

# A Sustainable Approach to Prepectoral Breast Reconstruction Using Meshed Acellular Dermal Matrix

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**Background:** Prepectoral implant-based breast reconstruction provides an alternative to submuscular reconstruction, but the increased acellular dermal matrix (ADM) required has the potential to lead to increased costs and decreased supply of this limited-resource material. We present a method for prepectoral reconstruction utilizing skin-graft meshing techniques to increase the surface area of usable ADM.

**Methods:** Forty-four patients underwent this technique from February 2019 to February 2020. Patient characteristics, operative details, and outcomes, including complications and patient satisfaction utilizing the BREAST-Q, were analyzed. Cost analysis relative to projected cost of nonmeshed techniques was performed.

**Results:** There were 20 unilateral and 24 bilateral procedures, for a total of 68 breast reconstructions. Mean age was 45.9 years (32–71). Mean implant volume was 485 cm<sup>3</sup> (265–800), and one sheet of ADM was used for each breast with an average surface area of 161 cm<sup>2</sup>. Median follow-up was 350 days (212–576). Minor complications included an infection treated with oral antibiotics. Major complications included one axillary hematoma and one delayed implant loss. One patient underwent revision for asymmetry. Mean BREAST-Q score was 47.4/60. Cost ranged from \$4113 to 5025 per breast, compared with the projected \$9125–18250 per breast for other techniques in the literature.

**Conclusions:** In contrast to previously described uses of ADM in prepectoral reconstruction, meshing maximizes resource utilization by expanding the coverage of a single sheet. Early findings demonstrate minimal complications and high patient satisfaction, suggesting the approach has potential to provide the benefits of prepectoral reconstruction while responsibly preserving product availability and tempering healthcare costs. (*Plast Reconstr Surg Glob Open* 2021;9:e3392; doi: 10.1097/GOX.0000000000003392; Published online 21 January 2021.)

## INTRODUCTION

In the setting of robust soft-tissue coverage and appropriate patient selection, prepectoral implant breast reconstruction provides a safe alternative to total and partial submuscular breast implant reconstruction. Prepectoral breast reconstruction avoids breast animation deformity,<sup>1–6</sup> reduces postoperative pain<sup>2,6–8</sup> and recovery time,<sup>7,9</sup> may be better tolerant to postmastectomy radiation therapy,<sup>10–13</sup> and achieves favorable cosmetic outcomes.<sup>4,7,12,14–17</sup>

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The presence of acellular dermal matrix (ADM) also seems to limit long-term issues with capsular contracture in some patients.<sup>13,16,18</sup> In contrast to subpectoral reconstruction, which most often utilizes only an inferior sling of ADM, most prepectoral placement techniques describe complete ADM coverage of the implant. This approach requires a greater surface area of ADM than comparable subpectoral implant procedures, resulting in significantly increased cost and accelerated utilization of a limited resource. Some techniques utilize 2–4 times the surface area of ADM compared with traditional subpectoral techniques.<sup>8,17,19–24</sup> As the prepectoral technique has gained popularity, the increased use of ADM, coupled with the requirement for additional surface area of allograft, has the potential to deplete product stores.

As ADM is used in the majority of implant-based breast reconstructions, including most subpectoral and

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prepectoral procedures, shortages of ADM can have a far-reaching impact on the availability of breast reconstruction to patients undergoing mastectomy. The incidence of breast cancer is 1 in 8 women, and the demand for breast reconstruction is growing.<sup>25</sup> In 2016, 109,256 breast reconstruction procedures were performed, according to the American Society of Plastic Surgeons. A steady annual growth in rates of breast reconstruction has occurred, with a 39% increase in procedural volume since 2000.<sup>26</sup> It is therefore incumbent upon plastic surgeons, who provide implant-based breast reconstruction using ADM material, to exercise responsible utilization of this resource.

We present a method for prepectoral implant breast reconstruction adopting standard skin-graft meshing techniques to increase the surface area of usable ADM and maintain structural integrity. Our series demonstrates excellent clinical results as well as improved cost-efficacy and responsible stewardship of this valuable material.

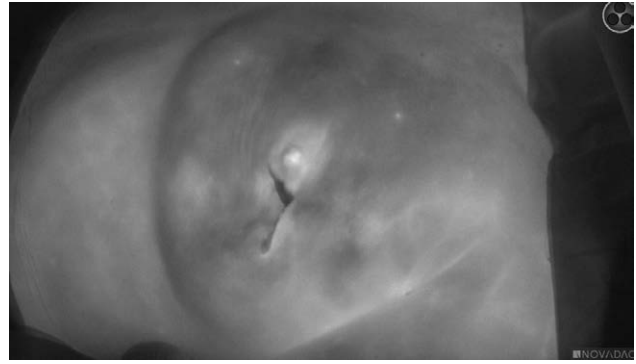
## METHODS

### Patient Selection

This is a single-center, single-surgeon retrospective cohort study of patients who underwent prepectoral breast reconstruction using meshed ADM between February 2019 and February 2020 by the senior surgeon. This study was approved by our institution's Institutional Review Board, and the principles outlined in the Declaration of Helsinki have been followed. The risks and benefits of the prepectoral approach were discussed preoperatively with all patients who were scheduled to undergo a nipple- or skin-sparing mastectomy, and informed consent was obtained. The decision to pursue the prepectoral approach was made intraoperatively based on the adequacy of the mastectomy flaps. This was defined as a thickness >6–8 mm and brisk perfusion as assessed by indocyanine green angiography (SPY portable handheld imager; Stryker, Inc., Kalamazoo, Mich.) based on literature demonstrating increased flap loss with fluorescence >50 seconds.<sup>27</sup> Exclusion criteria included current smoking status and poorly controlled diabetes, defined as a hemoglobin A1C > 7.0%. Anticipated incomplete resection margins and the need for postoperative radiation was considered a contraindication, although 2 patients unexpectedly did go on to require radiation. A relative contradiction was prior radiation, although 1 patient who had completed breast radiation 14 months before reconstruction was included. Patients whose mastectomy flaps were considered to have tenuous or inadequate perfusion were converted to a subpectoral approach. The majority of patients underwent direct-to-implant placement; however, if a patient met the criteria for prepectoral placement, but insufficient skin laxity was present to accommodate the desired implant size, an expander was instead placed in the prepectoral space.

### Surgical Technique

Nipple-sparing or skin-sparing mastectomies were performed through an infra-areolar, vertical, or inframammary incision, selected at the discretion of the breast surgeon.



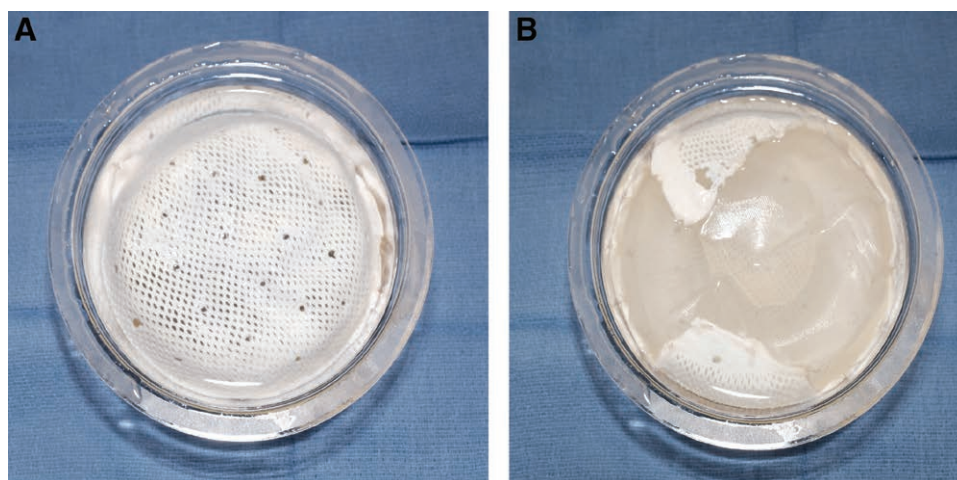
**Fig. 1.** Perfusion assessed with indocyanine green angiography.

Following the resection, 3 cm<sup>3</sup> of indocyanine green was administered intravenously within 20 minutes of mastectomy completion, and the perfusion of the nipple and mastectomy flaps was assessed with SPY angiography (Fig. 1). If the mastectomy flaps were determined to be adequate, implant sizers were placed in the prepectoral plane, and an appropriately sized ADM allograft was chosen based on the selected implant volume and projection. All implants were Natrelle (Allergan Corporation, Branchburg, N.J.) smooth, round, silicone implants. Patients received either the soft touch or responsive gel consistency. All reconstructions were performed with Alloderm regenerative tissue matrix (Allergan Corporation, Branchburg, N.J.). For implants with a volume greater than 360 cm<sup>3</sup>, a crescent-shaped contour fenestrated ADM measuring 10.7 cm × 21.5 cm (164 cm<sup>2</sup>) with a thickness of 1.0 mm ± 0.2 mm (thin type) was used. For patients with implants smaller than 360 cm<sup>3</sup>, a 9.6 cm × 19.3 cm (132 cm<sup>2</sup>) sheet was used. The ADM was then passed through a skin-graft mesher (Brennen mesher; Molnlycke, Gothenburg, Sweden) with a blade size of 2:1. (See Video 1 [online], which displays Part 1 of the technique for meshing, as well as the appearance of the mesh immediately after being passed through the mesher.) (See Video 2 [online], which displays Part 2 of the meshing technique.)

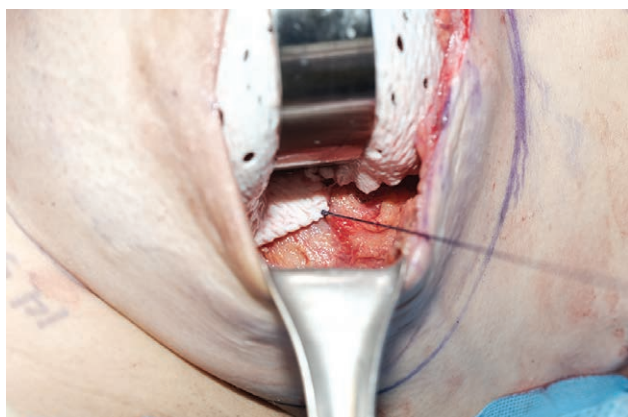
The meshed ADM was subsequently irrigated with an antibiotic solution until the irrigant ran clear, positioned on the anterior surface of the implant, and secured to a sheet of 6 × 6 cm Vicryl (Ethicon Inc, Somerville, N.J.) polyglactin knitted mesh posteriorly (Fig. 2). The implant/allograft construct was inserted into the prepectoral mastectomy pocket – along with two 15 French Jackson-Pratt drains. Tacking sutures were placed to secure the mesh to the underlying pectoralis major muscle and help maintain the implant's position (Fig. 3). Drains stayed in place for 7–14 days. All patients remained on oral antibiotics until 3 days after the last drain was removed. Figures 4 and 5 demonstrate an example of a prepectoral reconstruction using a 520 cm<sup>3</sup> implant and a 295 cm<sup>3</sup> implant.

### Outcomes

Patient demographic information was collected, including age, comorbidities, timing of reconstruction (immediate versus delayed), direct to implant versus 2-stage with expander, unilateral versus bilateral reconstruction, and



**Fig. 2.** Implant and allograft construct on back table demonstrates (A) meshed ADM anteriorly and (B) polyglactin knitted mesh posteriorly.



**Fig. 3.** Tacking sutures to approximate mesh to the lateral border of the pectoralis muscle.

radiation status. Operative details, including implant size, ADM size, and operative duration, were also recorded from the operative log. Complications were classified as “major” if the patient returned to the hospital for reoperation and “minor” if the complication was managed without operative intervention. Specific complications of interest included infection, hematoma, seroma, skin necrosis, delayed wound healing, implant exposure, and implant loss. Aesthetic satisfaction and patient quality of life (QoL) were evaluated by the BREAST-Q,<sup>28</sup> which was sent to all patients postoperatively. The postoperative satisfaction with breast module and postoperative satisfaction with implants module were used.

#### Cost Analysis

A cost analysis was conducted to compare our approach with other prepectoral approaches described in the literature, as well as with our own subpectoral approach at our institution. The price of the Alloderm and that of Vicryl mesh, as well as the operative time for the procedure, were recorded for all patients. At our institution, the cost of the Contour Perforated Large ADM was \$4676.00 and

the Contour Perforated Medium ADM was \$3764.00. The 6 × 6 cm Vicryl mesh was \$349.67. The cost of the 16 × 20 cm piece most frequently reported in other studies was \$9125.00. The operating room cost was estimated using an analysis by Childers et al, which determined a rate of \$36.14 per minute for ambulatory surgery centers in California.<sup>29</sup> For comparison, operative time for the subpectoral approach at our institution was obtained from a set of historical controls.

#### Statistical Analysis

All data were queried in Microsoft Office Excel (version 16.3, Microsoft Corporation, Redmond, Wash.). Statistical analysis was done in SPSS (SPSS Statistics for Windows, Version 26.0, Chicago, Ill.). All outcomes were reported with descriptive statistics for scale variables.

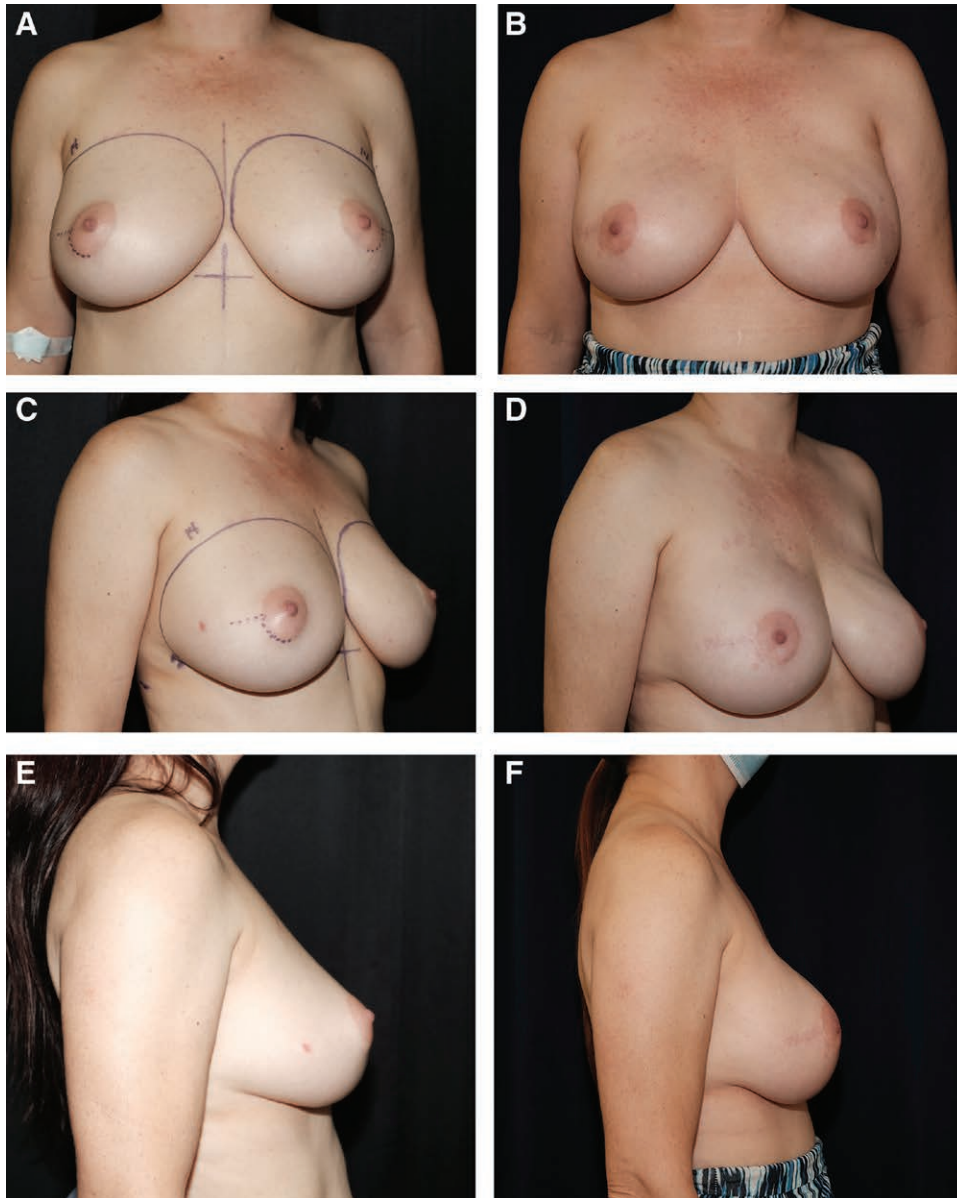
## RESULTS

#### Patient Demographics

Forty-four patients met inclusion criteria. Patient and operative characteristics are listed in Table 1. There were 20 unilateral and 24 bilateral procedures, for a total of 68 breasts reconstructed with this technique. Of the 68 mastectomies, 36 were performed prophylactically. Only 1 patient had a history of prior breast irradiation, completed 14 months before her reconstruction. There was an even distribution of nipple-sparing (21 patients) versus skin-sparing mastectomy (23 patients). Patient age ranged from 32–71 years, with a mean age of 45.9 years, and an average BMI of 27.3 kg/m<sup>2</sup> (range, 19–39 kg/m<sup>2</sup>). Eleven patients carried BRCA mutations. No patients were active smokers. Two patients carried a diagnosis of diabetes mellitus and 2 patients went on to complete postoperative radiation (Fig. 6).

The majority of prepectoral cases were immediate reconstructions (n = 39); however, this method was also successfully applied in a delayed setting in five cases. Three patients had tissue expanders placed due to





**Fig. 4.** A 44-year-old woman with left breast infiltrating ductal carcinoma. The patient underwent infra-areolar incision for bilateral nipple-sparing mastectomy with placement of 520 cm<sup>3</sup> implants. Results are shown at 12 months postoperatively. A, C, and E are postoperative photographs. B, D, and F, 12 months postoperative results.

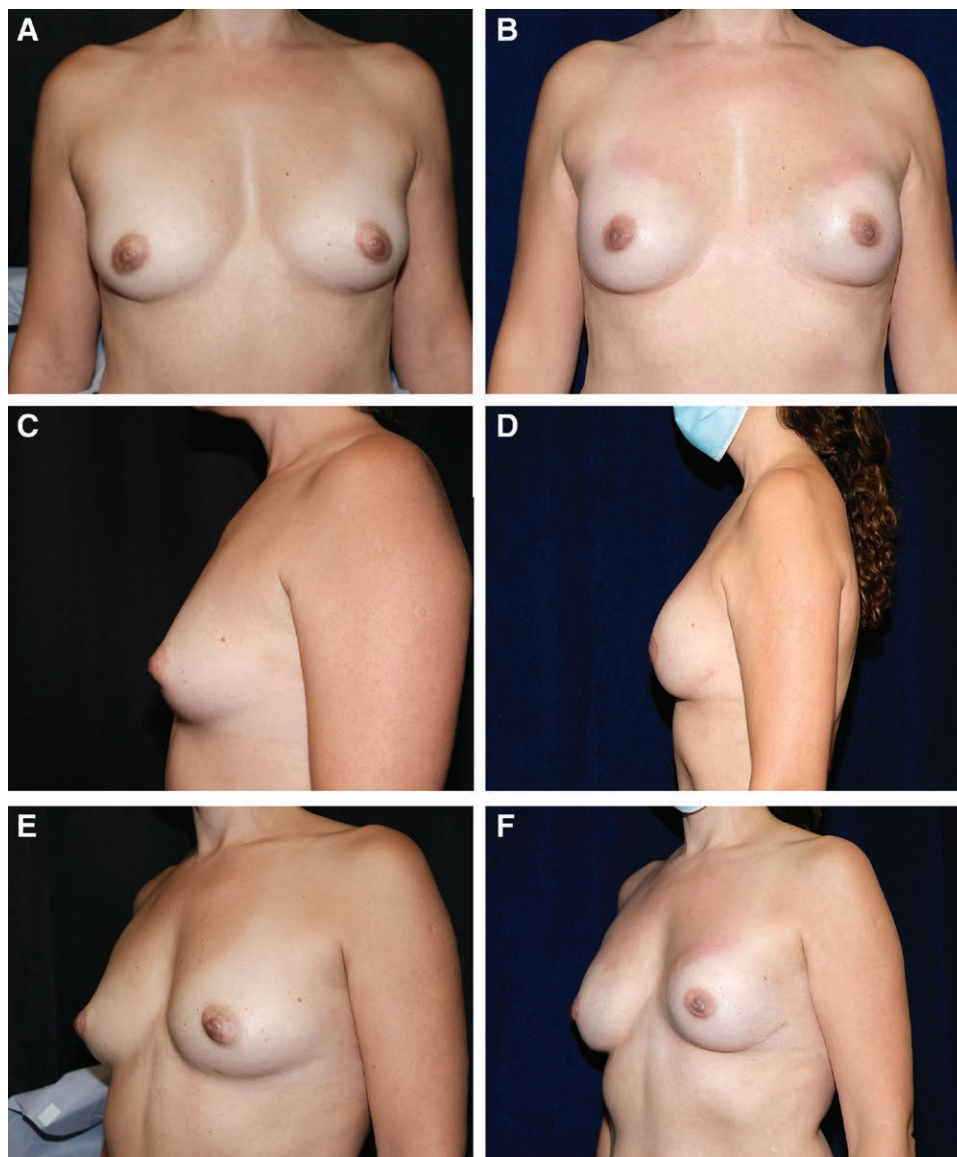
insufficient skin laxity, whereas the rest were direct-to-implant. Implant volume spanned a broad range, from 265 cm<sup>3</sup> to 800 cm<sup>3</sup> (median volume, 485 cm<sup>3</sup>). One sheet of ADM and 1 sheet of Vicryl mesh were used for each breast. The average surface area of ADM per breast reconstruction was 161 cm<sup>2</sup>. Average duration of follow-up was 350 days (212–576 days).

#### Outcomes

Few complications were seen postoperatively, as shown in [Table 2](#). All complications occurred in direct-to-implant patients. Minor complications occurred in 1 patient with superficial infection, which was successfully treated with oral antibiotics without the need for re-operation. Major

complications occurred in 2 patients. One patient developed an axillary hematoma on postoperative day 1 at the site of the axillary dissection. This hematoma was promptly evacuated, and the reconstruction was preserved. There was 1 case of implant loss, caused by an infection 1 year postoperatively, which required explantation. This patient was a non-insulin-dependent diabetic who had undergone postoperative radiation, and she delayed presentation to the hospital by over a week.

One patient required reconstruction revision for breast asymmetry in a bilateral reconstruction, due to lateral displacement of 1 implant. All other patients expressed satisfaction with the contour and aesthetic appearance of their breasts. On the BREAST-Q postoperative satisfaction with



**Fig. 5.** A 40-year-old woman with right breast infiltrating ductal carcinoma. The patient underwent inframammary incision for bilateral nipple-sparing mastectomy with placement of 295 cm<sup>3</sup> implants. Results are shown preoperatively (A, C, E) and 12 months postoperatively (B, D, F).

breast module, mean score was 47.7 out of a possible 60 (range, 29–60). On the implant postoperative satisfaction module, the mean score was 5.8 out of a possible 8 (range, 2–8). Although this does indicate that a percentage of patients both felt and saw implant rippling, no patients were bothered enough to desire revision surgery. There were no reports of malposition or capsular contracture.

#### Cost

Four patients (5 breasts) utilized the medium contour ADM (132 cm<sup>2</sup>) and 40 patients (63 breasts) utilized the large contour ADM (164 cm<sup>2</sup>). All patients utilized a single piece of 6 × 6 Vicryl mesh for each breast reconstructed. Our previous subpectoral technique utilized the same medium and large contour ADM; so, apart from the Vicryl mesh, there was no increased cost in terms of materials.

The cost of the Vicryl mesh (\$349.67) was further offset by the shorter operative times for prepectoral versus subpectoral reconstruction. The average operative time for the prepectoral group was 60 minutes, compared with 90 minutes for our subpectoral technique. Based on the estimated cost per minute of operating room time in the ambulatory setting in California, this equates to approximately \$1110.00 in time savings alone.

Although comparisons within the literature are somewhat limited by the range of ADMs used in other techniques, including Flex-HD (MTF Biologics, Edison, N.J.),<sup>20,30–32</sup> Braxon (Medical Biomaterial Products, Neustadt-Glewe, Germany),<sup>5,7,8</sup> Strattice (Allergan Corporation, Branchburg, N.J.),<sup>18,19,33</sup> and CG CryoDerm (CGBio Co., Seongnam, Korea),<sup>23</sup> direct cost comparison was possible in a number of studies that utilized

**Table 1. Patient and Surgical Characteristics**

	N = 44 Patients (68 Breasts)
Age (mean, range, SD)	45.9 years (32–71, 11.1)
BMI (mean, range, SD)	27.3 kg/m <sup>2</sup> (19–39, 4.0)
Mastectomies	
Skin-sparing	22
Nipple-sparing	21
Reconstructive timing	
Immediate	39
Delayed	5
Reconstructive laterality	
Unilateral	20
Bilateral	24
Reconstructive staging	
Direct-to-implant	41
Expander	3
Patient comorbidities	
History of prior breast radiation	1
History of diabetes mellitus	2
Operative details	
Implant volume (median, range, SD)	485 cm <sup>3</sup> (265–800, 157.8)
ADM surface area per breast (mean, range, SD)	161 cm <sup>2</sup> (132–164, 9.3)
Follow-up time (d) (median, range)	350 d (212–576)

Alloderm.<sup>2–4,17,22,24,34–36</sup> These studies most frequently used 1–2 sheets of 16 × 20 cm (320–640 cm<sup>2</sup>). Utilizing the cost data for Alloderm at our institution, these approaches would have ranged between \$9125 and \$18,250 per breast. Given our current approach with a cost of \$4113.67 per breast when the medium contour was used, and \$5025.67 per breast when the large contour was used, a significant cost savings was achieved.

## DISCUSSION

Based on our institution's results, breast reconstruction with meshed allograft and prepectoral implant placement can offer reliable and aesthetically pleasing outcomes. Meshing facilitates the use of a single sheet of ADM for coverage of the implant, which results in no change in our ADM usage volume or cost compared with standard subpectoral techniques. The majority of the existing literature describes a prepectoral technique dependent on large sheets of allograft (16 × 20 cm matrix, 320 cm<sup>2</sup>), whereas our method utilized an average surface area of 161 cm<sup>2</sup> per breast. This protocol provided appropriate coverage for even our largest implants. The majority of studies describing techniques for prepectoral reconstruction reported implant sizes of <450 cm<sup>2</sup>.<sup>4,19,21,24,35</sup> Those that reported the use of implants greater than 500 cm<sup>3</sup> noted the requirement for 2 full sheets of 16 × 20 cm Alloderm to be used to ensure implant coverage.<sup>21,34</sup> Therefore, our cost comparison may be an underestimate given our larger average implant size of 485 cm<sup>3</sup>, and 48.8% of patients greater than 500 cm<sup>3</sup>.

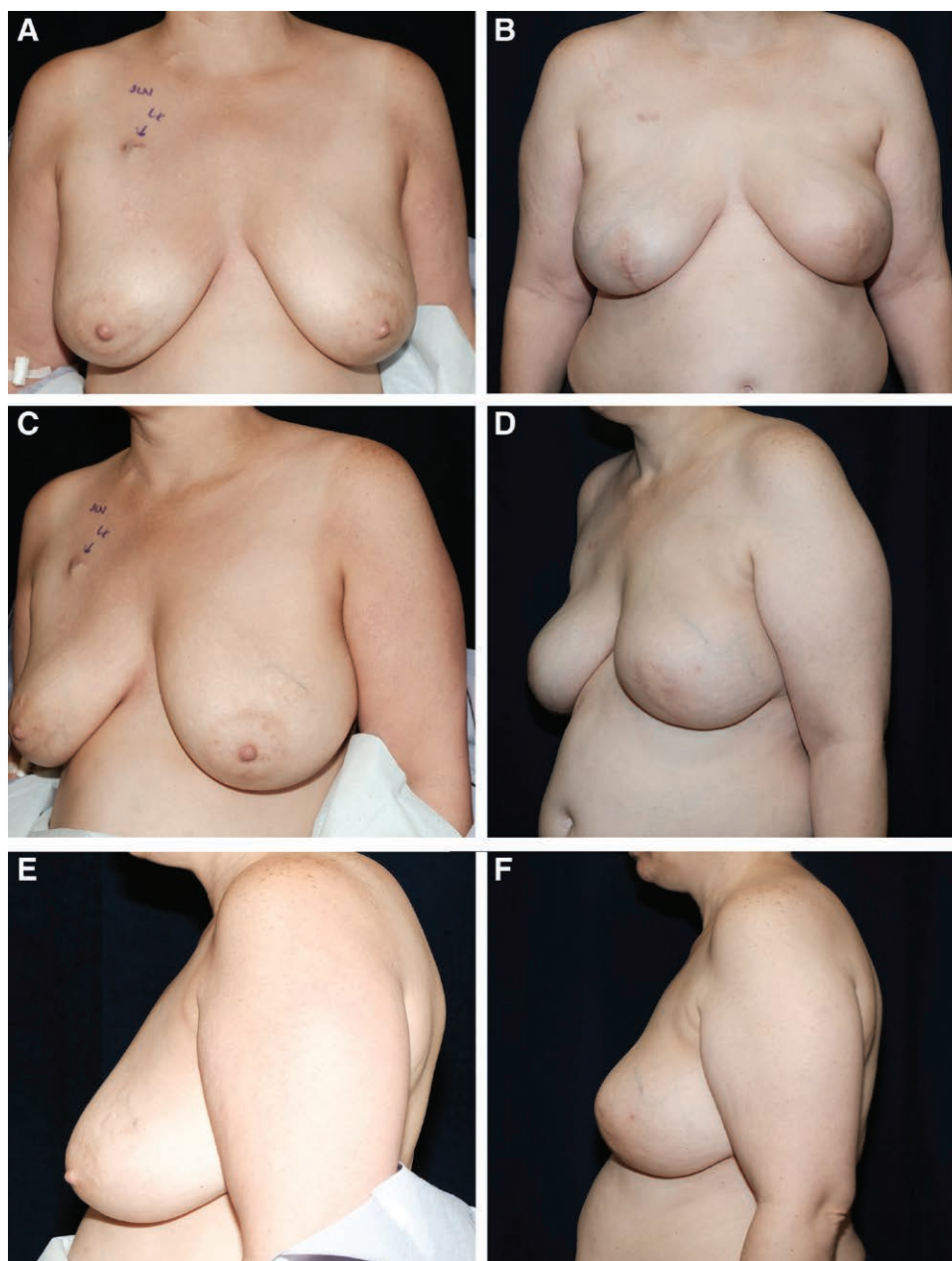
Although these data currently lack long-term follow-up, early findings demonstrate minimal complications. Regarding patient selection, there are several salient features in our population. All patients were current non-smokers; 6 patients had been former smokers but had quit at least 6 months before presentation. The 2 patients with a history of type 2 diabetes were well-controlled (A1c < 7%), on oral agents alone. Although our technique was

successfully applied in one instance of prior radiation, a history of prior irradiation was considered a relative contraindication to prepectoral reconstruction. There were 2 cases in which prepectoral meshed ADM and direct-to-implant reconstruction was performed and patients went on to require radiation. One patient experienced no issues with implant infection, extrusion, or symptomatic contracture 19 weeks after the completion of therapy; however, the other patient represented the single case of implant loss (at 1 year postoperatively and 10 months after the completion of radiation). Prepectoral implant placement has been shown in other studies to be safe in patients facing post mastectomy chest wall radiation,<sup>4,11,13</sup> but this patient's combination of risk factors, including diabetes in addition to her radiation therapy, likely compounded her risk of failure.

Our other complication rates were low compared with those previously documented in prepectoral reconstruction with nonmeshed techniques.<sup>4,8,18,20,33</sup> There were no cases of seroma, as the meshing allows an egress for fluid, which has been shown to reduce the risk of seroma in ADM-assisted reconstruction.<sup>31,32</sup> The meshing itself also appears to not only maintain product integrity, but to promote integration. In a mouse model, Lotan et al evaluated histopathologic evidence of the impact of standard skin-graft meshing techniques on a variety of ADM and found at 3 months that, compared with nonmeshed controls, the meshed ADM showed fewer giant cells and less foreign body reaction, deeper penetration of fibroblasts, and more remodeling with mature native porcine collagen, suggesting not only maintenance of structural integrity but a benefit to meshing in terms of integration.<sup>36</sup> The meshing technique also allows for improved conformability of the ADM, minimizing bunching and wrinkling, which has also been suggested to lead to more optimal incorporation.<sup>37,38</sup> Although not evaluated on all patients, clinical and histopathologic evidence on our subset of patients who underwent 2-stage reconstruction support these findings. **Figure 7** demonstrates both clinical and histologic vascular ingrowth in a biopsy of the tissue taken from a patient who underwent expander-based reconstruction and who had exchange to implants at 4 months. It is plausible that meshing the allograft promotes faster integration of the ADM and that this also contributes to lower infection risk, 1.4% compared with the 2%–8% reported elsewhere.<sup>2,4,8,18,20,33</sup> However, further investigation would be needed to support this hypothesis.

Additionally, our findings demonstrate a notably low rate of revision surgery and high patient satisfaction. Some note a concern around the potential for increased rippling or visibility of the implant necessitating further fat grafting in the prepectoral approach,<sup>23,33</sup> whereas others have found decreased revision rates and improved aesthetic outcomes relative to subpectoral placement.<sup>12,16,39,40</sup> In our own series, we found high rates of satisfaction on the BREAST-Q survey, and although the implant-specific module mean score was 5.8, indicating a percentage of patients noted rippling of the implant, no patients desired revision surgery. The prepectoral placement of the implant also eliminates pectoral muscle animation and





**Fig. 6.** A 44-year-old woman with infiltrating ductal carcinoma of bilateral breasts underwent bilateral skin sparing mastectomies and immediate reconstruction with placement of 560cm<sup>3</sup> implants. The patient is shown preoperatively (A, C, E) and postoperatively (B, D, F) 6 months after receiving 5040 cGy of radiation to the left chestwall.

therefore reduces the need for capsulorrhaphy to control lateral implant drift. Additionally, technical details of our approach, in particular the use of Vicryl mesh posteriorly,

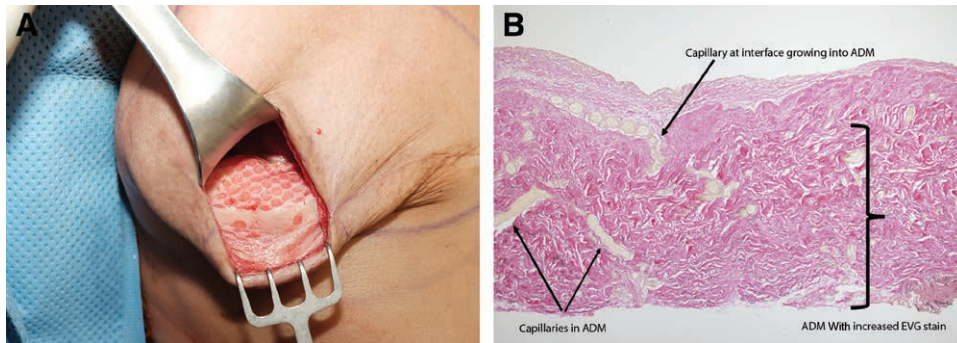
which provides a secure suture interface, likely contributed to the low need for revision. Securing the mesh to both the ADM and the chest wall not only allows more stable fixation of the ADM, but ensures adherence of the ADM-implant construct to the underlying pectoralis major muscle, reducing the risk of lateral displacement.

**Table 2. Postoperative Complications**

Complication	No. Patients
Axillary hematoma	1
Infection	1
Implant exposure	0
Reconstruction revision	1
Explantation/implant loss	1

### LIMITATIONS

The study has several limitations. Most importantly is the small sample size, which makes firm conclusions difficult and limits the ability to perform any statistical calculations.



**Fig. 7.** Illustration of allograft integration demonstrates (A) appearance of capsule at 4 months and (B) histologic integration of ADM showing increased EVG (Elastic van Gieson) staining and capillary ingrowth.

Additionally, the heterogeneity of the small sample limits its generalizability—although the majority of cases were direct-to-implant reconstructions, 3 cases utilized a 2-stage approach with expanders. There was also heterogeneity in terms of immediate versus delayed reconstruction, which impacts the vascularity of the mastectomy flaps. Over half of the reconstructions were bilateral with a prophylactic breast, with the exception of 3 cases of bilateral cancer, which also likely improved the quality of the mastectomy flaps on the prophylactic side and may limit generalizability to oncologic-only reconstructions. The cost analysis is limited by the variable ADM products described in the literature. Because only Alloderm is used at our institution, and, therefore, specific product costs were not available on alternative ADM products, we were unable to draw direct cost-comparisons to techniques that described other ADM products. Broader cost analysis across products would be beneficial given the range of products and techniques employed.

### CONCLUSIONS

Meshed allograft in conjunction with prepectoral implant placement is a promising approach for breast cancer reconstruction, in carefully selected patients. Given the current healthcare environment, any novel technique must give consideration to sustainability and cost-containment, in addition to safety and clinical outcomes. Prepectoral implant-based breast reconstruction techniques, which typically require 3–4 times as much ADM per breast compared with standard subpectoral techniques, can be extremely costly to healthcare institutions where reimbursements do not cover the material costs. Without efforts to alter this pattern, which allows ADM to remain in short supply, it is conceivable that some patients may not be able to have timely breast reconstruction surgery.

Faced with higher prices, hospitals and third-party payors may ultimately refuse to cover this valuable reconstructive tool or limit its usage in prophylactic surgery. It is imperative that surgeons preemptively consider the economics as well as the sustainability of their surgical approaches. Although data are still lacking, there is early evidence to suggest a long-term economic benefit in terms of shorter hospital stays and fewer revision procedures associated with prepectoral reconstruction<sup>7,35</sup>; however, this benefit may be

outweighed, or at least overshadowed, by upfront materials cost. Meshing ADM to increase usable product surface area has the potential to provide the benefits of prepectoral implant reconstruction while responsibly preserving product availability and tempering healthcare costs.

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### REFERENCES

- Gabriel A, Sigalove S, Sigalove NM, et al. Prepectoral revision breast reconstruction for treatment of implant-associated animation deformity: a review of 102 reconstructions. *Aesthet Surg J*. 2018;38:519–526.
- Sigalove S, Maxwell GP, Sigalove NM, et al. Prepectoral implant-based breast reconstruction: rationale, indications, and preliminary results. *Plast Reconstr Surg*. 2017;139:287–294.
- Antony AK, Poirier J, Madrigano A, et al. Evolution of the surgical technique for “breast in a day” direct-to-implant breast reconstruction: transitioning from dual-plane to prepectoral implant placement. *Plast Reconstr Surg*. 2019;143:1547–1556.
- Sbitany H, Piper M, Lentz R. Prepectoral breast reconstruction: a safe alternative to submuscular prosthetic reconstruction following nipple-sparing mastectomy. *Plast Reconstr Surg*. 2017;140:432–443.
- Vidya R, Iqbal FM. A guide to prepectoral breast reconstruction: a new dimension to implant-based breast reconstruction. *Clin Breast Cancer*. 2017;17:266–271.
- Kobraei EM, Cauley R, Gadd M, et al. Avoiding breast animation deformity with pectoralis-sparing subcutaneous direct-to-implant breast reconstruction. *Plast Reconstr Surg Glob Open*. 2016;4:e708.
- Cattelani L, Polotto S, Arcuri MF, et al. One-step prepectoral breast reconstruction with dermal matrix-covered implant compared to submuscular implantation: functional and cost evaluation. *Clin Breast Cancer*. 2018;18:e703–e711.
- Berna G, Cawthorn SJ, Papaccio G, et al. Evaluation of a novel breast reconstruction technique using the Braxon acellular dermal matrix: a new muscle-sparing breast reconstruction. *ANZ J Surg*. 2017;87:493–498.
- Yang JY, Kim CW, Lee JW, et al. Considerations for patient selection: prepectoral versus subpectoral implant-based breast reconstruction. *Arch Plast Surg*. 2019;46:550–557.
- Storm-Dickerson T, Sigalove N. Prepectoral breast reconstruction: the breast surgeon’s perspective. *Plast Reconstr Surg*. 2017;140(6S Prepectoral Breast Reconstruction):43S–48S.



11. Sigalove S. Prepectoral breast reconstruction and radiotherapy—a closer look. *Gland Surg.* 2019;8:67–74.
12. Antony AK, Robinson EC. An algorithmic approach to prepectoral direct-to-implant breast reconstruction: version 2.0. *Plast Reconstr Surg.* 2019;143:1311–1319.
13. Sinnott CJ, Persing SM, Pronovost M, et al. Impact of postmastectomy radiation therapy in prepectoral versus subpectoral implant-based breast reconstruction. *Ann Surg Oncol.* 2018;25:2899–2908.
14. Salibian AA, Frey JD, Choi M, et al. Subcutaneous implant-based breast reconstruction with acellular dermal matrix/mesh: a systematic review. *Plast Reconstr Surg Glob Open.* 2016;4:e1139.
15. Casella D, Bernini M, Bencini L, et al. TiLoop Bra mesh used for immediate breast reconstruction: comparison of retropectoral and subcutaneous implant placement in a prospective single-institution series. *Eur J Plast Surg.* 2014;37:599–604.
16. Bernini M, Calabrese C, Cecconi L, et al. Subcutaneous direct-to-implant breast reconstruction: surgical, functional, and aesthetic results after long-term follow-up. *Plast Reconstr Surg Glob Open.* 2015;3:e574.
17. Jones G, Yoo A, King V, et al. Prepectoral immediate direct-to-implant breast reconstruction with anterior AlloDerm coverage. *Plast Reconstr Surg.* 2017;140(6S Prepectoral Breast Reconstruction):31S–38S.
18. Maxwell GP, Gabriel A. Bioengineered breast: concept, technique, and preliminary results. *Plast Reconstr Surg.* 2016;137:415–421.
19. Reitsamer R, Peintinger F. Prepectoral implant placement and complete coverage with porcine acellular dermal matrix: a new technique for direct-to-implant breast reconstruction after nipple-sparing mastectomy. *J Plast Reconstr Aesthet Surg.* 2015;68:162–167.
20. Becker H, Lind JG II, Hopkins EG. Immediate implant-based prepectoral breast reconstruction using a vertical incision. *Plast Reconstr Surg Glob Open.* 2015;3:e412.
21. Sigalove S. Options in acellular dermal matrix-device assembly. *Plast Reconstr Surg.* 2017;140(6S Prepectoral Breast Reconstruction):39S–42S.
22. Downs RK, Hedges K. An alternative technique for immediate direct-to-implant breast reconstruction—a case series. *Plast Reconstr Surg Glob Open.* 2016;4:e821.
23. Lee JS, Kim JS, Lee JH, et al. Prepectoral breast reconstruction with complete implant coverage using double-crossed acellular dermal matrixes. *Gland Surg.* 2019;8:748–757.
24. Nahabedian MY, Cocilovo C. Two-stage prosthetic breast reconstruction: a comparison between prepectoral and partial subpectoral techniques. *Plast Reconstr Surg.* 2017;140(6S Prepectoral Breast Reconstruction):22S–30S.
25. *Breast Cancer: Facts and Figures 2019–2020.* Available at <https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/breast-cancer-facts-and-figures/breast-cancer-facts-and-figures-2019-2020.pdf>. Published 2019. Accessed December 11, 2019.
26. Liu D. *New Plastic Surgery Statistics and Breast Reconstruction Trends.* Available at <https://www.plasticsurgery.org>. Published 2017. Accessed December 11, 2019.
27. Holm C, Dornseifer U, Sturtz G, et al. The intrinsic transit time of free microvascular flaps: clinical and prognostic implications. *Microsurgery.* 2010;30:91–96.
28. Pusic AL, Klassen AF, Scott AM, et al. Development of a new patient-reported outcome measure for breast surgery: the BREAST-Q. *Plast Reconstr Surg.* 2009;124:345–353.
29. Childers CP, Maggard-Gibbons M. Understanding costs of care in the operating room. *JAMA Surg.* 2018;153:e176233.
30. Hill EJ, Buck DW II. The “butterfly” wrap: a simplified technique for consistent prosthesis coverage in prepectoral breast reconstruction. *Plast Reconstr Surg Glob Open.* 2018;6:e2007.
31. Paydar KZ, Wirth GA, Mowlds DS. Prepectoral breast reconstruction with fenestrated acellular dermal matrix: a novel design. *Plast Reconstr Surg Glob Open.* 2018;6:e1712.
32. Palaia DA, Arthur KS, Cahan AC, et al. Incidence of seromas and infections using fenestrated versus nonfenestrated acellular dermal matrix in breast reconstructions. *Plast Reconstr Surg Glob Open.* 2015;3:e569.
33. Baker BG, Irri R, MacCallum V, et al. A prospective comparison of short-term outcomes of subpectoral and prepectoral strattice-based immediate breast reconstruction. *Plast Reconstr Surg.* 2018;141:1077–1084.
34. Woo A, Harless C, Jacobson SR. Revisiting an old place: single-surgeon experience on post-mastectomy subcutaneous implant-based breast reconstruction. *Breast J.* 2017;23:545–553.
35. Viesel-Mathieu A, Alnaif N, Aljerian A, et al. Acellular dermal matrix-sparing direct-to-implant prepectoral breast reconstruction: a comparative study including cost analysis. *Ann Plast Surg.* 2020;84:139–143.
36. Lotan AM, Cohen D, Nahmany G, et al. Histopathological study of meshed versus solid sheet acellular dermal matrices in a porcine model. *Ann Plast Surg.* 2018;81:609–614.
37. Zammit D, Kanevsky J, Meng FY, et al. Meshed acellular dermal matrix: technique and application in implant based breast reconstruction. *Plast Aesthet Res* 2016;3:254–256.
38. Cottler PS, Sun N, Thuman JM, et al. The biointegration of a porcine acellular dermal matrix in a novel radiated breast reconstruction model. *Ann Plast Surg.* 2020;84(6S Suppl 5): S417–S423.
39. Thangarajah F, Treeter T, Krug B, et al. Comparison of subpectoral versus prepectoral immediate implant reconstruction after skin- and nipple-sparing mastectomy in breast cancer patients: a retrospective hospital-based cohort study. *Breast Care (Basel).* 2019;14:382–387.
40. Mirhaidari SJ, Azouz V, Wagner DS. Prepectoral versus subpectoral direct to implant immediate breast reconstruction. *Ann Plast Surg.* 2020;84:263–270.