

Prepectoral Implant-Based Breast Reconstruction

Lyndsey Highton, BMBCh, MA,
FRCS(Plast)
Richard Johnson, MBChB, BSc,
FRCS
Cliona Kirwan, MBChB, PhD,
FRCS
John Murphy, MBChB, PhD,
FRCS

Background: The development of acellular dermal matrices (ADMs) has facilitated single-stage implant breast reconstruction (IBR) following skin-sparing mastectomy. The conventional approach of postpectoral implant placement with lower pole ADM confers a good cosmetic result by improving lower pole projection and control, while minimizing issues of implant visibility, palpability, and rippling. This is balanced with potential disadvantages including pain, disruption of pectoral muscle function, and animation. We report the results of a prospective study of prepectoral IBR with total ADM coverage.

Methods: Prepectoral IBR with total ADM coverage was performed in 106 patients (166 breasts) in our institution from 2013 to 2017. The cohort included patients undergoing immediate IBR (113 breasts) and revision of existing submuscular IBR (53 breasts). Patient demographics, surgical complications, and outcomes from a prospective database were analyzed.

Results: At a mean follow-up of 485 days, patient satisfaction and cosmetic outcomes have been good, with no significant capsular contractures or animation deformity. Minor complications including delayed healing, red breast, or seroma occurred in 14 breasts (8.4%). Major complications including necrosis and implant loss occurred in 5 breasts (3 patients), with a total explantation rate of 3%. No patients required more than an overnight stay in hospital, and there were no delays to adjuvant treatment in therapeutic cases.

Conclusion: Prepectoral implant placement with ADM cover is emerging as an alternative approach for IBR. This method facilitates breast reconstruction with a good cosmetic outcome for patients who want a quick recovery without potential compromise of pectoral muscle function and associated problems. (*Plast Reconstr Surg Glob Open* 2017;5:e1488; doi: 10.1097/GOX.0000000000001488; Published online 19 September 2017.)

INTRODUCTION

The removal of breast tissue during a mastectomy can often leave behind a very thin flap that provides inadequate soft-tissue coverage for IBR. For this reason, submuscular implant placement became the standard of care. Placing the implant behind the pectoralis major muscle (PMM) reduces implant visibility, palpability, rippling, and the risk of capsular contracture. However, pectoral muscle detachment has been associated with a number of complications including pain and functional impairment of PMM.¹⁻³ This is often unacceptable to women who require PMM function for occupational or sporting requirements and activities of daily living. Patients may

also complain of breast animation on contraction of the pectoral muscle.³ In addition, early techniques involving complete submuscular placement often resulted in unnatural appearing breast, as the muscle limited lower pole expansion and ptosis.

Acellular dermal matrices (ADMs) are increasingly used as an adjunct in IBR following mastectomy.⁴ ADMs are decellularized soft-tissue matrix grafts that behave as a collagen scaffold, allowing repopulation, revascularization and integration of the host's cells into the implanted tissue.⁵ These matrices can be made from human cadaveric skin or xenogenic materials such as porcine skin or bovine pericardium. Techniques have evolved from 2-stage complete submuscular placement of tissue expander (TE),^{6,7} to single-stage direct to implant (DTI) reconstruction using partial submuscular coverage and an ADM to cover the lower part of the implant.⁸⁻¹⁰ Excellent cosmetic outcomes can be achieved as the ADM facilitates natural ptosis and definition of the inframammary fold. Despite this, there are problems with subpectoral implant placement.

From the Nightingale Breast Centre, University Hospital of South Manchester NHS Foundation Trust, United Kingdom.

Received for publication May 5, 2017; accepted July 19, 2017.

Copyright © 2017 The Authors. Published by Wolters Kluwer Health, Inc. on behalf of The American Society of Plastic Surgeons. This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

DOI: 10.1097/GOX.0000000000001488

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.

Although the prevalence of animation is unclear in the literature, it is apparent in over 60% of subpectoral breast augmentations and presumed to be more problematic in reconstruction patients with less soft-tissue cover.³ Additionally, over a period of time the natural ptosis can be blunted by the continuous “pull” on the ADM by the still partially functional PMM.

We hypothesize that the prepectoral placement of an implant with total ADM coverage can provide an excellent cosmetic result by camouflaging upper pole irregularities and creating a well-defined pocket to avoid implant malposition, while avoiding the complications associated with detachment of the pectoral muscle. This technique has not been extensively described in the literature to date. We report the initial results of a prospective cohort study of prepectoral implant placement with total ADM cover.

METHODS

A prospective database was maintained for all patients undergoing prepectoral reconstruction at our institution since 2013. All patients provided informed consent for inclusion in the study, after a detailed description of the technique as well as all the potential risks and benefits. The data collected included patient demographics, baseline characteristics, indication for surgery, oncological data, surgical technique, and follow-up visits. Outcome data included length of hospital stay, complications, delay to adjuvant treatment, and the need for revisional surgery. Early complications were classified as “major” if the patients required a readmission to hospital and “minor” if they responded to nonoperative management. Specific complications included unplanned return to theatre, skin or nipple necrosis, implant loss, hematoma or seroma, infection requiring antibiotics, and delayed wound healing. Late complications of animation, rippling, or capsular contracture (graded using the Baker classification¹¹) were documented.

Surgical Technique

Prepectoral implant placement with total ADM cover is indicated for women undergoing immediate IBR and revision of existing IBR. We used the porcine ADM Strattice™ or Artia™ (LifeCell™ Corporation, Bridgewater, N.J.).

Immediate Prepectoral Implant-Based Reconstruction

Reconstruction is performed following skin-sparing, nipple-sparing (NSM), or skin-reducing mastectomy (SRM). The mastectomy pattern selected depended on the oncological status and/or the patient’s wish to retain the nipple and the degree of breast ptosis present. In all cases, great care was taken to maintain a well-vascularized subcutaneous tissue layer to ensure adequate blood supply to promote wound healing and ADM integration through neovascularization.

Two sheets of Strattice or Artia (generally Contour 2 and 8×16cm products) are prepared and sutured together on the bench using undyed 3/0 polydioxanone (Ethicon, N.J.). The superior edge of the ADM sheet is sutured to the upper mastectomy flap close to the chest wall interface. The cavity is irrigated and gloves changed before inserting the implant. An appropriately sized cohesive silicone gel implant is placed in the prepectoral position, beneath the ADM. The ADM is draped over the implant and sutures placed medially and laterally to create a snug pocket ensuring accurate implant positioning and good medial projection. Finally, sutures are placed to secure the ADM to fascia and periosteum, defining the inframammary fold. In total, 10–15 interrupted undyed 3/0 PDS (Ethicon) sutures are used to secure the ADM.

When nipple-sparing mastectomy was performed through an inframammary incision, the superior sutures were placed; then, the ADM construct was parachuted into the cavity (Figs. 1, 2). Other incisions in nonptotic breasts included periareolar (Fig. 3) and skin ellipse, depending on whether the nipple was to be retained or excised, respectively. In patients with significant breast ptosis, SRM was performed through a Wise pattern inci-

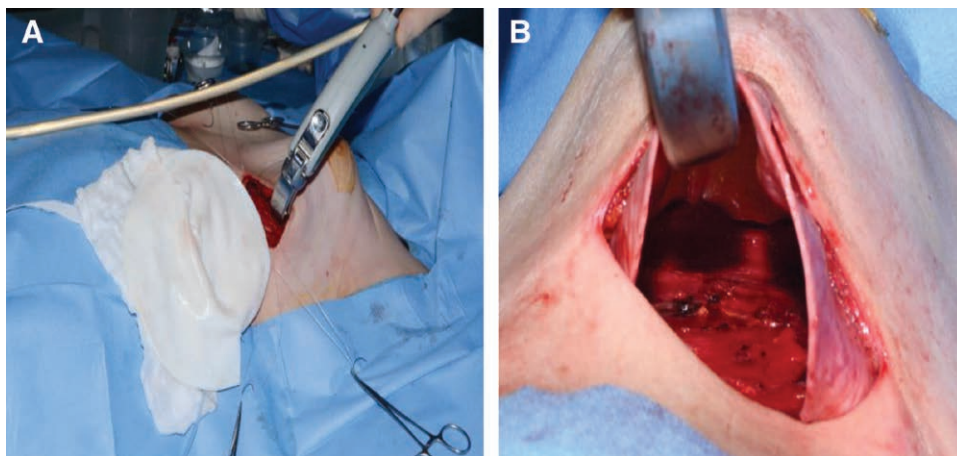


Fig. 1. An NSM has been performed through an inframammary fold incision. A, The 2 sheets of ADM are sutured together, and a series of superior sutures are placed. B, The ADM is parachuted into the cavity. Following prepectoral implant insertion, the ADM is draped over the implant and secured medially, laterally, and inferiorly to ensure accurate implant positioning.

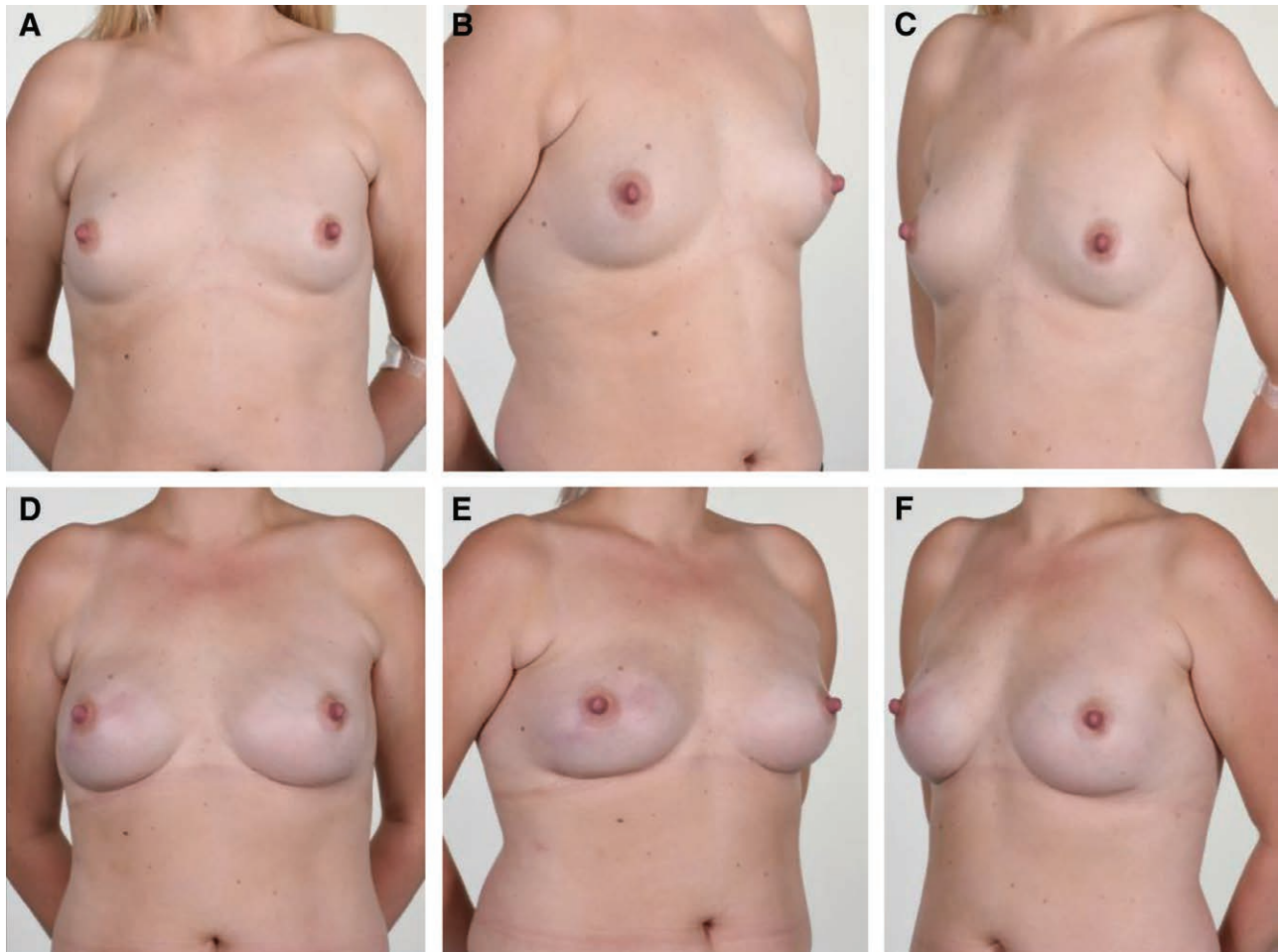


Fig. 2. Patients with minimal ptosis are good candidates for NSM and prepectoral implant-based reconstruction with full ADM cover. This figure shows a patient who had inframammary fold incision NSMs and prepectoral implant-based reconstruction. Patient shown preoperatively (A-C) and postoperatively (D-F).

sion (Figs. 4–6). In these cases, an inferior dermal flap was developed and used sutured to a superior sheet of ADM to provide full prepectoral implant coverage (Fig. 4).

Revision of Existing Submuscular Implant-Based Reconstruction

The technique has also been used for revision of existing submuscular IBR due to animation, disruption of pectoral muscle function, implant malposition, or capsular contracture. In these cases, the mastectomy plane is reentered through existing scars. Following implant removal, the pectoral muscle fibers are detached from the skin flap, replaced to their anatomical position, and sutured to the chest wall with 2/0 prolene (Ethicon). The technique then continues as described above.

Perioperative Care

A single-suction drain is inserted between the ADM and the skin flap and remains in situ for 7 days to minimize seroma. Antibiotic prophylaxis is teicoplanin and coamoxiclav on induction, followed by oral coamoxiclav for 5 days. Patients are discharged either on the same day or 1 day postoperatively.

RESULTS

Between June 2013 and February 2017, prepectoral implant-based breast reconstruction was performed for 166 breasts in 106 patients (Table 1). One hundred thirteen immediate reconstructions (68.1%) were performed following therapeutic (34 breasts) or risk-reducing (79 breasts) mastectomy. Fifty-three prepectoral reconstructions (31.9%) were performed for revision of existing submuscular implant-based reconstruction. In total, 27.7% of patients underwent unilateral procedures and 72.3% bilateral surgery.

The mean patient age was 44 years (range, 20–78), and the mean body mass index was 25.4 (range, 17.3–36.6). Among the cohort, 7 patients were smokers (6.6%) and 2 patients diabetic (1.9%).

In total, 73.5% of prepectoral reconstructions had full implant coverage with 2 sheets of Strattice™ or Strattice™/Artia™ combination, and 26.5% of breast had significant ptosis to allow prepectoral reconstruction with upper pole ADM and inferior dermal flap supporting the lower pole of the implant (Fig. 4; Table 2).

For patients having immediate reconstruction, the mean mastectomy weight was 527 g (range, 69–3,720 g;

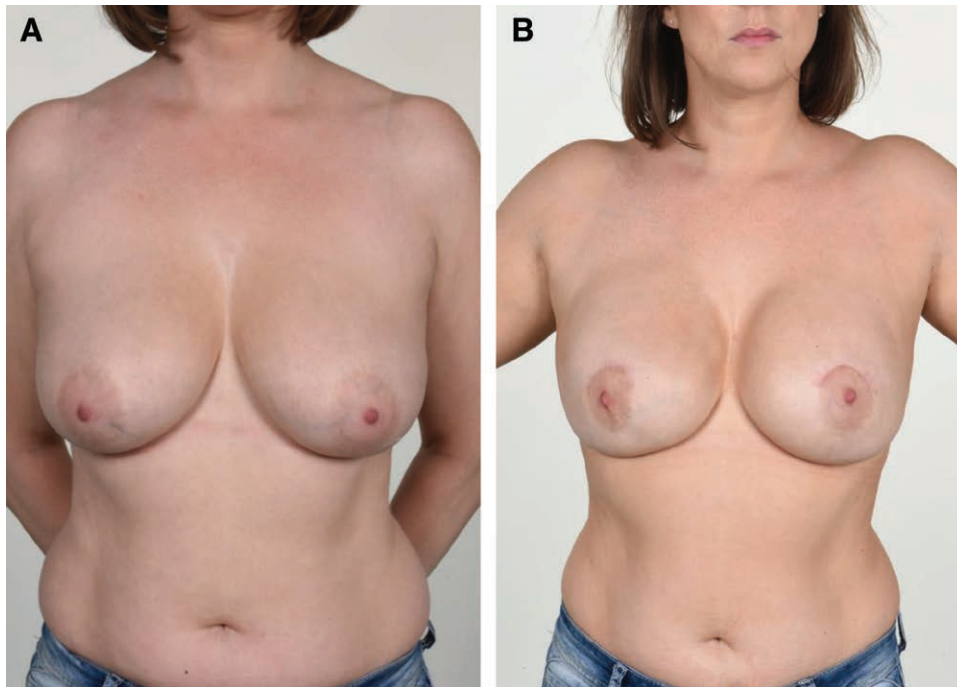


Fig. 3. A patient who had mastectomies through a superior periareolar incision, allowing slight nipple elevation, followed by prepectoral implant-based reconstruction. Patient shown preoperatively (A) and postoperatively (B).

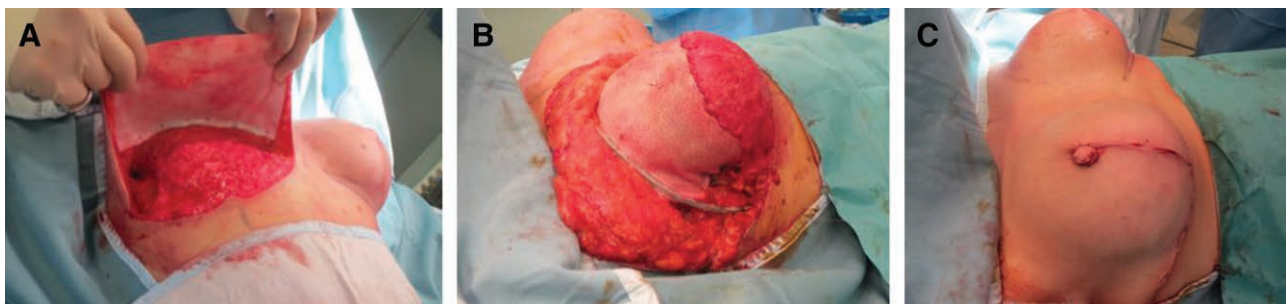


Fig. 4. An SRM is performed through a Wise pattern incision. Prepectoral implant-based reconstruction is performed, with superior ADM and inferior dermal flap coverage of the implant. A, The ADM is secured superiorly, then (B) the implant is inserted and the ADM and inferior dermal flap are sutured together. Finally, the mastectomy skin envelope is draped over the implant, and in this case, immediate nipple reconstruction is performed with a local flap (C).

SD, 532). Reconstruction was DTI in 92.8.2% of breasts and 2 stage with initial TE placement in 7.2% of breasts. The mean implant volume was 423 cc (range, 120–620 cc; SD, 113) in the patients undergoing DTI reconstruction. A nipple-sparing approach was used in 51 breasts (45.1% immediate IBR). Immediate nipple areolar complex reconstruction with free areolar graft was performed in 28 breasts (24.7%), and a free nipple graft was used in 4 breasts (3.5%).

Revisional prepectoral reconstruction was performed on 53 breasts with existing submuscular implant-based reconstruction. In these cases, previous implant placement had been total submuscular in 39 breasts (73.5%) and partial subpectoral with lower ADM pole cover in 14 breasts (26.4%). Revision was required due to breast animation in 39 breasts (74%), implant malposition in 8 breasts (15%), intractable pain in 4 breasts (8%), and Baker grade IV

capsular contracture in 2 breasts (4%). Some patients presented with more than 1 problem.

Neoadjuvant chemotherapy was given to 5 (14.7%) therapeutic cases and adjuvant chemotherapy to 6 (17.6%) therapeutic cases. Ten breasts had received prior radiotherapy (whole breast or mantle; 6%), and 4 therapeutic cases required adjuvant radiotherapy (11.8%).

Using this technique, no patients required more than a 1-night stay in the hospital, with many patients allowed home on a day case basis. There were no delays to adjuvant treatment.

To date, patients have been followed up for a mean of 485 days (range, 81–1,446 days; SD, 279 days). They were reviewed in the clinic at 1, 2, and 6 weeks postoperatively and at 3-monthly intervals thereafter. Information about the outcome of the surgery was collected and recorded in the prospective database at each visit.

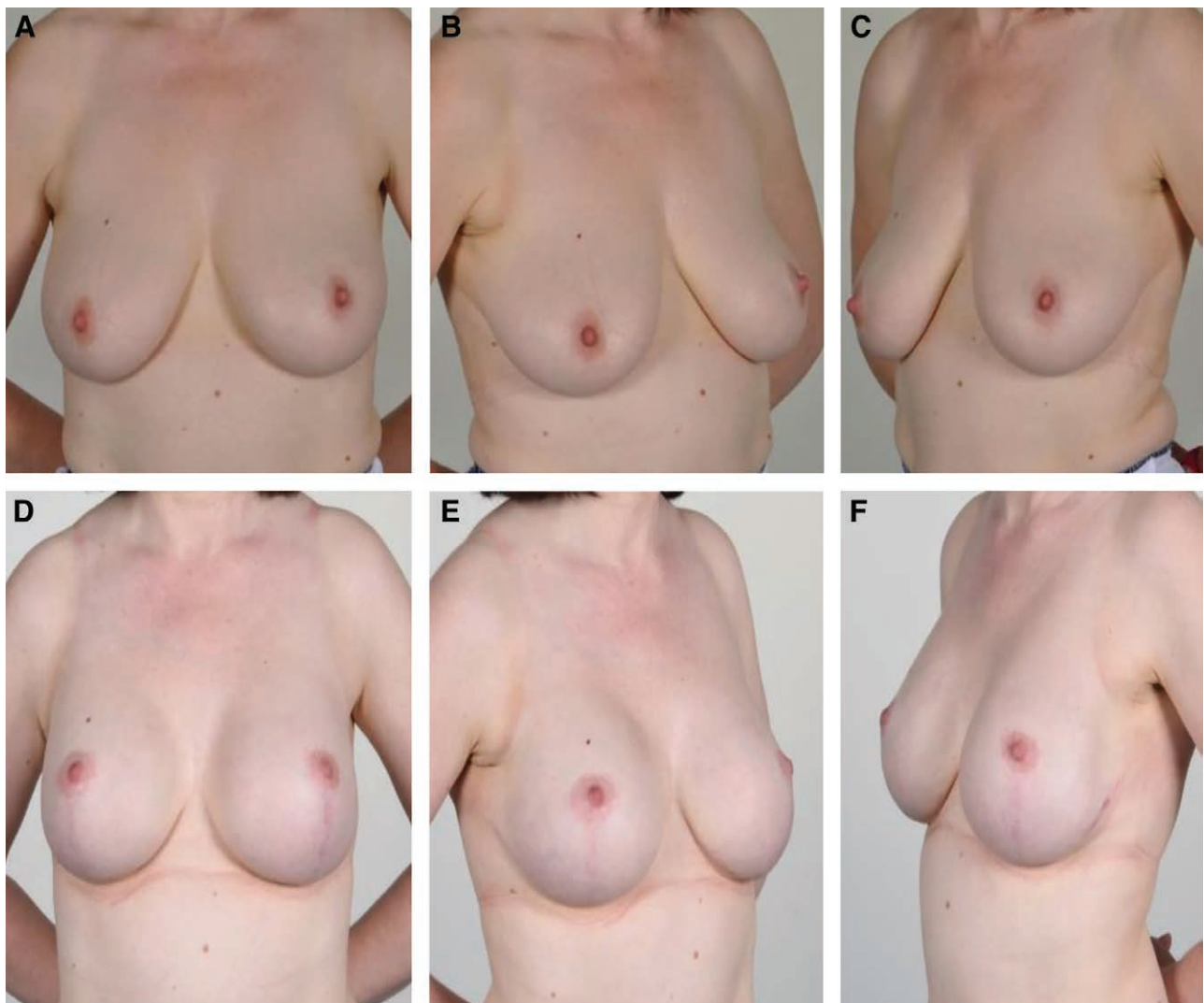


Fig. 5. NSMs in patients with ptosis can be problematic. A patient who had nipples elevated on a superior dermal flap and direct to prepectoral implant-based reconstruction with ADM and inferior dermal flap. Patient shown preoperatively (A-C) and postoperatively (D-F).

Complications occurred in 19 breasts (11.4%; Table 3). Minor complications occurred in 14 breasts (8.4%) including red breast, seroma, or minor wound issues (Table 4).

Major complications of skin or nipple necrosis or major wound healing delay occurred in 5 breasts in 3 patients and resulted in implant loss (Table 5; Fig. 7). All major complications were seen in the group undergoing immediate prepectoral DTI reconstruction, giving an implant loss rate of 4.4% in this cohort and 0% in the revisional group.

In patients followed up for longer than 12 months, the complications usually associated with submuscular implant placement such as breast animation, implant malposition, restriction in shoulder mobility, and postoperative pain have not been reported. Four patients have had reoperation for rippling (Fig. 8), which included fat grafting and exchanging to a cohesive gel polyurethane-coated implant, which objectively improved the appearance of rippling. No patients have developed Baker grade 3 or 4 capsular contracture to date.

DISCUSSION

The use of ADM in IBR is a technique that has gained increasing popularity and acceptance in the field of reconstructive breast surgery over the last decade. Prepectoral implant placement with total ADM coverage avoids disruption of PMM function, animation deformity, and implant malposition. Using this technique, postoperative pain appears to be reduced and recovery is faster. Results are promising, with a complication rate comparable, if not superior to published series of subpectoral implant reconstruction with lower pole ADM coverage^{8-10,12-14} and good aesthetic outcomes. The limited number of complications observed, despite adopting a new technique, may be explained by our previous extensive experience with the use of ADMs. In addition, patients are closely monitored for complications in the postoperative phase, and these are managed aggressively. This includes ultrasound aspiration of seroma and the application of topical negative pressure and/or wound debridement and closure if dehiscence occurs.

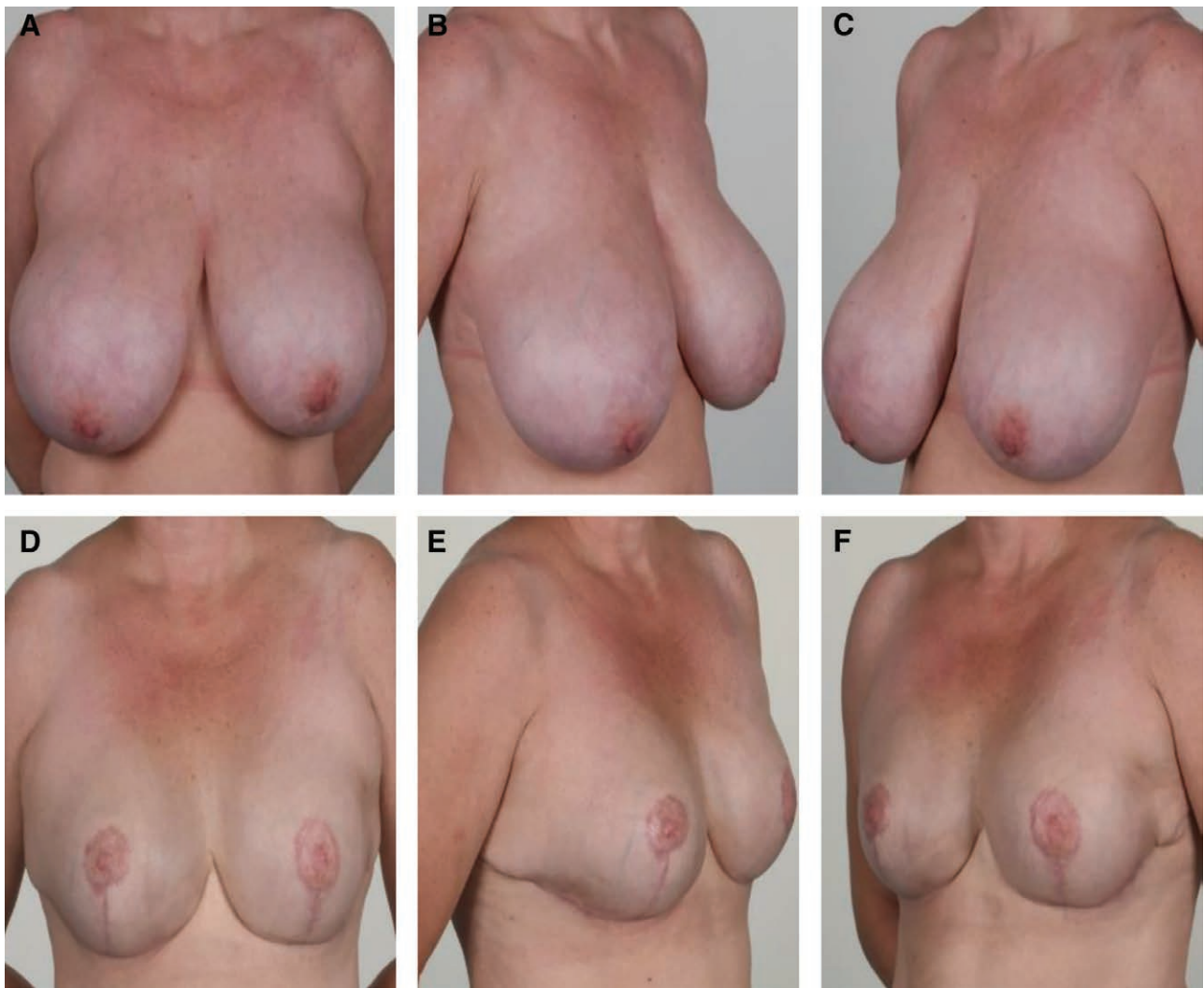


Fig. 6. With this patient, the distance required to elevate the nipples is larger so a free nipple graft technique was employed. Again, reconstruction was direct to prepectoral implant-based reconstruction with ADM and inferior dermal flap. Patient shown preoperatively (A-C) and postoperatively (D-F).

Table 1. Patient Demographics

Category	Value
No. patients	106
No. breasts	166
Age at the time of surgery (y)	
Mean	44
Range	20–78
BMI (kg/m ²)	
Mean	25.4
Range	17.3–36.6
Smokers, n (% patients)	7 (6.6)
Diabetics, n (% patients)	2 (1.9)
Radiation, n (% of breasts)	10 (6.0)
Previous	6 (3.6)
Adjuvant	4 (11.8% therapeutic cases)
Chemotherapy, n (% of breasts; therapeutic cases)	11 (32.4)
Neoadjuvant	5 (14.7)
Adjuvant	6 (17.6)
Follow-up duration (d)	
Mean	485
Range	81–1,446
SD	279

BMI, body mass index.

Given the small cohort, no association can be made between radiotherapy and outcomes. We generally advocate autologous reconstruction for patients requiring radiotherapy. The cohort who underwent radiotherapy developed no major complications, and it remains to be seen whether ADM provides any protection against the deleterious effects of radiotherapy on IBR.

Although a substantial body of literature exists describing the use of ADMs for primary and revision breast reconstruction, this has not extended to total implant coverage. Reitsamer and Peintinger¹⁵ have described a similar technique of prepectoral implant placement and complete coverage with porcine ADM (Strattice™) for IBR. They used the technique in a total of 22 breasts in 13 patients following NSM. After a mean follow-up of 6 months, the results were extremely promising with a low rate of complications and excellent patient satisfaction regarding the cosmetic outcome. Berna et al.¹⁶ also reported a technique of prepectoral muscle-sparing breast reconstruction using a preshaped ADM (Braxon®) in 15 breasts. Using this technique, they reported no major

Table 2. Surgical Data

Category	Value
Indication for surgery, n (% of breasts)	
Immediate IBR	113 (68.1)
Therapeutic mastectomy	34 (20.5%)
Risk reducing mastectomy	79 (47.6%)
Revision of existing sub-muscular IBR	53 (31.9%)
Unilateral implants, n (% of breasts)	46 (27.7%)
Bilateral implants, n (% of breasts)	120 (72.3%)
Mastectomy specimen weight (g)	
Mean	526.8
Range	69–3,720
SD	532
Axillary surgery, n (% of breasts; therapeutic cases)	30 (88.2)
Sentinel lymph node biopsy	22 (64.7)
Axillary node clearance	8 (23.5)
Implant size (CC)	
Mean	423
Range	120–620
SD	113
DTI, n (%)	154 (92.8)
TE, n (%)	12 (7.2)
ADM coverage, n (% of breasts)	
Full ADM coverage	122 (73.5)
ADM + inferior dermal flap	44 (26.5)
Incision pattern, n (% of breasts)	
IMF	71 (42.8)
Periareolar	45 (27.1)
Ellipse	24 (14.5)
Wise	14 (8.4)
Previous scar	12 (7.2)

IMF, inframammary fold.

complications, no long-term complications including capsular contracture and a satisfying aesthetic result. Similar results have been achieved with prepectoral implant placement and implant coverage with the synthetic mesh TiLoop®.¹⁷

Sigalove et al.¹⁸ published the largest series to date of 350 immediate prepectoral breast reconstructions using Alloderm™, coupled with routine delayed lipofilling to augment the soft-tissue coverage of the implant. The rate of complications was < 5%, and there were no cases of capsular contracture.

Capsular contracture is a well-known complication of implant-based breast reconstruction and is one of the most common reasons for revision surgery. The immunologically inert nature of ADMs has been suggested to confer a protective effect against capsule formation, fibrosis, and contraction by minimizing this inflammatory cascade.^{19–21} To date in our series, capsular contracture has not been problematic. A low incidence of capsular contracture was also reported in the other recent studies of prepectoral implant-based reconstruction with total ADM coverage.^{15,16,18}

Other studies of prepectoral reconstruction have excluded patients with large size or ptotic breasts. By using an inferior dermal flap in conjunction with an ADM, we have been able to offer prepectoral reconstruction to a wider range of patients.

We also report this as a valuable technique that can also be applied to challenging cases requiring revision of previous subpectoral implant-based breast reconstructions presenting to our tertiary oncoplastic unit. The repositioning of the pectoral muscles fibers to their anatomical position and the change of pocket plane to prepectoral with total ADM cover has been successful in treating breast animation. Furthermore, we are accumulating data to demonstrate that this technique is beneficial for patients experiencing functional difficulties and chronic pain due to existing subpectoral reconstruction.

Table 3. Complications

	Immediate IBR	Revision of Submuscular IBR	Total
No. patients	71	35	106
No. breasts, n (%)	113	53	166
DTI	103 (91.2)	51 (96.2)	(92.8)
TE	10 (8.8)	2 (3.8)	12 (7.2)
Complications, n (% of breasts)			
Major (necrosis/implant loss)	5 (4.4)	0	5 (3.0)
Minor (delayed healing/red breast/seroma)	10 (8.8)	4 (7.5)	14 (8.4)
Explantation rate	5 (4.4)	0	5 (3.0)

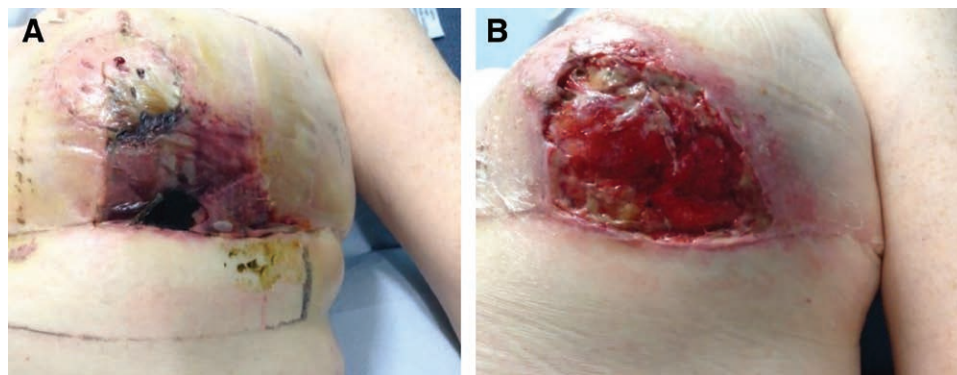


Fig. 7. Major complications leading to implant loss occurred in 5 breasts in 3 patients, with a total explantation rate of 3%. Photographs show skin flap necrosis requiring debridement and explantation.

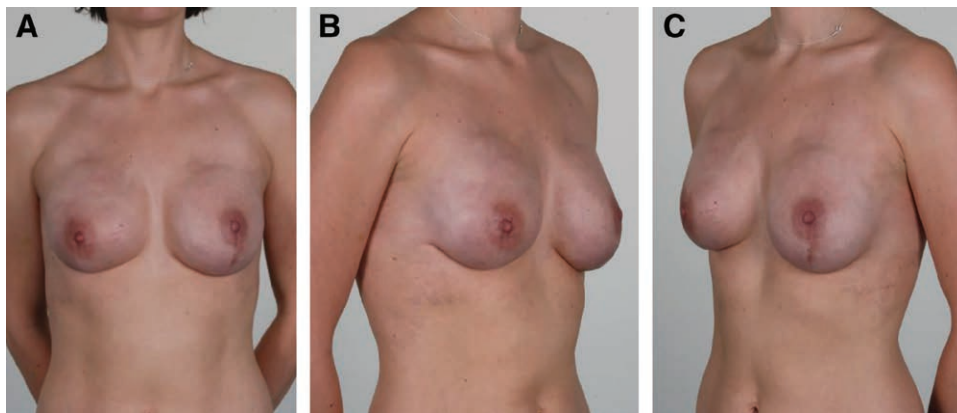


Fig. 8. A patient who underwent NSMs through inframammary fold incisions and prepectoral implant-based reconstruction with ADM cover. She has minor contour deformities/rippling in the upper poles amenable to correction with fat grafting.

Table 4. Minor Complications

Complication	Percentage of Breasts
Red breast	1.2
Seroma	3
Minor slough/infection/healing delay	4.2

Although early results with prepectoral ADM implant-based reconstruction are promising, there is a need for larger cohort studies directly comparing the outcomes of pre- and subpectoral, including outcome measures for animation and rippling. An unpublished pilot study conducted in our department compared 20 prepectoral and 20 subpectoral/lower pole ADM breast reconstructions. There was no significant difference in pain scores between the prepectoral group (mean, 1.45) and the subpectoral group (mean, 1.51) during the first 7 days ($P = 0.45$). Thirty-one BREAST-QTM were returned at 3 months postoperatively; mean Q scores were similar for both prepectoral (72) and subpectoral (71) groups ($P = 0.81$). There was no significant difference in length of stay (median 1 day in both groups; $P = 0.53$) or early morbidity. These early results suggest at least noninferiority to subpectoral and ADM IBR.

A significant concern with prepectoral reconstruction is the development of traction rippling, particularly for individuals in whom the mastectomy skin flaps are naturally thin. It is important to emphasize that we do not alter

mastectomy skin flap thickness to avoid this potential issue, and mastectomy is always performed along the correct anatomical plane. Indeed, leaving “thicker” mastectomy skin flaps puts patients at unnecessary and unacceptable risk, both in the therapeutic and risk-reducing setting. In patients in whom the mastectomy skin thickness is naturally thin (< 5 mm), the risk of rippling is apparent. However, this can be minimized using firm, highly cohesive gel implants, for example, Mentor CPGTM Gel Breast Implants Cohesive III, Polyurethane-coated implants (POLYTECH Health and Aesthetics GmbH), or dual gel anatomical implants (Allergan NatrelleTM 510), and also by ensuring a very snug pocket for the implant to sit in encouraging close implant/ADM adhesion and thereby minimizing the risk of rippling. We have used lipofilling to effectively address this problem in a small group of patients, although do not advocate routine lipofilling as suggested by Sigalove et al.¹⁸

ADMs are expensive materials and there are cost implications to using 2 sheets in place of 1 for complete implant coverage. Although an economic analysis was not the primary aim of this study, this additional expense may be offset by reductions in length of stay; patient recovery is faster and postoperative pain is reduced when the pectoral muscle is not detached. Long-term savings in the form of a reduction in incidence of capsular contracture and the need for revision surgery may also be areas for future cost savings. Companies are now tailoring the manufacture of these matrices to meet the demand of surgeons

Table 5. Major Complications

Major Complications (5 Breasts in 3 Patients)	Indication	Technique	Comorbidities	Complication
Patient 1 (age, 32 y)	Bilateral risk-reducing mastectomies	Wise pattern incision with nipples elevated on pedicles Prepectoral IBR with full Strattice cover	None	Skin and nipple necrosis leading to prosthetic exposure
Patient 2 (age, 42 y)	Bilateral risk-reducing mastectomies	Periareolar incision with nipple sacrifice Prepectoral IBR with full Strattice cover	Smoker	Recalcitrant seroma leading to wound breakdown and prosthetic exposure
Patient 3 (age, 59 y)	Unilateral therapeutic mastectomy + SLNB	Wise pattern incision with nipple sacrifice Prepectoral IBR with upper Strattice and lower dermal sling cover	Previous breast reduction	Skin necrosis leading to prosthetic exposure

SLNB, sentinel lymph node biopsy.

with the development of single large sheets and ready made “envelopes.” Several studies have compared the cost-effectiveness of breast reconstruction with autologous and nonautologous tissue, including ADMs and reported no significant differences.^{22–25}

CONCLUSIONS

Prepectoral implant placement with full ADM cover is emerging as a technique for breast reconstruction. This method facilitates immediate IBR with a good cosmetic outcome for patients who want a quick recovery, without the potential compromise of pectoral muscle disruption. By using Wise pattern incisions and an inferior dermal flap when available, this approach can be offered to a wider range of patients. Furthermore, it is a useful technique for revision of existing submuscular IBR in patients complaining of animation or functional disturbance. Although this cohort study has shown promising initial results, there is a need for further cohort studies comparing pre- and subpectoral IBR and an economic analysis.

Lyndsey Highton, *BMBCh, MA, FRCS(Plast)*
Nightingale Breast Centre
University Hospital of South Manchester
NHS Foundation Trust
Southmoor Road
Wythenshawe
Manchester
United Kingdom M23 9LT
E-mail: lyndseyhighton@hotmail.com

ACKNOWLEDGMENTS

The authors thank Ben Baker, Specialty Registrar in Plastic Surgery, James Harvey, Consultant Breast Surgeon, and Siobhan O’Ceallaigh, Consultant Plastic Surgeon.

REFERENCES

- de Haan A, Toor A, Hage JJ, et al. Function of the pectoralis major muscle after combined skin-sparing mastectomy and immediate reconstruction by subpectoral implantation of a prosthesis. *Ann Plast Surg.* 2007;59:605–610.
- Madsen RJ, Jr, Chim J, Ang B, et al. Variance in the origin of the pectoralis major muscle: implications for implant-based breast reconstruction. *Ann Plast Surg.* 2015;74:111–113.
- Spear SL, Schwartz J, Dayan JH, et al. Outcome assessment of breast distortion following submuscular breast augmentation. *Aesthetic Plast Surg.* 2009;33:44–48.
- Ibrahim AM, Ayeni OA, Hughes KB, et al. Acellular dermal matrices in breast surgery: a comprehensive review. *Ann Plast Surg.* 2013;70:732–738.
- Wainwright DJ. Use of an acellular allograft dermal matrix (AlloDerm) in the management of full-thickness burns. *Burns.* 1995;21:243–248.
- Sbitany H, Sandeen SN, Amalfi AN, et al. Acellular dermis-assisted prosthetic breast reconstruction versus complete submuscular coverage: a head-to-head comparison of outcomes. *Plast Reconstr Surg.* 2009;124:1735–1740.
- Hanna KR, DeGeorge BR, Jr, Mericli AF, et al. Comparison study of two types of expander-based breast reconstruction: acellular dermal matrix-assisted versus total submuscular placement. *Ann Plast Surg.* 2013;70:10–15.
- Salzberg CA, Ashikari AY, Koch RM, et al. An 8-year experience of direct-to-implant immediate breast reconstruction using human acellular dermal matrix (AlloDerm). *Plast Reconstr Surg.* 2011;127:514–524.
- Salzberg CA, Dunavant C, Nocera N. Immediate breast reconstruction using porcine acellular dermal matrix (Strattice™): long-term outcomes and complications. *J Plast Reconstr Aesthet Surg.* 2013;66:323–328.
- Colwell AS, Damjanovic B, Zahedi B, et al. Retrospective review of 331 consecutive immediate single-stage implant reconstructions with acellular dermal matrix: indications, complications, trends, and costs. *Plast Reconstr Surg.* 2011;128:1170–1178.
- Spear SL, Baker JL, Jr. Classification of capsular contracture after prosthetic breast reconstruction. *Plast Reconstr Surg.* 1995;96:1119–1123; discussion 1124.
- Chun YS, Verma K, Rosen H, et al. Implant-based breast reconstruction using acellular dermal matrix and the risk of postoperative complications. *Plast Reconstr Surg.* 2010;125:429–436.
- Ho G, Nguyen TJ, Shahabi A, et al. A systematic review and meta-analysis of complications associated with acellular dermal matrix-assisted breast reconstruction. *Ann Plast Surg.* 2012;68:346–356.
- Sbitany H, Serletti JM. Acellular dermis-assisted prosthetic breast reconstruction: a systematic and critical review of efficacy and associated morbidity. *Plast Reconstr Surg.* 2011;128:1162–1169.
- 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.
- 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.
- 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.
- 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.
- Schmitz M, Bertram M, Kneser U, et al. Experimental total wrapping of breast implants with acellular dermal matrix: a preventive tool against capsular contracture in breast surgery? *J Plast Reconstr Aesthet Surg.* 2013;66:1382–1389.
- Stump A, Holton LH, 3rd, Connor J, et al. The use of acellular dermal matrix to prevent capsule formation around implants in a primate model. *Plast Reconstr Surg.* 2009;124:82–91.
- Cheng A, Lakhiani C, Saint-Cyr M. Treatment of capsular contracture using complete implant coverage by acellular dermal matrix: a novel technique. *Plast Reconstr Surg.* 2013;132:519–529.
- Bank J, Phillips NA, Park JE, et al. Economic analysis and review of the literature on implant-based breast reconstruction with and without the use of the acellular dermal matrix. *Aesthetic Plast Surg.* 2013;37:1194–1201.
- Johnson RK, Wright CK, Gandhi A, et al. Cost minimisation analysis of using acellular dermal matrix (Strattice™) for breast reconstruction compared with standard techniques. *Eur J Surg Oncol.* 2013;39:242–247.
- Grover R, Padula WV, Van Vliet M, et al. Comparing five alternative methods of breast reconstruction surgery: a cost-effectiveness analysis. *Plast Reconstr Surg.* 2013;132:709e–723e.
- Kilchenmann AJ, Lardi AM, Ho-Asjoe M, et al. An evaluation of resource utilisation of single stage porcine acellular dermal matrix assisted breast reconstruction: a comparative study. *Breast.* 2014;23:876–882.