Ann Surg Oncol
https://doi.org/10.1245/s10434-018-6602-7

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY

ORIGINAL ARTICLE – BREAST ONCOLOGY

Impact of Postmastectomy Radiation Therapy in Prepectoral Versus Subpectoral Implant-Based Breast Reconstruction

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ABSTRACT

Background. This study aimed to compare the impact of postmastectomy radiation therapy (PMRT) on outcomes after prepectoral versus subpectoral implant-based breast reconstruction with local deepithelialized dermal flap and acellular dermal matrix (ADM).

Methods. From 2010 to 2017, 274 patients (426 breasts) underwent prepectoral reconstruction. In this group, 241 patients (370 breasts) were not exposed to PMRT, whereas 45 patients (56 breasts) were exposed to PMRT. Of 100 patients (163 breasts) who underwent partial subpectoral reconstruction, 87 (140 breasts) were not exposed to PMRT, whereas 21 patients (23 breasts) were exposed. The outcomes were assessed by comparing complication rates between the pre- and subpectoral groups.

Results. A higher rate of capsular contracture was found for the prepectoral patients with PMRT than for those without PMRT (16.1 vs 3.5%; $p = 0.0008$) and for the subpectoral patients with PMRT than for those without PMRT (52.2 vs 2.9%; $p = 0.0001$). The contracture rate was three times higher for the subpectoral patients with PMRT than for the prepectoral patients with PMRT (52.2 vs 16.1%; $p = 0.0018$). In addition, 10 (83.3%) of 12 cases with capsular contracture in the subpectoral cohort that received PMRT were Baker grades 3 or 4 compared with only 2 (22.2%) of 9 cases of the prepectoral group with PMRT ($p = 0.0092$).

Conclusions. The patients undergoing subpectoral breast reconstruction who received PMRT had a capsular contracture rate three times greater with more severe contractures (Baker grade 3 or 4) than the patients receiving PMRT who underwent prepectoral breast reconstruction.

Approximately 80% of all breast reconstructions performed after mastectomy in the United States are implant-based reconstructions.[1] Traditionally, implant-based breast reconstruction involves subpectoral reconstruction with total coverage of the implant and with elevation of the pectoralis major muscle and rectus abdominis and serratus fascia. Over time, reconstruction techniques to cover tissue expanders and implants have evolved from total muscular coverage to implant coverage with only the elevated pectoralis major muscle in conjunction with an acellular dermal matrix (ADM) sling to cover the lower lateral pole. As a natural progression, the use of ADM to cover the entire device has evolved during the last few years, with more and more implant surface being covered by ADM rather than muscle.

With the proven safety of ADM in breast reconstruction during the last few years, techniques have evolved that increase the percentage of implant pocket lined by ADM rather than elevated chest wall muscles. The initially used lower-pole ADM sling in conjunction with pectoralis major muscle upper-pole coverage has given way to total implant coverage in a "ravioli"-style wrap of ADM over the implantable device, with the edges of the ADM secured to the anterior aspect of the chest wall muscle or in combination with an inferior deepithelialized dermal flap, with an upper-pole ADM sling covering the implantable device and

First Received: 24 April 2018

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Published online: 05 July 2018

securing it in place in a prepectoral plane. Using this approach, elevation of the pectoralis major muscle, adjacent muscles, and fascia is not necessary.[2]

The patients in this study underwent a technique taking advantage of the surplus of lower breast-pole skin by using it as a deepithelialized dermal flap for lower-pole implant coverage in conjunction with a superior-pole dermal matrix placement allowing for implant coverage without the use of pectoralis major muscle elevation. The deepithelialized flap also serves as a safety net in case of t-zone mastectomy skin necrosis by providing living tissue with the ability to reepithelialize over the implant. Prepectoral reconstruction has been shown to reduce the incidence of animation deformity[3] and postoperative pain[4] and has a complication profile comparable with that of subpectoral implant-based breast reconstruction in the nonradiated setting.[5]

Postmastectomy radiation therapy (PMRT) is a well-known risk factor for complications after breast reconstruction, particularly capsular contracture and reconstructive failure.[6] Findings also have shown that PMRT after implant-based breast reconstruction is associated with a higher rate of revisional surgery and worse cosmetic outcome as well as lower patient satisfaction.[7] The impact of PMRT on outcomes after prepectoral versus subpectoral implant-based reconstruction has not been clearly defined to date. This study aimed to compare the impact of PMRT on outcomes after prepectoral versus subpectoral implant-based breast reconstruction.

METHODS

Study Design

Institutional review board approval to perform this study was obtained through New York University (NYU) Winthrop Hospital Institutional Review Board Services. A retrospective chart review of all pre- and subpectoral breast reconstructions performed by the senior plastic surgeon (A.O.Y.) from January 2010 to December 2017 was performed. Patients who underwent pre- or subpectoral implant-based breast reconstruction in a single-stage, direct-to-implant approach or a two-stage approach with a tissue expander placed initially, followed by replacement with an implant were included in this study. Only patients who received Wise-pattern or modified-Wise-pattern mastectomy incisions were included in this study. Patients who received other mastectomy incision patterns were excluded. Patients who received premastectomy radiation therapy were excluded to enable effective evaluation of the impact that postmastectomy radiation therapy has on outcomes after breast reconstruction.

A database was created, and patients were placed into pre- and subpectoral groups. Demographic characteristics were reviewed and analyzed including age, body mass index (BMI), current smoking, medical history of diabetes, and both radiation and chemotherapy exposure. Clinical and operative characteristics also were reviewed including uni- or bilateral procedure, prophylactic or therapeutic indication, single- or two-stage approach, implant volume, use of ADM, and adjuvant lipofilling performed at a secondary procedure. Patients who were suitable candidates and for whom it was oncologically safe (i.e., when the tumor-to-nipple areolar complex was > 2 cm on magnetic resonance imaging (MRI) and fresh-frozen retroareolar biopsy, the results were negative) had the nipple-areolar complex harvested as a full-thickness graft and grafted to the new location. Outcomes and complications also were reviewed and analyzed including infection, seroma, hematoma, dehiscence, necrosis, capsular contracture, rippling, implant loss, local recurrence, and metastatic disease.

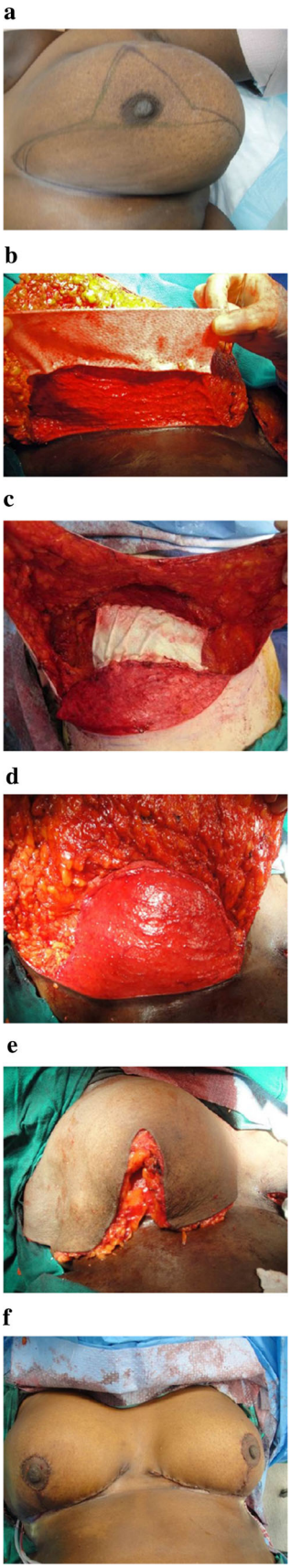
Capsular contracture was graded using the four-grade Baker scale as follows: grade 1 (a normally soft breast with a nonpalpable implant), grade 2 (a breast slightly firm to touch that appears normal), grade 3 (a breast firm to touch that appears distorted), and grade 4 (a breast hard and painful to touch that appears distorted).

Materials

All reconstructions were performed with smooth, round silicone gel implants or expandable saline implants (Mentor Worldwide LLC, Irvine, CA, USA). All pre- and subpectoral reconstructions were performed using porcine-derived Strattice acellular dermal matrix (Allergan Inc., Irvine, CA, USA).

Prepectoral Reconstruction Technique

Prepectoral reconstruction was performed using a Wise-pattern or modified-Wise-pattern mastectomy incision. A deepithelialized dermal flap was created from the surplus lower-pole breast skin and soft tissue. The implant pocket was shaped by sewing a sufficiently large piece of Strattice ADM to the medial aspect of the mastectomy pocket, the superior aspect of the pectoralis major, and the superior aspect of the inferior deepithelialized dermal flap. The implant was placed in the mastectomy pocket, and the mastectomy pocket was closed by sewing the ADM down to the chest wall, serratus fascia, and inferior deepithelialized dermal flap (Fig. 1).



◀**FIG. 1** Prepectoral breast reconstruction technique. **a** Wise-pattern design for mastectomy incision and dermal flap harvest. **b** Deepithelialized dermal flap from inferior breast skin sewn to the acellular dermal matrix (ADM). **c** ADM and deepithelialized dermal flap sewn to the chest wall to create a prepectoral implant pocket. **d** Implant in place, covered with deepithelialized dermal flap at the inferior pole and the ADM superior pole. **e** Draping of the mastectomy flaps over the implant. **f** Flap inset with free nipple grafting

Subpectoral Reconstruction Technique

Subpectoral reconstruction was performed using a Wise-pattern or modified-Wise-pattern mastectomy incision. A deepithelialized dermal flap was created from the surplus lower-pole breast tissue. The pectoralis major muscle was dissected off the chest wall to allow sufficient elevation to accommodate for implant projection and footprint. The implant pocket then was fashioned by sewing the inferior aspect of the elevated pectoralis major muscle to the superior aspect of the inferior deepithelialized dermal flap and placing a lateral Strattice ADM patch sewn to the dermal flap and pectoralis major muscle as well as the lateral chest wall fascia. The implant then was placed in the mastectomy pocket, and the mastectomy pocket was closed by placing the last lateral sutures into the ADM.

Postmastectomy Radiation Therapy

Postmastectomy radiation therapy was delivered to all the patients with stage 3 breast cancer and selectively used for patients who had stage 2 breast cancer with one to three positive axillary lymph nodes to the internal mammary nodes and supraclavicular-axillary apical nodes as well as the chest wall and reconstructed breast.[8] Conventional postmastectomy radiation therapy was given in all cases at a prescribed dose of 50 Gy in 2-Gy daily fractions 5 days per week for 5–6 weeks according to the same protocol and using the same technology in the departments of radiation oncology at South Nassau Communities Hospital and Bridgeport Hospital-Yale New Haven Health.

Statistical Analysis

Continuous variables are reported as the mean ± SD and compared using a two-tailed *t* test. A two-tailed Fisher's exact test was used to evaluate associations between categorical values and complication rates. To determine the clinical variables associated with capsular contracture for patients who received PMRT, a multivariable logistic regression model was constructed, with the results reported as odds ratios (ORs) and lower and upper limits of the 95% confidence intervals (CIs). All statistical

analyses were performed using SPSS software version 25 (SPSS, Chicago, IL, USA, IBM), with p values lower than 0.05 considered significant.

RESULTS

Table 1 compares the demographic, clinical, and outcomes characteristics of the pre- and subpectoral groups. The prepectoral group was made up of 274 patients and 426 breasts, and the subpectoral group comprised 100 patients and 163 breasts. The mean follow-up period was longer for the subpectoral group than for the prepectoral group (31.9 ± 22.4 vs 19.0 ± 16.9 months; $p = 0.0001$) because the prepectoral technique had been adopted more recently. The patients in the prepectoral group were older (52.4 ± 9.7 vs 46.9 ± 8.8 years; $p = 0.0001$) and had a higher BMI (29.0 ± 6.0 vs 25.2 ± 5.0 kg/m^2; $p = 0.0001$) than the patients in the subpectoral group. More of the patients in the subpectoral group were exposed to postmastectomy chemotherapy (35.0 vs 19.3%; $p = 0.0023$). Almost all the prepectoral reconstructions were performed with a single-stage, direct-to-implant approach compared

TABLE 1 Demographic, clinical, and outcome characteristics in prepectoral versus subpectoral groups

	Prepectoral *n* (%)	Subpectoral *n* (%)	*p* value
No. of patients	274	100	
No. of breasts	426	163	
Follow-up (months)	19.0 ± 16.9	31.9 ± 22.4	0.0001[a]
Demographic			
Mean age (years)	52.4 ± 9.7	46.9 ± 8.8	0.0001[a]
Mean BMI (kg/m^2)	29.0 ± 6.0	25.2 ± 5.0	0.0001[a]
Smokers	7.7 (21)	5.0 (5)	0.4925
Diabetes	6.6 (18)	3.0 (3)	0.2154
Postmastectomy radiation	13.1 (56)	14.1 (23)	0.7873
Premastectomy chemotherapy	11.3 (31)	12.0 (12)	0.8557
Postmastectomy chemotherapy	19.3 (53)	35.0 (35)	0.0023[a]
Clinical			
Unilateral	44.5 (122)	37.0 (37)	0.2373
Bilateral	55.4 (152)	63.0 (63)	
Prophylactic	45.5 (194)	37.4 (61)	0.0782
Therapeutic	54.5 (232)	62.6 (102)	
Single-stage	97.2 (414)	72.4 (118)	0.0001[a]
Two-stage	2.8 (12)	27.6 (45)	
Implant volume (ml)	386.7 ± 118.5	366.1 ± 136.8	0.0714
No. with ADM	100 (426)	100 (100)	
Adjuvant lipofilling	39.7 (169)	77.9 (127)	0.0001[a]
Free nipple grafts	46.9 (200)	33.1 (54)	0.0029[a]
Complications			
Infection	2.8 (12)	1.2 (2)	0.3696
Seroma	0.2 (1)	1.2 (2)	0.1869
Hematoma	0	0	
Dehiscence	0.9 (4)	1.2 (2)	0.6707
Necrosis	1.1 (5)	1.2 (2)	1.0000
Capsular contracture	5.2 (22)	9.8 (16)	0.0588
Rippling	0.5 (2)	0	1.0000
Implant loss	4.0 (17)	4.3 (7)	0.8195
Local recurrence	1.8 (8)	1.2 (2)	0.734
Metastatic disease	0.2 (1)	0	1.0000

Continuous variables are reported as mean ± SD, and categorical variables are reported as percentages of the total number in the group

BMI body mass index, *ADM* acellular dermal matrix

[a] The difference is statistically significant

with approximately three-fourths of all the subpectoral reconstructions (97.2 vs 72.4%; $p = 0.0001$, respectively), with the remaining reconstructions performed as two-stage expander-to-implant procedures.

It is important to note that all the reconstructions in both the pre- and subpectoral groups were performed using porcine-derived ADM because it is believed that ADM may protect against capsular contracture after implant-based breast reconstruction in the non-radiated and PMRT settings. A greater percentage of patients in the subpectoral group required adjuvant lipofilling during a second procedure for soft tissue deficiencies in the upper and lateral pole than in the prepectoral group (77.9 vs 39.7%; $p = 0.0001$, respectively). More patients in the prepectoral group than in the subpectoral group had the nipple-areolar complex harvested as a free graft and grafted to the new location at the time of mastectomy and reconstruction (46.9 vs 33.1%; $p = 0.0029$). The outcomes between the two groups did not differ with regard to major infection, seroma, hematoma, dehiscence, mastectomy flap necrosis, capsular contracture, rippling, implant loss, local recurrence, or metastatic disease. The rate of capsular contracture in the subpectoral group was nearly twice that in the prepectoral group, with this difference approaching significance (9.8 vs 5.2%; $p = 0.0588$).

As expected, the prepectoral patients who received PMRT had a higher rate of capsular contracture than the non-radiated prepectoral patients (16.1 vs 3.5%; $p = 0.0008$; Table 2). A higher percentage of prepectoral non-radiated patients underwent free nipple areolar complex grafting at the time of reconstruction than prepectoral patients who received PMRT (49.5 vs 30.4%; $p = 0.0093$; respectively). Similarly, as expected, a higher percentage of prepectoral patients who received PMRT were exposed to premastectomy (33.3 vs 7.9%; $p = 0.0001$) and postmastectomy chemotherapy (42.2 vs 16.6%; $p = 0.0004$) than non-radiated prepectoral patients. A similar pattern of results was seen when subpectoral patients who received PMRT were compared with non-radiated subpectoral patients (Table 3). However, the increase in the capsular contracture rate due to PMRT was significantly more pronounced among the subpectoral reconstruction patients (52.2 vs 2.9%; respectively; $p = 0.0001$).

Table 4 shows the demographic, clinical, and outcome characteristics for the pre- and subpectoral patients exposed to PMRT. The subpectoral group had a three times greater rate of capsular contracture than the prepectoral group (52.2 vs 16.1%; $p = 0.0018$). In addition, 10 (83.3%) of the 12 capsular contracture cases in the subpectoral group that received PMRT were Baker grade 3 or 4 compared with only 2 (22.2%) of 9 cases in the prepectoral group with PMRT ($p = 0.0001$). More patients in the subpectoral group receiving PMRT had adjuvant lipofilling performed at a second procedure than in the prepectoral group receiving PMRT (73.9 vs 41.1%; $p = 0.0126$).

To determine the independent effect of reconstruction technique (i.e., prepectoral vs subpectoral) on the odds of capsular contracture for the patients who received PMRT, we constructed a multivariable logistic regression model (Table 5). Capsular contracture was not significantly associated with age, postmastectomy, chemotherapy, or whether the patient received a single-stage versus a two-stage procedure or not. The patients who experienced capsular contracture had longer follow-up evaluation (OR, 1.06; 95% CI 1.02–1.10; $p = 0.008$) and lower BMI (OR, 1.14; 95% CI 1.00–1.30; $p = 0.049$) and greater likelihood of receiving adjuvant lipofilling (OR, 7.20; 95% CI 1.21–42.80; $p = 0.03$). Furthermore, the patients who received a subpectoral reconstruction showed nearly four times the odds of capsular contracture after control was used for age, length of follow-up evaluation, BMI, postmastectomy chemotherapy, single-stage versus two-stage procedure, and whether adjuvant lipofilling was performed or not. However, this difference was not statistically significant (OR, 3.79; 95% CI 0.50–28.91; $p = 0.20$).

DISCUSSION

In most fields of surgery, minimally invasive approaches have been pioneered to reduce pain, recuperation time, immediate and late side effects, procedural costs, and interference with quality of life. In breast reconstruction, however, the more invasive procedures (i.e., autologous tissue transfer) have gained increasing popularity due to high complication rates, especially high-grade capsular contracture, associated with implant-based submuscular reconstruction in the radiated field. Patients with higher-risk disease and worse prognosis who required PMRT were subjected to the most invasive autologous procedures or left with significant complications after implant-based breast reconstruction.

The results of this study showed that prepectoral, ADM-covered, implant-based reconstruction had a complication profile similar to that of partial subpectoral ADM-assisted implant-based breast reconstruction. The patients who underwent prepectoral reconstruction were older and had a higher BMI than the patients who underwent subpectoral implant-based breast reconstruction. These findings are consistent with the fact that more upper-pole soft-tissue coverage is needed to perform prepectoral implant-based breast reconstruction. Furthermore, the patients in this study who required PMRT after subpectoral reconstruction had a capsular contracture rate three times greater, with more severe grade 3 or 4 contractures, than the patients

TABLE 2 Demographic, clinical, and outcome characteristics in prepectoral non-radiated versus prepectoral with postmastectomy radiation therapy (PMRT) groups

	Non-radiated *n* (%)	PMRT *n* (%)	*p* value
No. of patients	241	45	
No. of breasts	370	56	
Follow-up (months)	18.7 ± 17.0	20.6 ± 15.4	0.4857
Demographic			
Mean age (years)	52.4 ± 9.4	52.7 ± 11.1	0.8488
Mean BMI (kg/m^2)	28.9 ± 5.9	30.0 ± 5.9	0.2519
Smokers	7.0 (17)	4.4 (2)	0.7475
Diabetes	6.6 (16)	4.4 (2)	0.7479
Premastectomy chemotherapy	7.9 (19)	33.3 (15)	0.0001[a]
Postmastectomy chemotherapy	16.6 (40)	42.2 (19)	0.0004[a]
Clinical			
Unilateral	46.5 (112)	75.6 (34)	0.0003[a]
Bilateral	53.5 (129)	24.4 (11)	
Prophylactic	50.0 (185)	16.1 (9)	0.0001[a]
Therapeutic	50.0 (185)	83.9 (47)	
Single-stage	97.2 (361)	94.6 (53)	0.2002
Two-stage	2.4 (9)	5.4 (3)	
Implant volume (ml)	387.2 ± 118.4	383.8 ± 120.8	0.8418
No. with ADM	100 (370)	100 (56)	
Adjuvant lipofilling	39.5 (146)	41.1 (23)	0.8837
Free nipple grafts	49.5 (183)	30.4 (17)	0.0093[a]
Complications			
Infection	2.4 (9)	5.4 (3)	0.2002
Seroma	0.3 (1)	0	1.0000
Hematoma	0	0	
Dehiscence	0.8 (3)	1.8 (1)	0.4321
Necrosis	1.1 (4)	1.8 (1)	0.5075
Capsular contracture	3.5 (13)	16.1 (9)	0.0008[a]
Rippling	0.5 (2)	0	1.0000
Implant loss	3.8 (14)	5.4 (3)	0.4780
Local recurrence	1.4 (5)	5.4 (3)	0.0745
Metastatic disease	0.3 (1)	0	1.0000

Continuous variables are reported as mean ± SD, and categorical variables are reported as percentages of the total number in the group

BMI body mass index, *ADM* acellular dermal matrix

[a] The difference is statistically significant

who required PMRT after prepectoral implant-based reconstruction. In the regression analysis, the patients who received a subpectoral reconstruction had nearly four times the odds of capsular contracture after control was used for age, length of follow-up evaluation, BMI, postmastectomy chemotherapy, single-stage versus two-stage procedure, and whether adjuvant lipofilling was performed or not. Although the increased odds of capsular contracture among patients receiving a subpectoral reconstruction did not attain statistical significance after the study accounted for potential confounders, the point-estimate was substantial, and we hypothesized that the study was merely underpowered to detect a difference.

The results of our study compare favorably to previously published studies on pre- and subpectoral implant-based breast reconstruction. In our study, the capsular contracture rate for the prepectoral reconstruction group was 5.6%, approximately half that reported by Downs and Hedges[9] (10%). Bettinger et al.[10]. showed a comparable complication profile between pre- and subpectoral implant-based breast reconstruction, as seen in our study. Sigalove et al.[11]. showed a complication rate lower than 5% for seroma,

TABLE 3 Demographic, clinical, and outcome characteristics in subpectoral non-radiated versus subpectoral with postmastectomy radiation therapy (PMRT) groups

	Non-radiated *n* (%)	PMRT *n* (%)	*p* value
No. of patients	87	21	
No. of breasts	140	23	
Follow-up (months)	30.8 ± 22.2	35.4 ± 21.1	0.3917
Demographic			
Mean age (years)	46.9 ± 8.7	44.6 ± 9.9	0.2923
Mean BMI (kg/m^2)	24.8 ± 4.6	25.8 ± 6.3	0.4094
Smokers	5.7 (5)	4.8 (1)	1.0000
Diabetes	3.4 (3)	0	1.0000
Premastectomy chemotherapy	9.2 (8)	28.6 (6)	0.0284[a]
Postmastectomy chemotherapy	29.9 (26)	71.4 (15)	0.0008[a]
Clinical			
Unilateral	39.1 (34)	90.5 (19)	0.0001[a]
Bilateral	60.9 (53)	9.5 (2)	
Prophylactic	(42.9) 60	0	0.0001[a]
Therapeutic	(57.1) 80	100.0 (23)	
Single-stage	(72.9) 102	69.6 (16)	0.8024
Two-stage	27.1 (38)	30.4 (7)	
Implant volume (ml)	364.8 ± 135.3	374.1 ± 148.3	0.7635
No. with ADM	100 (140)	100 (23)	
Adjuvant lipofilling	78.6 (110)	73.9 (17)	0.5955
Free nipple grafts	36.4 (51)	13.0 (3)	0.0312[a]
Complications			
Infection	0.7 (1)	4.3 (1)	0.2630
Seroma	1.4 (2)	0	1.0000
Hematoma	0	0	
Dehiscence	0.7 (1)	4.3 (1)	0.2630
Necrosis	1.4 (2)	0	1.0000
Capsular contracture	2.9 (4)	52.2 (12)	0.0001[a]
Rippling	0	0	
Implant loss	2.9 (4)	13.0 (3)	0.0591
Local recurrence	1.4 (2)	0	1.0000
Metastatic disease	0	0	

Continuous variables are reported as mean ± SD, and categorical variables are reported as percentages of the total number in the group

BMI body mass index, *ADM* acellular dermal matrix

[a] The difference is statistically significant

infection, and flap necrosis and no cases of capsular contracture in 350 prepectoral implant-based breast reconstructions. Sbitany[12] also showed a similar complication profile between pre- and subpectoral implant-based breast reconstructions. In this study, the author showed that pre- and subpectoral groups had similar comorbidities and postoperative radiation exposure but not a higher rate of capsular contracture for subpectoral patients receiving PMRT, as seen in our study. In our study, the lower capsular contracture rate after PMRT in the prepectoral group than in the subpectoral group may have been related to the increased implant surface area covered by ADM with the prepectoral approach.

Several studies have shown the beneficial effect of ADM on the capsular contracture rate after implant-based breast reconstruction.[13]–[15] Lardi et al.[16] showed that ADM use in implant-based subpectoral breast reconstruction is associated with a lower rate of capsular contracture than in subpectoral reconstruction without ADM. Furthermore, the beneficial effect of ADM on the capsular contracutre rate was maintained after postmastectomy radiation therapy. Salzberg et al.[17] reported a low capsular contracture rate

TABLE 4 Demographic, clinical, and outcome characteristics in prepectoral versus subpectoral with postmastectomy radiation therapy (PMRT) groups

	Prepectoral *n* (%)	Subpectoral *n* (%)	*p* value
No. of patients	45	21	
No. of breasts	56	23	
Follow-up (months)	20.6±15.4	35.4±21.1	0.0020[a]
Demographic			
Mean age (years)	52.7±11.1	44.6±9.9	0.0058[a]
Mean BMI (kg/m^2)	30.0±5.9	25.8±6.3	0.0105[a]
Smokers	4.4 (2)	4.8 (1)	1.0000
Diabetes	4.4 (2)	0	1.0000
Premastectomy chemotherapy	33.3 (15)	28.6 (6)	0.7821
Postmastectomy chemotherapy	42.2 (19)	71.4 (15)	0.0357[a]
Clinical			
Unilateral	75.6 (34)	90.5 (19)	0.1982
Bilateral	24.4 (11)	19.0 (4)	
Prophylactic	16.1 (9)	0	0.0524
Therapeutic	(83.9) 47	100.0 (23)	
Single-stage	(94.6) 53	69.6 (16)	0.0053[a]
Two-stage	5.4 (3)	30.4 (7)	
Implant volume	383.8±120.8	374.1±148.3	0.7627
No. with ADM	100 (56)	100 (23)	
Adjuvant lipofilling	41.1 (23)	73.9 (17)	0.0126[a]
Free nipple grafts	30.4 (17)	13.0 (3)	0.1556
Complications			
Infection	5.4 (3)	4.3 (1)	1.0000
Seroma	0	0	
Hematoma	0	0	
Dehiscence	1.8 (1)	4.3 (1)	0.5002
Necrosis	1.8 (1)	0	1.0000
Capsular contracture	16.1 (9)	52.2 (12)	0.0018[a]
Baker grade 3 or 4	3.6 (2)	43.5 (10)	0.0001[a]
Rippling	0	0	
Implant loss	5.4 (3)	13.0 (3)	0.3496
Local recurrence	5.4 (3)	0	0.5521
Metastatic disease	0	0	

Continuous variables are reported as mean ± SD, and categorical variables are reported as percentages of the total number in the group

BMI body mass index, *ADM* acellular dermal matrix

[a] The difference is statistically significant

(1.9%) when ADM was used in one-stage partial subpectoral implant-based breast reconstruction, and this lower capsular contracture rate persisted after postmastectomy radiation therapy. The results reported by Salzberg et al.[17] contrast with the results of our study, which showed a significantly increased rate of capsular contracture after PMRT for the patients who underwent partial subpectoral implant-based breast reconstruction with ADM. Vardanian et al.[18] demonstrated a reduced capsular contracture rate after partial submuscular implant-based breast reconstruction with ADM than after total submuscular reconstruction without ADM (3.9 vs 19.4%).

In the current study, the patients in the subpectoral group had a significantly longer follow-up period than the patients in the prepectoral group. At the beginning of the study, the majority of the implant-based breast reconstructions performed by the senior author were in the subpectoral plane. As time passed, the prepectoral technique was adopted more frequently and currently is used by the senior author for the vast majority of implant-based

TABLE 5 Univariable and binary logistic regression analysis of demographic and clinical characteristics associated with capsular contracture in patients who receive postmastectomy radiation therapy (PMRT)

	Univariable analysis				Multivariable analysis 95% CI		
	No CC *n* (%)	CC *n* (%)	*p* value	OR	Lower limit	Upper limit	*p* value
n	58	21					
Mean age (years)	50.4 ± 10.6	48.0 ± 11.6	0.398	0.975	0.909	1.045	0.468
Mean follow-up (months)	19.9 ± 16.2	39.5 ± 17.0	< 0.001[a]	1.058	1.015	1.104	0.008[a]
Mean BMI (kg/m^2)	28.8 ± 5.7	28.2 ± 6.9	0.755	1.142	1.001	1.303	0.049[a]
Subpectoral reconstruction	19.0 (11)	57.1 (12)	0.001[a]	3.792	0.497	28.906	0.198
Postmastectomy chemotherapy	44.8 (26)	76.2 (16)	0.014[a]	1.286	0.310	5.327	0.729
Single-stage	74.1 (43)	66.7 (14)	0.513	1.329	0.177	9.962	0.782
Adjuvant lipofilling	41.4 (24)	85.7 (18)	< 0.001[a]	7.199	1.211	42.797	0.030[a]

Continuous variables are reported as mean ± SD, and categorical variables are reported as percentages of the total number in the group

CC contracture, *BMI* body mass index

[a] The difference is statistically significant

breast reconstructions, whereas the subpectoral technique is reserved for a select few patients. Although the follow-up period for the subpectoral group may account for the higher rate of capsular contracture in this group, we do not expect that this had a significant impact on the capsular contracture rates in the two groups because capsular contracture usually develops within 1 year after breast reconstruction, and the mean follow-up time was far longer than 1 year in both the pre- and supectoral groups (19 and 32 months, respectively). Furthermore, although a higher percentage of patients in the subpectoral groups received adjuvant chemotherapy, this would not be expected to have an impact on the rates of capsular contracture because studies have not shown that adjuvant chemotherapy is a significant risk factor for the development of capsular contracture.

A significant advantage of this study was that all the reconstructions in the pre- and subpectoral groups were performed using a Wise-pattern mastectomy incision combined with an inferior deepithelialized dermal flap. The Wise-pattern mastectomy incision combined with an inferior deepithelialized dermal flap for coverage of the lower pole was adopted from the reduction mammaplasty technique and designed to create a more natural-appearing breast with reduced tension on the flaps and lower risk for complications in patients with larger breasts. No evidence exists to suggest that the deepithelialized Wise-pattern mastectomy incision leads to a higher rate of capsular contracture.

Another advantage of this study was that all the mastectomies were performed by the same two breast surgeons, so the thickness of the mastectomy flaps was consistent throughout the study and was not a confounding variable in the development of capsular contracture. Further advantages of this study included the substantial number of subjects in both the pre- and subpectoral groups, the extended follow-up period, and the fact that all the reconstructions in both groups were performed by a single surgeon (A.O.Y.).

The results of this study are limited by the nonrandomized, retrospective design and the potential selection bias associated with selecting patients for pre- or subpectoral implant based breast reconstruction. The positive results from this investigation of outcomes in prepectoral, ADM-covered, implant-based breast reconstruction in the radiated field encourage further investigation of implant-based minimally invasive breast reconstruction. Our preliminary data show acceptable complication rates, but larger studies are needed for further investigation of outcomes.

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