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Comparison of Range of Motion (ROM) Limitations and Lymphedema in Breast Cancer Patients Following Axillary Lymph Node Dissection (ALND) and Sentinel Lymph Node Biopsy (SLNB): A Systematic Review

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ABSTRACT
Axillary lymph node dissection (ALND) and sentinel lymph node biopsy (SLNB) are widely used surgical procedures for breast cancer management. Previous studies have reported a lower incidence of range of motion (ROM) limitations and lymphedema following SLNB. However, no systematic review has been conducted to consolidate these findings. This research aims to systematically compare the incidence of ROM limitations and lymphedema in breast cancer patients undergoing ALND versus SLNB. The methods follow PRISMA 2020 guidelines, with a literature search conducted using PubMed, ScienceDirect, and Cochrane databases. The population included early-stage invasive breast cancer patients who underwent either SLNB or ALND. A qualitative analysis was performed to assess postoperative ROM limitations and lymphedema. Ten studies involving 8,523 patients were included. Both procedures were applied to patients with operable, early-stage invasive breast cancer. Qualitative analysis indicated that SLNB was generally associated with fewer postoperative complications, particularly in terms of ROM limitation and lymphedema. Some studies reported similar outcomes for both techniques regarding ROM limitation and lymphedema, but SLNB showed better outcomes in terms of postoperative complications such as lymphedema and ROM limitation. However, heterogeneity in definitions, assessment methods, lymph node involvement, and surgical techniques was noted across studies. This systematic review suggests that SLNB is associated with a lower incidence of ROM limitations and lymphedema compared to ALND, supporting its use as a less morbid surgical approach in early-stage breast cancer.

Keywords: *Axillary lymph node dissection, breast cancer, sentinel lymph node biopsy*

INTRODUCTION

Breast cancer is a common cancer in women worldwide and has continued to increase over the past five years. Data from GLOBOCAN show that in 2020 there were 2,261,419 new cases with a mortality rate of 685,000 (Sung et al., 2021). In 2022, there were 2,300,000 new cases with a mortality rate of 670,000. The 2025 projection shows more than 2,500,000 new cases with a mortality rate of 700,000. This indicates that in the past five years, new cases of breast cancer have increased along with the mortality rate (Bray et al., 2024). Breast cancer patients with positive axillary lymph nodes have a worse prognosis than those without axillary lymph node involvement (Ott et al., 2017; Wu et al., 2025).

Detection of nodal metastases is carried out using a combination of clinical examination, radiological imaging, and biopsy (De Bree et al., 2015; Ehteshami Bejnordi et al., 2017; Marino et al., 2020; Woo et al., 2018). Clinical examination is performed to determine whether there is palpable nodal enlargement, followed by radiological examinations such as ultrasound, CT scan, or MRI to confirm non-palpable and deeper lymph nodes and to evaluate more extensive metastases (Liang & Tiong, 2025). Nodal metastases are definitively identified through biopsy, in the form of sentinel lymph node biopsy (SLNB) (Manca et al., 2016). Based on ASCO guidelines (2025), SLNB is recommended for patients with clinically node-negative (cN0) breast cancer who are candidates for local therapeutic surgery (Park et al., 2025), as initial therapy followed by whole-breast radiation. If all of these criteria are not met and nodal status will affect regional chemotherapy or radiation, SLNB is still recommended.

Axillary lymph node dissection (ALND) is not necessary and can be omitted in patients with clinically node-negative (cN0) invasive breast cancer with tumor size ≤5 cm who have undergone mastectomy and have one to two positive sentinel lymph nodes (Jatoi et al., 2016). Several studies have found that breast cancer patients with criteria such as T1–2, cN0, and ≤2 SLN+ who underwent SLNB alone had a regional recurrence rate of <2% over an average follow-up period of 3 years (Yahata et al., 2022; Zaveri et al., 2023). These results are similar to ALND and indicate that SLNB-only can be used as an alternative to ALND in patients meeting certain criteria (Chen et al., 2026; Gentilini et al., 2023). This is one of the foundations for de-escalation of therapy to prevent post-procedural morbidity without compromising therapeutic effectiveness (Cao et al., 2021; Occhipinti et al., 2025; Potpara et al., 2024; Pourmir et al., 2024; Sibbing et al., 2019). This de-escalation applies the principle of balancing the benefits and risks of breast cancer therapy to ensure that patients are not overtreated or undertreated (Pourmir et al., 2024).

Sentinel lymph node biopsy and ALND both carry morbidities such as lymphedema due to disruption of the lymphatic network, resulting in impaired lymphatic flow, decreased arm strength, and limited mobility caused by postoperative pain, local inflammation, tissue edema, and scar formation. These complications affect the patient's long-term quality of life (O'Toole et al., 2013). Several randomized clinical trials, cohort studies, and recent meta-analyses have shown that SLNB has significantly lower morbidity than ALND (Che Bakri et al., 2023). particularly regarding the incidence of lymphedema, postoperative pain, impaired shoulder function, and decreased quality of life, with comparable oncological outcomes in selected patient groups. However, SLNB can still cause complications, although they are generally mild and transi ent.[12] Although some studies have reported higher morbidity rates, such as lymphedema and limited range of motion (ROM) with ALND, and have suggested that therapeutic effectiveness is not inferior to SLNB, this has not been clearly established. There are no clear qualitative studies comparing the morbidity of lymphedema and ROM limitation between SLNB and ALND. Therefore, this systematic review was designed as a qualitative study with the aim of filling the knowledge gap regarding the functional impact after ALND compared to SLNB. By consolidating available evidence, this review seeks to provide clinicians with a clearer understanding of the functional impact associated with each procedure, thereby supporting informed, shared decision-making and reinforcing the rationale for axillary de-escalation in appropriate candidates.

METHODS

Article search and study selection

A systematic literature search was conducted in PubMed, ScienceDirect, and the Cochrane Library from the inception of indexing until August 10th, 2025, using the PRISMA 2020 guidelines. The search strategy was adjusted per database. The Boolean operators ("Sentinel Lymph Node Biopsy" OR "Axillary Lymph Node Dissection") AND ("Breast Cancer") AND ("Side Effects" OR "Quality of Life") were used. Duplicates were removed before filtering. Title and abstract selection and full-text review were performed by two independent reviewers, and discrepancies were resolved through discussion.

Inclusion and Exclusion Criteria

Inclusion criteria included human clinical studies of SLNB and/or ALDN, with a measurable range of motion and lymphedema outcome. Animal studies, in vitro studies, narrative reviews, editorials, and single case reports were excluded.

Study Selection and Quality Assessment

Assessment of methodological quality and risk of bias was adjusted according to design. Multicenter, blinded randomized trials were assessed using the Cochrane Risk of Bias 2.0 in the domains of randomization, deviation from intervention, missing data, outcome measurement, and selective reporting. Prospective comparative nonrandomized studies were evaluated with the Newcastle Ottawa Scale (NOS). Risk of bias assessment was carried out by two reviewers. Differences of opinion were resolved through discussion.

Extraction and analysis of data

Data extraction was performed in a standardized manner by two independent reviewers using a pre-specified form, and discrepancies were resolved through consensus. Qualitative synthesis was planned using a structured narrative approach with evidence organized by study design, the incidence of ROM limitation, and lymphedema. The risk of bias from the RoB-2, ROBINS-I, and JBI was integrated into the qualitative interpretation to assess the strength of the conclusions.

RESULTS

Literature searching

A literature search was conducted through three databases: PubMed (n = 507), ScienceDirect (n = 4193), and Cochrane (n = 2), resulting in a total of 4702 identified records. Before the screening stage, 12 duplicate records were removed, and 3898 records were eliminated using automation tools. The automation tool criteria for PubMed were “free full text” articles in English, while for ScienceDirect, they were “research articles” with the categories “open access” and “open archives.” After this process, 792 records were screened based on title and abstract, with 775 records excluded. Next, 17 reports were searched for retrieval, and all were successfully retrieved (reports not retrieved = 0). These 17 reports were then assessed for eligibility, and 8 reports were excluded due to irrelevant data, while none were excluded due to incomplete data (n = 0). Ultimately, 9 studies met the criteria and were included in the review, with a total of 9 included studies.

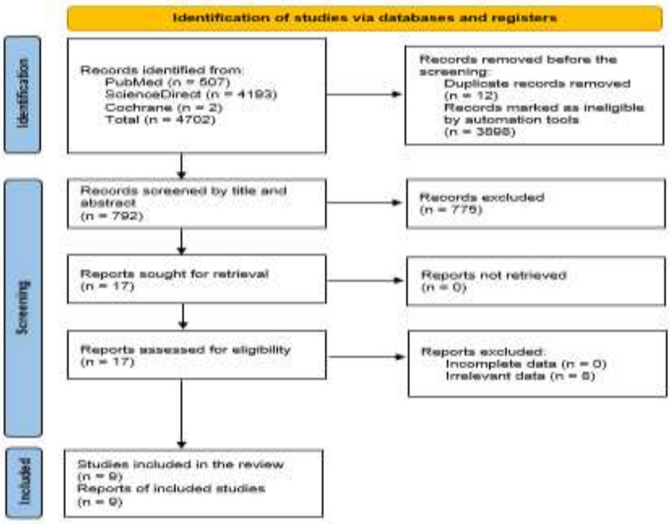

Figure 1. PRISMA Flowchart

Source: Generated by the authors based on the search results from PubMed, ScienceDirect, and Cochrane databases (accessed August 10th, 2025)

Study Characteristics

Table 1 shows that there were 9 studies evaluating the outcomes of shoulder range of motion limitation and/or upper extremity swelling after axillary surgery for breast cancer, with designs predominantly randomized controlled trials and several prospective cohorts and one cross-sectional study. The studies originated primarily from the United States, Spain, Australia, and France and involved invasive breast cancer populations at various stages with varying nodal status, including clinically node-negative, node-positive, early-stage cases after sentinel node biopsy with a majority of positive 1-2 sentinel nodes, and a small proportion of high-grade ductal carcinoma in situ lesions. The types of surgery compared were generally ALND versus SLNB, although some studies reported only one treatment group.

Mean/median age was available in some studies (around the late 50s to early 60s in most reports), but several studies did not report age (N/R). Regarding the outcome of range of motion limitation, studies that did report data showed a generally lower proportion in the SLND group compared to the ALND group, although the effect size varied. Lucci et al. reported the difference was also clear (39% vs. 9%).13 Conversely, some studies showed relatively high and nearly equivalent rates between the two groups,14,15 indicating possible differences in outcome definition, follow-up time, or measurement methods between studies.

For upper extremity swelling outcomes, a more consistent pattern was observed, with ALND tending to be associated with a higher proportion of swelling than SLND in studies reporting both, for example, Belmonte et al. (35.5% vs 11.8%),16 Lucci et al (11% vs 6%),13 and Wetzig et al. (26% vs 17%).17 Overall, the variation in design, population (node-negative vs node-positive), type of procedure (direct vs single-arm comparison), and incomplete reporting of several key variables indicate methodological heterogeneity that should be considered when synthesizing the evidence and interpreting the magnitude of postoperative outcome risks.

Table 1. Study characteristics

Author, year	Country	Mean/ Median age	Study design	Disease grade	Type of surgery	Sample size		ROM limitation		Upper limb swelling	
						ALND	SLND	ALND	SLND	ALND	SLND
Ashikaga et al., 2010(Ashikaga et al., 2010)	United states	N/R	Randomized Controlled Trials	Invasive breast cancer, clinically node negative	SLND, ALND	1975	2008	86.8%	87.6%	79.4%	79.2%
Belmonte et al., 2018(Belmonte et al., 2018)	Spain	59.4	Prospective Cohort	High-grade DCIS	SLND, ALND	31	46	90.3%	89.1%	96.7%	89.1%
Chang et al., 2019(Chang et al., 2019)	Australia	62	Cross-sectional	Invasive breast cancer, early-stage after SLNB (92,1% positive 1-2 SLN)	ALND	69	N/R	46.4%	N/R	26%	N/R
Zhang et al, 2025(Zhang et al., 2023)	USA	48	Prospective Cohort	Invasive breast cancer, clinically node positive	ALND	242	N/R	N/R	N/R	18%	N/R
Lucci et al., 2007(Lucci et al., 2007)	USA	56	Randomized Controlled Trials	Breast cancer, T1 or T2, N0, M0, positive 1-2 SLN	SLND, ALND	445	446	39%	9%	11%	6%
Roy et al., 2018(Roy et al., 2018)	France	59.2	Randomized Controlled Trials	Invasive breast cancer, N0, M0	SLND, ALND	774	770	27.3%	13.4%	N/R	N/R
Belmonte et al., 2012(Belmonte et al., 2012)	Spain	59.2	Prospective cohort	Invasive breast cancer or high-grade DCIS	SLND, ALND	21	51	15.4%	9.8%	35.5%	11.8%
Wetzig et al., 2017(Wetzig et al., 2017)	Australia	N/R	Randomized Controlled Trials	Invasive breast cancer, clinically node negative	SLND, ALND	509	519	N/R	N/R	26%	17%
Wesley et al., 2006(Francis et al., 2006)	USA	N/R	Prospective cohort	Operable invasive breast cancer	SLND, ALND	105	41	N/R	N/R	69%	63%

Source: Adapted from studies included in this systematic review

Risk of Bias

Figure 2 shows that the overall risk of bias in randomized controlled trials was low in most domains, particularly in randomization sequence generation, allocation concealment, blinding of participants and investigators, blinding of outcome assessors, and other biases, all of which were predominantly assessed as low risk. Unclear risk persisted in some studies, particularly in the domains of incomplete outcome data and selective reporting, indicating that some publications did not adequately report on loss to follow-up/handling of missing data or consistent reporting of outcomes according to the protocol. No domains with a high risk of bias were identified, so the overall methodological quality of the randomized controlled trials in this review was assessed as quite strong, with the main limitation being incompletely transparent reporting in some domains.

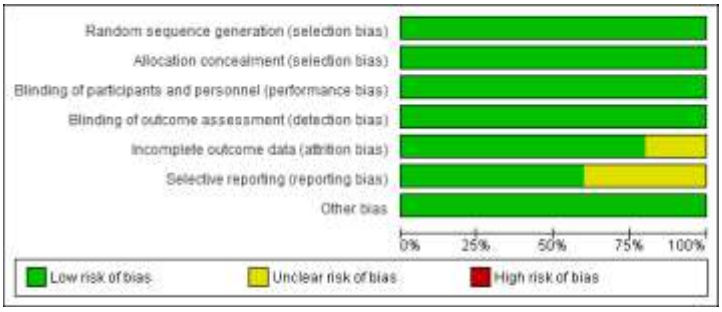

Figure 2. Risk of Bias Analysis for Randomized Controlled Trials
Source: Generated by the authors based on risk of bias assessment using Cochrane RoB 2.0 tool

Based on Table 2, the quality of observational and cohort studies varied according to the Newcastle-Ottawa Scale: Roset et al. (2012) scored 8 (good quality), Belmonte et al. (2018) scored 7 (fair-good quality), Wesley et al. (2006) and Jennifer et al. (2025) each scored 6 (fair/adequate quality), while Chang et al. (2019) scored 3 (low quality for causal inference). In general, the domains of selection and outcome assessment were relatively adequate in some studies, but the comparability domain was often weak due to limited or no adjustment for confounding factors, including in studies without a control group. Therefore, findings remain informative for describing postoperative outcome patterns but need to be interpreted with caution when used to infer causal differences between procedures.

Table 2. Risk of Bias Analysis for Observational and Cohort Studies

Author, year	Selection	Comparability	Outcomes	Overall	Interpretation
Belmonte et al., 2012(Belmonte et al., 2012)	3	2	3	8	Good quality, though confounding cannot be excluded; results supportive but not definitive.
Belmonte et al., 2018	3	1	3	7	Moderate quality; findings consistent but affected by potential confounding.
Wesley et al., 2006	3	1	2	6	Fair quality; internal validity limited by lack of adjustment.
Chang et al.,	2	0	1	3	Low quality for causal inference;

2019					descriptive value only.
Jennifer et al., 2025	3	0	3	6	Moderate quality; useful for within-patient trajectory, but no control group.

Source: Generated by the authors based on risk of bias assessment using the Newcastle-Ottawa Scale (NOS) for cohort studies

We conducted a systematic review to evaluate whether axillary lymph node dissection (ALND) is associated with greater postoperative morbidity compared to sentinel lymph node biopsy (SLNB) in breast cancer patients, specifically in terms of range of motion (ROM) limitations and lymphedema. All comparative studies in this review consistently found lower rates of lymphedema and ROM limitation in the SLNB group than in the ALND group. The findings of this systematic review are consistent with previous studies and meta-analyses that reported higher rates of lymphedema and ROM limitation in the ALND group compared to SLNB (Wetzig et al., 2017). The findings of this systematic review are consistent with previous evidence showing that ALND significantly increases the risk of lymphedema and ROM limitation compared to SLNB in breast cancer patients. Data from NSABP B-32 showed that patients undergoing ALND had a higher percentage of arms with a ≥10% volume difference (an indicator of lymphedema) up to 36 months postoperatively. The prevalence of a 10% arm volume difference in the SLNB group remained stable at 7–9%, whereas in the ALND group it remained relatively stable at 13–14%, with corresponding OR values ranging from 0.45 to 0.69 at follow-up. Similar findings were also reported in SNAC-1, showing that the incidence of lymphedema in the ALND group was significantly higher than in the SLNB group up to five years postoperatively, confirming lymphedema as a long-term complication of extensive axillary dissection.

A meta-analysis by Bakri et al. reported that the prevalence of lymphedema and postoperative ROM limitations was higher in the ALND group compared to SLNB. The difference in lymphedema prevalence between SLNB and ALND was 13.7% (95% CI: 10.5–16.8, p <0.005) and 24.2% (95% CI: 12.1–36.3, p <0.005), respectively, indicating a clinically significant risk difference. The same study reported that the pooled estimated prevalence of ROM limitation in the SLNB group was 17.1% (95% CI: 11.1–23.1, I^2=96%, p <0.0005) and in the ALND group was 29.8% (95% CI: 17.5–42.0, I^2=98.1%, p <0.0005). These results are consistent with a previous systematic review by Levangie et al., which reported that ALND increased the risk of lymphedema 2–4-fold compared to SLNB, with odds ratios ranging from 2.0 to 4.5 depending on the measurement method and follow-up duration. That review also showed a greater reduction in ROM with ALND than with SLNB (9–56% vs. 3–24%) and a mean difference of 1–20° at 12 months, with ORs of 1.02–9.0 based on goniometric measurements.

A recent systematic review also showed that an SLNB-based approach was associated with a 65% lower risk of lymphedema than ALND, with no significant differences in overall survival (OS), disease-free survival (DFS), or recurrence rates at 5, 8, or 10 years (Fan et al., 2023; Mattar et al., 2025). Other studies have reported decreases in abduction and flexion ROM ranging from 132–175° in 1–67% of patients after ALND (Lee et al., 2008), whereas after SLNB, ROM limitation was reported in 6–31% of patients at 12 months and decreased to 0–

9% at 24 months. In this review, we found that the incidence of lymphedema and ROM limitation was higher in the ALND group than in the SLNB group across a wide range. This wide range in both groups reflects heterogeneity between studies that may be influenced by differences in definitions (subjective vs. objective), measurement methods (arm circumference, volume, bioimpedance), type of surgery, timing of postoperative evaluation, patient characteristics, disease stage, and the use of adjuvant therapy such as regional radiotherapy.

Pathophysiologically, post-ALND patients are more susceptible to lymphedema due to more extensive lymphatic tissue damage, postoperative fibrosis formation, impaired lymphatic flow, and an increased risk of complications such as seroma and infection, all of which contribute to chronic lymphatic dysfunction and long-term arm morbidity (Fan et al., 2023; Mattar et al., 2025). Limitations of movement following ALND are also more pronounced due to greater fibrosis formation (Yang et al., 2010), accompanied by pain (Che Bakri et al., 2023), decreased muscle strength (Che Bakri et al., 2023; Hidding et al., 2014), and tenderness/numbness, all of which arise from nerve damage during axillary surgery (Li et al., 2015). These complications can persist and collectively contribute to reduced patient quality of life in the long term (Fan et al., 2023; Hidding et al., 2014; Mattar et al., 2025). Limitations of movement following ALND are also more pronounced due to greater fibrosis formation, accompanied by pain, decreased muscle strength, and complications such as seroma and cording, which hinder shoulder mobilization. Furthermore, ALND is often associated with the need for regional radiotherapy, which can cause fibrosis of the skin and subcutaneous tissue and thereby contribute to stiffness and limited arm/shoulder ROM.

The comparison of morbidity between SLNB and ALND reflects the impact of surgery on upper-extremity function. Current evidence suggests that ALND is consistently associated with a higher and more persistent risk of lymphedema and limited shoulder ROM due to impaired lymphatic drainage and axillary tissue fibrosis, whereas SLNB, although not completely free of complications, generally results in only mild and transient functional impairment. ROM limitations following SLNB are more often related to postoperative pain, local inflammation, or minimal scarring and tend to resolve with early rehabilitation. This difference in morbidity underscores the importance of an axillary de-escalation approach, whereby selecting SLNB in appropriate patients reduces long-term functional impact without compromising oncological safety and improves quality of life in breast cancer patients.

The strength of this systematic review lies in its focus on clinically relevant functional outcomes, namely limited shoulder range of motion and upper-extremity lymphedema/swelling, providing practical value for decision-making regarding axillary de-escalation of therapy in patients with early-stage breast cancer. However, major limitations include high inter-study heterogeneity in outcome definitions, measurement methods, timing of postoperative evaluation, and variations in patient characteristics, surgical techniques, and adjuvant therapies such as regional radiotherapy, which limit direct comparability and reduce the precision of effect size estimates.

CONCLUSION

Sentinel lymph node biopsy is generally associated with a lower incidence of shoulder range of motion limitation and upper extremity lymphedema/swelling compared with ALND, supporting SLNB as an axillary de-escalation option for selected early-stage breast cancer. However, heterogeneity in outcome definitions, measurement methods, evaluation timing, and variations in patient characteristics, surgical techniques, and adjuvant therapies limits comparability and the precision of effect sizes. It is recommended that SLNB be implemented according to clinical selection criteria with early rehabilitation and structured monitoring of shoulder function and lymphedema. Future studies should use standardized definitions and measurements and control for major confounding factors for more precise risk estimation.

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