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ORIGINAL ARTICLE – BREAST ONCOLOGY

The Effect of Oncoplastic Reduction Mammoplasty on the Incidence of Breast Lymphedema in Women Undergoing Breast Conservation Surgery

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ABSTRACT

Introduction. Women with macromastia are susceptible to less favorable postoperative outcomes following breast conservation surgery (BCS). Among those, breast lymphedema is a severe complication that impacts functional and aesthetic outcomes. However, effective prevention strategies remain understudied. We aim to assess whether women with macromastia who receive oncoplastic reduction mammoplasty (ORM) have reduced incidence of postoperative breast lymphedema compared with patients who receive BCS alone.

Methods. A retrospective analysis of patients who underwent BCS alone or ORM followed by radiation was conducted. Demographics, treatment details, operative techniques, and postoperative outcomes were compared between BCS alone and ORM groups using inferential statistics. A subanalysis was similarly conducted to identify differences in postoperative outcomes between women with and without macromastia. Regression analysis was used to evaluate the effects of ORM and the factors associated with breast lymphedema.

Results. The overall incidence of breast lymphedema was 10.6%. Black race, preoperative breast volume ≥ 1500 cm^3, axillary lymph node dissection at time of surgery, incidence of cellulitis, and incidence of arm lymphedema were positively associated with breast lymphedema rate. Regression analysis demonstrated that women with breast volumes ≥ 1500 cm^3 who underwent BCS alone were 6.575 times more likely to develop breast lymphedema than patients who underwent ORM ($p = 0.014$).

Conclusions. Women with macromastia who receive BCS alone have an increased incidence of postoperative breast lymphedema. Oncoplastic reduction mammoplasty is an alternative treatment option that reduces the likelihood of postoperative breast lymphedema compared with BCS alone in patients with breast volumes ≥ 1500 cm^3.

Breast lymphedema, a condition defined by poor lymphatic drainage resulting in persistent breast swelling, is receiving increased attention by physicians responsible for the treatment of breast cancer patients. Studies have demonstrated that patients with breast lymphedema are prone to higher risks of postoperative complications, including delayed wound healing and infection.[1,2] Studies have also demonstrated that patients with breast lymphedema experience inferior patient reported outcomes, including chronic pain, negative body image, and impaired physical functioning.[3] Breast lymphedema has various etiologies but is most commonly a result of iatrogenic damage to lymphatic channels as a result of breast cancer treatment that involves breast surgery or radiation therapy.[4,5] Various surgical options for breast cancer treatment exist, including total mastectomy, partial mastectomy with radiation, and oncoplastic reduction mammoplasty (ORM). Because breast conservation surgery (BCS) is the most common treatment option, it is crucial for providers to understand the risk of breast lymphedema, although the literature discussing this topic remains scarce.

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Given the increased consideration for breast lymphedema by surgeons, recent research has aimed to identify the specific patient and treatment factors that predispose individuals to the complication. A recent study demonstrated that the incidence of breast lymphedema is higher in black women, patients who receive neoadjuvant or adjuvant chemotherapy, patients who develop postoperative cellulitis, patients who develop postoperative breast cancer-related arm lymphedema (BCRaL), and patients with macromastia (defined as preoperative breast volume $\geq$ 1500 cm^3).[6] Of these factors, macromastia was the strongest predictor for the development of breast lymphedema. Patients with macromastia account for roughly 40% of all breast cancer patients and are therefore a crucial demographic to consider when investigating clinical outcomes associated with BCS and radiation.[7] Women with macromastia are subject to greater radiation exposure and radiation-induced changes following BCS compared with those without macromastia.[8–13] Women with macromastia also have inferior cosmetic outcomes, namely breast asymmetry and retraction, than those without macromastia.[7,13,14]

Oncoplastic reduction mammoplasty has emerged as an alternative surgical approach that introduces bilateral breast reduction at the time of partial mastectomy, optimizing cosmesis by restoring upper pole volume, increasing projection of the breast, and correcting ptosis.[7,15] When performed concomitantly with a contralateral symmetry procedure, ORM decreases the risk of cosmetic deformity and disproportion to the lumpectomized breast that may occur secondary to radiation therapy.[16] Performing ORM as an immediate reconstruction at the time of lumpectomy has also been shown to offer several benefits ranging from improved margin control, fewer re-excisions, and decreased rates of completion mastectomy.[17] Despite the known benefits, there are a number of known risks to the ORM procedure, including breast seroma, wound dehiscence, and infection.[18]

The various risks and benefits of ORM must be weighed against those of BCS alone when determining the optimal intervention for patients with macromastia. The risk of breast lymphedema as a physically and psychologically debilitating consequence of treatment must also be considered. It remains to be determined whether ORM performed at the time of lumpectomy decreases the incidence of breast lymphedema in patients with macromastia. The primary aim of this study is to determine the impact of ORM on breast lymphedema rates in patients with macromastia compared with patients with macromastia who do not undergo ORM. Study findings may help surgeons determine the appropriate surgical approach for breast cancer treatment that also minimizes the risk of developing breast lymphedema in women with macromastia.

METHODS

Study Design

Following approval by the Henry Ford Health Institutional Review Board, a retrospective evaluation of all women who underwent BCS or ORM breast cancer treatment followed by whole breast radiation from 2016 to 2023 was performed at a large, metropolitan cancer institute in Southeast Michigan. Patient demographics, treatment details, operative techniques, radiation characteristics, postoperative follow-up outcomes, and postradiation follow-up outcomes were collected via manual chart review of provider notes, therapy notes, and mammography reports. Women who underwent either BCS alone or ORM at the time of BCS followed by adjuvant whole breast radiation therapy were enrolled in this study. Patients were excluded if they were diagnosed with stage IV breast cancer or if they had received radiation therapy at an outside institution. While breast lymphedema has not been defined by any particular staging system, we defined it as any of the following: (1) patient reported symptoms of heaviness, pain, swelling, significant increase in size relative to the contralateral side, or difficulty with wearing their bras; (2) physical examination specifically compared with the contralateral nonaffected breast; (3) mammographic findings of swelling that persisted 1 year after completion of radiation therapy. On mammogram, breast lymphedema may present with skin thickening, diffuse increased parenchymal enhancement, prominent interstitial markings, coarse trabecular patterns, or dilated lymphatics.[19,20] Time to follow-up was defined as the time between the date of a patient's final breast cancer radiation treatment and the date of the most recent follow-up evaluation of the breast by either the breast surgical team, oncology, plastic surgery, radiation oncology, or physical therapy.

Data Collection

Preoperative breast volumes were determined by adding the volume determined by three-dimensional breast contour analysis (cm^3) to a volume determined by pathology-defined lumpectomy specimen weight (grams); 1 g in weight was equated to 1 cm^3 in volume. If contour analysis could not be performed, breast volumes were estimated using 95% isodose volumes from the Eclipse RT treatment planning system (Varian, Palo Alto, CA). In order to define macromastia, a cutoff value for breast volume was identified using a Kernal density curve analysis. Breast volumes for all patients within the cohort were plotted, and the distribution overlap between patients with and without breast lymphedema was identified. The peak intersection between the two distributions was used to define macromastia using an exact breast volume threshold.

Demographic variables include age, race, and body mass index (BMI). Operative characteristics include lumpectomy specimen weight, time to follow-up, axillary lymph node dissection (ALND) at time of surgery, adjuvant and neoadjuvant chemotherapy, time from surgery to adjuvant radiation, and total radiation dose. Postoperative complications include hematoma, seroma, wound complications, cellulitis requiring treatment, radiation dermatitis (graded 0–3), breast lymphedema, breast-cancer related arm lymphedema (BCRaL), reoperation, readmission, need for conversion to mastectomy, need for re-excision, and size of negative margin at first operation. Patients who developed cellulitis were treated with antibiotic therapy. Wound complications were defined as wound dehiscence and/or skin necrosis. BCRaL was defined as greater than one year of post-radiation arm swelling requiring complete decongestive therapy with symptoms of heaviness, numbness, and/or pain.

Statistical Analysis

Univariate regression analysis was used to compare patient demographics and complication rates, including breast lymphedema, between patients with macromastia who underwent ORM and patients with macromastia who solely underwent BCS. Multivariate regression analysis was used to determine factors associated with breast lymphedema. Outcomes were also compared between patients with macromastia who underwent ORM and all-comers who underwent BCS alone.

Continuous variables that demonstrated normal distributions were described with mean and standard deviation. For nonnormal distributions, continuous variables were described with median and interquartile range. Normality was assessed using the Shapiro-Wilk test ($p > 0.05$). The dataset did not follow a normal distribution, and nonparametric statistics were employed to analyze our data. Fisher's exact test was performed to analyze categorical data and Wilcoxon rank-sum test was performed to compare continuous data. The assumption of equal variances between the intervention and control groups was tested using Levene's F test, and Satterthwaite's approximation was used when groups had unequal variances.

For multivariate analyses, logistic regression was performed to estimate adjusted odds ratios to control for potential confounding variables. All tests were two-sided and considered statistically significant at the $p < 0.05$ level and when 95% confidence intervals did not include zero. All statistical analyses were carried out using computer package R, version 3.6.1 (R Foundation, Vienna, Austria).[21]

RESULTS

A total of 782 patients were included in this analysis; 718 (91.8%) patients underwent BCS alone, and 64 (8.2%) patients underwent ORM. The average time to follow-up was 48.84 months (SD = 17.24 months). The Kernel density curve analysis used to define macromastia showed that the peak intersection between breast volume distributions for patients with and without breast lymphedema was approximately 1462 cm^3 (Fig. 1). This value was rounded to 1500 cm^3 to serve as a minimum threshold value that defines macromastia within this cohort.

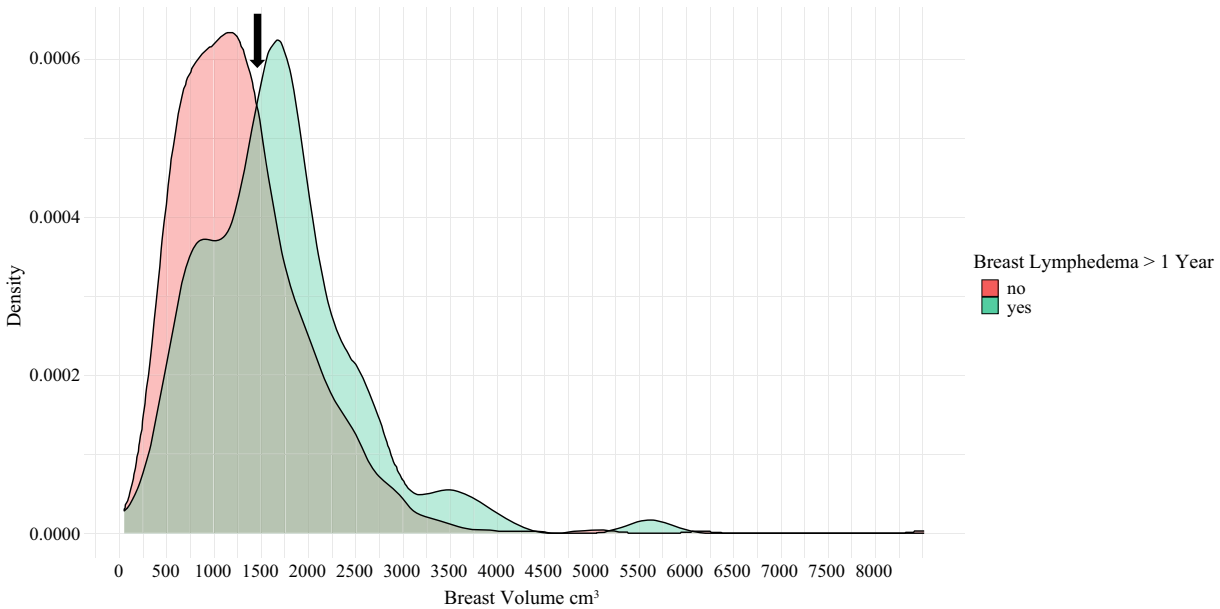

FIG. 1 Kernal density curve highlighting breast volumes for patients with and without breast lymphedema

Cohort Demographics

Patients who underwent BCS alone were older (mean = 64.13 years, SD = 10.9 years) than those who received ORM (mean = 55.25 years, SD = 8.69 years; $p < 0.001$; Table 1). Significant differences were found in racial distributions of the two groups, as the ORM patients were 53.1% black and 46.9% white, while the BCS patients were 36.6% black, 59.7% white, and 3.6% other races ($p = 0.018$). The BMIs of the ORM cohort were higher (mean = 33.71, SD = 7.02) than those of the BCS alone cohort (mean = 31.02, SD = 7.04; $p = 0.003$).

Preoperative and Operative Treatment Exposures

On average, patients who underwent ORM experienced shorter times to follow-up compared with those who underwent BCS alone (40.09 months vs. 49.62 months; $p < 0.001$; Table 1). Patients who received ORM also had larger lumpectomy specimen weights compared with those who underwent BCS alone (927.6 cm^3 vs. 124.85 cm^3; $p < 0.001$). Patients who received ORM had longer average times from surgery to adjuvant radiation (mean = 91.41 days, SD = 59.13 days) compared with those who underwent BCS alone (mean = 76.32 days, SD = 56.08 days; $p = 0.043$). No significant differences were detected for rates of adjuvant or neoadjuvant chemotherapy, incidence of ALND at surgery, or radiation dose between those who received ORM and those who received BCS alone.

Postoperative Complications

Univariate analysis demonstrated that patients who underwent ORM were significantly more likely to experience wound complications (10.9 vs. 1.5%; $p < 0.001$) and hematoma (12.5 vs. 5%; $p = 0.027$) compared with those who received BCS alone (Table 2). In contrast, those who received BCS alone demonstrated a higher incidence of seroma compared with the ORM group (41.1 vs. 10.9%; $p < 0.001$). The BCS alone group also demonstrated greater need for re-excision compared with the ORM group (13.9 vs. 3.1%; $p = 0.011$). The ORM cohort demonstrated significantly greater sizes of negative margins at first operation (3.29 ± 3.98 cm vs. 0.51 ± 0.44 cm; $p < 0.001$) compared with the BCS alone cohort. There were no significant differences for radiation dermatitis, cellulitis requiring treatment, reoperation, readmission, need for conversion to mastectomy, BCRaL, or breast lymphedema between BCS alone and ORM cohorts.

TABLE 1 Baseline demographics and operative characteristics for patients who underwent oncoplastic reduction mammaplasty compared to those who underwent breast conservation surgery alone between 2016 and 2023 at a single health facility

Variable	Total cohort *n* = 782 *n* (%) *Mean ± SD*	ORM *n* = 64 *n* (%) *Mean ± SD*	BCS alone *n* = 718 *n* (%) *Mean ± SD*	*p*
Age (years)	63.41 ± 11.00	55.25 ± 8.69	64.13 ± 10.90	< 0.001
Race				
White	459 (58.7)	30 (46.9)	429 (59.7)	0.018
Black	297 (38.0)	34 (53.1)	263 (36.6)	
Other	26 (3.3)	0 (0.0)	26 (3.6)	
BMI (kg/m^2)	31.24 ± 7.07	33.71 ± 7.02	31.02 ± 7.04	0.003
Time to follow-up (months)	48.84 ± 17.24	40.09 ± 16.77	49.62 ± 17.07	< 0.001
Lumpectomy specimen weight (cm^3)	190.55 ± 457.30	927.60 ± 1331.73	124.85 ± 138.35	< 0.001
Time from surgery to adjuvant radiation (days)[a]	77.63 ± 56.47	91.41 ± 59.13	76.32 ± 56.08	0.043
Adjuvant chemotherapy	714 (91.3)	58 (90.6)	656 (91.4)	1.000
Neoadjuvant chemotherapy	68 (8.7)	6 (9.4)	62 (8.6)	1.000
ALND at time of surgery	87 (11.1)	5 (7.8)	82 (11.4)	0.501
Total radiation dose (Gy)	58.05 ± 16.87	59.95 ± 20.23	57.88 ± 16.54	0.348
Breast volume (cm^3)				
Breast volume <1,500 cm^3	430 (55.0)	15 (3.5)	415 (96.5)	0.001
Breast volume ≥1,500 cm^3	352 (45.0)	49 (13.9)	303 (86.1)	

ORM oncoplastic reduction mammaplasty; *BCS* breast conservation surgery; *BMI* body mass index; *ALND* axillary lymph node dissection

Data are reported as frequencies (percentages) for categorical variables and mean ± standard deviation for continuous variables

[a]All patients who underwent adjuvant chemotherapy were excluded in this calculation.

TABLE 2 Complication incidence for patients who underwent oncoplastic reduction mammaplasty compared to those who underwent breast conservation surgery alone between 2016 and 2023 at a single health facility

Treatment outcome	Total cohort $n = 782$ n (%)	ORM $n = 64$ n (%)	BCS alone $n = 718$ n (%)	p
Radiation dermatitis				
Grade 0	84 (10.8)	5 (7.8)	79 (11)	0.61
Grade 1	642 (82.2)	53 (82.8)	589 (82.1)	
Grade 2	54 (6.9)	6 (9.4)	48 (6.7)	
Grade 3	1 (0.1)	0 (0)	1 (0.1)	
Cellulitis requiring treatment	66 (8.4)	4 (6.2)	62 (8.6)	0.643
Wound complications	18 (2.3)	7 (10.9)	11 (1.5)	< 0.001
Reoperation	4 (0.5)	1 (1.6)	3 (0.4)	0.290
Readmission	15 (1.9)	0 (0)	15 (2.1)	0.626
Need for re-excision	102 (13)	2 (3.1)	100 (13.9)	0.011
Size of negative margin at first operation (cm)[a]	0.74 ± 1.45	3.29 ± 3.98	0.51 ± 0.44	< 0.001
Hematoma	44 (5.6)	8 (12.5)	36 (5)	0.027
Seroma	302 (38.6)	7 (10.9)	295 (41.1)	< 0.001
Breast cancer-related arm lymphedema ≥ 1 year	32 (4.1)	3 (4.7)	29 (4)	0.74
Breast lymphedema ≥ 1 year	83 (10.6)	2 (3.1)	81 (11.3)	0.053
Need for conversion to mastectomy[b]	17 (2.2)	0 (0)	17 (2.4)	0.387

Data are reported as frequencies (percentages) for categorical variables and mean ± standard deviation for continuous variables

[a]All patients who needed re-excision were excluded in this calculation

[b]All patients who underwent mastectomy were excluded from our study analysis due to the inability to develop the breast lymphedema. The statistics in this row were calculated by diving the number of excluded patients who underwent conversion to mastectomy by the sum of patients included in the study cohort plus excluded patients who underwent conversion to mastectomy

Complications Stratified by Preoperative Breast Volume

Among all patients with preoperative breast volumes ≥ 1500 cm^3, 303 patients underwent BCS alone and 49 underwent ORM. Patients who underwent BCS alone were older (mean = 63.21 years, SD = 9.96 years) compared with those who received ORM (mean = 54.59 years, SD = 8.15 years; $p < 0.001$; Table 3). Patients who underwent ORM had significantly larger specimen weights than those who underwent BCS alone (1176.7 ± 1433.7 cm^3 vs. 181.43 ± 188.05 cm^3; $p < 0.001$). The ORM cohort also had a significantly higher incidence of wound complications (12.2 vs. 1%; $p < 0.001$) and hematoma formation (16.3 vs. 6.6%; $p = 0.04$), but lower incidence of seroma formation (12.2 vs. 43.6%; $p < 0.001$) compared with macromastia patients who received BCS alone. Compared with the ORM cohort, the BCS alone cohort had greater need for re-excision (13.5 vs. 2%, $p = 0.017$) and greater development of breast lymphedema (16.8 vs. 4.1%, $p = 0.017$). Those who underwent ORM experienced shorter times to follow-up compared with those who underwent BCS alone (39.07 months vs. 49.57 months; $p < 0.001$). No significant differences were detected between BCS and ORM patients regarding race, BMI, ALND at surgery, radiation dose, need for conversion to mastectomy, reoperation, BCRaL, or incidence of cellulitis requiring treatment.

Among all patients with preoperative breast volumes < 1500 cm^3, 415 patients underwent BCS alone and 15 underwent ORM. Patients who underwent BCS alone were older (mean = 64.81 years, SD = 11.5 years) compared with those who received ORM (mean = 57.4 years, SD = 10.28 years; $p = 0.014$). The average BMI in the ORM group was higher (mean = 31.66, SD = 8.44) than that of the BCS alone cohort (mean = 27.95, SD = 5.54; $p = 0.013$). Patients who underwent ORM had significantly larger specimen weights (113.88 ± 82.56 cm^3 vs. 83.55 ± 57.46 cm^3; $p = 0.049$). Patients who underwent ORM also had a lower incidence of seroma formation (6.7 vs. 39.3%; $p = 0.012$) compared with patients who received BCS alone. No significant differences were detected between groups regarding time to follow-up, ALND at surgery, need for re-excision, need for conversion to mastectomy, reoperation, BCRaL, breast lymphedema, radiation dose, wound complications, hematoma, or cellulitis requiring treatment.

TABLE 3 Baseline characteristics and outcomes for patients who underwent oncoplastic reduction mammaplasty compared to breast conservation surgery alone, stratified according to a breast volume threshold of 1500 cm^3

Variable	Breast volume ≥ 1500 cm^3			Breast volume < 1500 cm^3		*p*
	BCS alone	ORM	*p value*	BCS alone	ORM	
	n = 303	*n* = 49		*n* = 415	*n* = 15	
	n (%)	*n* (%)		*n* (%)	*n* (%)	
	mean ± SD	mean ± SD		mean ± SD	mean ± SD	
Age (years)	63.21 ± 9.96	54.59 ± 8.15	< 0.001	64.81 ± 11.5	57.4 ± 10.28	0.014
Race						
White	165 (54.5)	22 (44.9)	0.339	264 (63.6)	8 (53.3)	0.391
Black	134 (44.2)	27 (55.1)		129 (31.1)	7 (46.7)	
Other	4 (1.3)	0 (0)		22 (5.3)	0 (0)	
BMI (kg/m^2)	35.22 ± 6.71	34.34 ± 6.49	0.395	27.95 ± 5.54	31.66 ± 8.44	0.013
Time to follow-up (months)	49.57 ± 17.51	39.07 ± 16.19	< 0.001	49.66 ± 16.77	43.41 ± 18.76	0.159
Lumpectomy specimen weight (cm^3)	181.43 ± 188.05	1176.7 ± 1433.7	< 0.001	83.55 ± 57.46	113.88 ± 82.56	0.049
ALND at time of surgery	39 (12.9)	5 (10.2)	0.771	43 (10.4)	0 (0)	0.382
Need for re-excision	41 (13.5)	1 (2)	0.017	53 (12.8)	0 (0)	0.234
Need for conversion to mastectomy	6 (2)	0 (0)	1.000	11 (2.7)	0 (0)	1.000
Reoperation	2 (0.7)	0 (0)	1.000	1 (0.2)	1 (6.7)	0.069
Breast cancer-related arm lymphedema ≥ 1 year	12 (4.0)	2 (4.1)	1.000	17 (4.1)	1 (6.7)	0.479
Breast lymphedema ≥ 1 year	51 (16.8)	2 (4.1)	0.017	30 (7.2)	0 (0.0)	0.613
Radiation dose (Gy)	57.74 ± 15.97	60.76 ± 20.40	0.239	57.99 ± 16.96	57.30 ± 20.14	0.878
Cellulitis requiring treatment	36 (11.9)	3 (6.1)	0.327	26 (6.3)	1 (6.7)	1.000
Wound complications	3 (1)	6 (12.2)	< 0.001	8 (1.9)	1 (6.7)	0.276
Hematoma	20 (6.6)	8 (16.3)	0.04	16 (3.9)	0 (0.0)	1.000
Seroma	132 (43.6)	6 (12.2)	< 0.001	163 (39.3)	1 (6.7)	0.012

BCS breast conservation surgery; *ORM* oncoplastic reduction mammoplasty; *BMI* body mass index; *ALND* axillary lymph node dissection

TABLE 4 Univariate analysis of breast lymphedema rates based on volume with and without oncoplastic reduction mammoplasty

Breast lymphedema	No	Yes	*p*
	n (%)	*n* (%)	
Radiation volume			< 0.001
Entire ORM cohort	62 (96.9)	2 (3.1)	
Breast volume ≥ 1500 cm^3 without ORM	252 (83.2)	51 (16.8)	
Breast volume < 1500 cm^3 without ORM	385 (92.8)	30 (7.2)	

Categorical or ordered data are given as frequency (row percentage) for the overall row

Breast Lymphedema

Univariate analysis demonstrated that patients with breast volumes ≥ 1500 cm^3 who received BCS alone had significantly higher rates of breast lymphedema compared with all patients who received ORM and also compared with patients with breast volumes < 1500 cm^3 who received BCS alone ($p < 0.001$; Table 4). When accounting for potential confounding variables, multivariate regression analysis demonstrated that patients with preoperative macromastia (breast volumes ≥ 1500 cm^3) who did not undergo immediate reduction were 6.575 times more likely to develop breast lymphedema compared with the cohort of patients who received ORM ($p = 0.014$; Table 5). The analysis also showed that black women had 2.018 times higher odds of developing breast lymphedema than white women ($p = 0.006$). Patients who received ALND at surgery exhibited 2.282 times higher odds ($p = 0.016$) of developing breast lymphedema than those who did not receive ALND. Patients who developed cellulitis had 3.56 times higher odds ($p < 0.001$), and patients who developed BCRaL had 2.894 times higher odds ($p = 0.024$) of developing breast lymphedema relative to those without these complications, respectively.

DISCUSSION

Breast lymphedema is a chronic complication with debilitating implications, including breast pain, burning sensations, psychological distress, difficulty finding appropriate clothing and bra support, neck and back pain,

TABLE 5 Multivariate regression analysis for breast lymphedema persisting for at least 1-year post-radiation

	Estimate	OR	LCL	UCL	*p* value
Race (black)	0.702	2.018	1.224	3.329	0.006
Race (other)	-0.517	0.596	0.075	4.739	0.625
BMI	0.014	1.014	0.976	1.054	0.475
Breast volume ≥ 1500 cm^3 without ORM	1.883	6.575	1.473	29.348	0.014
Breast volume < 1500 cm^3 without ORM	1.178	3.249	0.702	15.048	0.132
ALND at surgery	0.825	2.282	1.163	4.478	0.016
Adjuvant chemotherapy	− 0.611	0.543	0.217	1.357	0.191
Total radiation dose	− 0.004	0.996	0.980	1.012	0.625
Cellulitis	1.270	3.560	1.815	6.984	<0.001
Seroma	0.256	1.292	0.787	2.120	0.310
Arm lymphedema > 1 year	1.063	2.894	1.149	7.293	0.024

Categorical breast volume with oncoplastic reduction

musculoskeletal dysfunction, and breast asymmetry.[22–24] This is a difficult complication to manage with inadequate means of management. In this study cohort of all women undergoing BCS or ORM, 10.6% of patients developed breast lymphedema (Table 2). Patients with macromastia are disproportionately affected by breast lymphedema following BCS and radiation therapy, with reported odds being roughly twice as high as those without macromastia.[6,12] Our study demonstrates that women with macromastia, defined as breast volumes ≥ 1500 cm^3, who underwent BCS alone were nearly seven times more likely to suffer from breast lymphedema than women who underwent immediate oncoplastic reduction at the time of lumpectomy ($p = 0.014$; Table 5). A potential explanation for the increased susceptibility to breast lymphedema in patients with macromastia who undergo BCS may be that these patients have longer lymphatic channels with increased scarring potential, resulting in lymphatic flow impediment.[25] Breast lymphedema also commonly occurs secondary to cellulitis in women with macromastia who receive BCS. This underlying pathophysiology may be due to altered breast biocomposition or from lymphangiectasis as a result of lymph stasis.[6,26,27] By reducing breast volume and skin length, ORM can minimize the risk of breast lymphedema by decreasing weight compression on remaining tissue, mitigating blocked lymphatic draining.[28] Similar to a conventional reduction mammoplasty, it is important that the integrity of blood supply and skin quality are considered intraoperatively when deciding which pedicle to use at the time of lumpectomy.

Amongst patients with macromastia, the oncologic and general health benefits of extracting greater breast volumes are both clinically meaningful and readily achievable. In addition to reducing the risk of breast lymphedema, ORM can offer functional quality of life benefits such as improved body image, reduction in chronic back pain, and improved sexual satisfaction.[29,30] Furthermore, due to permittable wide resections with free margins, ORM has been shown to reduce locoregional recurrence and may be especially important for treating larger cancers.[29,31] Our study demonstrated that the cohort of patients who underwent ORM had significantly greater negative margin rates than the cohort patients who received BCS alone. Support ORM as a safe and effective means of protecting against breast lymphedema, particularly in patients with macromastia.

It is important to note that the patients who underwent ORM experienced higher rates of wound complications and higher rates of hematoma with the possibility of requiring takeback to the operating room. However, our findings also demonstrated that ORM resulted in decreased risks of seroma and decreased need for re-excision. Although the time from surgery to adjuvant radiation was 2 weeks longer on average for the ORM cohort than the BCS cohort, all patients received radiation within the optimal timeframe of three months post-lumpectomy. In assessing the utility of ORM for a patient, one must weigh all of these discussed risks and benefits. Furthermore, patients must also be willing to undergo a breast reduction procedure, which is a personal choice that is not necessarily suitable for all. It should also be highlighted that this procedure is not an ideal choice for patients with uncontrolled diabetes. In this cohort of patients who underwent ORM, patients only had this operation if their hemoglobin A1C was <7%. Nonetheless, for eligible candidates, it is important to discuss the long-term benefits of ORM, which can ultimately enhance long-term functional benefits and quality of life.

Candidates for ORM may vary based on surgeon preference, patient preference, cancer location, medical optimization, and ability to coordinate cases. Importantly, screening for patients who are good candidates for ORM can be optimized by estimating their breast volumes and skin ptosis preoperatively. Beyond clinical assessment, ORM candidacy can be assessed using mammography, MRI, anthropomorphic-based volume formulas, or software-based breast density measurement technology.[32–34] At our institution, patients

were referred for ORM if they were concerned with symptoms related to macromastia, had significant breast ptosis, or desired a breast lift and/or reduction. They were also referred if they were to have a quadrantectomy and had sufficient breast tissue to accommodate ORM.

Another notable finding from our study is that the likelihood of breast lymphedema in black women is two times higher than in white women. This is consistent with current literature that discusses higher rates of breast lymphedema, in addition to other types of lymphedemas such as BCRaL, in black patients.[6,35] It is hypothesized that the prevalence of fibroproliferative disease in patients of African ancestry may play a role in this pathogenesis, as a higher rate of single nucleotide polymorphisms for this disease class has been discovered in this population.[36] This finding promotes the importance of physician awareness of racial disparities when treating patients with breast cancer, and approaches to mitigate these differences should be investigated to a further degree in the future.

Although this study successfully identified breast lymphedema incidence amongst women undergoing various surgical treatment options for breast cancer, it faced some limitations. Despite a large overall sample size, only 64 patients underwent ORM, of which only two patients were diagnosed with breast lymphedema. This effect is accentuated when disaggregated according to categorical breast volume. Our study is therefore at risk for type II error. A potential limitation to this study is the possibility of a breast lymphedema detection bias within the macromastia population, given the shorter follow-up duration in the ORM group versus BCS group (39.07 vs. 49.57 months, respectively; $p < 0.001$). However, as the incidence of lymphedema is greatest in the first 12–30 months after lymphatic insult (e.g., radiation therapy),[37] it becomes difficult to ascertain whether a 10-month difference in follow-up times between groups meaningfully impacted the breast lymphedema detection rate, especially since both groups had mean follow-up times surpassing this high-risk window. Lastly, our breast volume calculation had limitations. Breast volume was calculated by using the sum of lumpectomy specimen volume and postoperative breast volume as measured by contour analysis at the time of radiation therapy. While these measurements are not exact, they represent a close estimate of patients' breast volumes.

CONCLUSIONS

Oncoplastic reduction mammoplasty is a widely accepted treatment approach because of its capacity to improve cosmesis and perform wider tumor excisions, which has been shown to prevent locoregional recurrence.[7,11–14,17,38,39] This study is the first to examine the impact of ORM on the risk of breast lymphedema, a distressing complication of breast surgery. Oncoplastic reduction mammoplasty demonstrates a potential protective effect against breast lymphedema amongst women with breast volumes ≥ 1500 cm^3. Future research may seek to prospectively evaluate patients undergoing ORM to draw more definitive conclusions regarding its impact on breast lymphedema rates, to identify pertinent patient-reported outcome measures, and to establish a threshold volume in which ORM meaningfully reduces breast lymphedema.

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