

REVIEW

Editorial Process: Submission:07/17/2023 Acceptance:04/13/2024

Comparison of Intraoperative Imprint Cytology versus Frozen Section for Sentinel Lymph Node Evaluation in Breast Cancer. A study along with Systematic Review and Meta-analysis of literature

Sana Ahuja¹, Priya Yadav¹, Marzieh Fattahi-Darghlou², Sufian Zaheer^{1*}

Abstract

Background: Sentinel lymph node (SLN) is the first lymph node to drain the lymph from a particular region involved by cancer. The commonly performed intraoperative methods for SLN evaluation are touch imprint cytology (TIC) and frozen section (FS). The present study aimed to determine the sensitivity, specificity and accuracy of TIC and FS with histopathological diagnosis as gold standard. **Materials and Methods:** The nodes were bisected along their long axis and wet surface was imprinted on to clean glass slides followed by toluidine blue and rapid Papanicolaou staining. Subsequently the lymph node slices were cut at three levels using the cryostat machine and stained with Hematoxylin and eosin stain. The cytological and FS findings were compared and the specificity, sensitivity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) of TIC and FS was evaluated taking histopathological diagnosis as gold standard. In addition, pooled sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy for touch imprint cytology and frozen section were assessed for the studies included in the meta-analysis. **Results:** The specificity, sensitivity, diagnostic accuracy, positive predictive value and negative predictive value of touch imprint cytology were 100%, 88.2%, 90%, 100% and 60% respectively. The specificity, sensitivity, diagnostic accuracy, PPV and NPV of frozen section were 100%, 94.1%, 95%, 100% and 75% respectively. The sensitivity of TIC and FS for detection of micrometastasis was 60% and 80% respectively. The pooled sensitivity and specificity for touch imprint cytology were 85.24% (95% CI, 83.46%-86.90%), and 98.99% (95% CI, 98.69%-99.23%) respectively. The pooled sensitivity and specificity for frozen section examination were 90.45% (95% CI, 85.15%-94.34%), and 100% (95% CI, 99.24%-100%) respectively. **Conclusion:** Even though the sensitivity of FS was better than imprint cytology in detection of micrometastasis, TIC is a rapid inexpensive technique which can be utilized in remote areas in absence of cryostat machine. The sensitivity of the two techniques with respect to detection of macrometastasis was comparable. This meta-analysis highlights the accuracy of the touch imprint cytology and frozen section examination in the intra-operative detection of malignancy in breast cancer.

Keywords: Sentinel lymph node- touch imprint cytology- frozen section- breast cancer- micrometastasis

Asian Pac J Cancer Prev, 25 (4), 1113-1119

Introduction

Axillary lymph nodal status is a crucial prognostic factor in breast cancer as it determines the necessity of adjuvant therapy [1]. Sentinel lymph node is the first lymph node to drain the lymph from a particular region involved in cancer. Gradually, there has been a paradigm shift from the radical axillary nodal dissection to a more conservative approach involving sentinel lymph node biopsy.

Intraoperative evaluation of sentinel lymph node biopsy helps reduce the morbidity and complications like

decreased range of shoulder movement and lymphedema associated with axillary dissection especially in patients with an uninvolved axilla [2].

Preoperative clinical staging has high false negative rates while radiological workup like ultrasonography and magnetic resonance staging also have a limited role. Thus, intraoperative examination is the gold standard for axillary lymph node assessment [3].

Touch imprint cytology, frozen section examination, rapid immunohistochemistry and infrared spectroscopy are the different techniques available for intraoperative sentinel node evaluation. Touch imprint cytology is a

¹Department of Pathology, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India. ²Department of Epidemiology, School of Public Health, Hamadan University of Medical Sciences, Fahmideh Ave., Hamadan, Iran.

*For Correspondence: sufianzaheer@gmail.com

rapid, inexpensive technique without any tissue loss. However, frozen section examination has an advantage in case of micrometastasis where imprint cytology may give false negative results [4].

The present study aimed to determine the sensitivity, specificity and accuracy of touch imprint cytology and frozen section with histopathological diagnosis as gold standard.

Materials and Methods

This was a cross-sectional study done in the Department of Pathology after obtaining patient consent and ethical clearance from Institutional Ethics Committee. All biopsy proven cases of breast carcinoma who underwent breast conservation surgery or modified radical mastectomy over a one-year period from December 2019 to November 2020 were included and clinical details were retrieved from the requisition form. A total of forty cases which conformed with the inclusion criteria were taken for study. Any breast sarcomas, premalignant or metastatic lesions were excluded. Sentinel lymph nodes were identified with the help of methylene blue dye injected in the peri-areolar region. They were dissected out and sent for intraoperative imprint cytology and frozen section examination. The nodes were bisected along their long axis and wet surface was imprinted on to clean glass slides followed by toluidine blue and rapid Papanicolaou staining. Subsequently the lymph node slices were cut at three levels using the cryostat machine and stained with Hematoxylin and eosin stain for frozen section examination. The cytological and frozen section findings were compared and results were conveyed to the surgeon. Thereafter, the biopsy was fixed in 10% formalin followed by paraffin embedding with Hematoxylin and eosin staining.

PubMed and EMBASE were searched for studies published until August 04, 2023, which was the date of the final search. The authors were contacted if full texts could not be retrieved or for any supplementary information.

The search strategy was to find articles at the intersection of four main concepts: breast cancer (the site of the lesion), touch imprint cytology/ frozen section (the index test) and diagnostic accuracy (the type of study). These four concepts were joined by the Boolean "AND" operator. Related search terms within each main concept were joined using the Boolean "OR" operator and used to expand the search.

Statistical analysis

All analyses were performed using Review Manager Software version 5.4 and Stata version 14.2 (StataCorp, College Station, TX, USA). The specificity, sensitivity, diagnostic accuracy, positive predictive value and negative predictive value of touch imprint cytology and frozen section was evaluated taking histopathological diagnosis as gold standard. In addition, pooled sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy for touch imprint cytology and frozen section were assessed for the studies included in the meta-analysis.

Methodological quality

We checked the quality of the included studies using the revised Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool.[5] The QUADAS-2 tool helps quality assessment by assessing the risk of bias and applicability of results across four domains: participant selection, index test, reference standard, and flow and timing.

Data synthesis

We displayed individual study results graphically by plotting estimates of sensitivity and specificity in forest plots. For studies that used multiple thresholds for the index test, we utilized the hierarchical summary receiver operating characteristic (HSROC) model. [6]We used the random effects model and metandi command for the HSROC model.

Results

The mean age of the patients was 45.2 ± 8.6 years with majority (56.7%) of patients belonging to 41-50 years of age. Based on laterality, the left breast (60%) was involved more often than the right breast. Out of the 40 cases, there were 35 cases (87.5%) of invasive ductal carcinoma, not otherwise specified and 5 cases (12.5%) of lobular carcinoma respectively. The cases were categorized according to modified Bloom Richardson classification with 6 (15%), 18 (45%) and 16 (40%) cases belonging to Grade 1, 2 and 3 respectively.

Out of the 40 cases evaluated by touch imprint cytology, 30 (75%) were positive while 10 (25%) were negative for malignancy. By frozen section examination, 32 (80%) and 8 (20%) cases were positive and negative for malignancy respectively. (Figure 1) The histopathological examination showed 34 (85%) to be positive and 6 (15%) to be negative for malignancy. The specificity, sensitivity, diagnostic accuracy, positive predictive value and negative predictive value of touch imprint cytology were 100%, 88.2%, 90%, 100% and 60% respectively. The specificity, sensitivity, diagnostic accuracy, positive predictive value and negative predictive value of frozen section were 100%, 94.1%, 95%, 100% and 75% respectively. Out of 34 sentinel lymph nodes which exhibited metastasis, 10 and 24 showed micrometastasis and macrometastasis respectively. Imprint cytology was able to identify six out of the ten micrometastasis while frozen section picked up eight out of the ten cases of micrometastasis. The sensitivity of TIC and FS for the detection of micrometastasis was 60% and 80% respectively.

The PRISMA diagram for the study selection is presented in Figure 2. For touch imprint cytology, a total of eleven studies were evaluated with a total of 7312 cases while for frozen section, a total of seven studies were assessed with a total of 664 cases (including the present study). [Table 1 shows a comparison of the performance analysis parameters of touch imprint cytology and frozen section in sentinel lymph node evaluation of the previous studies with the present study]. The risk of bias was assessed for each study and Figures 3 and 4 depict the methodological quality summary and graph across all

Table 1. Performance Analysis of the Different Studies Evaluating Touch Imprint Cytology and Frozen Section for Sentinel Lymph Node in Breast Cancer

Sr. No	Author Name	No. of sentinel lymph nodes examined	Technique	Sensitivity	Specificity	Accuracy	Positive predictive	Negative predictive
1	Uno et al. (2020)	507	TIC	84.10%	100%	97.40%	-	-
2	Chang et al. (2022)	4327	TIC	82.70%	99.30%	95.90%		
3	Licham et al (2022)	1712	TIC	91.60%	97.70%	96%	94.10%	96.70%
4	Khanna et al (2011)	102	TIC	88%	98%	94%	97%	92%
5	Safai et al (2012)	49	TIC	90%	100%	95.90%	100%	93%
6	Abe et al (2020)	55	FS	90%	100%	95.90%	100%	93%
			TIC	50%	100%	90.70%	100%	60%
7	Mori et al (2006)	138	FS	83%	100%	96.40%	100%	95%
			TIC	47.10%	98.30%	92%		
8	Hashmi et al (2021)	114	FS	88.20%	100%	98.60%		
			TIC	83.70%	98.50%	92.10%		
9	Aihara et al (2004)	208	FS	93.90%	100%	97.40%		
			TIC	85.70%	99.40%	97.10%		
10	Petropoulou et al (2017)	60	FS	88.50%	100%	98.10%		
			TIC	90%	100%	98%	100%	98%
11	Present study	40	FS	80%	100%	97%	100%	96.15%
			TIC	88.20%	100%	90%	100%	60%
			FS	94.10%	100%	95%	100%	75%

Table 2. Pooled Parameters for Touch Imprint Cytology and Frozen Section with 95% CI

Sr. No.	Parameter	Touch imprint cytology		Frozen section	
		Pooled value	95% CI	Pooled value	95% CI
1	Sensitivity	85.24%	83.46-86.90%	90.45%	85.15-94.34%
2	Specificity	98.99%	98.69-99.23%	100%	99.24-100%
3	Positive predictive value	96.19%	95.11-97.03%	100%	97.73-100%
4	Negative predictive value	95.72%	95.22-96.17%	96.62%	94.79-97.82%
5	Positive likelihood ratio	84.12	64.92-108.99	-	-
6	Negative likelihood ratio	0.15	0.13-0.17	0.1	0.00-0.15
7	Diagnostic accuracy	95.82%	95.33-96.26%	97.44%	95.93-98.5%

included studies.

The pooled sensitivity and specificity for touch imprint cytology were 85.24% (95% CI, 83.46%-86.90%), and

98.99% (95% CI, 98.69%-99.23%) respectively. The pooled sensitivity and specificity for frozen section examination were 90.45% (95% CI, 85.15%-94.34%), and

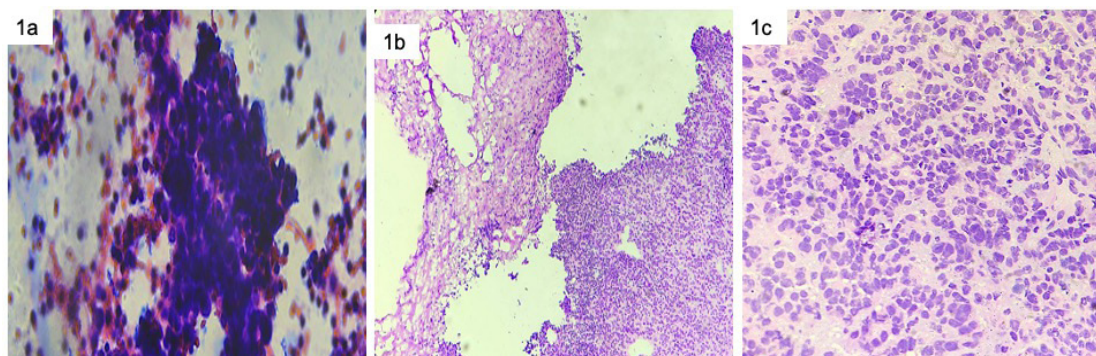


Figure 1. Touch Imprint Cytology and Frozen Section in Sentinel Lymph Node. a, b) Touch imprint cytology smears from a case reported as positive for malignancy exhibiting singly scattered atypical cells with enlarged hyperchromatic nuclei, scant cytoplasm against a lymphoid background. [Toluidine blue stain, x40]. c, d) Frozen section examination shows sheets of tumor cells exhibiting moderate pleomorphism with enlarged hyperchromatic nuclei, scant cytoplasm. [Hematoxylin and eosin, x10, x40]

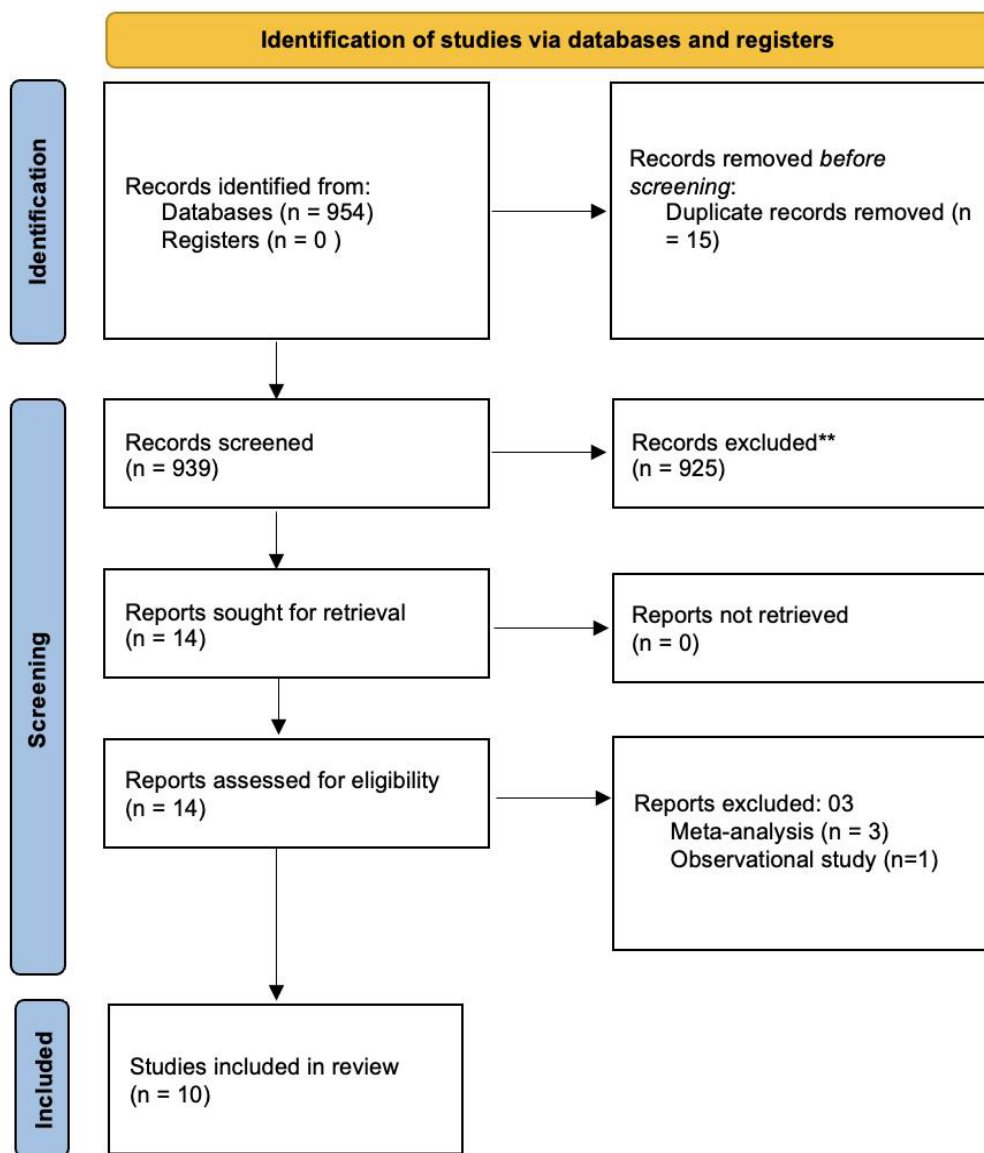


Figure 2. PRISMA Flow Diagram for Selection of Studies.

100% (95% CI, 99.24%-100%) respectively. The pooled diagnostic accuracy for TIC and FS was 95.82% (95% CI, 95.33%-96.26%) and 97.44% (95% CI, 95.93%-98.5%) respectively. The detailed pooled parameters along with 95% confidence intervals are summarised in Table 2. The forest plots for sensitivity and specificity for TIC and FS are depicted in Figures 5 and 6.

Table 3 and 4 (see Supplemental File 1) illustrate the meta-analysis for the diagnostic accuracy of TIC and FS. Based on the above results, TIC can correctly diagnose 83.1% of patients and 99.2% of non-patients. In addition, the odds of a positive test in patients are more than 664 times the odds of a positive test in non-patients. Also, the probability of a positive test result in patients is more than 112 times that of non-patients, and the probability of a negative test result in patients is only 17% of non-patients, or in other words, the probability of a negative test result in non-patients is more than 5 times that of patients. The probability results show that the positive results of the diagnostic test have a strong relationship

with being patients and the negative test results have a strong relationship with not being patients. Therefore, this diagnostic test is considered a very valuable and useful test.

Further, FS can correctly diagnose 89.6% of patients and 100% of non-patients. In addition, the odds of a positive test in patients is 1.27E+11 times the odds of a positive test in non-patients. Also, the probability of a positive test result in patients is 1.32E+10 times that of non-patients, and the probability of a negative test result in patients is only 10% of non-patients, or in other words, the probability of a negative test result in non-patients is more than 9 times that of patients. The probability results show that the positive results of the diagnostic test have a strong relationship with being patients and the negative test results have a strong relationship with not being patients. Therefore, this diagnostic test is considered a very valuable and useful test.

	Was a consecutive or random sample of patients enrolled?(Patient Selection)	Was a case-control design avoided?(Patient Selection)	Did the study avoid inappropriate exclusions?(Patient Selection)	Could the selection of patients have introduced bias?(Patient Selection)	Are there concerns that the included patients do not match the review question?(Patient Selection)	Were the index test results interpreted without knowledge of the results of the reference standard?(Index Test)	If a threshold was used, was it pre-specified?(Index Test)	Could the conduct or interpretation of the index test have introduced bias?(Index Test)	Are there concerns that the index test, its conduct, or interpretation differ from the review question?(Index Test)	Is the reference standard likely to correctly classify the target condition?(Reference Standard)	Were the reference standard results interpreted without knowledge of the results of the index test?(Reference Standard)	Could the reference standard, its conduct, or its interpretation have introduced bias?(Reference Standard)	Are there concerns that the target condition as defined by the reference standard does not match the review question?(Reference Standard)	Was there an appropriate interval between index test(s) and reference standard?(Flow and Timing)	Did all patients receive a reference standard?(Flow and Timing)	Did all patients receive the same reference standard?(Flow and Timing)	Were all patients included in the analysis?(Flow and Timing)	Could the patient flow have introduced bias?(Flow and Timing)
Abe 2020	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-
Ahuja 2023	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-
Aihara 2004	+	?	-	-	-	+	?	-	-	+	?	-	-	?	+	+	+	-
Chang 2022	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-
Hashmi 2021	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-
Khanna 2011	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-
Licham 2022	+	?	-	-	-	+	?	-	-	+	+	-	-	?	+	+	+	-
Mori 2006	+	?	-	-	-	+	?	-	-	+	?	-	-	?	+	+	+	-
Petropoulou 2017	+	?	-	-	-	+	?	-	-	+	?	-	-	?	+	+	+	-
Safai 2012	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-
Uno 2022	+	?	-	-	-	?	?	?	-	+	?	-	-	?	+	+	+	-

Figure 3. Methodological Quality Summary: Review Authors' Judgements About Each Methodological Quality Item For Each Included Study

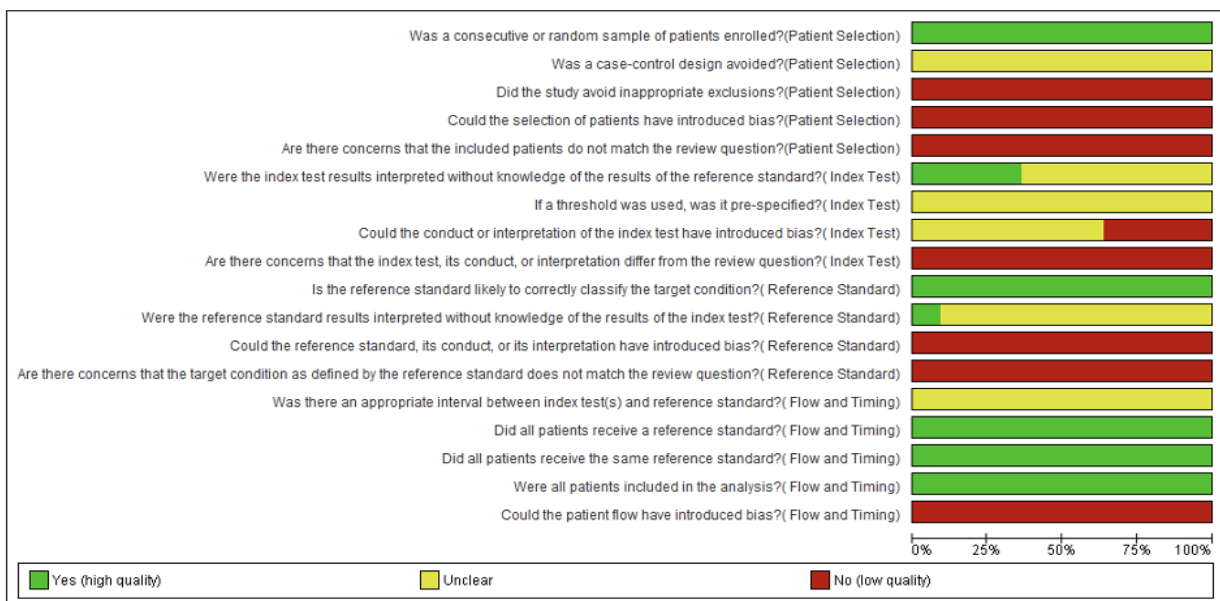


Figure 4. Methodological Quality Graph: review authors' judgements about each methodological quality item presented as percentages across all included studies

TIC

Study	TP	FP	FN	TN	Sensitivity	Specificity
Abe 2020	6	0	6	43	0.50 [0.21, 0.79]	1.00 [0.92, 1.00]
Aihara 2004	30	1	5	172	0.86 [0.70, 0.95]	0.99 [0.97, 1.00]
Chang 2022	740	24	155	3408	0.83 [0.80, 0.85]	0.99 [0.99, 1.00]
Hashmi 2021	41	1	8	64	0.84 [0.70, 0.93]	0.98 [0.92, 1.00]
Khanna 2011	37	1	5	59	0.88 [0.74, 0.96]	0.98 [0.91, 1.00]
Licham 2022	449	24	41	1194	0.92 [0.89, 0.94]	0.98 [0.97, 0.99]
Mori 2006	8	2	9	119	0.47 [0.23, 0.72]	0.98 [0.94, 1.00]
Petropoulou 2017	9	0	1	50	0.90 [0.55, 1.00]	1.00 [0.93, 1.00]
present study 2023	30	0	4	6	0.88 [0.73, 0.97]	1.00 [0.54, 1.00]
Safai 2012	19	0	2	28	0.90 [0.70, 0.99]	1.00 [0.88, 1.00]
Uno 2022	69	0	13	425	0.84 [0.74, 0.91]	1.00 [0.99, 1.00]

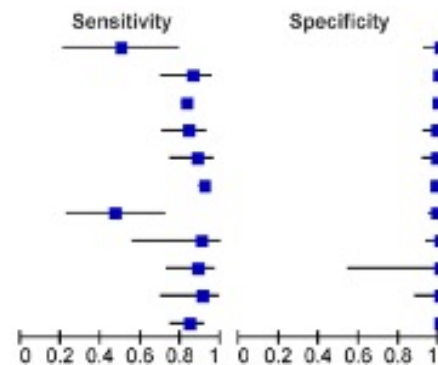


Figure 5. Forest Plot of Sensitivity and Specificity of Touch Imprint Cytology

Frozen section

Study	TP	FP	FN	TN	Sensitivity	Specificity
Abe 202	10	0	2	43	0.83 [0.52, 0.98]	1.00 [0.92, 1.00]
Aihara 2004	31	0	4	173	0.89 [0.73, 0.97]	1.00 [0.98, 1.00]
Hashmi 2021	46	0	3	65	0.94 [0.83, 0.99]	1.00 [0.94, 1.00]
Mori 2006	15	0	2	121	0.88 [0.64, 0.99]	1.00 [0.97, 1.00]
Petropoulou 2017	8	0	2	50	0.80 [0.44, 0.97]	1.00 [0.93, 1.00]
Present study 2023	32	0	2	6	0.94 [0.80, 0.99]	1.00 [0.54, 1.00]
Safai 2012	19	0	2	28	0.90 [0.70, 0.99]	1.00 [0.88, 1.00]

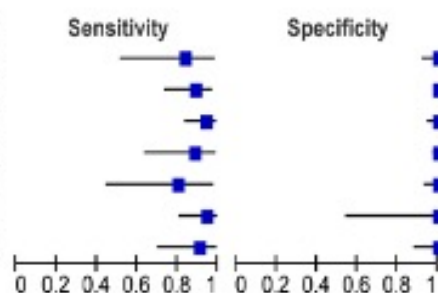


Figure 6. Forest Plot of Sensitivity and Specificity of Frozen Section

Discussion

Intraoperative sentinel lymph node evaluation reduces the rate of unnecessary axillary resection as the axillary nodes need to be resected only in cases of positive sentinel nodes. This also reduces the morbidity and mortality associated with axillary dissection like lymphedema, arm pain and reduced range of shoulder motion [2].

The majority (56.7%) of patients were of the age group 41-50 years with a mean age of 45.2 ± 8.6 years which was similar to the distribution of previous studies [4-6]. Most (87.5%) of the cases in the present study were invasive ductal carcinoma which is in concordance with previous data. Based on Bloom Richardson scoring, the cases were 15%, 45% and 40% Grade 1, 2 and 3 respectively which is almost similar to the data of Hashmi et al. [6].

Touch imprint cytology is an easy to use, inexpensive, rapid technique which can be used in the absence of a cryostat machine. Imprint cytology could identify 30 out of 34 cases of metastasis in sentinel lymph nodes. The specificity, sensitivity, diagnostic accuracy, positive predictive value and negative predictive value of touch imprint cytology in the present study were 100%, 88.2%, 90%, 100% and 60% respectively. The four cases which were false negatives were cases of micrometastasis resulting in a lower sensitivity (60%) of TIC for micrometastasis.

The performance analysis of TIC in the present study is comparable to the findings of previous studies [7, 6, 4,

8, 5, 9, 10]. Frozen section examination is despite being time consuming and expensive technique is more reliable. However, its limitation lies in the need for a cryostat machine due to which it cannot be used in resource-limited or remote settings. The specificity, sensitivity, diagnostic accuracy, positive predictive value and negative predictive value of the frozen section in the present study were 100%, 94.1%, 95%, 100% and 75% respectively which was comparable to the results of Safai et al. [5], Hashmi et al. [6], Aihara et al. [11], Petropoulou et al. [9] and Mori et al. [12]. FS was able to correctly identify eight out of the ten cases of micrometastasis resulting in higher sensitivity than TIC (80%) in the diagnosis of micrometastasis.

The pooled analysis exhibited a greater sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy for frozen section in comparison to the touch imprint cytology. The likelihood ratio suggests that the FS examination is useful in ruling in and out malignancy as the negative likelihood ratio was less than 0.1 while the positive likelihood ratio was greater than 10. However, TIC is useful in ruling in but not ruling out malignancy as it has a positive likelihood ratio greater than 10 but a negative likelihood ratio greater than 0.1.

In conclusion, even though the sensitivity of the frozen section was better than imprint cytology in the detection of micrometastasis, TIC is a rapid inexpensive technique which can be utilized in remote areas in the absence of a cryostat machine. The sensitivity of the two techniques with respect to the detection of macrometastasis was

comparable, thus making TIC a useful technique for rapid diagnosis in sentinel lymph nodes. This meta-analysis highlights the accuracy of the touch imprint cytology and frozen section examination in the intra-operative detection of malignancy in breast cancer.

Author Contribution Statement

All authors contributed equally in this study.

Acknowledgements

Data Availability statement

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

Patient consent

The study was conducted after obtaining informed consent from the patient.

Conflicts of interest

None.

References

- Giuliano AE, Edge SB, Hortobagyi GN. Eighth edition of the ajcc cancer staging manual: Breast cancer. *Ann Surg Oncol.* 2018;25(7):1783-5. <https://doi.org/10.1245/s10434-018-6486-6>.
- Kootstra JJ, Hoekstra-Weebers JE, Rietman JS, de Vries J, Baas PC, Geertzen JH, et al. A longitudinal comparison of arm morbidity in stage i-ii breast cancer patients treated with sentinel lymph node biopsy, sentinel lymph node biopsy followed by completion lymph node dissection, or axillary lymph node dissection. *Ann Surg Oncol.* 2010;17(9):2384-94. <https://doi.org/10.1245/s10434-010-0981-8>.
- Zahoor S, Haji A, Battoo A, Qurieshi M, Mir W, Shah M. Sentinel lymph node biopsy in breast cancer: A clinical review and update. *J Breast Cancer.* 2017;20(3):217-27. <https://doi.org/10.4048/jbc.2017.20.3.217>.
- Uno Y, Akiyama N, Yuzawa S, Kitada M, Takei H. The value and practical utility of intraoperative touch imprint cytology of sentinel lymph node(s) in patients with breast cancer: A retrospective cytology-histology correlation study. *Cytojournal.* 2020;17:11. https://doi.org/10.25259/Cytojournal_80_2019.
- Safai A, Razeghi A, Monabati A, Azarpira N, Talei A. Comparing touch imprint cytology, frozen section analysis, and cytokeratin immunostaining for intraoperative evaluation of axillary sentinel lymph nodes in breast cancer. *Indian J Pathol Microbiol.* 2012;55(2):183-6. <https://doi.org/10.4103/0377-4929.97859>.
- Hashmi AA, Naz S, Ahmed O, Yaqeen SR, Afzal A, Asghar IA, et al. Diagnostic accuracy of intraoperative touch imprint cytology for the diagnosis of axillary sentinel lymph node metastasis of breast cancer: Comparison with intraoperative frozen section evaluation. *Cureus.* 2021;13(1):e12960. <https://doi.org/10.7759/cureus.12960>.
- Khanna R, Bhadani S, Khanna S, Pandey M, Kumar M. Touch imprint cytology evaluation of sentinel lymph node in breast cancer. *World J Surg.* 2011;35(6):1254-9. <https://doi.org/10.1007/s00268-011-1094-7>.
- Chang YC, Tzen CY. Intraoperative sentinel lymph node imprint cytology diagnosis in breast cancer patients by general surgical pathologists: A single-institution experience of 4327 cases. *J Cytol.* 2022;39(1):20-5. https://doi.org/10.4103/joc.Joc_41_21.
- Petropoulou T, Kapoula A, Mastoraki A, Politi A, Spanidou-Karvouni E, Psychogios I, et al. Imprint cytology versus frozen section analysis for intraoperative assessment of sentinel lymph node in breast cancer. *Breast Cancer (Dove Med Press).* 2017;9:325-30. <https://doi.org/10.2147/bctt.S130987>.
- Abad-Licham M, Astigueta J, De Las Casas L, Gonzales-Saravia J, Ortiz C, Vásquez O, et al. Intraoperative cytology when cryostat is not available. A 7-year experience in a peruvian cancer center. *Diagn Cytopathol.* 2023;51(2):E45-e53. <https://doi.org/10.1002/dc.25062>.
- Aihara T, Munakata S, Morino H, Takatsuka Y. Comparison of frozen section and touch imprint cytology for evaluation of sentinel lymph node metastasis in breast cancer. *Ann Surg Oncol.* 2004;11(8):747-50. <https://doi.org/10.1245/aso.2004.01.014>.
- Mori M, Tada K, Ikenaga M, Miyagi Y, Nishimura S, Takahashi K, et al. Frozen section is superior to imprint cytology for the intra-operative assessment of sentinel lymph node metastasis in stage i breast cancer patients. *World J Surg Oncol.* 2006;4:26. <https://doi.org/10.1186/1477-7819-4-26>.
- Abe M, Yamada T, Nakano A. Prospective comparison of intraoperative touch imprint cytology and frozen section histology on axillary sentinel lymph nodes in early breast cancer patients. *Acta Cytol.* 2020;64(5):492-7. <https://doi.org/10.1159/000508016>.



This work is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.