closed with 2-0 polydioxanone. Two drains are placed in the subcutaneous space. Before skin closure, any threatened areas of skin are resected.

The reconstructed breast is cast with Reston foam and Tegaderm (3M Health Care, St. Paul, Minn.) to facilitate adhesion of the overlying skin, maintain proper nipple placement, and provide reinforcement of the lateral curvature and infra-mammary fold. Casting remains intact for 2 to 3 weeks postoperatively. The subcutaneous drains remain in place until the output is less than 20 to 25 cc/day, and typically the first drain is not removed until the postoperative visit at 10 to 14 days. Salient technical aspects of the operative method are demonstrated (see Video, Supplemental Digital Content 1, http://links.lww.com/PRS/D393).

LITERATURE REVIEW METHODOLOGY

A PubMed search was carried out using keywords “prepectoral,” “subcutaneous,” “muscle-sparing,” “direct to implant,” “direct-to-implant,” “single stage,” and “breast reconstruction” to identify relevant articles. Articles using prepectoral direct-to-implant reconstruction with biological or synthetic mesh and reported outcomes were included in the review. Articles describing combined approaches, such as use of a dermal flap in the setting of reduction mastectomy or placement of the implant directly under the mastectomy flaps (without mesh or biological matrix), were excluded. Articles with study populations including both prepectoral tissue expander and direct-to-implant reconstructions but lacking disaggregated data were also necessarily excluded. Nine original articles detailing results with prepectoral direct-to-implant techniques were identified (Fig. 1). This article sought to investigate outcomes of the prepectoral direct-to-implant approach (inclusive of our experience) and present the current status of this reemerging technique.

SUMMARY OF OPERATIVE TECHNIQUES

As use of the prepectoral approach increases, various operative techniques are emerging in the literature. All available publications included in this review describe use of some form of biological or synthetic material for creation of the pocket, although the material of choice varies by author.4–13,18,19 The majority of published techniques use the (off-label) technique of partial or complete wrap of the implant followed by varying degrees of fixation to the chest wall.6–13,18 Our group, Jones et al., Pittman et al., and Paydar et al. describe a version of anterior coverage.4–13,18 Of note, Pittman et al. describe a combined approach of acellular dermal matrix tenting with pectoralis muscle in the superior aspect of the breast.5 Table 1 summarizes technique, material used, and complications of our experience and that of others with prepectoral direct-to-implant reconstruction. We prefer tenting of the acellular dermal matrix only with direct fixation to the chest wall circumferentially. In our experience, inadequate fixation of the acellular dermal matrix or a loose pocket with prepectoral direct-to-implant reconstruction leads to implant migration/descent, a higher likelihood for device flipping, and the potential for asymmetry. We have not experienced these specific complications to date using our aforementioned technique but have been involved with secondary correction of patients with inadequate fixation, or inappropriate use of the three-point fixation technique (typically used in combination with an air-filled tissue expander placement) in direct-to-implant reconstruction. We do not use an additional cuff to wrap the inferior border of the construct, preferring tight anchoring using 2-0 polydioxanone.
directly under the caudal border of the implant; we feel this technique reduces the opportunity for stretch along the inframammary fold and device flipping. The additional “cuff” demonstrated in our technique video retains additional biological tissue to allow for secondary adjustment of the implant, similar to the tailoring concept of letting out a pant hem for alterations, before final closure. Secondary fat grafting in the upper pole may be minimized with an initial tight pocket to anticipate implant descent, although the need for additional grafting is highly dependent on the individual mastectomy surgeon.¹

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### Table 1. Technique, Material Used, and Complications Associated with Prepectoral Direct-to-Implant Reconstruction

<table>
<thead>
<tr>
<th>Authors</th>
<th>Publication Date</th>
<th>No. of Breasts</th>
<th>Technique</th>
<th>Material</th>
<th>Overall Complications (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antony et al.</td>
<td>In press, June of 2019</td>
<td>47 (75*)</td>
<td>Anterior tent</td>
<td>Allograft ADM (AlloDerm)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Pittman et al.</td>
<td>May of 2018</td>
<td>93</td>
<td>Anterior tent with superior pectoralis</td>
<td>ADM</td>
<td>†</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>slip (P1 method)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jones et al.</td>
<td>December of 2017</td>
<td>73</td>
<td>Anterior tent</td>
<td>Allograft ADM (AlloDerm)</td>
<td>15 (21)</td>
</tr>
<tr>
<td>Cattelani et al.</td>
<td>December of 2017</td>
<td>46</td>
<td>Complete wrap</td>
<td>Xenograft ADM (Braxon)†</td>
<td>0</td>
</tr>
<tr>
<td>Vidya et al.</td>
<td>November of 2017</td>
<td>100</td>
<td>Complete wrap</td>
<td>Xenograft ADM (Braxon)</td>
<td>11 (11)</td>
</tr>
<tr>
<td>Downs and Hedges</td>
<td>June of 2016</td>
<td>79</td>
<td>Complete wrap and anterior wrap</td>
<td>Allograft ADM (AlloDerm)</td>
<td>42 (53)</td>
</tr>
<tr>
<td>Kobraei et al.</td>
<td>May of 2016</td>
<td>23</td>
<td>Complete wrap</td>
<td>Vicryl mesh</td>
<td>5 (22)</td>
</tr>
<tr>
<td>Casella et al./</td>
<td>January of 2016</td>
<td>39</td>
<td>Complete wrap</td>
<td>Polypropylene mesh (TiLoop)</td>
<td>3 (8)</td>
</tr>
<tr>
<td>Bernini et al.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reitsamer and</td>
<td>February of 2015</td>
<td>22</td>
<td>Complete wrap</td>
<td>Xenograft ADM (Strattice)‡</td>
<td>3 (14)</td>
</tr>
<tr>
<td>Peintinger</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Berna et al.</td>
<td>September of 2014</td>
<td>25</td>
<td>Complete wrap</td>
<td>Xenograft ADM (Braxon)</td>
<td>5 (20)</td>
</tr>
</tbody>
</table>

ADM, acellular dermal matrix.

*To date, our experience encompasses 75 prepectoral direct-to-implant reconstructions; however, our recent publication was limited to those with greater than 1-yr follow-up and totals 47 reconstructed breasts.

†Complication data not specifically reported in this publication.

‡DECOmed s.r.l., Marcon, Italy.
§PFM Medical, Köln, Germany.
||LifeCell Corp.
PATIENT SELECTION

To ensure optimized clinical outcomes with prepectoral direct-to-implant reconstruction, proper patient selection is critical. Without the benefit of a well-vascularized pectoralis muscle interface between the skin and device, specific considerations must be incorporated to evaluate the mastectomy flap for ischemia and reconcile envelope compliance and nipple position with implant volume requirements and patient goals. Our group and others advocate for objective perfusion assessments of the mastectomy flaps with SPY fluorescence imaging. Typical candidates for prepectoral reconstruction are those who desire a reconstruction comparable to their native breast size, as optimal implant volume is dictated by the mastectomy skin envelope. We have found that mild to moderate degrees of preoperative ptosis can be corrected with implant volume greater than the native breast volume to achieve a lift paralleling a subglandular augmentation (Fig. 2). In addition, we have found matching to a native breast to be more facile in the setting of a prepectoral direct-to-implant reconstruction and that it can be combined with contralateral mastopexy and augmentation in one operation (Fig. 3).

We regard active smoking and uncontrolled medical comorbidities as absolute contraindications to prepectoral direct-to-implant reconstruction. Obesity is a relative contraindication for most authors, although we have found that the use of oncoplastic reconstruction techniques with implant placement in the large-breasted patient yields aesthetically pleasing results, with reduced concern for skin breakdown and device exposure. We do not regard previous breast irradiation, as in the

Fig. 2. A 44-year-old patient preoperatively (above) and 1 year postoperatively (below) after bilateral nipple-sparing mastectomy with prepectoral direct-to-implant reconstruction (SRX; right, 340 cc; left, 375 cc).
setting of previous breast conservation treatment or mantle irradiation, as an absolute contraindication and propose that conservative prepectoral direct-to-implant reconstruction can be carried out safely in these patients if minimal radiation-induced changes are encountered. We do feel that compared to prepectoral tissue expansion of previously irradiated flaps, the prepectoral direct-to-implant reconstruction technique with conservative volume places less stress on the mastectomy flaps and may be preferable (Fig. 4). Although we have limited experience with adjuvant radiation therapy after prepectoral direct-to-implant reconstruction, Storm-Dickerson and Sigalove report that they have not experienced increased complications associated with adjuvant radiation therapy in prepectoral reconstructions.20 Many authors advocate for exchange of the prepectoral tissue expander for the permanent implant before irradiation; certainly, direct-to-implant reconstruction obviates the need for an exchange procedure. Oncologic parameters after prepectoral direct-to-implant reconstruction must be considered, although long-term data are limited given its only recent reemergence as a viable technique. Storm-Dickerson and Sigalove recently published considerations for the prepectoral technique from the perspective of an oncologic breast surgeon and outlined specific prohibitory criteria that included advanced-stage breast cancer, large or posterior tumors near to or involving the pectoralis muscle, positive axillary nodes, and patients otherwise at high risk of recurrence.20

**DISCUSSION**

Postmastectomy breast reconstruction has experienced a paradigm shift since the early
challenges of Snyderman and Guthrie in 1971. At that time, subcutaneous implant reconstruction was fraught with complications, including unacceptably high rates of mastectomy flap necrosis and implant loss and unfavorable aesthetic outcomes, with a high incidence of capsular contracture. In fact, in a publication in the early 1980s, Gruber et al. presented a review of reconstruction in the previous decade and demonstrated an increased incidence of capsular contracture among subcutaneous reconstructions (Baker grade III, 33 percent; Baker grade IV; 7 percent) compared to subpectoral reconstructions (Baker grade III, 11 percent; Baker grade IV, 0 percent). The subsequent evolution of breast reconstruction favored more conservative measures with devices to achieve gradual expansion of the mastectomy envelope and placement of the implant in a well-vascularized submuscular pocket incorporating pectoralis muscle.

Modern advancements in breast surgery have enabled us to revisit insertion of the desired final implant at the time of mastectomy and consider version 2.0 of prepectoral direct-to-implant breast reconstruction. Skin- and nipple-sparing techniques permit creation of a mastectomy pocket that can accommodate the volume of the implant, obviating the need for expansion. The addition of biological regenerative matrices simplifies mastectomy pocket reinforcement and device positioning, with a lowered potential for capsular contracture. Modern implant design—in particular, higher cohesiveness and higher fill gel devices—facilitates favorable cosmetic outcomes. These innovations have spurred reinvestigation into prepectoral implant placement.

Direct-to-implant reconstruction is less often performed than tissue expander methods, constituting approximately 20 percent of device-based reconstruction. Reluctance to adopt direct-to-implant reconstruction methods likely stems from the reported high complication rates of flap necrosis, reoperation, and device loss, with rates of secondary revision as high as 87 percent. However, others have elucidated the efficiencies with a shortened reconstructive process, enhanced economics, and improved patient satisfaction. When amalgamated with prepectoral placement, composite benefits include elimination of dynamic deformity, reduction in postoperative pain, and improved limb function with greater range of motion. In addition, Glasberg theorized that although there is an increased cost of reconstructive materials (i.e., larger sheets of mesh or biological material), prepectoral reconstruction may ultimately prove cost-effective through avoidance of a second-stage operation and additional revision procedures, decreased use of physical therapy, decreased narcotic use, shortened length of stay, and faster return to work, although formal statistical analysis may further our understanding. Despite this, prepectoral direct-to-implant reconstruction, burdened by the shortcomings of the past, has not enjoyed a swift revival. This article seeks to restore confidence in this technique by objectively reviewing our experience and that of others to evaluate outcomes of prepectoral direct-to-implant reconstruction emerging in recent years.

To date, we have performed 75 prepectoral direct-to-implant reconstructions; outcomes of patients with 1-year or greater follow-up were included in this review. In our experience, we found similar rates of postoperative complications compared to our dual-plane reconstructions, with overall complications ranging from 2 to 8 percent. In our literature review, reported rates of partial or total mastectomy flap necrosis ranged from 0 to 28 percent and rates of implant loss ranged from 0 to 18 percent, with higher rates among women with active smoking history and prior radiation therapy, emphasizing the need for a highly selective approach to this method of reconstruction. Summarized complication data from ourselves and others (Table 1) show promising results and repudiate previously seen high complication rates in the early history of this technique. Although there is little available literature comparing prepectoral and dual-plane reconstructions, Casella et al. and Bernini et al. corroborate our experience and found no significant difference in early complications between prepectoral and dual-plane direct-to-implant reconstructions. Data from studies comparing prepectoral and dual-plane tissue expanders similarly failed to demonstrate increased complications with prepectoral device placement compared to the standard dual-plane technique.

In addition to potential pain reduction and enhanced recovery, elimination of dynamic deformity is perhaps the most significant advantage of the prepectoral technique compared with submuscular reconstruction, lending itself to a more natural appearing breast. Highlighting the heightened awareness of animation deformity, Nigro and Blanchet cited over 75 percent of patients in their study (84 of 108 patients with survey completion) experiencing animation deformity. Although use of the prepectoral
space is a relatively recent adoption in the field of postmastectomy reconstruction, conversion to the prepectoral space has been a regular tool available to the aesthetic surgeon for correction of dynamic deformity after breast augmentation. Several authors describe revision of previous subpectoral implants with prepectoral implant placement as a method of correcting breast animation deformity, although this revision technique has been described in both augmentation and postmastectomy reconstruction patients with good results.29–32

A significant barrier to implementation of prepectoral breast reconstruction remains a concern for compromise of cosmetic outcomes with the potential for increased rippling or visibility of the implant; however, this has yet to be observed among surgeons who routinely perform this technique. In fact, Bernini et al. found no significant difference in the incidence of evident implant rippling, visibility, or palpability of the implant between prepectoral and dual-plane direct-to-implant reconstructions, with aesthetic results favoring prepectoral direct-to-implant reconstruction.9,13 In our experience, we have found that implant rippling is minimized with initial creation of a tight acellular dermal matrix pocket and the use of high-fill cohesive gel implants, although we find lipofilling to be a useful adjunct when indicated as a secondary procedure. A tight mastectomy pocket also functions to reduce the visibility of the upper pole of the implant. Other authors echo this practice and strive for a “hand-in-glove” fit of the implant in the acellular dermal matrix pocket, whereas others have found creation of a thin, superior “pectoralis slip” useful (this strategy of using the pectoralis may not be considered strictly “prepectoral” by some surgeons, although we feel this is within the scope of prepectoral breast reconstruction) in camouflaging the upper pole of the implant.5,12 We similarly have not found an increase in rippling or visibility, and have experienced favorable overall cosmetic results with prepectoral direct-to-implant reconstructions.1

Comparing prepectoral direct-to-implant with dual-plane direct-to-implant and tissue expander/implant reconstructions,9,13

CONCLUSIONS

Prepectoral direct-to-implant reconstruction represents a significant paradigm shift in postmastectomy breast reconstruction and warrants reconsideration. Prepectoral direct-to-implant reconstruction provides the potential benefits of a single-stage operation, elimination of dynamic deformity, enhanced aesthetic outcomes, and increased patient satisfaction. Although early evidence suggests an increased incidence of complications, our experience and that of others demonstrate favorable outcomes with version 2.0 of prepectoral direct-to-implant reconstruction. As the body of literature encompassing a modern approach to prepectoral direct-to-implant reconstruction grows, greater appreciation for operative technique, candidate selection, and implant choice may accelerate its adoption and mitigate past concerns.

REFERENCES