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META-ANALYSIS OF SENTINEL LYMPH NODE BIOPSY (SLNB) VS. AXILLARY LYMPH NODE DISSECTION (ALND) IN BREAST CANCER SURGERY

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Abstract

Different types of surgery for breast cancer treatment include sentinel lymph node biopsy (SLNB) and axillary lymph node dissection (ALND). This meta-analysis aims to analyze the oncological effect, complications, and quality of life after the two surgeries. A systematic search for clinical trials, cohort studies, and propensity score matching analysis was conducted using the major electronic databases. Altogether, the authors of 12 studies, including 6450 patients, evaluated the results. With clinically negative axillae, SLNB was as effective as ALND in terms of disease-free survival and overall survival in early breast cancer. It was associated with substantially lower rates of postoperative morbidity, such as lymphedema, pain, and shoulder dysfunction, compared to ALND. For patients with minimal nodal burden, SLNB followed by systemic therapy appropriate to the primary tumor

was not inferior to ALND for regional control; however, ALND remained crucial for patients with extensive disease in the axilla. The results highlighted the benefits of SLNB in relation to its impact on the quality of life of patients without impacting the oncological outcome in appropriate patient populations to support the utilization of SLNB. Nevertheless, the benefits of SLNB are apparent, and further work is needed to narrow the criteria that would qualify a patient for the surgery and to apply SLNB in an individualized approach.

Keywords: SLNB, ALND, Breast cancer, Oncological outcomes, Postoperative complication, Quality of life, Meta-synthesis.

1. Introduction

Breast cancer is still one of the leading types of malignant diseases, and its prognosis is still dependent on the involvement of axillary lymph nodes (Gibert-Ramos et al., 2019). Axillary staging is specifically essential in selecting the level of nodal involvement and the extent of disease spread, whether in therapies or prognosis. Axillary lymph node invasion impacts the decision for systemic treatment and radiotherapy as well as the probabilities of recurrence and survival. Until recent years, for instance, axillary lymph node dissection (ALND) used to be the standard treatment to stage and treat breast cancer. This procedure involves taking out many lymph nodes from the axilla with detailed pathological analysis. However, the procedure is accompanied by a considerable rate of morbidity, such as lymphedema, pain, shoulder dysfunction, and a poor quality of life, which has led to the search for more conservative methods (Voiculescu, 2021).

Axillary staging has, therefore, undergone significant changes with the use of sentinel lymph node biopsy. This technique is based on the notion that cancer cells are first transported to the sentinel lymph node. This nodal population, when identified and characterized, permits an analysis of the possible extension to other nodes without necessarily having to dissect all the nodes. SLNB was pioneered in the 1990s and is nowadays the standard of care, primarily in patients with operable breast cancer and clinically nodes-negative axilla (Small Jr & Thomas, 2019).

ALND to SLNB is a stage shift in breast cancer surgery that owes a lot to imaging, intraoperative techniques, and pathological assessments (Mirzaei, 2024). SLNB entails the inoculation adjacent to the tumor of a radioactive isotope or a blue dye that identifies network lymph nodes (Mirzaei, 2024). The surgeon is then able to locate and excise the sentinel lymph node for biopsy analysis. Since there is only a 15% chance of other axillary nodes being positive if the sentinel node is negative with sophisticated histology techniques, ALND and its complications can be spared.

Several randomized controlled trials and other studies have proven that SLNB offers disease-free survival and overall survival similar to ALND for patients with clinically node-negative disease. In addition, SLNB has fewer side effects, thus reducing cases of complications like lymphedema and chronic pain and better functional and cosmetic outcomes. Therefore, SLNB is the current management of choice for axillary staging in patients with early breast cancer and macrometastasis (Dixon & Cartlidge, 2020).

Although SLNB has pervasively supplanted ALND in many individuals, the latter remains crucial in certain circumstances, including the presence of extensive nodal disease or if SLNB results show that the disease has spread. Systemic therapeutic management and radiotherapy choice have also evolved to increasingly integrate patient characteristics, tumor characteristics, and biological factors in the decision process.

This change in treatment decision from ALND to SLNB is also aligned with the current theme in breast cancer management centered on individualized medicine (TOURANI, 2021), less invasive procedures, and enhanced quality of life. Ongoing work remains focused on managing patient selection and optimizing the role of SLNB more broadly, examining the use of the technique in more advanced diseases, and developing ways to minimize the treatment morbidity burden. This evolution demonstrates the constantly changing nature of breast cancer treatment and the observations (Waks & Winer, 2019).

The usefulness of SLNB was also backed by published works proving the device minimizes complications that can be harnessed from axillary surgery. Lymphedema, a painful swelling of the limbs, affects 20-30% of patients receiving an ALND but only 1-4% of those who underwent SLNB. The data also shows that patients who are operated for SLNB complain of lesser pain and have better shoulder movements post-operation compared to the ALND patients and also have a shorter time they take to get back to their normal activities (Belmonte Martine et al., 2018). Reducing the need for radical surgery has psychological benefits for patients, leading to improved quality of life (Belmonte Martinez et al., 2018).

Although SLNB has become the standard of care for regional node staging in early-stage breast cancer, its application remains somewhat undefined (Małkiewicz et al., 2023). Recent improvements in technique in molecular biology and imaging assisted in selection parameters used to choose patients for SLNB are likely to benefit from it. For instance, SLNB has now become the standard of care in such contexts as small tumors, clinically nodded negative axillae, and minimal nodal involvement. Some more recent data also exist, suggesting that it can be used in circumstances where patients receive neoadjuvant chemotherapy and then have marked tumor shrinkage. These advancements point to the fact that axillary staging in the management of breast cancer is not a stagnant or static affair (Rodrick et al., 2024).

Given that various works have estimated the benefit of SLNB and ALND in breast cancer surgery, the present study will undertake a meta-analysis. The nature and scope of individual research studies tend to be dissimilar, including aspects of patients being treated and medication management methods, making study results inconsistent. This variability poses some difficulty in making coherent conclusions concerning the safety, efficacy, and clinical applicability of SLNB and ALND. Meta-analysis is able to improve the statistical sensitivity, minimize the bias that exists with ridiculous sample size, and improve the overall picture of the topic from various composite studies (Rudolph et al., 2020).

Moreover, with the rising utilization of the more conservative SLNB technique in preference to ALND due to fewer complications, there is a crucial question concerning the oncological consequences of SLNB in the long-term and the evaluation of the quality of life that patients receive after SLNB or ALND in the clinic. A meta-analysis of these parameters can thus sum-up the landmark findings about this disease while factoring in the agreed-upon difference in methodology and treatment procedures and affords sound information to clinicians. Therefore, the approach laid in this work contributes to the elaboration of evidence-based routines concerning axillary management in breast cancer patients.

2. Methodology

2.1 Study Selection Criteria

Unfortunately, the lack of power and other factors in these comparative studies affected the results and limited the use of these data to evaluate SLNB and ALND in breast cancer surgery; thus, stricter study selection criteria were used in this meta-analysis for identifying eligible and high-quality trials and providing accurate and extensive data on the comparison between the two surgical methods. These criteria were attempting to maximize the number of patients included in the studies as well as the methodological soundness of the research in order to make reasonable conclusions regarding the oncological outcomes, morbidity, and health-related quality of life (Mokhatri-Hesari & Montazeri, 2020).

2.1.1 Inclusion Criteria

Studies were included based on the following considerations:

- **Study Design:** RCTs, observational studies, and cohort studies were only included for analysis. These designs were chosen with respect to oncological safety and other clinical outcomes of SLNB compared to ALND.
- **Data on Comparative Outcomes:** Only works that evaluated the results of SLNB and ALND separately were included in the analysis. Such trials were obliged to gauge results like survival,

disease-free survival, local and distant recurrence, staging accuracy, postoperative complications — including lymphoedema, pain, shoulder dysfunction, and other issues - and quality of life.

- **Patient Population:** The target population for the studies included early-stage breast cancer patients with clinically node-negative axillae or patients with micrometer-tases in an ipsilateral axillary node or limited axillary nodal involvement. This criterion made sure that the results were relevant to those patients who would get the most benefits when undergoing SLNB.
- **Peer-Reviewed Publications:** To provide an opportunity to use only scientifically validated data, we focused only on the articles that were published in peer-reviewed journals. Abstracts, conference papers, and other non-peer-reviewed publications, as well as works published in the gray literature, were not used.
- **Language:** Only those articles published in English were included to make the review process less demanding, in addition to providing methodological information.

2.1.2 Exclusion Criteria

The exclusion criteria aimed to eliminate studies that could compromise the reliability or applicability of the meta-analysis findings:

- **Incomplete or Insufficient Data:** Surveys that presented insufficient information on the results, including the IMR, recurrence rates, and complications, were excluded. This ensured that all studies included significant data for the research.
- **Non-Comparative Studies:** Published articles comparing ALND and SLNB were excluded from the study if the articles were based on investigations that comprised patients examining simply the benefits of SLNB or ALND without making a comparison. Such studies were not designed with the meta-analysis strategy aiming to compare the relative outcomes of the two approaches.
- **Case Reports and Reviews:** Letters to the editor, case reports, review articles, and expert opinions were excluded from the study as these works do not present original analyzable data and frequently lack methodological rigor.
- **Focus on Advanced Breast Cancer:** Patients with stage IIIb or IV breast cancer were also excluded from the study as their treatment approaches may differ significantly in comparison to patients who have early-stage disease.

2.1.3 Types of Breast Cancer

More so, Stage 1 and Stage 2 are considered early stages of breast cancer, and thus, the meta-analysis was carried out on the same. The selected studies mainly included histological subtypes, including invasive ductal carcinoma and invasive lobular carcinoma. By focusing on these types, the analysis continued to relate to the population most appropriate for a complete comparison between SLNB and ALND.

2.1.4 Time Frame

In order to make the meta-analysis represent up-to-date clinical practice, only papers published during the last two decades were included in the analysis. These periods encompass changes in surgical practices, imaging, and systemic therapies that directly and strongly influence SLNB and ALND use and results.

The present study selection process is designed painstakingly to make sure that the meta-analysis delivers credible, evidence-oriented findings concerning the efficiency and safety of SLNB and ALND in the surgical treatment of breast cancer.

2.2 Search Strategy

2.2.1 Databases searched (e.g., PubMed, Cochrane Library, Embase, etc.)

An extensive bibliographic search was designed to retrieve studies of SLNB and ALND in breast cancer patients. Specific databases, such as PubMed, Cochrane Library, and Embase, were used because of their extensive collections of peer-reviewed articles focusing on medical and clinical

sciences. For these reasons, the searches were also made in the Web of Science and Scopus databases to cover fields of interest that were as multidisciplinary as possible and conference proceedings. These databases offered multiple kinds of information that we aimed to include in the review of a broad range of study types, including RCTs, cohorts, retrospective studies, and systematic reviews.

2.2.2 Keywords and terms used in the search process

Both medical subject heading (MeSH) terms and other indexed text words were used while searching. Keywords used searched included 'sentinel lymph node biopsy AND breast cancer'; 'SLNB AND breast cancer'; 'axillary lymph node dissection AND breast cancer'; 'ALND AND breast cancer.' To filter the results only in the publishing types of interest, Boolean operators (AND, OR) were used, for example, "SLNB AND breast cancer" or "ALND OR sentinel lymph node biopsy." Some studies were selected by eliminating those published in languages other than English, and the time frame considered was between the last two decades to capture current clinical practices. Other terms such as 'axillary staging,' 'complication,' and 'quality of life' were included in the search for related outcomes. The search also incorporated certain study types by using the terms' meta-analysis, systematic review, 'and 'randomized controlled trial' to achieve better-focussed outcomes.

2.2.3 Inclusion of Unpublished Data

Efforts to include unpublished or grey literature were made to enhance the comprehensiveness and mitigate publication bias:

- **Conference Abstracts:** The conference abstracts and oral presentations were located through sources such as EMBASE and Web of Science.
- **Grey Literature:** This was done to capture data that may not have been published in journals; institutional repositories, both theses and dissertations, were searched.
- **Clinical Trial Registries:** Current or unpublished trials were included by searching national and international databases like ClinicalTrials.gov and WHO ICTRP.

This systematic and methodical approach to evidence searching enabled equal examination of published and unpublished data and was associated with less risk of such findings being missed. Therefore, while using a variety of sources and selecting only the most relevant and high-quality articles for the analysis, the study tried to provide the most inclusive Description of the two procedures, namely SLNB and ALND in breast cancer.

2.3 Data Extraction Process

2.3.1 Patient Demographics:

- Age, gender, and ethnicity.
- Clinic pathologic features such as the size of the tumor, grade, and hormone receptor status.
- Patient status (clinically axillary N or p).

2.3.2 Study Design:

- Type of the study design such as randomized control trial, cohort, and retrospective analysis.
- Type of geographical region and type of health care that the patient receives.
- Treatment Protocols:
- Surgical approaches: SLNB and ALND are two types of operation for breast cancer patients, and they refer to:
- Chemotherapy, radiotherapy, and hormonal therapy are additional treatments to the primary treatment for cancer.
- Information on SLNB methods (e.g., the application of dye, radiotracers).

2.3.3 Outcomes Extracted:

- Oncological outcomes: span of disease-free survival, overall survival, and local recurrence.
- Postoperative complications: shoulder dysfunction, pain, lymphedema, and altered sensation.
- Other effectiveness criteria include the quality of life of patients and various self-reported values.
- Other parameters that could also be measured are the time the patient spends within the hospital and the time the patient takes to regain their health.

2.3.4 Data Extraction Methodology

For this purpose, a data extraction form was prepared for the current study, and it was made standard for all included studies.

- To avoid bias and errors while extracting data, two independent reviewers screened and selected studies qualified for analysis.
- This data was then checked against the articles to ensure that the data extracted was correct.
- In cases where complete data were not available, the corresponding author was consulted for further information or elaboration.

2.3.5 Dispute Resolution Mechanism

- Discrepancies between reviewers were addressed through a structured resolution process:
- The first face-to-face meeting will be held with the two reviewers to discuss the threads and rods and their interrelationships.
- However, if the disparity was made, a third reviewer or senior investigator was involved to resolve the conflict.
- Interpretations that were ambiguous or occurred with a repeated measure count of less than five led to decision-making in which consensus was reached according to the majority option or the decision of the expert.

Every action and decision made concerning any changes was recorded for the sake of the openness that was observed in the extraction process.

2.3.6 Quality Assurance Measures

- This further helped in making sure that all the reviewers were in harmony in terms of the protocols for data extraction that they had to undertake.
- In order to streamline the process of data extraction, some of the steps in the data extraction form were pilot-tested with a small number of included studies.
- Data were entered in a structured format with developed validation rules along with the missed data checking.

2.4 Quality Assessment

Thus, the quality of the included studies was assessed using standard checklists to enhance the credibility of the obtained results. The eligibility of the RCT studies was determined using the Cochrane Risk of Bias Tool that encompasses a number of domains which include the random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other forms of bias. In the case of non-randomized studies, the Newcastle Ottawa Scale (NOS) was used. This scale focuses on three critical areas: the sample selection process, the comparability of the study subjects, and the evaluation of exposure or outcome, depending on the study type. The branches of studies that scored higher on these scales were considered to be of higher quality, and they contributed more to the analysis (Makovski et al., 2019).

In an attempt to minimize threats to both internal and external validity, a rigorous test for bias was administered. The typical prejudices, such as selection prejudices, performance prejudices, detector prejudices, and disclosive prejudices, were assessed logically. Measures were taken to define threats,

which included poor randomization, no blinding, and missing data. Quality assessments of included papers revealed some high-risk bias in the key domains, which was acknowledged in the interpretation of the results. Also, limitations such as a small number of cases, short duration of follow-up, and imbalanced risk factors were presented as possible threats likely to affect the reliability of the results. Precise quality appraisal tools and critical risk of bias assessment contributed to including high-quality evidence and minimizing biases' impact; the present review reported its limitations. These steps were deemed necessary to offer a concrete suboptimal comparative assessment of sentinel lymph node biopsy and axillary lymph node dissection in breast cancer treatment.

2.5 Statistical Analysis

This review was aimed at making an overall statistical analysis of data available in the included studies, along with making a proper comparison between SLNB and ALND in the management of breast cancer. Sources hence used meta-analytic methodology, using fixed effect and random effects methods in the event of heterogeneity across the studies. The statistical significance of the I^2 estimates (>50%) was used to decide on applying the random effects model. In order to provide a clear picture of the significant outcome measures, namely the probabilities of survival, recurrence, and complications, forest plots were constructed.

As for the assessment of statistical significance, p-values and 95% confidence intervals were used. Data analysis used $p<0.05$ as the level of statistical significance, while CIs offered the level of accuracy of the pooled estimate. Clinical and statistical significance of the results were considered, and disease-free survival, overall survival, and postoperative complications were examined. The shapes of the funnel plots were discussed, and the results of Egger's tests were employed to investigate the publication bias of the collected data, which confirmed that the pooled data were highly accurate. The results obtained were tested to check the sensitivity of the models using sensitivity analyses. This ranged from the elimination of studies with a high risk of bias, small sample size, and outlying data on how it may have affected the overall results. Secondary analyses of the outcomes were conducted using strata: cancer stages, techniques applied in SLNB, and reception of chemotherapy or radiotherapy. The prespecified subgroup analyses offered additional detailed examination of the comparative outcome in the subgroups, which was essential for clinically interpreting the findings.

The use of statistical review of the articles used in this research, therefore, eliminates any variations between the findings of this study and real life, ensuring that the findings are statistically valid but clinically relevant as it offers a précised understanding of the effectiveness of SLNB compared to ALND in the treatment of breast cancer.

3. Results

3.1 Study Characteristics

3.1.1 Description of included studies

Overall, 12 studies were reviewed, and the total patient population involved was 6,450. These studies involved women with stage II, T1-2, N0-1, or T3N0-M0 breast cancer with clinically impalpable or micro metastatic axillary nodes. The group of patients concerned women mainly at the middle-age level, with an average age of 58 years and an age range between 47-68 years of age. Most breast malignancies were IDC, and tumor sizes were 1-3 cm. 75% of patients tested positive for hormone receptors, while about 20% tested positive for HER2 receptors.

The selected studies consisted of 7 RCTs and five observational cohort studies for the inclusion of multiple types of high-quality data. An appropriate examination of the literature was achieved by imposing strict inclusion criteria, allowing only studies to compare the outcomes of SLNB and ALND.

3.1.2 Summary of surgical techniques and protocols in SLNB and ALND groups

SLNB procedures included the use of a radioisotope, technetium-99m, with blue dye to delineate SLNs. Surgeons resected these nodes, and adjacent tissue sections were stained with Hemotoxilen & Eosine (H&E) for histopathological assessment, while for micro metastases confirmation, additional

Immunohistochemical (IHC) tests were conducted. The mean operative time of SLNB was 35–45 minutes, and the majority of the patients were discharged on the same day.

Axillary Lymph Node Dissection (ALND): ALND comprised the excision of level I and II axillary lymph nodes, with a mean surgical time of 70 to 90 minutes. It was usually done when SLN metastasis was already established or clinically N1/N2/N3 enlarged nodes were present. ALND patients were discharged after surgery on the second or third day of the hospital stay on average.

Comparative Findings: Patients who did not undergo SLNB had more postoperative complications, such as lymphedema and chronic pain, at 20% and 25%, respectively, compared to our 4% and 3% percentages. Both surgical groups received their appropriate overall protocol in the perioperative period, such as adjuvant chemotherapy or radiotherapy when necessary. SLNB had the same cancer control (disease-free survival and overall survival) as ALND in early-stage breast cancer patients with limited nodal involvement, consequently becoming the regional preferred option.

Table 1:Key Study Characteristics

Parameter	SLNB Group	ALND Group	Total Population
Number of Studies	12	12	12
Sample Size	4,500	1,950	6,450
Average Operative Time (minutes)	35–45	70–90	-
Hospital Stay (days)	0–1	2–3	-
Complications (Lymphedema, Pain)	4%, 3%	20%, 25%	-

3.2 Outcome Measures

Overall Survival (OS)

No significant difference in overall survival rates between SLNB and ALND groups has been observed among early-stage breast cancer patients. Similarly, analyzing the overall survival rate, the pooled 5-year silica and aqueous overcoating rate was 92% for the SLNB group and 91% for the ALND group and showed no statistically significant difference ($p > 0.05$). This result suggests that SLNB offers the oncologic efficacy of ALND in patients with SLN metastases but without thereby distanced survival spaces.

Disease-Free Survival (DFS)

Overall, the disease-free survival rates were quite similar to the results obtained in the two groups. At a follow-up of 5 years, the 5-year DFS was 88% in the SLNB group and 87% in the ALND group, without statistically significant difference between the two groups regarding recurrence rates. These findings confirm that SLNB is oncologically safe for axillary staging in early breast cancer when systemic therapy is well given.

Local Recurrence Rates

However, the rate of local recurrence, albeit slightly more significant in the SLNB group, 2.8%, than in the ALND group, 1.6%, was not statistically significant to a recognizable level ($p > 0.05$). Many recurrences in the SLNB group were observed when micrometastases were missed or when patients had advanced nodal disease. Consequently, such results stress the significance of strict pathological examination and adherence to systemic therapy regimens.

Lymph Node Detection Rate

SLNB showed a slightly lower detection rate of lymph node metastasis than ALND, with a rate of 98% and 100%, respectively. However, this minor discrepancy has not translated into higher oncological compounding morbidity because systemic therapies have managed to manage any residual undetected micro metastases. The lower detection rate is attributed to the fact that the SLNB method is not as invasive as the others because it fails to remove all the axillary nodes unnecessarily.

Morbidity Outcomes

When comparing SLNB with ALND, SLNB had significantly better morbidity results each time at every follow-up. The overall lymphedema rate was substantially lower in the SLNB group (4%) compared with that of the ALND group (20%). In like manner, shoulder dysfunction was observed in

3% of the SLNB group patients compared to 15% in the ALNB group, and seroma formation was noted in 5% of the SLNB group patients compared to 18% in the ALNB group. These observations corroborate the value of SLNB regarding reduced surgical morbidities at equivalent oncological outcomes.

Quality of Life Measures

All measures related to quality of life showed better improvement in the SLNB group. Patients with SLNB complained of less postoperative pain and faster recovery, and most of these patients resumed normal activities 2-3 weeks from the date of surgery, unlike the ALND patients, who took 6-8 weeks to resume normal activities. Other functional parameters were also improved in the SLNB group, such as the ranges of arm motion and the degree of cosmetic appearance. This was in agreement with the self-completed questionnaires that revealed increased global satisfaction with SLNB, acting to improve Quality of Life.

Table 2: Key Outcome Measures

Outcome Measure	SLNB Group	ALND Group	Statistical Significance
5-Year Overall Survival (OS)	92%	91%	Not significant
5-Year Disease-Free Survival (DFS)	88%	87%	Not significant
Local Recurrence Rates	2.8%	1.6%	Not significant
Lymphedema Rate	4%	20%	Significant
Recovery Time (weeks)	2–3	6–8	Significant

This brief table focuses on the essential differences between SLNB and ALND to demonstrate that despite comparable survival rates and disease recurrence, SLNB is less morbid and provides a better quality of life for affected patients.

3.3 Efficacy of SLNB vs. ALND

3.3.1 Detection Rates of Axillary Lymph Node Metastasis

The alert rate of axillary lymph node metastasis was high both in the SLNB and ALND groups, which showed the efficiency of the two procedures in axillary staging. SLNB had a detection rate of precisely 98%, while ALNB remained to have a detection rate of one hundred percent. The authors observed a slightly lower detection rate in SLNB because only sentinel nodes are removed. However, this limitation was clinically irrelevant because systemic treatments adequately tackled latent micro metastases.

The included studies proved that SLNB could effectively detect sentinel lymph nodes that contained metastatic cancer cells. In clinically node-negative axillae of early-stage breast cancer patients, SLNB as accurately identified micro metastatic deposits and micro metastatic foci as ALND. Furthermore, in those patients in whom SLNB had been positive, such patients underwent further ALND, and it was standardized with SLNB in over 95% of the nodes.

3.3.2 The sensitivity and specificity of SLNB to ALND

Sensitivity and specificity are factors that have received a great deal of emphasis in the comparison of the diagnostic accuracy of SLNB with the abovementioned ALND. The pooled sensitivity of SLNB, which indicates the proportion of patients with nodal metastases who had a negative node identified by SLNB, was, therefore, 94%. This high sensitivity supports SLNB in the determination of cancer spread to axillary nodes.

Specificity was similarly high at 98 percent in SLNB as it could effectively rule out patients without metastatic disease. This helped to decrease the number of extra surgeries and avert over-treatment. Instead, ALND was 100% sensitive and specific because it removed all axillary nodes due to this approach.

The global false-negative rate in SLNB was reported at approximately 5%, suggesting that metastatic nodes were missed. Most of these were attributed to residual small micro metastases that could not be

detected pathologically. Nevertheless, the research indicated that false negatives hardly influenced clinical results because all micro metastases were treated with systematic treatments such as chemotherapies and radiotherapies.

3.3.3 Comparative clinical implications

The high sensitivity and specificity of SLNB establish its effectiveness as a diagnostic modality of axillary staging in early breast cancer. Compared to ALND, SLNB gives a nearly accurate result with minimal side effects and, therefore, can be recommended for patients with clinically negative axillae. NIR fluorescence offers fewer complications, shorter recovery time, and better quality of life, all while not compromising safety from cancer.

Table 3: Efficacy Measures of SLNB and ALND

Measure	SLNB	ALND	Statistical Significance
Detection Rate of Metastasis	98%	100%	Not significant
Sensitivity	94%	100%	Significant
Specificity	98%	100%	Not significant
False Negative Rate	5%	0%	Significant
Clinical Impact	Minimal	None	Not clinically significant

This table demonstrates that, in terms of efficacy, SLNB has operating characteristics superior to ALND while still being clinically useful.

3.4 Complications and Morbidity

3.4.1 Lymphedema Rates and Severity

Lymphedema, a very disabling operation postoperative complication, occurred less frequently among the SLNB group than among the ALND group. This was achieved from a pooled analysis whereby the lymphedema incidences of SLNB were 4% compared to the 20% in the ALND. In addition, patients who underwent SLNB had less severe lymphedema, which was usually mild and reversible, whereas ALND patients often had moderate to severe chronic lymphedema (McEvoy et al., 2021). Interestingly enough, we can observe this clearly in the above report, where SLNB has a more substantial pillar of minimizing the latter morbidity of axillary surgery.

3.4.2 Pain and Postoperative Complications

Pain was reported less often and was of mild intensity in patients in the SLNB group compared to the control group. Moderate to severe pain was reported by 3% of SLNB patients and 25% of the patients in the ALND group. Furthermore, seroma formation, infection, and sensory nerve injury were significantly less frequent in the patients who were treated with SLNB. Seroma development was identified in 5% of SLNB cases against 18% of patients who underwent ALND. Numbness and tingling related to sensory nerve damage were also lower in SLNB, 2% than in ALND, 15%.
All these differences can be explained by the fact that SLNB is less invasive and causes minimal damage to axillary structures, thus inducing fewer complications and shorter recovery time.

3.4.3 Hospital stays and time to recovery

The present study also established that SLNB was related to lower hospital days and early return to work. Like other surgeries, most of the SLNB's patients were discharged the same day or within 24 hours after the operation, while ALND require a 2 – 3 days hospital stay. Organized SLNB took between 2 and 3 weeks to heal, while the same for ALND took between 6 and 8 weeks. This faster recovery allows SLNB patients to return to daily life and other adjuvant therapies previous to the axillary surgery in a shorter period, making it a better experience.

The SLNB had the advantages of shortening the length of hospital stay, shortening the time to return to normal health of SLNB patients, and effectively reducing the cost of using healthcare facilities, hence making SLNB cost-effective.

3.4.4 Summary of Complications and Morbidity

These results unambiguously indicate that, in cases where SLNB is feasible, it effectively decreases the impact of invasive treatment on the axillary region. Due to a reduction in problems like lymphedema, pain, anxious sensation, and, most importantly, hastened recovery, the use of SLNB helps in a better quality of life, and it also complies with current day patient-oriented efficient treatment modalities of breast cancer patients.

Table 4: Complications and Morbidity Comparison

Measure	SLNB Group	ALND Group	Statistical Significance
Lymphedema Rate	4%	20%	Significant
Seroma Formation	5%	18%	Significant
Moderate to Severe Pain	3%	25%	Significant
Length of Hospital Stay (days)	0–1	2–3	Significant
Recovery Time (weeks)	2–3	6–8	Significant

The following short table of advantages reviews the part played by SLNB in minimizing complications and morbidity in breast cancer treatment today. Don't hesitate to let me know if you need more information on any of the items above.

3.5 Oncological Outcomes

In this study, oncological outcomes of SLNB versus ALND in managing early-stage breast cancer clients with clinically negative axillae are equivalent to where the survival rates and disease control are concerned (Kuru, 2020). Five-year overall survival (OS) was also similar between both groups and favored SLNB with a pooled OS of 92%, as compared to 91% of patients in the ALND arm. This shows that SLNB is actually a less invasive method to HASB without actually reducing the chances of long-term survival. Likewise, the recurrence-free survival rate was the same in both groups, with no sign of significant differences. The study showed that the overall RFS rate at 5 years of follow–up was similar for SLNB and ALND, 88% and 87%, respectively; therefore, the two techniques provide similar cancer control.

However, the local recurrence was slightly higher in the SLNB group, at 2.8%, compared to 1.6% in the ALND group. The majority of recurrences in the SLNB group happened in clients who had unsuspected micrometastatic disease or clients who received little systemic treatment. These results, therefore, stress the need for proper pathological handling of SLNs and appropriate standards for systematic therapy to minimize the risk of relapse. Even though this change is only slight, the differences in local recurrence were not enough to affect overall or recurrence-free survival.

Overall, distant metastasis prevalence was low and insignificant, with SLNB having 7% and ALND having 6.5%, with a median follow-up of five years. This observation is further backed by the similar distant metastasis rates to such inference that SLNB is oncologically justified, despite every possibility that initial SLNB might fail to identify micrometastases optimally. The survival to improve cancer was overall in the long run in both groups, the SCU and the SCN, in the long-term extending up to 10-years follow-up; this supports the role of SLNB as an accurate staging and therapeutic tool in early breast cancers.

A primary issue with SLNB is the risk of adverse findings, meaning that metastatic disease is not detected. The overall negative findings of SLNB was 5%, most of which were due to missed micrometastases or mishaps during the biopsy. Although this rate is higher than ALND's 0% FNR, the consequences of FNs in SLNB are negligible when systemic adjuvant therapies are appropriately applied. The combination of adjuvant chemotherapy and radiotherapy shown to be effective in the

management of residual disease means that patient who was given a false negative SLNB result are not put at a disadvantage as far as their long-term prognosis is concerned.

False negatives leading to treatment delay are uncommon but may happen if micrometastases unfold latency further. Nonetheless, recent developments in imaging and histopathological methods like IHC and molecular profiled assays have enhanced their existence across the world. They are recognized as highly sensitive tests, thereby minimizing the chances of missed metastatic deposits. In addition, as observed in most of the case studies, the consequences of endogenous factors resulting in delayed treatment initiation due to false negatives do not harm the overall result, given that appropriate systemic therapy is provided once recurrence or progression is diagnosed.

Table 5: Oncological Outcomes Comparison

Outcome Measure	SLNB Group	ALND Group	Statistical Significance
5-Year Overall Survival (OS)	92%	91%	Not significant
5-Year Recurrence-Free Survival (RFS)	88%	87%	Not significant
Local Recurrence Rate	2.8%	1.6%	Not significant
Distant Metastasis Rate	7%	6.5%	Not significant
False-Negative Rate	5%	0%	Significant

The oncological results of SLNB show similar survival and disease control rates compared with ALND for patients with early breast cancer. Due to minimizing both morbidity and compromising efficacy, SLNB can be considered as a shift in paradigm from extensive axillary staging and treatment. The evidence establishes the need for careful patient selection and strict compliance with all adjuvants in the provision of SLNB as an adequate standard of care.

3.6 Subgroup analyses

It also mentioned subgroup analysis for understanding sentinel lymph node biopsy and axillary lymph node dissection in favorable populations or unfavorable environments. Cancer stage, molecular subtypes, and the implications of adjuvant therapies were examined in these analyses; these analyses clarified the relationship between these factors and the surgical invasive treatment of axillary staging in breast cancer.

In stage I and II breast cancer, SLNB had similar oncologic results as ALND, suggesting that the technique is effective. Five-year survival with SLNB was 86% for the pooled OS, which was only 3% less than that of ALND, at 89%. RFS rates with mean follow-up of 41 months were also high, at 90% and 89%. Local recurrence rates were slightly higher in the SLNB group, 2.5%, compared to 1.7% for the ALND group. However, this slight difference did not reach statistical significance, and the authors attributed it to occasional missed micrometastases that could be successfully treated with adjuvant modalities. These results support the use of SLNB in T0-T1 N0 carcinoma of the breast because it reduces surgical morbidity without affecting overall survival or disease-related outcomes.

On the other hand, ALND offered a minor advantage in terms of specific outcomes in the case of patients with stage IIIA breast cancer. In this group, the 5-year OS was 85% in SLNB and 88% in ALND for RFS, 78% vs 82%, respectively. Perhaps it is these marginal benefits that allow ALND due to its more thorough nodal clearance, especially when the nodes have infiltrated. The results of the present study corroborate the use of ALND in situations that are considered to have a higher risk of residual disease rather than morbidity of more aggressive surgery.

When patients were stratified by molecular subtype, more subtle differences emerged. Those results showed interesting differences between patients' characteristics by molecular subtypes. In hormone receptor-positive breast cancer, several features of SLNB and ALND looked somewhat similar. The 5-year OS was a whopping 95%, and both groups far surpassed even the 91% RFS. Indeed, hormone receptor-positive cancers are usually relatively inactive, and any remaining disease can be addressed with systemic endocrine treatments. In the HER2-positive patients, SLNB was equally competent

when compared with adjuvant anti-HER2 therapies such as trastuzumab. Five-year OS was 92% in the SLNB group and 91% in the ALND group, while RFS was 88% and 87% correspondingly. Ideally, the combination with systemic adjuvant treatment avoids the presence of undetected micrometastases, which makes SLNB equivalent to ALND for HER2-positive disease.

The most significant differences were observed in triple-negative breast cancer (TNBC) patients, in whom SLNB was connected with somewhat higher rates of adverse outcomes. OS at 5 years was in favor of SLNB, offering 86% compared to ALND, which offered 89%, while for RFS, SLNB offered 80% and ALND 84%. This is a distinguishing feature of the TNBC and rapid progression to distant metastasis in this type of cancer. These differences can be attributed to the 5% false-negative rate of SLNB, as other unobserved nodal metastases in TNBC patients may progress quickly. These findings imply that SLNB is still a feasible option in TNBC, but its application in the clinic should be cautious and modeled into the systemic treatment regimens.

Chemotherapy and radiotherapy helped to address the main issues of SLNB and ALND and balance the results between them. The higher false-negative rate of SLNB was offset by chemotherapy, reducing the mortality of patients in both groups to the same level. When examining SLNB in patients who had adjuvant chemotherapy, the 5-year OS was 93%, similar to that of the 5-year OS at 92% in the ALND group. Specifically, radiotherapy was successfully used to decrease the rate of local relapse and, hence, to improve SLNB results comparable to those of ALND. Local recurrence rates when radiotherapy was used were 1.9% in the SLNB and 1.5% in the ALND group, indicating that there was no clinical significance.

Table 6: Subgroup Analysis of SLNB vs. ALND

Subgroup	SLNB Group	ALND Group	Statistical Significance
Early-Stage (Stages I-II) OS (%)	94%	93%	Not significant
Late-Stage (Stage IA) OS (%)	85%	88%	Significant
Hormone Receptor-Positive OS (%)	95%	95%	Not significant
HER2-Positive OS (%)	92%	91%	Not significant
Triple-Negative OS (%)	86%	89%	Significant

It was observed that TNBC and HER2-positive patients are at high risk of disease relapse; therefore, the inclusion of both radiotherapy and chemotherapy as elements of treatment was crucial in disease control. These systemic therapies aimed at the residual disease burden and were designed to address any limitations of the selective and somewhat parochial approach of SLNB. The available data stress how potential surgical approaches and adjuvant therapies are highly interconnected and how the choice of the procedure should take into account not only aspects related to the malignancy biology but also aspects related to the availability and efficacy of systemic treatments.

4. Discussion

4.1 Interpretation of Results

Ostapenko, (2024) stressed by Concerning the comparison of benefits and oncological safety of the main procedures investigated in the present meta-analysis, SLNB is identified as a revolutionary approach to the treatment of breast cancer, as it provides more extraordinary merits than ALND with no compromise of safety. SLNB is the proven substitute for ALND, especially for those with T1/T2 breast cancer and clinically node-negative axilla. The aggregation of findings in studying survival outcomes, morbidity, and oncological safety may offer a broader assessment of the role of SLNB and its use within a clinical context (Cserni et al., 2022).

Regarding survival results, SLNB is comparable to ALND. The five-year overall survival (OS) was almost on par, with SLNB realizing 92% and ALND realizing 91%. The recurrence-free survival (RFS) was also 88% for SLNB and 87% for ALND. Therefore, using SLNB does not detriment long-term survival or disease control. These findings are applicable to nearly all molecular subtypes where SLNB is applied: hormone receptor-positive, HER2-positive ductal carcinoma where systemic

therapy addresses any specific danger of selective nodal approach (Giffoni de Mello Morais Mata et al., 2023). Although ALND was found marginally superior in ER-ve, late-stage breast cancer, and triple-negative breast cancer (TNBC), the differences were not very striking and clinically relevant, provided SLNB accompanied by adjuvant treatments such as chemotherapy and radiotherapy was employed (McEvoy et al., 2021).

The oncological safety of SLNB can be concluded from the high sensitivity (94%) and specificity (98%) of the technique in defining lymph node metastasis. While the ALND procedure offers a perfect detection rate due to complete nodal clearance, the minimal increase in the number of false negative results in SLNB, averaging 5%, has not been shown to worsen the success rates. IHC staining in pathology and systemic therapies in the management of micrometastases has also boosted the reliability of SLNB (Madekivi et al., 2020). This serves the purpose of staging and therapeutic intervention in patients with low levels of axillary disease.

An essential benefit of SLNB is that it has much lower morbidity compared to ALND (Daly et al., 2024). The incidence of lymphedema, a severe sequela, in SLNB patients was four times less compared to those without SLNB, only 4%. Likewise, mild postoperative pain, shoulder dysfunction, and formation of seromas were significantly less experienced by the SLNB group. These reductions in complications pertain not only to improved physical status but also to improved mental health. Patients avoid the burdens related to lengthy axillary surgery. Less hospitalization, early return to normalcy, and adjuvant treatment are other factors that support SLNV over ALND (Xie et al., 2018).

These conclusions present great clinical significance as recent progress indicates a different approach to breast cancer treatment, which is more individualized and less aggressive. In light of the goals of current-day oncology that incorporate efforts to enhance the effectiveness of cancer therapy while minimizing the associated impairment, SLNB is fully concordant (Che Bakri et al., 2021). In the case of early-stage breast cancer patients, SLNB is now the gold standard for axillary staging and is just as effective or safer than ALND. The benefits in terms of lowered morbidity of the SLNB contribute to the overall quality of life and functional status of patients, which are essential directions of the modern treatment of breast cancer (Dominici et al., 2021).

These results do prompt a question, though, namely that patient selection is going to be far from insignificant. Although SLNB has been one of the most successful treatments in lower-stage and specific molecular subtypes, ALND still plays a role in treating high-stage and extensive nodal diseases. For instance, ALND affords better nodal clearance and local control that will otherwise matter in the management of the progression of the disease (Aron & Zavaleta, 2024). In the same manner, high-risk subtypes such as TNBC, where the risk of distant metastases is higher than ALND, may be beneficial for a marginally higher survival benefit, provided the morbidity is worth bearing.

The combination of SLNB with systemic therapy has again broadened the usefulness of this technique, especially in intermediate and high-risk forms. The treatment is chemotherapy and radiotherapy; these forms of treatment adequately take care of any remaining disease, including micrometastases, to guarantee oncological safety. This acceptable interaction between surgical and systemic treatments epitomizes the changing face of breast cancer management – a patient profile-driven approach to treatment planning (Gripsrud et al., 2020).

4.2 Strengths and Limitations of SLNB

4.2.1 Strengths

SLNB has become an essential technique in the management of axillary metastases in breast cancer because of its benefits over ALND. They are most prominent in decreasing morbidity, promoting early recovery, and providing efficient use of healthcare resources, which makes them an essential part of neoadjuvant therapy for breast cancer. That said, like any surgical treatment, SLNB has some issues and disadvantages, such as its false negative rates, poor capability of identifying micrometastases, and a big part of the surgical learning curve (Fan et al., 2024).

This held for SLNB, which remains an effective technique owing to its inherent capacity to minimize morbidity. Compared with ALND, SLNB is less invasive and offers a dramatic decrease in the

incidence of lymphedema. This severe side effect occurs in any nodal region in up to 20% of patients receiving ALND but only in 4% of patients undergoing SLNB. Also, potential postmastectomy complications, including shoulder dysfunction, postoperative pain, and seroma formation, were notably reduced with SLNB, letting the patient leave the hospital with minimum disability (Onya, 2023). The precision of the operation also means that those healthy lymph nodes and axillary structures are left undamaged, thus alleviating the physical and psychological effects of more radical operations.

The other significant advantage of SLNB is in relation to recovery times. The majority of SLNB patients are discharged on the same day or the following day, while ALND patients have an average of 2 to 3 days of hospital stay. Recovery is quicker with SLNB patients returning to normal activities in two to three weeks as opposed to 6 to 8 weeks for patients who undergo an ALND. This faster recovery enhances the patient's quality of life and gets them to the following line of treatment, like chemotherapy or radiotherapy, without further undue delay (Alemany et al., 2021).

SLNB also has strengths concerning medical and healthcare expenses. SLNB's shorter operative time, fewer hospital days, and lower complication costs greatly improved cost-effectiveness for providers and consumers (Xue et al., 2018). SLNB not only affords better patient management by decreasing late effects such as lymphedema but also is cost-effective and has better long-term impacts on the quality of life as long-term cosmetic and reconstructive surgery expenses are curbed in patients undergoing SLNB.

4.2.2 Limitations

However, there are a number of issues and challenges that affect SLNB contemporarily. A significant concern is for the false negative rate, which stands at about 5%, while for ALND, it is zero percent. False negatives will lead to failure to detect metastatic nodes, likely to lead to a delay in treatment and consequently increase the risk of recurrence (Mathelin & Lodi, 2021), especially in aggressive types such as triple-negative breast cancer. However, current pathological methods, including immunohistochemical (IHC) staining, have enhanced the accuracy of SLNB, but they still fail to detect the minor deposits of cancer cells known as micro metastases. Systemic therapies may overcome this issue substantially, but the presence of false negatives does require a suitable patient selection and subsequent monitoring.

There is also a limitation in the SLNB learning curve. This requires a profound degree of skill in detecting and destroying sentinel lymph nodes using tracers such as radioactive technetium-99m and blue dye. It is unbearable for those patients, and the surgeons must be well-trained not to influence the outcome of the surgery in a way that will hinder the diagnosis of the ailment. Beginner experts may fail to locate the sentinel nodes, hence increasing the number of false negatives or complicacies. This challenge can only be solved by practicing constant training and following set standard protocols in the organization (Luthans et al., 2021).

4.3 Role of SLNB in Modern Breast Cancer Management

Sentinel lymph node biopsy (SLNB) has become a cornerstone of modern breast cancer management, particularly for patients with clinically node-negative disease (Xu et al., 2024). Over the years, its effectiveness in accurately staging axillary lymph nodes with minimal morbidity has solidified its role as the standard of care, supported by guidelines from leading oncology organizations such as the American Society of Clinical Oncology (ASCO) and the National Comprehensive Cancer Network (NCCN). These recommendations underscore the importance of SLNB in achieving optimal oncological outcomes while prioritizing patient quality of life (Casarin, 2023).

Current guidelines from ASCO emphasize SLNB as the preferred axillary staging procedure for patients with early-stage breast cancer and clinically node-negative axillae. ASCO highlights that SLNB provides equivalent oncological safety to axillary lymph node dissection (ALND) in terms of overall survival and recurrence-free survival while significantly reducing the risk of complications such as lymphedema, chronic pain, and shoulder dysfunction. Similarly, the NCCN includes SLNB

as the standard staging procedure for node-negative patients and those with limited nodal involvement, primarily when systemic therapies are employed to manage residual disease (Gradishar et al., 2022). These guidelines have been informed by numerous clinical trials, such as the ACOSOG Z0011 study, which demonstrated that ALND can be safely omitted in selected patients with positive sentinel nodes when adjuvant therapies are administered (Gradishar et al., 2022).

The adoption of SLNB as a standard of care is primarily driven by its minimally invasive nature and substantial diagnostic accuracy (Pesapane et al., 2023). By targeting only the first few lymph nodes likely to harbor metastatic disease, SLNB spares unnecessary removal of unaffected nodes. This targeted approach ensures accurate staging while avoiding the morbidity associated with ALND. In patients with clinically node-negative breast cancer, SLNB identifies nodal metastases with a sensitivity of approximately 94% and specificity of 98%, ensuring reliable staging information. Advances in pathological evaluation, including immunohistochemistry and molecular assays, have further improved its sensitivity, enabling the detection of micro metastases that may otherwise go unnoticed.

SLNB's integration into modern breast cancer management reflects a broader shift toward personalized and less invasive treatment paradigms. For patients with minimal axillary disease, SLNB avoids overtreatment, reducing the physical and emotional burden of surgery without compromising oncological safety (Li et al., 2024). Clinical trials have consistently demonstrated that SLNB provides outcomes equivalent to ALND in terms of survival and disease control in early-stage patients. Moreover, the reduced rates of complications like lymphedema (4% vs. 20% in ALND) and faster recovery times (2–3 weeks vs. 6–8 weeks) align with the growing emphasis on improving the quality of life for cancer survivors.

Importantly, SLNB also accommodates the evolving role of systemic therapies in breast cancer treatment. For patients undergoing neoadjuvant chemotherapy, SLNB has proven effective in accurately staging the axilla post-treatment, enabling tailored surgical decisions. Additionally, adjuvant therapies such as chemotherapy, radiotherapy, and targeted treatments effectively address undetected micro metastases, further supporting SLNB's oncological safety (Koirala, 2018).

4.4 Future Research Direction

Several limitations exist in current evidence, such as progressing SLNB in axillary management for breast cancer, and new opportunities that demand further research are identified. Other limitations include Further work should be done to enhance diagnostic reliability, and the extent to which SLNB may be incorporated with other therapeutic plans and individualized medicine ideas needs further investigation (Małkiewicz et al., 2023).

There are some critical areas involved with present evidence: The follow-up period is generally shorter, and the reduced long-term oncological safety and survival effects of SLNB have not yet been adequately assessed or compared with standard surgery. Outcomes have usually been measured at 5 and 10 years, and although these may be adequate for short- and mid-term outcome assessment, they are inadequate for late relapses and complications.

However, since the biological characteristics of specific subgroups, for example, TNBCs or HER2-positive patients, who are likely to experience later recurrences, remained unanswered by SLNB, more follow-up data are required (Cantini et al., 2023). However, for future research to enhance the generalizable results, the studies should enroll a more diverse sample of patients to include various racial, ethnic, and economic statuses. It is established that breast cancer survivorship also varies to some extent in relation to these factors, and scientific studies should guarantee that SLNB is effective and available for all patient populations.

Two promising anticancer therapy zones for further studies are Identifying a new approach for SLNB refinement and enhancing molecular and imaging methods to increase the method's sensitivity and lower the ratio of false-negative results. The false-negative rates of SLNB currently stand at about 5%, mainly because of cases of micro metastases or technical restrictions during the operation. Newer techniques, more precise PET-CT favored imaging, and MRI with LNM-specific contrast could

provide better preoperative identification of sentinel lymph nodes for their metastatic status. Likewise, new molecular markers based on real-time PCR or gene expression analysis may improve the intraoperative diagnosis by showing micrometastatic tumour spread that conventional histopathology cannot disclose. Such improvements could help cut out further surgeries and enhance the outcomes for such vulnerable groups as TNBC patients (Golshan et al., 2020).

4.5 Practical Considerations for Clinicians

SLNB is now considered standard in the axillary staging of breast cancer and depends on the accurate prognosis of patients, proper management of false negative results as well as proper handling of the procedure. SLNB is used in clinical treatment for patients with stage I and II breast cancer and clinically N0 axilla.

The appropriate patients are those with small primary tumors, low nodal involvement, or micrometastatic disease (Bochtler et al., 2018). SLNB may be applicable in those patients with clinically node-positive disease but which, following neoadjuvant chemotherapy, has shown nodal regression. That being said, axillary lymph node dissection (ALND) is still needed in patients with extensive nodal disease, palpable nodes, or those who underwent an SLNB and did not find SLNs. Consequently, preoperative imaging, along with clinical examination, is significant for the operative strategy (Bochtler et al., 2018).

Despite this, SLNB has a relatively low false negative rate of about 5%; sometimes, draining nodes with micrometastases are missed, which leads to delays in treatment or even recurrence. This risk can be attenuated if advanced pathological techniques like immunohistochemistry or molecular assays are used in an effort to increase micrometastase detection. Furthermore, it is essential to use systemic modalities, such as chemotherapy, radiotherapy, or both, to treat residual disease. Systemic therapies always help in the treatment of high-risk patients and, in addition, help address a disservice of SLNB where metastatic spread may have been omitted (Litterini & Wilson, 2021).

SLNB poses technical considerations for performing adequately and staging the sentinel node effectively. HMBN sentinel lymph nodes are detected using tracers like technetium-99m radioactive agent and blue dye injected into the skin around the tumor. In surgery, the sentinel lymph node or nodes are identified by a gamma probe or with direct visualization of dye and removed without causing significant damage to the tissue around it (Gariboldi et al., 2023). There are specific requirements for injection techniques and operative instruments for proper localization and removal of sentinel nodes. The removed nodes that are subjected to pathological analysis provide improved histopathological and molecular diagnoses. With respect to these practical considerations, clinicians are likely to gain maximum benefit from SLNB in terms of accuracy in staging, enhancing prognosis, and minimizing the morbidity associated with breast cancer management (Gariboldi et al., 2023).

5. Conclusion

Stated doubtlessly, this meta-analysis also emphasizes the SLNB in the management of breast cancer because of its efficiency and safety as compared to ALND. SLNB results in OS and RFS similar to those of ALND in patients with early-stage breast cancer and clinically node-negative axillae. SLNB was 92% for the five-year OS rate and 91% for the five-year OS rate in the ALND group; the five-year RFS rate of SLNB and ALND was 88% and 87%, respectively. Also, with concerns to morbidity, SLNB reduced the rates by half of the lymphedema (4% versus 20%) and fewer complications such as postoperative pain, shoulder dysfunction, seroma formation, and other lymph node-related complications. These reports strengthen the view that SLNB is a safer option for ALND, especially when there is inadequacy to SLNB, and SYT is administered to act on residual disease.

Concerning the improvements, the lower morbidity in SLNB patients yields a lot of clinical perquisites such as shortest recovery, reduced hospital stay, and enhanced quality of life. SLNB patients return to their everyday lives seven to fourteen days earlier than ALND patients, who take six to eight weeks. These advantages make SLNB the preferred method for use in early-stage breast cancer patients and those with minimal axillary nodal involvement. However, ALND remains helpful

in selected patients, including those with stage III or operable IV disease, patients with many affected nodal regions, or those with inflammatory breast cancers or triple-negative carcinomas, where clearance of more nodes can be beneficial.

From the clinical perspective, the results pinpoint the utility of individualized axillary treatment. SLNB alone should be the initial management of early breast cancer patients with clinically N-negative axillae. It is further enriched in immunohistochemistry and molecular assays to improve the detection of micrometastases at the molecular level. In patients with locally advanced disease or high-risk subgroups, ALND or SLNB, in combination with systemic treatments, may be required. Such information may help clinicians individualize axillary management according to patient characteristics while achieving the desirable oncologic results with minimal toxicity.

In the policy consideration of the findings, a favorable recommendation is given to SLNB as the preferred method for axillary staging in early breast cancer. Current national guidelines prepared by the American Society of Clinical Oncology (ASCO) and the National Comprehensive Cancer Network (NCCN) already recommend SLNB in clinically node-negative cases. It is now the policymakers' responsibility to promote programs to educate surgeons in SLNB techniques and increase the usage of accurate diagnostic equipment. SLNB should be adopted into various pathways of cancer care to allow patients to enjoy its benefits while at the same time following sound procedures in case of recurrence.

To wit, SLNB has brought a new concept into the management of breast cancer surgery, which effectively treats the disease while observing minimal side effects. It has been used as an example of how the approach to the use of systemic therapy became more oriented on the aspects of cancer safety complementary to the quality of life. With each advancement in the field of breast cancer treatment and consequent improvements in the specificity of treatment regimes, SLNB will remain a key element of a breast cancer patient's standard of care.

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