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Original Article

Comparison of Single Incision and Separate Incision Techniques in Sentinel Lymph Node Biopsy for Breast Cancer

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Abstract

Background: Breast cancer is the most common malignancy among Thai women, with approximately 50 new cases per 100,000 population annually. Sentinel lymph node biopsy (SLNB) is crucial for staging early breast cancer, and the choice of surgical technique can significantly impact outcomes. Identification of SLN using blue dye alone simplifies the procedure while remaining effective for resource-limited hospitals lacking frozen section analysis. Prior studies of single-incision SLNB focused on breast-conserving surgery.

Objective: This pilot study aimed to compare the single-incision and separate-incision techniques for SLNB in breast cancer patients, focusing on node harvesting, operative time, and postoperative complications.

Materials and Methods: Data were collected from Ubonratchatani Cancer Hospital between 2020 and 2024. A total of 59 patients with early-stage, clinically node-negative breast cancer were included: 31 underwent SLNB via the single-incision technique, and 28 via the separate-incision technique. Patients with biopsy-proven axillary node metastasis or those who received neoadjuvant chemotherapy were excluded. Multivariable regression analysis was used to assess key factors influencing node harvesting.

Results: The single-incision technique led to a 46% and 40% increase in lymph node yield compared to the separate-incision method in mastectomy with breast-conserving surgery and mastectomy alone, respectively. Operative times were shorter for the single-incision group, and postoperative complications, including seroma and wound infection, were less frequent. Tumor location, HER-2 status, and histologic grade significantly affected node harvesting. Both techniques showed comparable safety profiles, but the single-incision approach demonstrated improved surgical efficiency. Additionally, both techniques yielded similar survival outcomes, with no statistically significant differences in short-term overall survival and progression-free survival.

Conclusion: The single-incision technique for SLNB benefits node harvesting and operative efficiency while maintaining comparable postoperative complication rates. These findings suggest that the single-incision method may enhance patient outcomes, but further research is needed to validate these results and explore long-term oncological benefits.

Keywords: Breast cancer, Sentinel lymph node biopsy, Single-incision technique, Node harvesting, Surgical outcomes

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Introduction

Breast cancer is the most common malignancy among Thai women, with an incidence of approximately 50 new cases per 100,000 population per year.[1] The 5-year survival rates vary according to the stage of the disease: 94.4% for stage I, 85.0% for stage II, 56.6% for stage III, and 28.3% for stage IV.[2] Currently, The increasing availability of mammographic screening has led to a higher detection rate of early-stage breast cancer, which is associated with a favorable prognosis and a high likelihood of cure. Surgery remains the primary treatment modality for early-stage breast cancer.[3]

The sentinel lymph node biopsy (SLNB) is a minimally invasive technique that is crucial for staging and treatment planning in early-stage breast cancer patients who do not have clinically evident axillary lymph node involvement before surgery.[4] The ACOSOG Z0011 trial demonstrated that in patients undergoing breast-conserving surgery (BCS) with postoperative radiotherapy, those with 1-2 positive sentinel lymph nodes had similar rates of overall survival disease, free survival, and locoregional recurrence whether they underwent complete axillary lymph node dissection (ALND) or not.[5,6] Similarly, studies in patients undergoing mastectomy with positive sentinel lymph nodes (1-3 nodes) showed no significant differences in 5-year overall survival and recurrence-free survival between those who underwent ALND and those who received axillary radiotherapy instead.[7,8] A systematic review and meta-analysis further supported these findings, showing no differences in 5-year overall survival, disease-free survival, or recurrence rates between these treatment approaches.[9]

Sentinel lymph node biopsy can be performed using various tracers, including blue dye (BD), technetium-99m labeled nanocolloid (Tc-99m), and indocyanine green (ICG). The blue dye technique is widely used due to its simplicity and accuracy.[10] This dye binds to albumin and migrates to the sentinel lymph node, which is believed to be the first lymph node receiving drainage from the breast.[11] Surgeons use anatomical landmarks[12] and observe the dye's color at the lymphatic tracts to guide sampling.

Few studies have explored and developed techniques for single-incision sentinel lymph node biopsy (SLNB) and breast-conserving surgery (BCS). Brendan P et al.,[13] have published a technique for performing BCS using a single incision, which offers benefits such as reduced operative time and lower rates of complications, including pain, bleeding, numbness, and infection while maintaining equivalent quality in lymph node harvesting compared to the traditional separate-incision approach. However, this technique is primarily applicable to patients with tumors located in the upper outer quadrant of the breast.

Zhang et al. conducted a study comparing surgical outcomes between single-incision mastectomy with sentinel lymph node biopsy and separate-incision techniques. Using carbon nanoparticles and indocyanine green, they utilized a dual technique for sentinel lymph node identification. Their findings demonstrated that the single-incision approach was associated with shorter operative time, increased lymph node harvest, and reduced numbness in the axillary region.[14]

In rural or remote parts of developing nations such as Thailand, patient attitudes and difficulties in reaching cancer hospitals pose significant barriers to undergoing breast-conserving surgery (BCS), especially for cases of early-stage breast cancer.[15] Moreover, the increasing popularity of screening mammography in these regions could lead to a greater detection rate of conditions that make breast-conserving surgery unsuitable, such as multicentric lesions,[16] which accounts for 20-30%[17] of breast cancer cases identified by mammography or MRI breast. Therefore, most patients in these regions choose mastectomy as their preferred treatment.

The literature review discussed above predominantly focuses on studies from cancer centers or advanced institutions with abundant resources, in contrast to rural cancer hospitals in Thailand. These rural hospitals often depend on a single technique–using blue dye for sentinel lymph node biopsy–and lack the pathologists required for intraoperative frozen section consultations. Consequently, they must wait for permanent section pathological results. Research by Treeratanapun, N. et al. at King Chulalongkorn Memorial Hospital has shown that, in cases where patients are preoperatively clinically node-negative, the outcomes of node staging from permanent sections are comparable to those from frozen sections.[18]

The development of the single incision technique for mastectomy and BCS combined with sentinel lymph node biopsy (SLNB) originated from the traditional approach of using separate incisions for these procedures. Typically, surgeons would perform the SLNB at the axillary site first, followed by the mastectomy. This sequence was driven by the critical timing, or "golden period," associated with

Isosulfan Blue and Indocyanine Green. These tracers must be removed within 5 to 15 minutes post-injection,[19,20] as they rapidly travel through the lymphatic ducts to the sentinel node. If the SLNB is performed too early, the tracer may not have reached the sentinel node, resulting in a failure to identify it. Conversely, if the procedure is delayed, the tracer might spread to non-sentinel nodes, increasing the false-negative rate.

The single incision technique was developed to solve the limitations of the separate incision approach. Technically, the traditional technique involves making a direct incision over the axilla region to enter the cavipectoral fascia. However, if a small incision is made, it can compromise the adequacy of identifying the sentinel node. Additionally, if a catastrophic situation occurs, such as massive bleeding from a large vessel, it becomes difficult to control and handle it. By using a single incision, a large incision and clear visualization of the tissue and vessel in that area may facilitate the safe and accurate detection of the sentinel lymph node.

It not only reduces the number of incisions at the axillary site, but it also diminishes the discomfort associated with axillary incisions, which, although minor, can significantly affect the patient's daily life. Approximately 30% of patients experience chronic pain or numbness at the axillary site following an SLNB. Moreover, separate incisions can increase operative time, the risk of postoperative infection, and the incidence of seroma formation in the axillary region.[13,21,22] The primary objective of this study is to compare the efficacy of sentinel node biopsy, focusing on the number of nodes harvested, between two techniques: single incision versus separate incision. The secondary objective is to assess additional indicators of success in sentinel node biopsy between the two techniques, including identification rate, surgical outcomes, associated complications, and short-term survival outcomes in terms of overall and progression-free survival.

Materials and Methods

This retrospective cohort study was conducted at Ubonratchathani Cancer Hospital between 2020 and 2024. The inclusion criteria consisted of early-stage breast cancer patients with clinically node-negative status, as determined by physical examination and preoperative imaging (clinical stage I-II based on the 7th edition of the AJCC staging criteria). The exclusion criteria included patients with biopsy-confirmed axillary node metastasis, those who received neoadjuvant chemotherapy, and individuals with bilateral breast cancer. A total of 60 patients were initially included, but one was excluded due to a history of neoadjuvant chemotherapy, resulting in a final sample size of 59 patients. The cohort was divided into 31 patients in the single-incision group and 28 in the separate-incision group. The procedures for both groups were performed by a single surgeon who had achieved the learning curve criteria for proficiency in SNBx, which included a localization rate of $\geq 90\%$ and a false-negative rate of $\leq 5\%$. Clinical data were collected, including age, BMI, comorbidities, tumor characteristics, surgical approach, and complications. Survival outcomes were reported with median follow-up time and Kaplan-Meier curves for overall and progression-free survival. The primary outcome was lymph node yield, while secondary outcomes included operative time (time from incision to wound closure), node positivity, blood loss (overall blood loss), and complications such as seroma, wound infection, and hematoma. Additionally, survival outcomes were presented as 2-year overall survival and 2-year progression-free survival.

Descriptive statistics were used to summarize baseline characteristics and outcomes for both groups. Independent t-tests, Mann-Whitney U tests, chi-square tests, and Fisher's exact tests were performed for group comparisons. Survival outcomes were compared using the log-rank test. Univariable and multivariable regression analyses assessed factors affecting node harvesting. Generalized Linear Models (Poisson distribution) estimated incidence rate ratios (IRR) for node harvesting, while a gamma family model analyzed skewed continuous data, such as operative time and blood loss. Variables with $p < 0.05$ were retained. Model fit was evaluated using the Akaike Information Criterion (AIC) and log-likelihood ratio tests. Analyses were performed using Stata 18. The study was approved by the Ethics Committee of Ubonratchathani Cancer Hospital under protocol number EC 021/2024.

Sentinel Lymph Node Biopsy Procedure

Anesthesia and Preparation: The procedure begins with administering general anesthesia and administering prophylactic antibiotics to prevent surgical site infection.

Patient Positioning: The patient is positioned supine with the arm on the surgical side abducted to 90 degrees. A small cushion is placed under the shoulder, arm, and back to provide support.

Skin Preparation: The surgical site is thoroughly cleansed, and the area is draped to maintain a sterile field.

Injection of Tracers: Isosulfan blue dye is injected into the periductal area at 3 and 9 o'clock positions, with a subdermal injection of 2 milliliters on each side. The breast is massaged for approximately 5 minutes until the skin over the breast and axilla shows a blue discoloration, as shown in Figures 1A, 1B, and 1C.[23]

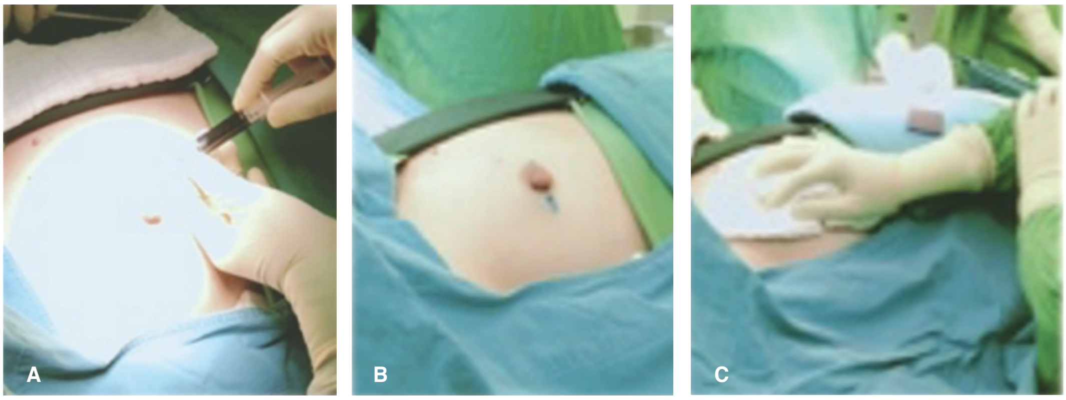

Figure 1

Incision Techniques

Separate Incisions: In cases where separate incisions are made, the axillary incision is placed at the lowest hairline, approximately 2 fingerbreadths from the axillary crease, with a length of 4-5 centimeters, as shown in Figure 2D.[23]

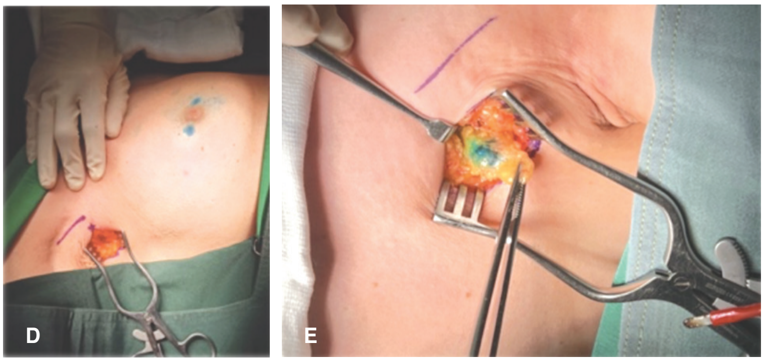

Figure 2

Single Incision: If a single incision is used, the breast incision is made first, starting at the upper outer quadrant, approximately 10 cm, to facilitate dissection toward the axilla, as shown in Figures 3F, 3G, and 3H.

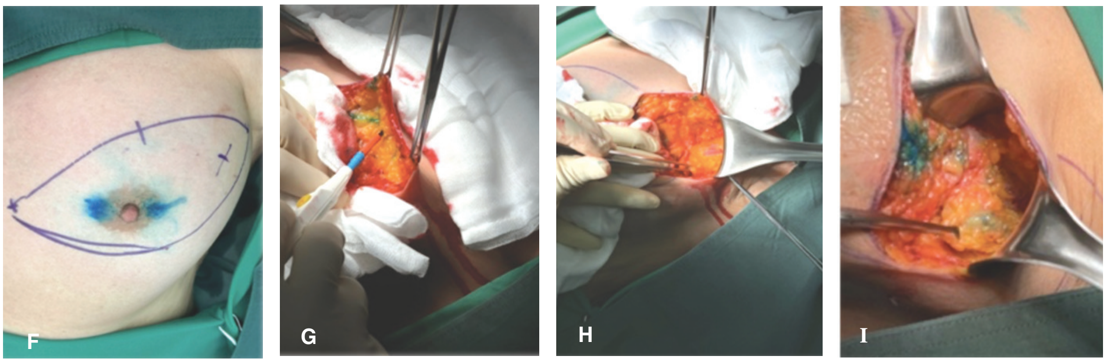

Figure 3

Dissection: After making the incision, the dissection proceeds through the subcutaneous tissue down to the axillary fascia. Upon reaching this layer, the dyed lymphatic vessels are identified and followed to locate the sentinel lymph node, as shown in Figures 2E and 3I. If the dyed lymphatic vessels are not clearly visible, anatomical landmarks, such as the edge of the pectoralis major muscle, are used to locate the sentinel lymph node.

Node Removal: Typically, 2-4 lymph nodes are excised. If an enlarged lymph node that is not stained is detected, it should also be removed.

Further Dissection: If the sentinel lymph node cannot be identified or the lymph nodes are not stained, an axillary lymph node dissection should be performed.

Breast surgery: After the removal of the sentinel lymph node, the breast operation was performed according to the planned procedure, either mastectomy or breast-conserving surgery.

RESULTS

Patient Characteristics

In Table 1, there were no statistically significant differences between the two groups in terms of age, BMI, comorbidities, tumor size, tumor side, multifocality, T stage, N stage, AJCC stage, histologic type, lymphovascular invasion (LVI), ER status, PR status, HER2 status, and tumor subtype. The surgical approach showed a significant difference between the groups, with a higher proportion of mastectomies in the single-incision group (96.77%) compared to the separate-incision group (32.14%) ($p < 0.001$). Tumors in the upper outer quadrant (UOQ) were more frequent in the separate-incision group (64.29%) than in the single-incision group (38.71%) ($p = 0.052$). Histologic Grade 1 tumors were more common in the separate-incision group (40.00%) compared to the single-incision group (17.24%) ($p = 0.089$).

Table 1 Clinical and pathological characteristics

Clinical Characteristics	Full cohort					Subgroup: Mastectomy				
	Single incision N = 31		Separate incision N = 28		*p*-value	Single incision N = 30		Separate incision N = 9		*p*-value
Age (Mean ± SD) year	53.71	± 11.32	54.21	± 12.70	0.872	54.03	± 11.37	61.11	± 11.77	0.113
Body mass index (BMI)	23.91	± 4.17	23.55	± 3.53	0.726	24.12	± 0.74	22.97	± 1.53	0.473
Comorbidity										
Yes	17	54.84%	10	35.71%	0.141	19	63.33%	5	55.56%	0.674
No	14	45.16%	18	64.29%		11	36.67%	4	44.44%	
Tumor size (Mean ± SD) cm	2.05	± 1.95	1.93	± 1.06	0.77	2.07	± 1.98	2.03	± 1.30	0.964
Surgical approach										
Mastectomy	30	96.77%	9	32.14%	< 0.001					
Breast-conserving surgery	1	3.23%	19	67.86%						
Biopsy type										
Core needle biopsy	25	80.65%	22	78.57%	0.843	25	83.33%	6	66.67%	0.277
Excision	6	19.35%	6	21.43%		5	16.67%	3	33.33%	
Side										
Right	12	38.71%	12	42.86%	0.746	12	40.00%	3	33.33%	0.718
Left	19	61.29%	16	57.14%		18	60.00%	6	66.67%	
Multifocal										
Yes	5	16.13%	2	7.41%	0.309	5	16.67%	0	0%	0.088
No	26	83.87%	25	92.59%		25	83.33%	8	88.89%	

Table 1 (cont.) Clinical and pathological characteristics

Clinical Characteristics	Full cohort					Subgroup: Mastectomy				
	Single incision N = 31		Separate incision N = 28		*p*-value	Single incision N = 30		Separate incision N = 9		*p*-value
Location: Quadrant (n, %)										
UOQ	12	38.71%	18	64.29%	0.052	11	36.67%	7	77.78%	0.184
UIQ	6	19.35%	1	3.57%		6	20.00%	0	0%	
LOQ	2	6.45%	5	17.86%		2	6.67%	1	11.11%	
LIQ	4	12.90%	2	7.14%		4	13.33%	0	0%	
Central quadrant	7	22.58%	2	7.14%		7	23.33%	1	11.11%	
T stage (n, %)										
T0	5	16.13%	4	14.29%	0.766	5	16.67%	1	11.11%	0.918
T1	16	51.61%	14	50.00%		15	50.00%	5	55.56%	
T2	9	29.03%	10	35.71%		9	30.00%	3	33.33%	
T3	1	3.23%	0	0.00%		1	3.33%	0	0%	
Node stage (n, %)										
N0	24	77.42%	23	82.14%	0.647	24	80.00%	7	77.78%	0.901
N1	4	12.90%	14	14.29%		4	13.33%	1	11.11%	
N2	3	9.68%	1	3.57%		2	6.67%	1	11.11%	
AJCC stage (n, %)										
0	6	19.35%	4	14.29%	0.776	6	20.00%	1	11.11%	0.870
1A	12	38.71%	12	42.86%		12	40.00%	5	55.56%	
2A	7	22.58%	9	32.14%		7	23.33%	1	11.11%	
2B	2	6.45%	2	7.14%		2	6.67%	1	11.11%	
3A	3	9.68%	1	3.57%		2	6.67%	1	11.11%	
4	1	3.23%	0	0.00%		1	3.33%	0	0.00%	
Pathological report (n, %)										
IDC	6	19.35%	7	25.00%	0.384	6	20.00%	4	44.44%	0.114
DCIS	5	16.13%	3	10.71%		5	16.67%	0	0%	
IDC with DCIS	17	54.84%	13	46.43%		16	53.33%	4	44.44%	
ILC	3	9.68%	2	7.14%		3	10.00%	0	0%	
Other	0	0.00%	3	10.71%		0	0%	1	11.11%	
LVI (n, %)										
Yes	11	40.47%	6	27.27%	0.325	10	33.33%	2	22.22%	0.770
No	16	59.26%	16	72.73%		16	53.33%	6	66.67%	
Histologic Grade (n, %)										
1	5	17.24%	10	40.00%	0.089	5	17.86%	4	50.00%	0.084
2	20	68.97%	10	40.00%		19	67.86%	2	25.00%	
3	4	13.79%	5	20.00%		4	14.29%	2	25.00%	

Table 1 (cont.) Clinical and pathological characteristics

Clinical Characteristics	Full cohort					Subgroup: Mastectomy				
	Single incision N = 31		Separate incision N = 28		*p*-value	Single incision N = 30		Separate incision N = 9		*p*-value
ER status (n, %)										
Negative	11	35.48%	5	19.23%	0.174	11	36.67%	2	22.22%	0.151
Positive	20	64.52%	21	80.77%		19	63.33%	6	66.67%	
PR status (n, %)										
Negative	15	48.39%	9	34.62%	0.294	15	50.00%	4	44.44%	0.181
Positive	16	51.61%	17	65.38%		15	50.00%	4	44.44%	
HER2 status (n, %)										
Negative	23	82.14%	19	79.17%	0.786	22	73.33%	6	66.67%	0.918
Positive	5	17.86%	5	20.83%		5	16.67%	2	22.22%	
Subtype (n, %)										
Luminal A	17	54.84%	19	67.86%	0.448	16	53.33%	5	55.56%	0.494
Luminal B HER-2 -	1	3.23%	0	0.00%		1	3.33%	0	0%	
Luminal B HER-2 +	1	3.23%	1	3.57%		1	3.33%	0	0%	
HER2+/neu	4	12.90%	4	14.29%		4	13.33%	2	22.22%	
Triple-negative	6	19.35%	1	3.57%		6	20.00%	0	0%	
Unknown	2	6.45%	3	10.71%		2	6.67%	2	22.22%	

UOQ = Upper outer quadrant, UIQ = Upper inner quadrant, LOQ = Lower outer quadrant, LIQ = Lower inner quadrant, IDC = Invasive ductal carcinoma, DCIS = Ductal carcinoma in situ, ILC = invasive lobular carcinoma, LVI = lymphovascular invasion, ER = Estrogen Receptor, PR = Progesterone Receptor, HER2 = Human Epidermal Growth Factor Receptor 2.

Node harvesting, surgical outcomes, and complications

The single-incision group had a significantly higher number of lymph nodes harvested compared to the separate-incision group. The median number of nodes harvested was 6 (IQR: 4–8) in the single-incision group compared to 3 (IQR: 2–6) in the separate-incision group, with a statistically significant difference ($p < 0.001$). The overall complication rates, including seroma, wound infection, and hematoma, were comparable between both groups. Partial wound dehiscence was slightly more common in the single-incision group (6.45% vs. 0%) but was not statistically significant. The safety profiles of both techniques were comparable, as shown in Table 2.

Table 2 Surgical outcomes (full cohort)

Outcome	Single incision N = 31		Separate incision N = 28		Co-efficiency	95% CI	*P*-value
Pathological outcome							
Node harvesting (Median, IQR)[##]	6	(4,8)	3	(2,6)	1.49[*]	(1.20, 1.84)	**< 0.001**
Node positive (Median, IQR)	0	(0,0)	0	(0,0)	1.35[*]	(0.65, 2.81)	0.415
Sentinel lymph node biopsy							
Identified	29	93.55%	26	92.86%	1.12	(0.15, 8.49)	0.916
Unidentified	2	6.45%	2	7.14%	ref	ref	
Reoperation							
Yes	2	6.45%	4	14.29%	0.41	(0.07, 2.46)	0.332
No	29	93.55%	24	85.71%	ref	ref	
Surgical outcome							
Operative time (Median) hr.	1.75	(1.25, 1.75)	2	(1.30, 2.50)	0.83[**]	(0.71, 0.96)	**0.011**
Blood loss (Median) cc	20	(10, 20)	20	(17.5, 50)	0.74[**]	(0.50, 1.10)	0.134
LOS (Median) day	4	(3, 5)	3.5	(3, 5)	0.96[**]	(0.79, 1.17)	0.661
Complication							
Seroma	3	9.68%	4	14.29%	0.64	(0.13, 3.16)	0.587
Partial wound dehiscence[###]	2	6.45%	0	0.00%	4.83	(0.22, 105.07)	0.316
Wound infection	1	3.23%	1	3.57%	0.9	(0.05, 15.10)	0.942
Hematoma or ecchymosis	4	12.90%	2	7.14%	1.92	(0.32, 11.43)	0.471
Survival Outcome[***]							
Median follow-up time (month)	7.1	(2.6,15.2)	10.9	(4.2, 28.9)	-	-	-
Median survival time (month)	N/A	-	N/A	-	-	-	-
Median progression survival time (month)	N/A	-	N/A	-	-	-	-
2 years OS (%, 95% CI)	94.74%	(68.12%, 99.24%)	100%	-	-	-	-
2 years PFS (%, 95% CI)	94.74%	(68.12%, 99.24%)	92.31%	(56.64%, 98.88%)	-	-	-

LOS = Length of hospital stay. A *p*-value of < 0.05 is considered statistically significant. Reference categories (ref) indicate the baseline comparison group for categorical variables.

[##] The count of harvested nodes includes only the sentinel lymph nodes from the initial operation. However, in cases where the sentinel nodes were not identified during the initial procedure, all nodes harvested during that operation are included in the total count. For patients who underwent reoperation, any additional nodes harvested in the subsequent procedure were excluded from the overall node count.

[*] Coefficient values for node harvesting and node positivity are incidence rate ratios (IRR) derived from a Poisson generalized linear model (GLM).

[###] The coefficiency (odds ratio) for partial wound dehiscence was calculated using Firth's penalized likelihood logistic regression due to the presence of a zero event in one group.

[**] Coefficients for operative time, blood loss, and length of stay (LOS) are IRRs obtained from a Gamma GLM.

[***] Due to the limited number of events, presenting descriptive results may be more informative than performing a Cox regression analysis.

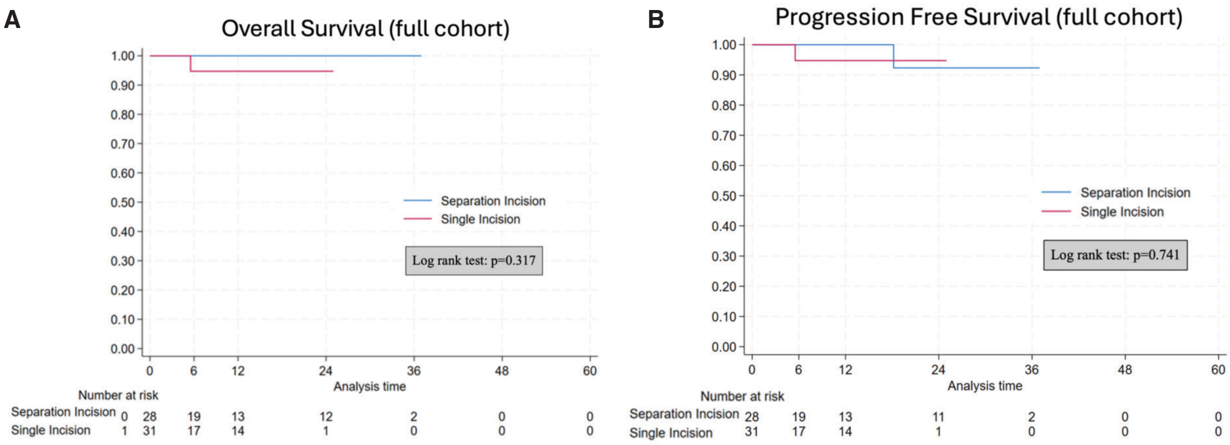

Figure 4 A: Overall Survival (full cohort)
B: Progression Free Survival (full cohort)

Survival outcome

The Kaplan-Meier survival curves for the full cohort show no significant differences in overall survival (OS) and progression-free survival (PFS) between the single-incision and separate-incision groups. The median follow-up time was longer in the separate-incision group (10.9 months, IQR 4.2–28.9) compared to 7.1 months (IQR 2.6–15.2) in the single-incision group. Two-year OS was 94.74% (95% CI: 68.12%–99.24%) for the single-incision group and 100% for the separate-incision group, with no significant difference (log-rank test, $p = 0.317$). Similarly, two-year PFS was 94.74% (95% CI: 68.12%–99.24%) and 92.31% (95% CI: 56.64%–98.88%) for the single-incision and separate-incision groups, respectively, with no significant difference (log-rank test, $p = 0.741$). These results indicate comparable survival outcomes between the two groups, as presented in Table 2, Figure 4 (A and B).

Table 3 Univariable and multivariable regression analysis for node harvesting (full cohort)

Clinical Characteristic	Univariable IRR (95% CI)	*p*-value	Multivariable IRR (95% CI)	*p*-value
Surgical Technique: Single vs. Separate Incision	1.49 (1.20-1.84)	< 0.001	1.46 (1.13-1.88)	0.003
Mastectomy vs. BCS	0.61 (0.48-0.78)	< 0.001	-	-
Age (per year increase)	0.99 (0.98-1.00)	0.058	-	-
BMI	1.03 (1.00-1.05)	0.036	-	-
Comorbidities	1.31 (1.07-1.61)	0.011	1.47 (1.17-1.85)	0.001
Biopsy type (Core needle biopsy vs excisional biopsy)	1.15 (0.90-1.48)	0.251	1.50 (1.10-2.03)	0.009
Tumor Location (UIQ)	1.68 (1.26-2.24)	< 0.001	1.70 (1.23-2.34)	0.001
Tumor Location (LIQ)	1.39 (1.00-1.92)	0.05	1.71 (1.19-2.48)	0.004
HER-2	1.30 (1.01-1.67)	0.041	1.36 (1.01-1.83)	0.040
Histologic Grade (3 vs. 1)	1.78 (1.29-2.46)	< 0.001	1.66 (1.23-2.23)	0.001

BCS = Breast conserving surgery, UIQ = Upper inner quadrant, LIQ = Lower inner quadrant, IRR = Incidence rate ratios

In Table 3, the single-incision technique is associated with a 46% higher likelihood of node harvesting compared to the separate-incision technique [IRR = 1.46, 95% CI (1.13-1.88), $p = 0.003$] even after adjusting for other clinical factors. Other factors independently associated with increased node yield include comorbidities (IRR = 1.47, $p = 0.001$), biopsy type (IRR = 1.50, $p = 0.009$), tumor location in the UIQ (IRR = 1.68, $p = 0.001$) and LIQ

(IRR = 1.71, p = 0.004), HER-2 positivity (IRR = 1.36, p = 0.040), and higher histologic grade (IRR = 1.66, p = 0.001). Age, BMI, and surgical approach (mastectomy vs. BCS) were insignificant after adjusting for other variables in the multivariable model.

Subgroup analysis

Patient Characteristics

In Table 1, In the mastectomy subgroup (N = 39), the mean age was higher in the separate incision group (61.11 vs. 54.03 years, p = 0.113), though not statistically significant. Tumor size was similar between the groups (2.03 vs. 2.07 cm, p = 0.964). Tumor location in the upper outer quadrant (UOQ) was more frequent in the separate incision group (77.78% vs. 36.67%, p = 0.184). There was a trend toward more Grade 1 tumors in the separate incision group (50% vs. 17.86%, p = 0.084). Subtype distribution showed no significant differences, with Luminal A being the most common subtype (55.56% vs. 53.33%, p = 0.494). Other clinical characteristics, including comorbidities, biopsy type, node status, and receptor status, showed no significant differences.

Node harvesting, surgical outcomes, complications

The single-incision group had a median of 6 nodes harvested (IQR 4–8) compared to 5 (IQR 2–10) in the separate-incision group, with no significant difference (p = 0.239). Sentinel lymph node biopsy identification rates were high in both groups (90% vs. 100%, p = 0.571). Operative time was significantly shorter in the single-incision group (1.75 hours vs. 2.5 hours, p < 0.001). Other outcomes, including reoperation rates, blood loss, length of stay, and complications, showed no significant differences between the groups, as presented in Table 4.

Table 4 Surgical outcomes (mastectomy subgroup)

Outcome	Single incision N = 30		Separate incision N = 9		Co-efficiency	95% CI	*P*-value
Pathological outcome							
Node harvesting (Median, IQR)[##]	6	(4,8)	5	(2, 10)	1.19	(0.89, 1.61)	0.239
Node positive (Median, IQR)	0	(0,0)	0	(0, 0)	0.7	(0.27, 1.82)	0.465
Sentinel lymph node biopsy							
Identified	27	90.00%	9	100.00%	0.41	(0.12, 8.76)	0.571
Unidentified	3	10.00%	0	0%	ref	ref	
Reoperation[***]							
Yes	2	6.67%	0	0%	1.67	(0.07, 37.89)	0.749
No	28	93.33%	100	100%	ref	ref	
Surgical outcome							
Operative time (Median) hr.	1.75	(1.25, 1.75)	2.5	(2, 2.5)	0.69[**]	(0.59, 0.82)	**< 0.001**
Blood loss (Median) cc	20	(10, 20)	20	(20, 50)	0.69[**]	(0.38, 1.25)	0.225
LOS (Median) day	4	(3, 4)	5	(3, 6)	0.84[**]	(0.63, 1.11)	0.219
Complication							
Seroma	2	6.67%	1	11.11%	0.57	(0.05, 7.14)	0.664
Partial wound dehiscence[###]	2	6.67%	0	0%	1.67	(0.07, 37.89)	0.749
Wound infection	1	3.33%	0	0%	0.97	(0.04, 25.75)	0.984
Hematoma or ecchymosis	4	13.33%	1	11.11%	1.23	(0.12, 12.65)	0.861
Survival Outcome[****]							
Median follow-up time (month)	7	(2.6, 14.4)	30.8	(28.8, 34.5)	-	-	-
Median survival time (month)		N/A		N/A	-	-	-
Median progression survival time (month)		N/A		N/A	-	-	-
2 years OS (%, 95%CI)	94.44%	(66.64%, 99.20%)	100%	-	-	-	-
2 years PFS (%, 95%CI)	94.44%	(66.64%, 99.20%)	87.50%	(38.70%, 98.14%)	-	-	-

A p-value of < 0.05 is considered statistically significant. Reference categories (ref) indicate the baseline comparison group for categorical variables.

[##] The count of harvested nodes includes only the sentinel lymph nodes from the initial operation. However, in cases where the sentinel nodes were not identified during the initial procedure, all nodes harvested during that operation are included in the total count. For patients who underwent reoperation, any additional nodes harvested in the subsequent procedure were excluded from the overall node count.

[###] The coefficiency (odds ratio) for partial wound dehiscence was calculated using Firth's penalized likelihood logistic regression due to the presence of a zero event in one group.

[*] Coefficient values for node harvesting and node positivity are incidence rate ratios (IRR) derived from a Poisson generalized linear model (GLM).

[**] Coefficients for operative time, blood loss, and length of stay (LOS) are IRRs obtained from a Gamma GLM.

[***] Due to statistical reasons, Firth's logistic regression was used instead of standard logistic regression to address the issue of perfect prediction.

[****] Due to the limited number of events, presenting descriptive results may be more informative than performing a Cox regression analysis.

Survival outcome

The Kaplan-Meier curves for overall survival (OS) and progression-free survival (PFS) in the mastectomy subgroup show no significant differences between the single-incision and separate-incision groups. The median follow-up time was longer in the separate-incision group (30.8 vs. 7 months). Two-year OS was 94.44% for the single-incision group and 100% for the separate-incision group, with the log-rank test indicating no significant difference ($p = 0.480$). Similarly, two-year PFS was 94.44% and 87.50%, respectively, with no significant difference ($p = 0.940$). These findings suggest that survival outcomes are comparable regardless of surgical technique, as shown in Table 4, Figures 5 (A and B).

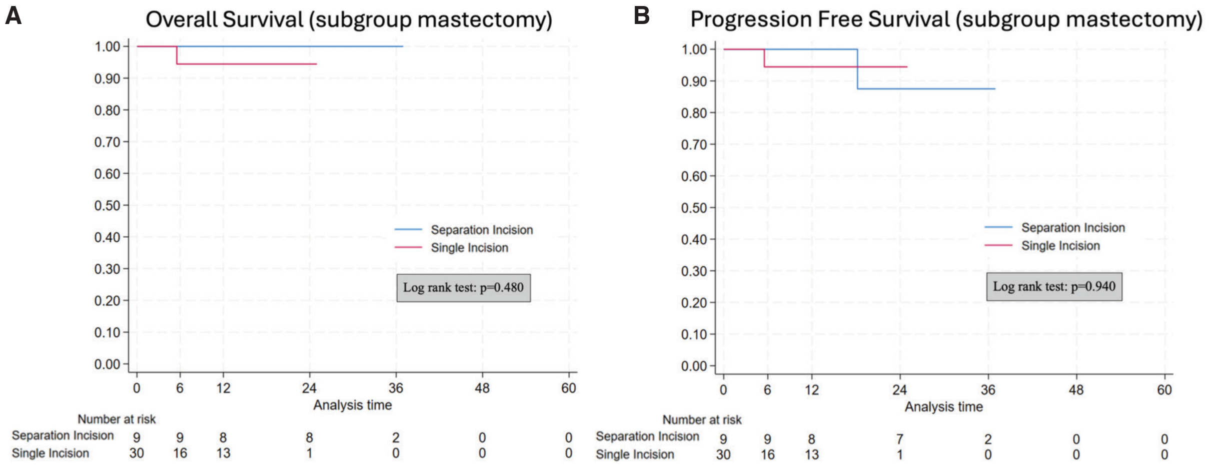

Figure 5 A: Overall Survival (subgroup mastectomy)
B: Progression Free Survival (subgroup mastectomy)

Table 5 Univariable and multivariable regression analysis for node harvesting (mastectomy subgroup)

Clinical Characteristic	Univariable		Multivariable	
	IRR (95% CI)	*p*-value	IRR (95% CI)	*p*-value
Surgical Technique: Single vs. Separate Incision	1.19 (0.89-1.60)	0.239	1.40 (1.00-1.95)	0.050
Age (per year increase)	0.99 (0.98-1.00)	0.043	-	-
BMI	1.03 (1.00-1.05)	0.048	1.05 (1.02, 1.09)	< 0.001
Tumor size	1.05 (0.99,1.12)	0.116	1.14 (1.06, 1.22)	< 0.001
Tumor Location (UIQ)	1.61 (1.21-2.13)	0.001	-	-
Tumor Location (LOQ)	1.58 (1.18,2.12)	0.002	-	-
Tumor Location (Central)	1.37 (0.97,1.93)	0.078	2.34 (1.54, 3.56)	< 0.001
LVI	0.93 (0.71,1.20)	0.572	0.51 (0.37, 0.70)	< 0.001
HER-2	1.08 (0.80-1.45)	0.619	-	-
Histologic Grade (3 vs. 1)	1.35 (1.00-1.82)	0.049	3.13 (2.09-4.67)	< 0.001

BCS = Breast conserving surgery, UIQ = Upper inner quadrant, LIQ = Lower inner quadrant, IRR = Incidence rate ratios

In Table 5, the single-incision technique is associated with a 40% higher likelihood of node harvesting compared to the separate-incision technique [IRR = 1.40, 95% CI (1.00–1.95), $p = 0.050$] after adjusting for other clinical factors. Other factors independently associated with increased node yield include BMI (IRR = 1.05, $p < 0.001$), tumor size (IRR = 1.14, $p < 0.001$), central tumor location (IRR = 2.34, $p < 0.001$), and higher histologic grade (Grade 3 vs. Grade 1, IRR = 3.13, $p < 0.001$). Lymphovascular invasion (LVI) was inversely associated with node yield (IRR = 0.51, $p < 0.001$). Age, HER-2 status, and tumors located in the UIQ and LOQ did not remain significant after adjusting for other variables in the multivariable model.

Discussion

This pilot study comparing the single-incision and separate-incision techniques for sentinel lymph node biopsy (SLNB) in breast cancer patients provides important insights into surgical outcomes, particularly in relation to lymph node harvesting. The single-incision technique demonstrated a 46% increase in the number of harvested lymph nodes compared to the separate-incision approach in both mastectomy and breast-conserving surgery (BCS) groups. Additionally, there was a 40% increase in lymph node yield with the single-incision technique compared to the separate-incision approach within the mastectomy subgroup. This increase in node yield may result from better access and visualization of the axillary nodes through a single incision, facilitating easier identification and removal of sentinel nodes. Moreover, the shorter operative time, particularly in the mastectomy subgroup associated with the single-incision technique, indicates improved surgical efficiency, potentially lowering the risk of complications and shortening recovery periods. The sentinel node identification rate using the single-dye technique, without a frozen section, is comparable to findings from other studies, achieving a 93% identification rate for the full cohort and 90% for the mastectomy subgroup with a single incision. These results did not show a statistically significant difference compared to the standard separate-incision technique. The safety profiles of both techniques were similar, with no significant differences observed in complications such as seroma formation, wound infections, or hematoma. However, partial wound dehiscence occurred more frequently in the single-incision group. Also, the survival outcomes, in terms of overall survival and progression-free survival, were comparable between both surgical techniques for the full cohort and the mastectomy subgroup.

Lovasik et al. (2018), in a study conducted at a tertiary academic cancer center in the United States with a sample size of 110 patients, demonstrated the benefits of the single-incision technique, showing a 12.5% reduction in operative time. However, there was no difference in node harvesting for early breast cancer patients. The number of identified nodes in their study was significantly lower for the single-incision group compared to the separate-incision group (Median [IQR] = 2[2,3], $p = 0.05$). Despite a 100% identification rate of sentinel nodes with the single tracer technique, the study's focus on breast-conserving surgery (BCS) for upper outer quadrant (UOQ) tumors likely limited visualization through a single incision. The study also reported comparable complication rates between the two techniques. Zhang et al. (2021), in a study conducted in China using advanced technology, focused on early breast cancer patients undergoing mastectomy and compared single-incision and separate-incision techniques for sentinel lymph node biopsy using a dual-tracer approach. The single-incision technique resulted in a higher median number of harvested nodes (3.2 ± 1.1 nodes in the single-incision group compared to 2.7 ± 1.0 nodes in the separate-incision group; $p = 0.001$), as well as a reduction in operative time and a decreased rate of upper limb numbness. Other complications and recurrence rates were comparable between the two groups.

The selection of techniques in this study was influenced by certain aspects of surgeon preference, introducing a potential selection bias. This bias arises because the technique provides easier access to the axillary region and facilitates sentinel lymph node identification, making it the preferred approach once the surgeon's learning curve stabilizes. For mastectomy patients, the criteria for choosing the single-incision technique included younger age and smaller breast size. For patients undergoing breast-conserving surgery (BCS), the single-incision technique was primarily selected for tumors located in the upper outer quadrant (UOQ). The separate-incision technique remains relevant for specific patient subgroups and tumor characteristics, particularly in cases of non-UOQ tumors, reoperations following mastectomy, and patients with high BMI. Veronesi et al. (2003) suggest that sentinel lymph nodes should be removed through the same incision for UOQ tumors, while a separate incision is recommended for non-UOQ tumors,[24] as it provides easier direct access to the nodes. This is especially important in oncoplastic surgery, where cosmetic outcomes are a concern.[25] Furthermore, in patients with high BMI, the higher failure rate of sentinel lymph node mapping[26] increases the likelihood of needing a complete axillary lymph node dissection, for which a direct axillary incision may facilitate easier dissection. The single-incision technique allows for better visualization due to its similarity to the approach used in modified radical mastectomy, a procedure familiar to most surgeons. This familiarity aids in identifying anatomical landmarks such as the clavipectoral fascia and pectoralis major. The technique also provides clear visualization of the blue-stained sentinel lymph node or the lymphatic tract originating from the injection site, enabling precise identification and removal of sentinel nodes. The single-incision technique is associated with a shorter operative time due to the need to suture only one incision. Postoperative complications such as seroma and ecchymosis were less common in the single-incision group, likely due to the wider surgical field, facilitating more efficient hemostasis. Also, the placement of a surgical drain covering both the axilla and the mastectomy wound is more efficient when these areas are treated as a single unit, leading to a reduced incidence of postoperative seroma. In terms of infection, the separate incision technique, with one incision located in the axillary region, is more prone to infection, partly due to the difficulty of adequate postoperative dressing in that area. Combining both incisions into a single wound reduces the risk of infectious complications. Lymph node harvesting is a critical factor in lymph node staging. While it is generally recommended to excise 2-4 sentinel nodes, some studies suggest that removing up to five nodes ensures the detection of metastatic nodes in over 99% of patients.[27] The number of excised nodes plays a key role in determining adjuvant treatment, influencing decisions about chemotherapy, its duration, and postoperative radiation therapy, including the radiation field and dose. A shorter operative time is especially beneficial in resource-limited settings, as it minimizes patients' exposure to general anesthesia and reduces the risk of complications such as infection, bleeding, and wound healing issues.[28] A study of the ACOSOG Z0011 trial with a 10-year follow-up of sentinel lymph node biopsy in patients who underwent breast-conserving surgery (BCS) reported a median follow-up time of 9.25 years. The cumulative incidence of locoregional recurrence was 3.8% at 10 years.[29] Another study demonstrated a 5-year survival rate of 94% (95% CI, 91%–97%) in patients who underwent dual-dye and separate-incision techniques for sentinel lymph node biopsy. However, this study had a prolonged follow-up period, with a minimum follow-up time of 5 years.[30] Although survival analysis of our current dataset showed no significant difference in survival outcomes between the two techniques, its interpretation is limited by the small number of events and the short follow-up duration, capturing only 2-year overall survival and progression-free survival.

This comparative study design is particularly relevant to real-world applications, especially in resource-limited centers that utilize a single-dye technique for sentinel lymph node biopsy without the availability of frozen section analysis. The single-incision technique has the potential to be incorporated into standard practices at such institutions. The study also employs multivariable analysis, using a generalized linear model (Poisson regression), to isolate the specific impact of the single-incision technique on node harvesting. This approach allows for controlling confounding variables and comprehensively analyzes the factors affecting node harvest. However, the study has several limitations. First, the sample size is relatively small, reflecting the limited annual case volume at the institute, making it smaller than comparable studies. Second, the lack of randomization is a limitation, partly due to the novelty of this technique in Thailand, which raises ethical concerns regarding randomization. Third, the study is confined to a single center and was performed by one surgeon, which may limit the generalizability of the findings to other settings. Surgeons in different institutions may also require a learning curve to perform the procedure effectively, which could influence the outcomes. The short follow-up period is also a notable limitation, as it prevents evaluating long-term survival outcomes.

Future research should focus on larger sample sizes and employ prospective, multicenter randomized controlled trials to validate the outcomes of the single-incision technique and improve the generalizability of findings. In addition, future research should analyze long-term oncological outcomes such as overall survival and recurrence-free survival. Incorporating cosmetic outcomes and quality-of-life assessments would provide valuable insights into the broader impact of this technique on patient satisfaction.

Conclusion

The single-incision technique for sentinel lymph node biopsy demonstrates significant advantages in node harvesting and surgical efficiency compared to the separate-incision method, as observed in both the full cohort and the mastectomy subgroup. This approach results in a 46% increase in node yield for the full cohort, a 40% increase for mastectomies, and reduced operative time. Moreover, complication rates are comparable to those of the separate-incision method, making the single-incision technique a viable and effective option for improving SLNB outcomes in breast cancer patients. However, the impact of increased node yields on long-term patient outcomes remains unclear. Future research should explore whether these advantages translate into improved oncological outcomes. Randomized controlled trials with larger sample sizes and longer follow-up periods are needed to confirm these findings and provide further insights into the safety and efficacy of the single-incision technique.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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REFERENCES

1. Vittayapipat N, Sa-nguanraksa D, Bhothisuwan K, et al. Comparing arm morbidity following sentinel lymph node biopsy and axillary lymph node dissection in thai patients with early breast cancer. J Med Assoc Thai. 2017;100(3):S61-S70.
2. Chitapanarux I, Sripan P, Somwangprasert A, et al. Stage-Specific Survival Rate of Breast Cancer Patients in Northern Thailand in Accordance with Two Different Staging Systems. Asian Pac J Cancer Prev. 2019;20(9):2699-706. doi: 10.31557/APJCP.2019.20.9.2699.
3. McCready D, Holloway C, Shelley W, et al. Surgical management of early stage invasive breast cancer: a practice guideline. Can J Surg. 2005;48(3):185-94.
4. Devarakonda S, Thomas SS, Sen S, et al. Sentinel Lymph Node Biopsy in Early Breast Cancer Using Methylene Blue Dye Alone: a Safe, Simple, and Cost-Effective Procedure in Resource-Constrained Settings. Indian J Surg Oncol. 2021;12(1):210-7. doi: 10.1007/s13193-020-01273-6.
5. Giuliano AE, McCall L, Beitsch P, et al. Locoregional recurrence after sentinel lymph node dissection with or without axillary dissection in patients with sentinel lymph node metastases: the American College of Surgeons Oncology Group Z0011 randomized trial. Ann Surg. 2010;252(3):426-32; discussion 432-3. doi: 10.1097/SLA.0b013e3181f08f32.
6. Giuliano AE, Ballman KV, McCall L, et al. Effect of Axillary Dissection vs No Axillary Dissection on 10-Year Overall Survival Among Women With Invasive Breast Cancer and Sentinel Node Metastasis: The ACOSOG Z0011 (Alliance) Randomized Clinical Trial. JAMA. 2017;318(10):918-26. doi: 10.1001/jama.2017.11470.
7. Donker M, van Tienhoven G, Straver ME, et al. Radiotherapy or surgery of the axilla after a positive sentinel node in breast cancer (EORTC 10981-22023 AMAROS): a randomised, multicentre, open-label, phase 3 non-inferiority trial. Lancet Oncol. 2014;15(12):1303-10. doi: 10.1016/S1470-2045(14)70460-7.
8. Alamoodi M, Patani N, Mokbel K, et al. Reevaluating Axillary Lymph Node Dissection in Total Mastectomy for Low Axillary Burden Breast Cancer: Insights from a Meta-Analysis including the SINODAR-ONE Trial. Cancers (Basel). 2024;16(4):742. doi: 10.3390/cancers16040742.
9. Petrelli F, Lonati V, Barni S. Axillary dissection compared to sentinel node biopsy for the treatment of pathologically node-negative breast cancer: a meta-analysis of four randomized trials with long-term follow up. Oncol Rev. 2012;6(2):e20. doi: 10.4081/oncol.2012.e20.
10. Zakaria S, Hoskin TL, Degnim AC. Safety and technical success of methylene blue dye for lymphatic mapping in breast cancer. Am J Surg. 2008;196(2):228-33. doi: 10.1016/j.amjsurg.2007.08.060.
11. Giammarile F, Vidal-Sicart S, Paez D, et al. Sentinel Lymph Node Methods in Breast Cancer. Semin Nucl Med. 2022;52(5):551-60. doi: 10.1053/j.semnuclmed.2022.01.006.
12. Lo C, Lee PC, Yen RF, et al. Most frequent location of the sentinel lymph nodes. Asian J Surg. 2014;37(3):125-9. doi: 10.1016/j.asjsur.2014.01.006.
13. Lovasik BP, Seidel RL, Novello M, et al. Single incision for oncologic breast conserving surgery and sentinel node biopsy in early stage breast cancer: A minimally invasive approach. Breast J. 2019;25(1):41-6. doi: 10.1111/tbj.13158.
14. Zhang X, Shen Q, Hu YJ. Comparison of two different surgical strategies for breast cancer patients treated with mastectomy plus sentinel lymph node biopsy. Updates Surg. 2021;73(6):2095-101. doi: 10.1007/s13304-021-01109-0.
15. Freitas-Junior R, Ferreira-Filho DL, Soares LR, et al. Oncoplastic Breast-Conserving Surgery in Low- and Middle-Income Countries: Training Surgeons and Bridging the Gap. Curr. Breast Cancer Rep. 2019;11:136-42. doi: 10.1007/s12609-019-00317-3.
16. Masannat YA, Agrawal A, Maraqa L, et al. Multifocal and multicentric breast cancer, is it time to think again? Ann R Coll Surg Engl. 2020;102(1):62-6. doi: 10.1308/rcsann.2019.0109.
17. Houssami N, Ciatto S, Macaskill P, et al. Accuracy and surgical impact of magnetic resonance imaging in breast cancer staging: systematic review and meta-analysis in detection of multifocal and multicentric cancer. J Clin Oncol. 2008;26(19):3248-58. doi: 10.1200/JCO.2007.15.2108.
18. Treeratanapun N, Lerttiendamrong B, Vacharathit V, et al. Is sentinel lymph node biopsy without frozen section in early stage breast cancer sufficient in accordance with ACOSOG-Z0011? A retrospective review from King Chulalongkorn Memorial Hospital. BMC Surg. 2022;22(1):261. doi: 10.1186/s12893-022-01709-6.
19. Rocco N, Velotti N, Pontillo M, et al. New techniques versus standard mapping for sentinel lymph node biopsy in breast cancer: a systematic review and meta-analysis. Updates Surg. 2023;75(6):1699-1710. doi: 10.1007/s13304-023-01560-1.
20. Hua B, Li Y, Yang X, et al. Short-term and long-term outcomes of indocyanine green for sentinel lymph node biopsy in early-stage breast cancer. World J Surg Oncol. 2022;20(1):253. doi: 10.1186/s12957-022-02719-7.
21. Swenson KK, Nissen MJ, Ceronsky C, et al. Comparison of side effects between sentinel lymph node and axillary lymph node

dissection for breast cancer. Ann Surg Oncol. 2002;9(8):745-53. doi: 10.1007/BF02574496.

22. Lucci A, McCall LM, Beitsch PD, et al. Surgical complications associated with sentinel lymph node dissection (SLND) plus axillary lymph node dissection compared with SLND alone in the American College of Surgeons Oncology Group Trial Z0011. J Clin Oncol. 2007;25(24):3657-63. doi: 10.1200/JCO.2006.07.4062.
23. Blidaru A, Bordea CI, Radu M, et al. Sentinel Lymph Node Biopsy Techniques. In: Rezai M, Kocdor MA, Canturk NZ, eds. Breast Cancer Essentials. Cham: Springer. 2021. doi: 10.1007/978-3-030-73147-2_43.
24. Veronesi U, Paganelli G, Viale G, et al. A randomized comparison of sentinel-node biopsy with routine axillary dissection in breast cancer. N Engl J Med. 2003;349(6):546-53. doi: 10.1056/NEJMoa012782.
25. Clough KB, Kaufman GJ, Nos C, et al. Improving breast cancer surgery: a classification and quadrant per quadrant atlas for oncoplastic surgery. Ann Surg Oncol. 2010;17(5):1375-91. doi: 10.1245/s10434-009-0792-y.
26. Derossis AM, Fey JV, Cody HS 3rd, et al. Obesity influences outcome of sentinel lymph node biopsy in early-stage breast cancer. J Am Coll Surg. 2003;197(6):896-901. doi: 10.1016/j.jamcollsurg.2003.08.005.
27. Yi M, Meric-Bernstam F, Ross MI, et al. How many sentinel lymph nodes are enough during sentinel lymph node dissection for breast cancer? Cancer. 2008;113(1):30-7. doi: 10.1002/cncr.23514.
28. Haddock NT, Wen YE, Steppe C, et al. Operative Time Predicts Postoperative Outcomes in Bilateral DIEP Flap Reconstruction: Multivariate 1000 Flap Analysis. Plast Reconstr Surg Glob Open. 2022;10(12):e4713. doi: 10.1097/GOX.0000000000004713.
29. Giuliano AE, Ballman K, McCall L, et al. Locoregional Recurrence After Sentinel Lymph Node Dissection With or Without Axillary Dissection in Patients With Sentinel Lymph Node Metastases: Long-term Follow-up From the American College of Surgeons Oncology Group (Alliance) ACOSOG Z0011 Randomized Trial. Ann Surg. 2016;264(3):413-20. doi: 10.1097/SLA.0000000000001863.
30. Carlo JT, Grant MD, Knox SM, et al. Survival analysis following sentinel lymph node biopsy: a validation trial demonstrating its accuracy in staging early breast cancer. Proc (Bayl Univ Med Cent). 2005;18(2):103-7. doi: 10.1080/08998280.2005.11928044.