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Shoulder MRI Findings in Breast Cancer–Related Lymphedema: A Case-Control Study of Rotator Cuff and Joint Pathology

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ABSTRACT

Objective: To investigate the prevalence and characteristics of shoulder pathologies in women with breast cancer–related lymphedema (BCRL) using magnetic resonance imaging (MRI), and to compare these findings with those in controls of comparable age distribution presenting with shoulder pain but without malignancy or lymphedema.

Methods: In this retrospective case-control study, 45 women with BCRL and 45 controls of comparable age underwent shoulder MRI for unilateral shoulder pain. MRI findings included rotator cuff tendinopathies or tears, joint degeneration, and intra-articular or bursal effusion. Associations between lymphedema-related factors and effusion were examined using univariable and multivariable logistic regression analyses. Inter-reader agreement for effusion detection was also assessed.

Results: MRI-detected effusion was significantly more frequent in the BCRL group than in controls (73.3% vs. 15.6%, $p < 0.001$), while the frequency of normal shoulder findings was notably lower (2.2% vs. 17.7%, $p = 0.03$). Rotator cuff and biceps pathologies were more common in the BCRL group, but the differences did not reach statistical significance. Within the BCRL group, patients with effusion had a significantly longer mean lymphedema duration in descriptive comparisons ($p = 0.007$), whereas lymphedema duration was not an independent predictor of effusion in logistic regression analysis. Lymphedema severity showed no significant association with specific MRI abnormalities.

Conclusion: Women with BCRL showed a higher prevalence of shoulder joint effusion on MRI than controls, while normal shoulder findings were less frequent. Effusion may represent a correlational imaging marker associated with chronic lymphatic dysfunction rather than a direct causal consequence. These findings support the selective use of imaging in BCRL patients presenting with shoulder complaints and highlight the need for prospective studies incorporating oncologic treatment parameters and functional outcomes.

1 | Introduction

Breast cancer is the most common malignancy in women worldwide, and breast cancer–related lymphedema (BCRL) complicates the recovery of roughly one-third of survivors, causing upper-limb pain, stiffness, and functional loss [1–3].

Rotator cuff (RC) pathologies, including tendinopathies and tendon ruptures, are commonly seen in the general population and are typically considered overuse injuries resulting from repetitive overhead activities. Such movements lead to microtrauma and inflammation in the supraspinatus tendon [4, 5]. In

BCRL, however, impaired lymphatic drainage and tissue fibrosis may also compromise the healing environment and shoulder biomechanics, potentially contributing to musculoskeletal dysfunction [6, 7].

Although shoulder pain is reported in approximately 30% of individuals with BCRL, the specific relationship between lymphedema and RC pathology remains unclear [8]. Existing studies investigating shoulder abnormalities in BCRL patients have largely relied on ultrasonographic evaluation [2, 9], which may not adequately detect deeper or intra-articular lesions.

Magnetic resonance imaging (MRI) provides superior soft tissue contrast and structural detail compared to ultrasound and has proven valuable in identifying RC tears, muscle atrophy, and glenohumeral (GH) or acromioclavicular (AC) joint abnormalities [10, 11]. Despite these advantages, the literature lacks studies employing MRI to assess shoulder pathology specifically in patients with BCRL.

This retrospective case-control study uses MRI to characterize shoulder pathology in women with BCRL and examines its association with lymphedema, compared with women of comparable age distribution presenting with unilateral shoulder pain but no history of cancer or lymphedema.

2 | Materials and Methods

This retrospective case-control study was conducted at the Lymphedema Unit of the Department of Physical Medicine and Rehabilitation, Ege University Faculty of Medicine, Izmir, Turkey. The study was approved by the university's ethics committee, and written informed consent was obtained from all participants. The study adhered to the principles of the Declaration of Helsinki and Good Clinical Practice guidelines.

Patients diagnosed with BCRL who underwent shoulder MRI due to ipsilateral shoulder pain between January 2022 and December 2024 were retrospectively reviewed. Inclusion criteria were as follows: unilateral BCRL, presence of shoulder pain on the same side, and availability of complete clinical and imaging data.

Exclusion criteria included incomplete cancer treatment, bilateral lymphedema, lymphangitis, skin conditions, inflammatory shoulder arthritis, prior shoulder trauma or surgery, and osseous metastasis.

The control group consisted of women without a history of malignancy or lymphedema who presented with shoulder pain and underwent shoulder MRI during the same period and had a comparable age distribution to the BCRL group. Age matching was performed at the group level rather than on a one-to-one basis, aiming to achieve comparable age distributions between the BCRL and control groups. Ultimately, 45 women with BCRL and 45 controls meeting the eligibility criteria were included in the final analysis. The participant selection process for both the BCRL and control groups is summarized in Figure 1.

2.1 | Lymphedema Assessment

Lymphedema severity was assessed by circumferential limb measurements, performed with the shoulder in 90° flexion, elbow extended, and wrist in neutral position. Measurements were taken at 5 cm intervals from the wrist to the axilla. Limb volumes were calculated using Limb Volume Professional software (Version 5.0), and percentage differences between affected and unaffected limbs were recorded. Staging was performed according to the National Cancer Institute criteria [12]. This volume-based severity stratification, rather than clinical ISL staging, was used to explore whether the degree of lymphedema burden was associated with shoulder MRI findings.

2.2 | MRI Protocol and Image Analysis

All shoulder MRIs were acquired using a 3T MRI system (Skyra; Siemens, Erlangen, Germany) with a dedicated shoulder coil. Imaging sequences included T1-weighted and fat-saturated proton-density (PD) T2-weighted images in sagittal, coronal, and axial planes. All MRI examinations were initially interpreted by a single experienced musculoskeletal radiologist as part of routine clinical practice. The radiologist was aware of the patients' clinical information at the time of reporting; however, image interpretation was performed before the conception of the present study, and the radiologist was unaware that the examinations would later be included in a research analysis. The images were systematically evaluated for RC tendinosis or tears, biceps pathology, AC and GH joint degeneration, and intra-articular or bursal effusion. Intra-articular and subacromial-subdeltoid effusion was defined as the presence of fluid with high signal intensity on T2-weighted or PD fat-suppressed sequences exceeding physiological joint fluid. Tendinosis was defined as increased intratendinous signal intensity on T1- and T2-weighted images without fiber discontinuity, whereas partial- and full-thickness tears were defined by focal or complete tendon fiber disruption. For the purposes of statistical analysis, intra-articular and subacromial-subdeltoid effusions were evaluated together as a single "effusion" category, and no subtype-specific analyses were performed.

To assess inter-reader reliability, all MRI examinations were independently re-evaluated by a second musculoskeletal radiologist who was blinded to the clinical information and group allocation. Effusion was assessed using the same predefined imaging criteria. Inter-reader agreement was evaluated using Cohen's kappa statistics.

2.3 | Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics Version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize patient demographics and clinical characteristics. Continuous variables were expressed as mean ± standard deviation (SD) and minimum–maximum values. Categorical variables were reported as frequencies and percentages.

The normality of continuous variables was assessed using the Shapiro–Wilk test, given that the sample size per group was less than 50. Between-group comparisons of continuous variables were conducted using the independent samples t-test for normally distributed data or the Mann–Whitney U test for non-normally distributed data. Categorical variables were compared using the chi-square (χ^2) test or Fisher's exact test, as appropriate. A two-tailed p value of < 0.05 was considered statistically significant. In addition, univariable and multivariable binary logistic regression analyses were performed

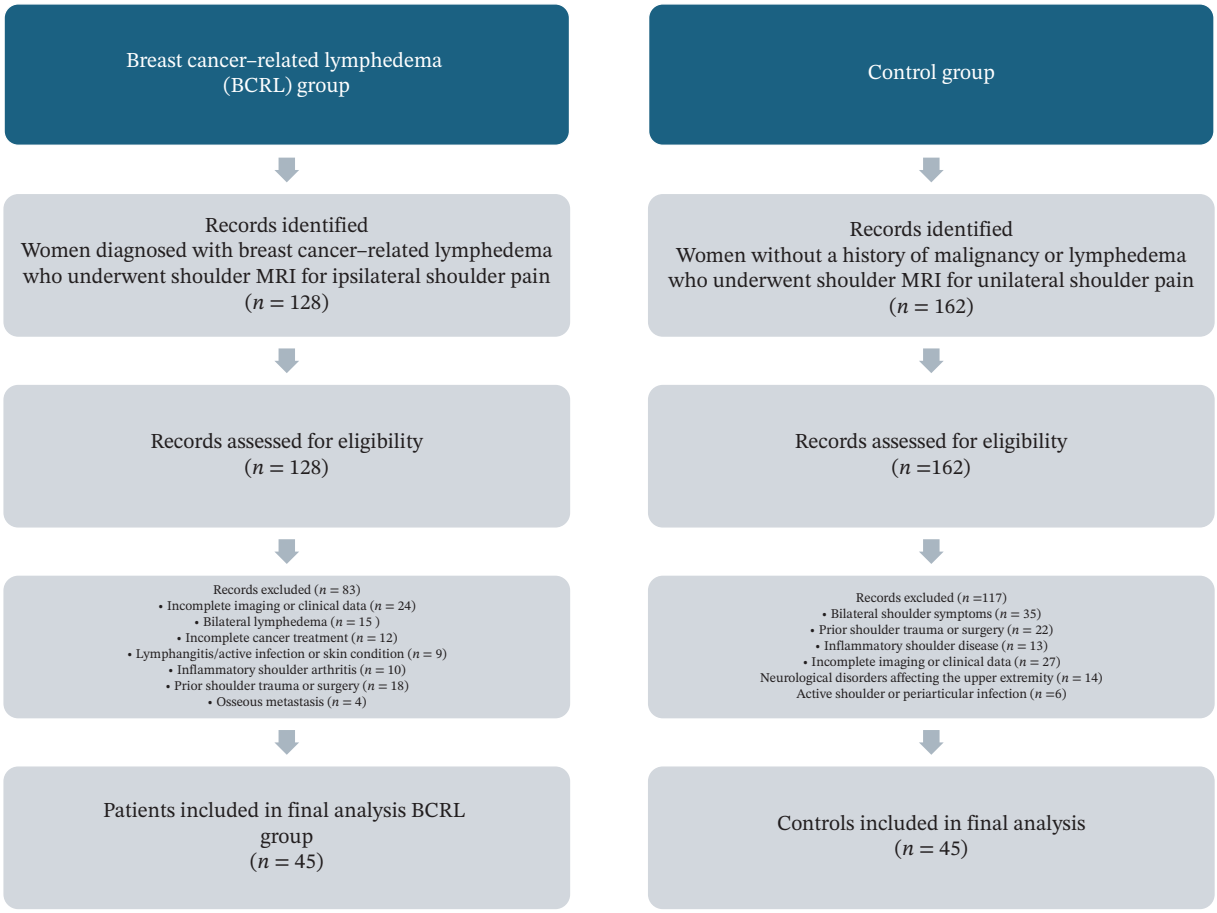

FIGURE 1 | Flow diagram illustrating the participant selection process for the breast cancer–related lymphedema (BCRL) group and the control group. Records were retrospectively assessed for eligibility based on predefined inclusion and exclusion criteria. After eligibility assessment, 45 women with BCRL and 45 controls were included in the final analysis.

within the BCRL group to identify factors associated with the presence of intra-articular and/or bursal effusion (Table 1). Variables entered into the multivariable model included age, body mass index (BMI), type of surgery (total mastectomy), axillary lymph node dissection, chemotherapy, radiotherapy, and duration of lymphedema.

To quantify the magnitude of differences between groups, effect size measures were calculated. For comparisons involving categorical outcomes (e.g., presence or absence of intra-articular effusion), odds ratios (OR) were calculated along with their corresponding 95% confidence intervals (CI) to express the strength and precision of associations. For continuous variables (e.g., duration of lymphedema), Cohen's d was calculated to estimate the standardized mean difference between groups, with thresholds of 0.2, 0.5, and 0.8 conventionally representing small, medium, and large effect sizes, respectively.

TABLE 1 | Factors associated with intra-articular and/or bursal effusion in the BCRL group: univariable and multivariable logistic regression analyses.

Variable	Univariable OR (95% CI)	*p*	Multivariable OR (95% CI)	*p*
Total mastectomy (yes vs. no)	**4.60 (1.10–18.90)**	0.034	4.1 (0.7–22.4)	0.108
Axillary lymph node dissection (yes vs. no)	**2.90 (0.20–50.60)**	0.464	6.6 (0.14–306.6)	0.334
Chemotherapy (yes vs. no)	**1.60 (0.30–8.90)**	0.591	1.5 (0.15–15.3)	0.727
Radiotherapy (yes vs. no)	**2.40 (0.30–22.70)**	0.432	1.9 (0.1–34.1)	0.654
Age	**1.02 (0.95–1.10)**	0.604	0.99 (0.91–1.1)	0.874
BMI	**1.20 (0.90–1.40)**	0.131	1.2 (0.94–1.53)	0.147
Lymphedema duration	**1.03 (0.99–1.07)**	0.132	1.02 (0.97–1.07)	0.466

Note: Model: binary logistic regression. Dependent variable: presence of intra-articular and/or bursal effusion (yes/no). Multivariable model adjusted for age, body mass index (BMI), type of surgery (total mastectomy), axillary lymph node dissection, chemotherapy, radiotherapy, and lymphedema duration. Bold values were intended to indicate statistically significant results ($p < 0.05$). In Table 1, only the univariable analysis for total mastectomy reached statistical significance ($p = 0.034$).
Abbreviations: BCRL, breast cancer–related lymphedema; CI, confidence interval; OR, odds ratio.

Given the retrospective design of the study, the sample size was determined by the number of eligible clinical records available during the study period. No a priori sample size calculation was performed; therefore, nonsignificant findings should be interpreted cautiously due to the possibility of Type II error.

3 | Results

A total of 45 women with BCRL and 45 controls with comparable age distribution were included in the study. Table 2 summarizes the demographic and clinical features of patients with BCRL included in the study. There was no statistically significant difference in age or BMI between the two groups ($p > 0.05$).

Intra-articular and/or bursal effusion was observed significantly more frequently in the BCRL group than that in the control group (73.3% vs. 15.6%, $p < 0.001$; OR = 14.9, 95% CI: 5.8–38.6), indicating a markedly increased likelihood of effusion in patients with lymphedema. Logistic regression analysis was therefore performed within the BCRL group to explore factors associated with effusion. In univariable logistic regression analysis, total mastectomy was associated with higher odds of effusion (OR 4.60, 95% CI 1.10–18.90, $p = 0.034$), whereas no other treatment-related variables showed significant associations (Table 1). However, when age, BMI, type of surgery (total mastectomy), axillary lymph node dissection, chemotherapy, radiotherapy, and lymphedema duration were simultaneously included in a multivariable logistic regression model, none of the evaluated variables remained statistically significant predictors of effusion (Table 1). Additionally, normal shoulder MRI findings were significantly less common in the BCRL group than those in the control group (2.2% vs. 17.7%, $p = 0.03$), indirectly supporting the higher prevalence of structural abnormalities in the BCRL population. Inter-reader agreement for effusion detection was substantial (Cohen's $\kappa = 0.69$).

Lymphedema duration was included as a continuous variable in the logistic regression analysis. Although longer BCRL duration was associated with slightly higher odds of effusion, the association did not reach statistical significance (OR 1.02, 95% CI 0.97–1.07, $p = 0.466$; Table 4). This finding should be interpreted cautiously, as the limited sample size may have reduced statistical power. Moreover, given the cross-sectional design, causality or progression over time cannot be established. Larger prospective studies are warranted to clarify whether chronic lymphatic dysfunction contributes to progressive periarticular fluid accumulation. Reverse causality, whereby pre-existing shoulder pathology may influence symptom duration rather than result from it, cannot be excluded.

AC joint degeneration and infraspinatus tendinosis were nominally less frequent in the BCRL group compared with the control group; however, these differences did not reach statistical significance ($p = 0.83$ and $p = 0.71$, respectively; Table 3). Notably, biceps tendinosis had a difference of potential clinical importance between the groups (28.9% in the BCRL group vs. 13.3% in controls), but this difference did not reach statistical significance ($p = 0.07$).

In the BCRL group, no statistically significant association was found between lymphedema severity—based on interlimb volume difference—and the presence of specific MRI abnormalities (Table 4). In descriptive comparisons, however, the mean duration of lymphedema was significantly longer in patients with effusion ($n = 33$) compared to those without effusion ($n = 12$)

TABLE 2 | Demographic and clinical characteristics of the BCRL and control groups.

Variables	BCRL group ($n = 45$)	Control group ($n = 45$)
Age (years)	57.71 ± 9.5 (38–87)	53.98 ± 9.1 (40–80)
BMI (kg/m^2)	30.86 ± 4.51 (23.70–39.19)	28.76 ± 3.78 (22.60–36.86)
Lymphedema severity (volume differences of arms)		
< 5%	8 (17.8%)	
5%–10%	14 (31.2%)	
10%–30%	16 (35.5%)	
> 30%	7 (15.5%)	
Duration of lymphedema (months)	28.11 ± 32.53 (1–132)	
Type of breast surgery		
Partial mastectomy	12 (26.7%)	
Total mastectomy	27 (60%)	
Modified radical mastectomy	6 (13.3%)	
Axillary lymph node dissection	43 (95.5%)	
Chemotherapy		
Yes	35 (77.8%)	
No	10 (22.2%)	
Radiotherapy		
Yes	38 (84.4%)	
No	7 (15.5%)	

Note: Data are presented as mean ± standard deviation or number (percentage), unless otherwise specified. Age, BMI, and duration of lymphedema are presented as mean ± standard deviation (minimum–maximum). Clinical and lymphedema-related variables were applicable only to the BCRL group.

TABLE 3 | Shoulder MRI findings in the BCRL and control groups.

MRI findings	BCRL group (*n*: 45)	Control group (*n*: 45)	*p* value	OR (95% CI)
Intra-articular and bursal effusion	33 (73.3%)	7 (15.6%)	**< 0.001***	14.9 (5.8–38.6)
Acromioclavicular joint degeneration	25 (55.6%)	26 (57.8%)	0.83	0.9 (0.4–2.1)
Supraspinatus tendinosis	25 (55.6%)	21 (46.7%)	0.39	1.4 (0.6–3.3)
Supraspinatus partial tear	12 (26.7%)	11 (24.4%)	0.80	1.1 (0.4–2.9)
Supraspinatus full-thickness tear	1	0	NA	NA
Biceps tendinosis	13 (28.9%)	6 (13.3%)	0.07	2.6 (0.9–7.7)
Biceps partial tear	1	0	NA	NA
Infraspinatus tendinosis	3 (6.7%)	5 (11.1%)	0.71	0.6 (0.1–2.6)
Infraspinatus partial tear	4 (8.9%)	0 (0%)	0.24	0.5 (0.15–1.2)
Glenohumeral joint degeneration	3 (6.7%)	2 (4.4%)	1	1 (0.4–2.3)
Normal shoulder joint	1 (2.2%)	8 (17.7%)	0.03	0.1 (0.01–0.9)

Note: Data are presented as number of patients (percentage). *p* values were calculated using chi-square or Fisher's exact test, as appropriate. NA: not applicable due to sparse cells (zero counts), precluding reliable odds ratio estimation. Bold values indicate statistically significant results ($p < 0.05$). In Table 3, statistically significant differences were observed for intra-articular and bursal effusion ($p < 0.001$) and normal shoulder joint ($p = 0.03$).
Abbreviations: BCRL, breast cancer–related lymphedema; MRI, magnetic resonance imaging.
*Statistically significant difference ($p < 0.05$).

TABLE 4 | Distribution of shoulder MRI findings by lymphedema severity in the BCRL group.

MRI findings	< 5% (*n*: 8)	5%–10% (*n*: 14)	10%–30% (*n*: 16)	> 30% (*n*: 7)	*p* value
Intra-articular and/or bursal effusion	5	12	12	4	0.468
AC joint degeneration	6	9	7	3	0.389
Supraspinatus tendinosis	4	9	8	4	0.864
Supraspinatus partial tear	2	4	6	0	0.315
Supraspinatus full-thickness tear	0	0	0	1	0.433
Biceps tendinosis	3	5	4	1	0.694
Biceps partial tear	0	0	0	1	0.136
Infraspinatus tendinosis	0	2	0	1	0.299
Infraspinatus partial tear	1	1	1	1	0.903

Note: Data are presented as number of patients (*n*). Severity categories are based on the interlimb volume difference. Group sizes: < 5% ($n = 8$), 5%–10% ($n = 14$), 10%–30% ($n = 16$), and > 30% ($n = 7$). *p* values were calculated using the chi-square or Fisher's exact test, as appropriate.
Abbreviations: BCRL, breast cancer–related lymphedema; MRI, magnetic resonance imaging.

(33.1 ± 36.3 months vs. 14.0 ± 9.9 months; $p = 0.007$; Cohen's $d = 0.72$), indicating a medium-to-large effect size.

4 | Discussion

This study contributes to the current literature by providing MRI-based structural imaging data in women with BCRL and comparing these findings with controls of comparable age distribution without lymphedema or malignancy. Previous studies investigating shoulder pain in this population often relied on ultrasound or clinical assessments [13, 14], whereas MRI offers greater sensitivity in detecting intra-articular effusion, tendinopathies, and subtle degenerative changes [15, 16]. This MRI-based case-control study objectively compares structural shoulder abnormalities in women with BCRL using high-resolution imaging.

In our study, the frequency of intra-articular and/or bursal effusion was significantly higher in the BCRL group than that in the control group. These findings suggest a possible association between chronic lymphatic dysfunction and periarticular fluid accumulation [14, 17]. Additionally, normal shoulder MRI findings were significantly less frequent in the BCRL group, suggesting a higher burden of subclinical abnormalities. However, no statistically significant association was found between lymphedema severity (based on volume difference) and specific MRI pathologies; this finding should be interpreted with caution given the limited sample size and potential for Type II error. While the presence of shoulder abnormalities was more common in BCRL, this study cannot establish lymphedema as an independent risk factor due to its retrospective and cross-sectional design. In addition, multivariable logistic regression analysis adjusting for age, BMI, surgical type, axillary lymph node dissection, chemotherapy, radiotherapy, and lymphedema duration did not identify treatment-related variables as independent predictors of effusion. This suggests that the increased prevalence of effusion in the BCRL group cannot be explained solely by oncologic treatment characteristics.

Notably, a longer duration of lymphedema was significantly associated with the presence of effusion. Previous studies have suggested that lymphatic stasis may be related to periarticular

fluid accumulation and tissue alterations through mechanical or inflammatory pathways [13, 14, 17–19]. These findings may underscore the importance of early detection and management of subclinical shoulder changes in this population.

Recent evidence has also reported progressive functional and neuromuscular deterioration of the shoulder with increasing lymphedema severity, including reduced mobility, strength, and altered muscle activation patterns. Although our MRI-based findings are structural in nature, they are broadly consistent with these observations and suggest a possible association between chronic lymphatic dysfunction and greater disease burden and periarticular structural changes [20].

Another limitation is that the initial MRI interpretations were performed by a single radiologist as part of routine clinical reporting and were not formally blinded to clinical information at the time of reporting. However, these interpretations were completed prior to the conception of the present study, which reduces the likelihood of hypothesis-driven bias. To enhance methodological rigor, all MRI examinations were subsequently re-evaluated by a second musculoskeletal radiologist who was blinded to clinical information and group allocation, and inter-reader agreement for effusion detection was assessed using Cohen's kappa statistics.

Despite this additional reliability assessment, the retrospective design and relatively limited sample size remain important limitations. Although multivariable logistic regression analysis adjusting for age, BMI, and oncologic treatment variables was performed, the relatively small sample size limits the statistical power of these analyses; therefore, the findings should be interpreted with caution.

In addition, intra-articular and subacromial-subdeltoid effusions were analyzed as a single composite outcome to preserve statistical power and reflect overall periarticular fluid burden rather than compartment-specific pathology. Although this approach simplified the analysis, it may have obscured potential pathophysiological differences between compartments. Future studies with larger sample sizes should evaluate these effusion types separately to clarify their distinct anatomical and clinical significance.

Given the limited sample size and number of events, the study may have been underpowered to detect small-to-moderate associations; therefore, nonsignificant findings should not be interpreted as evidence of absence of effect.

RC and biceps pathologies were more frequent in the BCRL group; however, these differences did not reach statistical significance, possibly due to limited statistical power. The absence of statistical significance in some comparisons, particularly biceps tendinosis, should therefore be interpreted with caution. Given the retrospective design and fixed sample size, these findings may reflect limited statistical power and the possibility of a Type II error rather than a true absence of association. Accordingly, these results should be considered exploratory and warrant confirmation in larger studies.

The control group consisted of symptomatic individuals presenting with shoulder pain but without malignancy or lymphedema. While this approach reduces referral bias by ensuring comparable clinical indications for MRI, it may increase the background prevalence of structural shoulder abnormalities and attenuate observed between-group differences. Because the control participants had no history of breast cancer, oncologic treatment exposures were not applicable, and sensitivity analyses based on comparable treatment exposure could not be performed.

Nonetheless, prior multivariable logistic regression analyses have identified BCRL, shoulder immobilization, and obesity as independent predictors of adhesive capsulitis and shoulder dysfunction, which is consistent with the clinical relevance of our findings [21]. Although volume-based severity stratification was performed (Table 4), volume measures and clinical ISL staging are related but not interchangeable. Therefore, the absence of more granular clinical staging (e.g., early vs. late Stage II or Stage III BCRL) may have limited our ability to fully capture lymphedema heterogeneity in relation to MRI findings.

RC pathology is classically associated with repetitive overhead activity [20, 22], yet BCRL patients are typically discouraged from such activities. Instead, they may experience immobilization and muscular disuse due to limb heaviness and fibrotic changes. RC tendinitis has been observed in BCRL patients even in the absence of overuse, with proposed mechanisms including intrinsic atrophic changes and altered biomechanics [17, 18]. Our findings of a high frequency of RC-related abnormalities in both groups (95.5% vs. 82.2%) support the notion that shoulder pain, regardless of cancer history, is often accompanied by structural abnormalities detectable by MRI.

Several factors related to cancer treatment—including surgical type, radiation exposure, aromatase inhibitor therapy, and cancer stage—are known to influence shoulder structure and function [19, 23, 24]. These variables were not stratified in the present study and should be considered in future research to better delineate the contribution of BCRL. In addition, molecular mechanisms such as cytokine-mediated inflammation and angiogenesis have been implicated in posttreatment shoulder dysfunction [25–27]. Emerging evidence also suggests that extracellular vesicle–mediated signaling may contribute to posttreatment tissue remodeling and chronic inflammation in breast cancer survivorship. Future studies integrating imaging findings with molecular and biomarker-based approaches, including biosensor technologies, may help advance the understanding and monitoring of musculoskeletal complications in this population [28].

Clinically, these findings suggest that women with long-standing BCRL may be at increased risk for joint effusion and other subclinical musculoskeletal changes. MRI-detected abnormalities such as effusion may reflect early inflammatory or overload responses, even without overt tendon damage. Early identification of such changes may facilitate individualized rehabilitation strategies. Manual lymphatic drainage (MLD), combined with range-of-motion and strengthening exercises, has shown efficacy in improving both lymphedema severity and shoulder function [29].

From a translational perspective, musculoskeletal MRI assessment is increasingly being integrated with artificial intelligence–supported image analysis. These approaches may enable more objective and reproducible evaluation of tissue alterations through automated segmentation, quantitative imaging metrics,

and longitudinal monitoring of periarticular structures. Such developments may enhance the clinical utility of MRI-based biomarkers in complex conditions such as BCRL and may facilitate earlier detection of subclinical musculoskeletal involvement while supporting more individualized rehabilitation planning [30, 31]. Such quantitative approaches may also help reduce reader subjectivity and improve the reproducibility of MRI-based biomarkers across centers.

4.1 | Clinical Implications

These findings suggest that women with long-standing BCRL may benefit from early musculoskeletal assessment when presenting with shoulder symptoms. MRI-detected effusion may represent an early inflammatory or mechanical overload–related change even in the absence of overt tendon tears. Recognition of such findings may support timely referral to rehabilitation programs, optimization of exercise programs, and potentially reducing the risk of progression to symptomatic shoulder dysfunction.

5 | Conclusion

In this MRI-based case-control study, intra-articular and/or bursal effusion was significantly more frequent in patients with BCRL than in controls of comparable age distribution without lymphedema or malignancy. While RC and biceps pathologies were also more prevalent, these differences did not reach statistical significance and may reflect limited power to detect small-to-moderate effects. Interestingly, lymphedema severity did not correlate with specific MRI abnormalities, whereas longer disease duration was associated with effusion. These findings suggest that chronic lymphatic dysfunction may contribute to periarticular fluid accumulation and subclinical musculoskeletal changes. Although causality cannot be established due to the retrospective and cross-sectional nature of the study, MRI appears to be a valuable tool in the clinical evaluation of shoulder pain in BCRL patients. Future prospective studies should incorporate oncologic treatment parameters and functional outcomes to clarify the complex interactions between lymphedema, cancer therapy, and musculoskeletal dysfunction.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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