Research Article

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The diagnostic accuracy of touch imprint cytology for sentinel lymph node metastases of breast cancer: An up-to-date meta-analysis of 4,073 patients

Abstract: This meta-analysis aimed to evaluate the diagnostic accuracy of touch imprint cytology (TIC) for sentinel lymph node (SLN) metastases of patients with clinical node-negative early breast cancer. The PubMed, Web of Science, Embase, and the Cochrane Library databases were meticulously searched to retrieve literature published from January 2005 to September 2022 by two independent reviewers. The meta-analysis was performed using STATA16.0, Meta-Disc 1.4, and RevMan 5.4.9. According to the inclusion criteria, 4,073 patients from 13 studies were included in this meta-analysis. The pooled sensitivity and specificity of TIC for detecting SLN metastases were 0.77 (95% CI 0.66–0.85) and 0.99 (95% CI 0.97–1.00), respectively. The pooled positive likelihood ratio and negative likelihood ratio were 76.15 (95% CI 29.16–198.84) and 0.23 (95% CI 0.15–0.36), respectively. The pooled diagnostic odds ratio was 326.82 (95% CI 132.76–804.56) and the area under the sROC curve was 0.97 (95% CI 0.95–0.98), respectively. This meta-analysis revealed that TIC with high sensitivity and specificity is a feasibility and accuracy diagnosis technique for intraoperative detection of SLN metastases in breast cancer.

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1 Introduction

Sentinel lymph node biopsy (SLNB) is a standard procedure for assessing axillary lymph node status in patients with clinically node-negative breast cancer [1,2]. Surgeons usually do not perform axillary lymph node dissection (ALND) in patients with pathologically-negative SLNs, which may avoid many potential and unnecessary complications including lymphedema, paresthesias, limitation of shoulder range of motion, and decline in quality of life [3–5]. However, when intraoperative SLNB demonstrates the detection of SLN metastases, ALND can be completed in a single operation. It can effectively prevent the patients suffering from a second surgical operation, additional pain, and financial burden.

Previous studies have indicated that the intraoperative techniques for evaluation of SLN status contain touch imprint cytology (TIC), frozen section (FS), one-step nucleic acid amplification (OSNA) assay, and immunohistochemistry [6–9]. FS and TIC are the two most commonly used methods for intraoperative evaluation of SLN in the world [10]. In recent years, OSNA and immunohistochemistry technologies have been gradually carried out in some hospitals. In China, FS is the most common method of intraoperative SLN diagnosis in many authoritative medical centers due to its advantage of high sensitivity of detecting macrometastases and micrometastases, and the proportion is surprisingly more than 90%. However, the FS technique is obviously accompanied with many disadvantages such as requirement of more time, tissue loss, and cost. Similarly, these drawbacks also exist in OSNA and immunohistochemistry, which might affect the subsequent histopathological examination [8].

TIC has several limitations such as lack of standardized procedure, minimal node sampling, difficulty in detecting micrometastases and macrometastases from lobular carcinoma, and the requirement of an experienced cytopathologist to interpret the imprints. However, TIC is a rapid, cost-effective, and more tissue conserving technique [11]. Not only that, several studies have demonstrated that TIC has sensitivity equivalent to or better than that of FS [12–15]. Thus, we performed an updated meta-analysis to collect data to evaluate the diagnostic feasibility and accuracy of TIC for detecting SLN metastases in patients with breast cancer.

2 Materials and methods

2.1 Search strategy

Four databases including PubMed, Embase, Cochrane Library, and Web of Science were systematically searched for articles published from January 2005 to September 2022 by two independent and experienced reviewers. The medical subject heading (Mesh) terms were defined as follows: "breast cancer," "imprint cytology," and "sentinel lymph node." Furthermore, we used combinations of "breast cancer," "imprint cytology," and "sentinel lymph node" as free text terms. Meanwhile, the references of selected articles were also carefully screened to identify additional relevant articles.

2.2 Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) patients included in the studies were finally diagnosed as breast cancer by postoperative pathology, (2) patients did not receive any neoadjuvant therapy or radiotherapy, (3) the purpose of diagnosis was to detect SLN metastases, (4) all specimens were fresh SLNs, (5) all specimens were evaluated by intraoperative TIC and postoperative histopathology, (6) postoperative hematoxylin–eosin staining technique was used as the reference standard in SLNs assessment, (7) detailed data analysis of all the studies was based on per-patient, and (8) providing sufficient information for calculating false-positive (Fp), false-negative (Fn), true-positive (Tp), and true-negative (Tn) values.

The exclusion criteria were as follows: (1) non-English literature; (2) data analysis of study was based on per-node but not on per-patient; (3) non-clinical research literature including reviews, letters, conference abstracts, basic experiments, case reports, and comments; and (4) published data were insufficient to form a 2 × 2 table.

2.3 Data extraction and quality assessment

Data extraction for each included study was performed independently by two reviewers, and then verified for accuracy by another reviewer. Any disagreement was resolved by team consensus through discussion. The following information was extracted: first author, publication year, country, number of patients, number of SLNs, mean age of patients, reference standard method, thickness of slices and interval of serial slices detected by pathological examination, number of Tp, Fp, Fn, and Tn.

Two reviewers independently assessed the quality of included studies using a standardized tool named Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2), which comprises four key domains: patient selection, a reference standard, index testing, and flow and timing. We classified the risk of bias as "low," "high," or "unclear." When the answers are "yes" to all signaling questions for a domain, the risk of bias can be considered low. But if any question is answered "no," the risk of bias should be judged as high. We used similar criteria to judge the applicability concerns.

2.4 Statistical analysis

First, Spearman's correlation coefficient was used to measure the threshold effect which is an important source of heterogeneity; when $P > 0.05$, there was no threshold effect. Heterogeneity caused by non-threshold effect between the studies was assessed by Cochran Q-test and expressed as an "I-square" value. I^2 values <25, 25–50, and >50% indicate mild, moderate, and significant heterogeneity, respectively [16]. If $P < 0.05$ or $I^2 > 50\%$, which was considered as significant statistical heterogeneity, the combined sensitivity, specificity, negative likelihood ratio (NLR), positive likelihood ratio (PLR), and diagnostic odds ratio (DOR) with the corresponding 95% CIs were calculated by a random-effect model. But if we obtained an insignificant heterogeneity, a fixed effects model was performed [17]. Similarly, Cochran Q-test and I^2 statistics were adopted to evaluate the heterogeneity of the pooled results. We constructed a summary receiver operating characteristic (sROC) curve to evaluate diagnostic accuracy for TIC, the area under the sROC curve (AUC) value is proportional to the diagnostic value. Deek's funnel plot asymmetry test was performed to assess publication bias.

The statistical analysis was carried out with STATA16.0 (StataCorp, College Station, TX, USA), Meta-Disc 1.4 (Unit of Clinical Biostatistics, Ramo e Cajal Hospital, Madrid, Spain), and RevMan 5.4 (Revman, the Cochrane Collaboration).

3 Results

3.1 Study selection

As shown in Figure 1, a total of 529 studies from PubMed, Embase, Cochrane Library, and Web of Science databases were retrieved according to the search strategy. We did not find eligible articles after screening the references. The publication dates of these articles ranged from January 2005 to September 2022. Of these, 32 duplicate studies were excluded and 37 studies were removed (e.g., review, letters, meeting abstracts, and proceeding articles). And 447 articles were excluded after screening the titles and abstracts since they did not meet the inclusion criteria: 215 articles were not related to the topic, 13 articles included patients who underwent neoadjuvant therapy or radiotherapy, 55 articles focused on non-sentinel lymph nodes rather than sentinel lymph nodes, 135 articles were non-clinical research literature, data analysis of 8 articles were not based on per-patient, and 21 articles had no sufficient data to form 2 × 2 tables. Finally, 13 articles satisfied the eligibility criteria (Table 1).
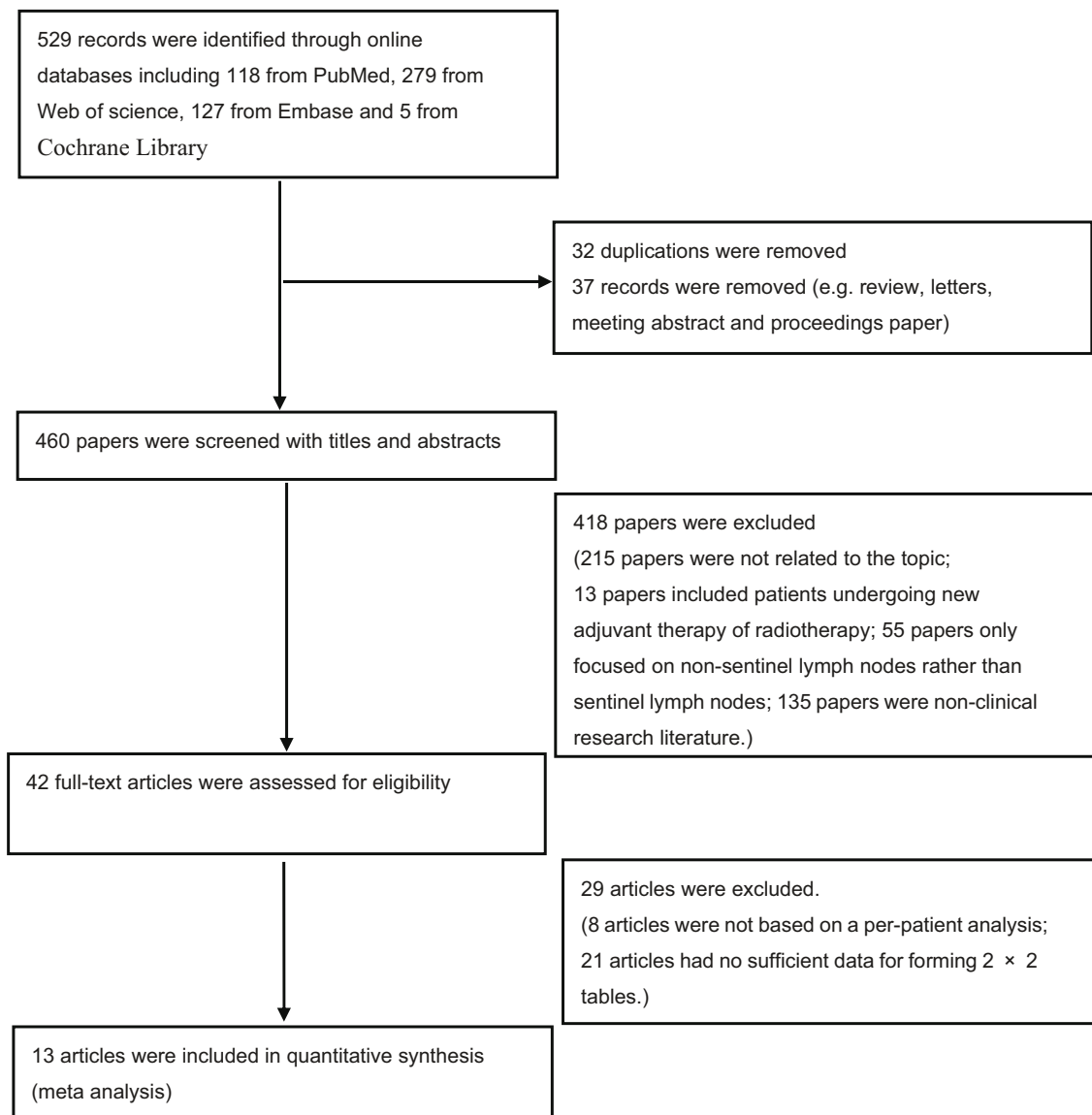
Figure 1: Flow diagram of the study selection process.

Table 1: Summary of patient characteristics of included studies

Author	Year	Country	No. of patients	No. of nodes	Mean age	Tp	Fp	Fn	Tn	Thicknesses (μm)	Interval (μm)	Reference method
Cotarelo [18]	2021	Germany	1,072	2,276	61.3	191	0	78	803	2,000	250	H&E
Hashmi [19]	2021	PAK	114	–	53.41 ± 12.46	41	1	8	64	2,000	–	H&E
Pétursson [20]	2018	Sweden	1,227	1,974	60	192	2	88	945	2,000	200	H&E and IHC
Sun [21]	2017	China	79	342	50	12	10	1	56	2,000	200	H&E
Bell [22]	2010	Ireland	102	–	58.8	33	0	8	61	2,000	–	H&E and IHC
Hamidian Jahromi [23]	2009	London	74	146	49.59 ± 13.6	11	1	6	56	–	–	H&E
Upender [24]	2009	India	40	–	49.80 ± 11.19	22	0	2	16	–	–	H&E and IHC
Tamiolakis [25]	2006	Greece	87	128	53.6	24	5	0	58	–	–	H&E and IHC
Clarke [11]	2009	UK	166	239	61.2	29	0	18	119	2,000	–	H&E
Van Eetvelde [26]	2011	Belgium	45	83	60	13	1	9	22	2,000	300	H&E and IHC
Motomura [27]	2008	Japan	631	–	54	110	17	20	484	2,000	200	H&E and IHC
Seenu [28]	2021	India	81	176	49.88	10	1	6	64	2,000	–	H&E
Lorand [29]	2010	France	355	–	56.9	32	2	56	265	2,000	250	H&E and IHC
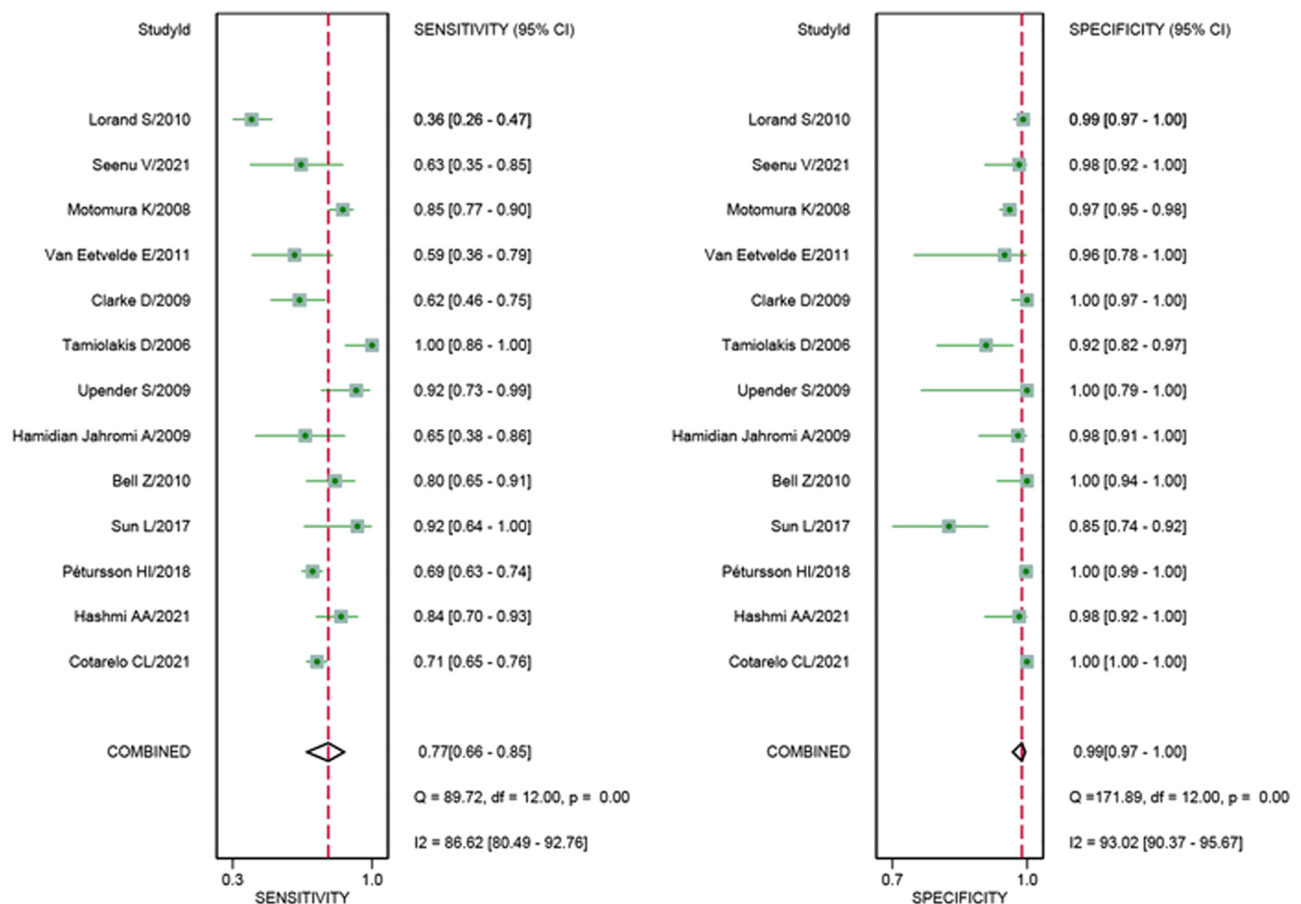
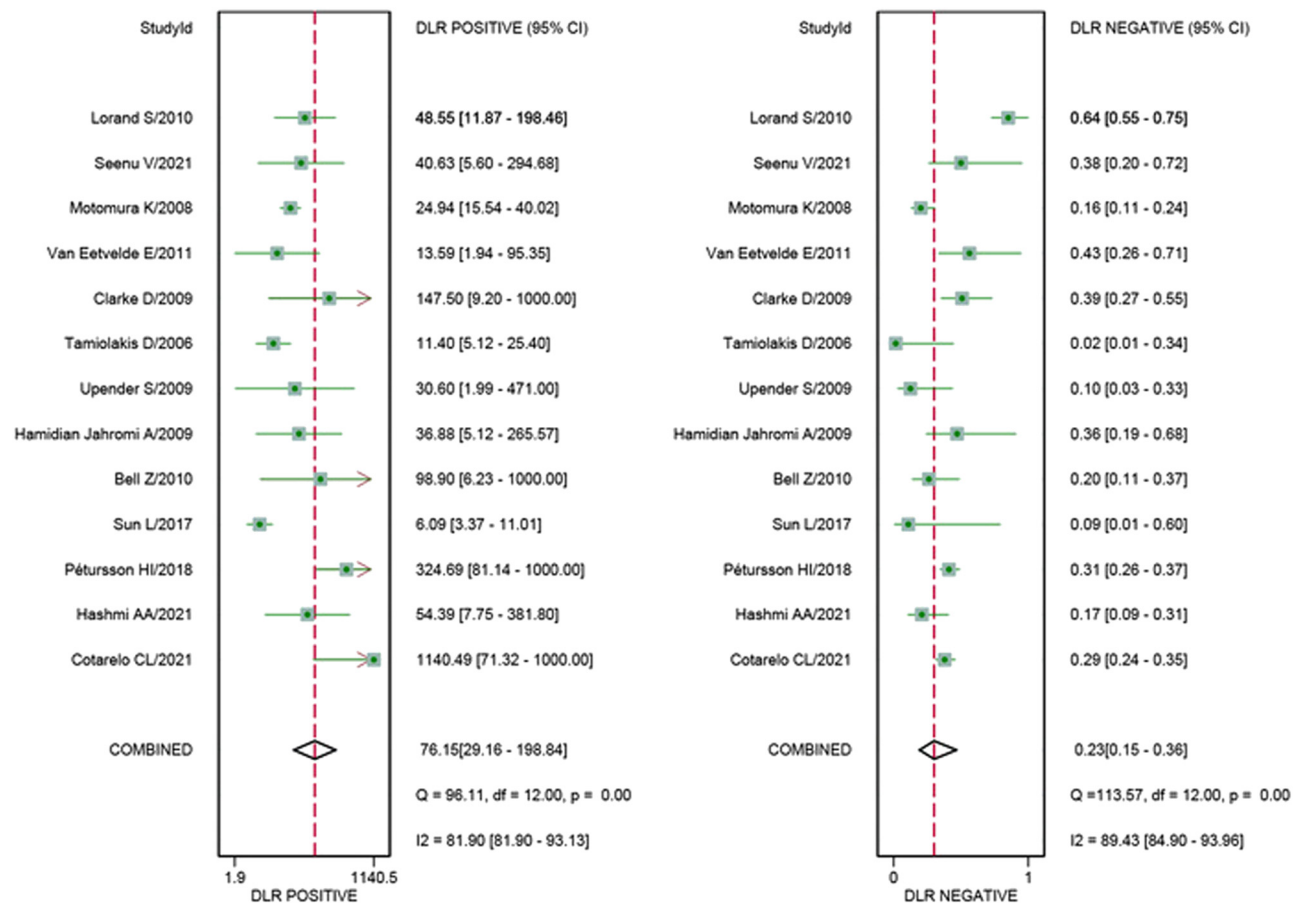**Figure 2:** Forest plots of pooled sensitivity and specificity.

Figure 3: Forest plots of pooled PLR and NLR.

3.2 Study characteristics

The 13 eligible articles (Cotarelo et al., 2021; Hashmi et al., 2021; Pétursson et al., 2018; Sun et al., 2017; Bell et al., 2010; Hamidian Jahromi et al., 2009; Upender et al., 2009; Tamiolakis et al., 2006; Motomura et al., 2008; Seenu et al., 2021; Clarke et al., 2009; Lorand et al., 2010; Van Eetvelde et al., 2011) containing a total of 4,073 patients were included in this meta-analysis [11,18–29]. There were two approaches of pathological examinations in different studies: six studies adopted H&E staining and seven studies combined detection of H&E and IHC.

3.3 Quality assessment

The QUADAS-2 was used to assess the quality of each study. Each question was evaluated separately by two independent reviewers, and the disputed issues were evaluated again by a third party to reach a consensus. The results

are shown in Figure 2, which indicate that the risk of bias was low and the quality was moderate to high.

3.4 Diagnostic performance

In the threshold analysis, Spearman's correlation coefficient was 0.45 and *P*-value was 0.12, which indicated that there was no evidence of a threshold effect. We adopted a random effect model since the significant heterogeneity caused by non-threshold effects to perform the follow-up meta-analysis. According to Figure 2, we figured out that the values of I^2 for sensitivity and specificity were 86.62 and 93.02%, respectively. The pooled sensitivity and specificity (Figure 2) of TIC for detecting SLN metastases were 0.77 (95% CI 0.66–0.85) and 0.99 (95% CI 0.97–1.00), respectively. The pooled PLR and NLR (Figure 3) were 76.15 (95% CI 29.16–198.84) and 0.23 (95% CI 0.15–0.36), respectively. The pooled DOR (Figure 4) was 326.82 (95% CI 132.76–804.56) and AUC (Figure 5) was 0.97 (95% CI 0.95–0.98), respectively.
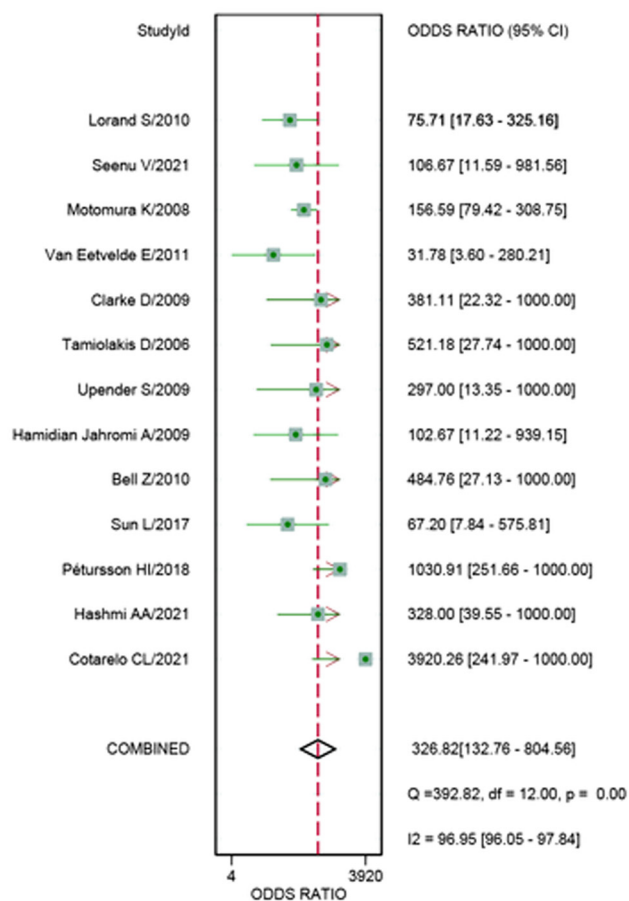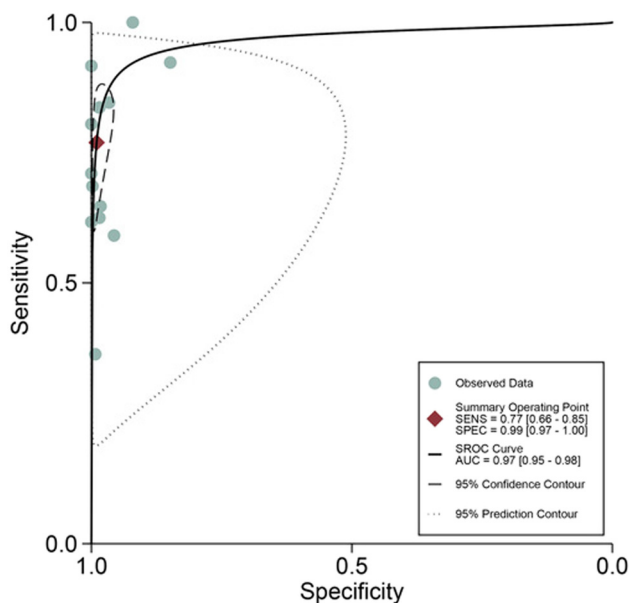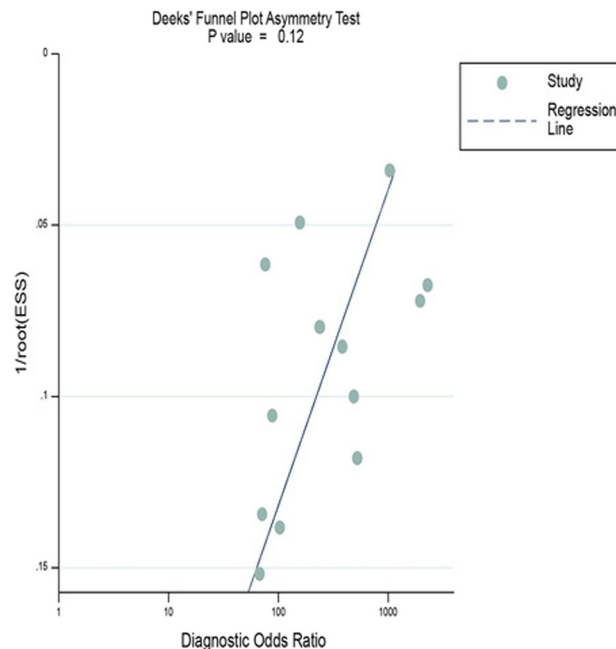
Figure 4: Forest plots of pooled DOR.

Figure 6: Deek's funnel chart asymmetry test of publication bias.

3.5 Publication bias

The evaluation of the publication bias among the included studies was carried out by performing Deek's funnel chart asymmetry test using STATA software. There was no evidence of significant publication bias since the shape of Deek's funnel chart was symmetrical and *P* value was 0.12 (Figure 6).

4 Discussion

There is no doubt that axillary lymph node status is a very important prognostic factor of invasive breast cancer. SLNB has become a routine method to predict lymph node status [30]. Since it not only enables patients with SLN metastases to complete ALND in one operation, but also enables patients with negative SLN to avoid suffering from long-term complications, such as upper limb lymph node edema, pain, numbness, etc. [3–5].

It is known that more than 90% of breast centers in China only use FS as a technique for intraoperative evaluation of SLN metastases in breast cancer. However, given the disadvantages of FS such as expensive, loss of tissue, time-consuming, and requirement of experienced and trained technologists and pathologists [8], some authoritative hospitals at home and abroad focused on TIC in view of its main advantages such as simple, rapid, cost-

Figure 5: ROC curve for the diagnostic accuracy of TIC in detecting SLN metastasis in breast cancer.

effective, and leaving more tissues for final postoperative pathological analyses [11].

Although some studies have reported the specificity and sensitivity of TIC for the SLN intraoperative diagnosis in breast cancer, the sample sizes of these studies are relatively moderate and the results vary to some extent. Therefore, we conducted the comprehensive meta-analysis to comprehensively analyze the accuracy of TIC in the intraoperative diagnosis of SLN in breast cancer, in the hope that both doctors and patients could benefit from it. In this study, we meta-analyzed 13 studies based on per-patient to evaluate the diagnosis value of TIC. We figured out that the pooled sensitivity, specificity, PLR, NLR, DOR, and AUC of TIC were 0.77 (95% CI 0.66–0.85), 0.99 (95% CI 0.97–1.00), 76.15 (95% CI 29.16–198.84), 0.23 (95% CI 0.15–0.36), 326.82 (95% CI 132.76–804.56), and 0.97 (95% CI 0.95–0.98), respectively. As reported by Kim et al., higher PLR values forecast a stronger association between a test result and a disease, but lower NLR values indicate a stronger association between a test result and the absence of a disease. Thus, given the PLR and NLR values obtained for TIC, this technique is reliable for the intraoperative evaluation of SLN metastases in breast cancer. Furthermore, the sROC value was 0.97, which proved a high degree of overall diagnostic accuracy [31].

Numerous studies have shown that the sensitivity of TIC for the diagnosis of macrometastasis is comparable to FS. However, TIC has a low sensitivity in the diagnosis of micrometastasis. Studies indicated that pathologists with proper technique and experience are more likely to detect micrometastasis. Moreover, even if the micrometastasis is detected in postoperative pathology, there is no necessity to perform ALND. This view has been recognized by the expert consensus [32]. Previous studies have shown that TIC is more accurate than FS in diagnosis of negative SLNs, which means that TIC has a better negative predictive value than FS [21]. The SLN metastasis in invasive lobular carcinoma is difficult to be diagnosed because of the different subtypes of lobular carcinoma with features of diverse cytological morphology. For instance, rosette-like pattern is usually detected in alveolar type; large cell is more common in the polymorphic type. Unfortunately, these subtypes are difficult to be identified except for some very experienced pathologists by TIC [33]. Although the sensitivity of TIC technique in detecting micrometastasis and metastatic sentinel nodes in invasive lobular carcinoma is not satisfactory, it has many obvious advantages such as simplicity, leaving more tissue for postoperative histopathological examination, and saving operative time and cost for some patients as compensation. More encouragingly,

it has been reported that the sensitivity of TIC is increasing over time [34].

Although we have conducted a comprehensive and rigorous analysis, there are still several limitations in our present study. First, we only adopted the literature published in English and excluded potential studies published in other languages. Second, our meta-analysis only incorporated published research. However, studies with meaningful positive results are much more likely to be published than those with negative results, which can lead to potential publication bias. Third, there were several factors contributing to clinical and methodological heterogeneity in our analysis, such as the populations of the study samples, proportions of patients with different age, tumor size, molecular subtype and histological grade, and reagent manufacturer selected. Unfortunately, when we tried to perform subgroup analysis, we found some data deficiencies.

5 Conclusions

Intraoperative evaluation of SLN in patients with clinically node-negative breast carcinoma by TIC is proved to be a reliable and feasible technique. TIC and FS showed similar low sensitivity in the diagnosis of micrometastasis. However, TIC retains more tissue for subsequent histological evaluation as compensation. As a result, we believe that the TIC technique for diagnosis of SLN metastasis in breast cancer deserves to be widely applied in clinical practice.

Abbreviations

ALND	axillary lymph node dissection
AUC	area under the sROC curve
DOR	diagnostic odds ratio
FS	frozen section
NLR	negative likelihood ratio
OSNA	one-step nucleic acid amplification
PLR	positive likelihood ratio
QUADAS	Quality Assessment of Diagnostic Accuracy Studies
SLNB	sentinel lymph node biopsy
SROC	Summary receiver operating characteristic
TIC	touch imprint cytology

References

[1] Veronesi U, Paganelli G, Viale G, Luini A, Zurrida S, Galimberti V, et al. Sentinel lymph-node biopsy as a staging procedure in breast cancer: update of a randomised controlled study. Lancet Oncol. 2006;7(12):983–90.

[2] Perkins CL, Weaver DL, Giuliano AE. Sentinel lymph node biopsy for patients with early-stage breast cancer: American Society of Clinical Oncology Clinical Practice Guideline Update. J Clin Oncol. 2017;35(5):561–4.

[3] Veronesi U, Paganelli G, Viale G, Luini A, Zurrida S, Galimberti V, 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.

[4] McLaughlin SA, Wright MJ, Morris KT, Sampson MR, Brockway JP, Hurley KE, et al. Prevalence of lymphedema in women with breast cancer 5 years after sentinel lymph node biopsy or axillary dissection: patient perceptions and precautionary behaviors. J Clin Oncol. 2008;26(32):5220–6.

[5] Mansel RE, Fallowfield L, Kissin M, Goyal A, Newcombe RG, Dixon JM, et al. Randomized multicenter trial of sentinel node biopsy versus standard axillary treatment in operable breast cancer: the ALMANAC Trial. J Natl Cancer Inst. 2006;98(9):599–609.

[6] Cserni G. The potential value of intraoperative imprint cytology of axillary sentinel lymph nodes in breast cancer patients. Am Surg. 2001;67(1):86–91.

[7] Lumachi F, Marino F, Zanella S, Chiara GB, Basso SM. Touch imprint cytology and frozen-section analysis for intraoperative evaluation of sentinel nodes in early breast cancer. Anticancer Res. 2012;32(8):3523–6.

[8] Hunter-Smith AE, Rayter Z. One-step nucleic acid amplification: the possible value in assessing sentinel lymph node metastasis during mastectomy. Breast Cancer (Dove Med Press). 2018;10:13–21.

[9] Nowikiewicz T, Srutek E, Zegarski W. Application of immunohistochemistry for detection of metastases in sentinel lymph nodes of non-advanced breast cancer patients. Pol J Pathol. 2015;66(1):22–9.

[10] Chen JJ, Yang BL, Chen JY, Zhang JX, Li DL, Xu WP, et al. A prospective comparison of molecular assay and touch imprint cytology for intraoperative evaluation of sentinel lymph nodes. Chin Med J (Engl). 2011;124(4):491–7.

[11] Clarke D, Leung E, Chachlani N, Rowlands D, Simon J, Hero I, et al. Intraoperative assessment of sentinel node using imprint cytology. World J Surg. 2009;34(1):55–61.

[12] Creager AJ, Geisinger KR, Shiver SA, Perrier ND, Shen P, Ann Shaw J, et al. Intraoperative evaluation of sentinel lymph nodes for metastatic breast carcinoma by imprint cytology. Mod Pathol. 2002;15(11):1140–7.

[13] Liang R, Craik J, Juhasz ES, Harman CR. Imprint cytology versus frozen section: intraoperative analysis of sentinel lymph nodes in breast cancer. ANZ J Surg. 2003;73(8):597–9.

[14] 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.

[15] Motomura K, Inaji H, Komoike Y, Kasugai T, Nagumo S, Noguchi S, et al. Intraoperative sentinel lymph node examination by imprint cytology and frozen sectioning during breast surgery. Br J Surg. 2000;87(5):597–601.

[16] Turner RM, Davey J, Clarke MJ, Thompson SG, Higgins JP. Predicting the extent of heterogeneity in meta-analysis, using empirical data from the Cochrane Database of Systematic Reviews. Int J Epidemiol. 2012;41(3):818–27.

[17] Borenstein M, Hedges LV, Higgins JP, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res Synth Methods. 2010;1(2):97–111.

[18] Cotarelo CL, Zschöck-Manus A, Schmidt M, Schad A, Brochhausen C, Kirkpatrick CJ, et al. Improved detection of sentinel lymph node metastases allows reliable intraoperative identification of patients with extended axillary lymph node involvement in early breast cancer. Clin Exp Metastasis. 2021;38(1):61–72.

[19] 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.

[20] Pétursson HI, Kovács A, Mattsson J, Olofsson, Bagge R. Evaluation of intraoperative touch imprint cytology on axillary sentinel lymph nodes in invasive breast carcinomas, a retrospective study of 1227 patients comparing sensitivity in the different tumor subtypes. PLoS One. 2018;13(4):e0195560.

[21] Sun L, Chen G, Zhou Y, Zhang L, Jin Z, Liu W, et al. Clinical significance of MSKCC nomogram on guiding the application of touch imprint cytology and frozen section in intraoperative assessment of breast sentinel lymph nodes. Oncotarget. 2017;8(44):78105–12.

[22] Bell Z, Cameron I, Dace JS. Imprint cytology predicts axillary node status in sentinel lymph node biopsy. Ulst Med J. 2010;79(3):119–22.

[23] Hamidian Jahromi A, Narayanan S, MacNeill F, Osin P, Nerurkar A, Gui G. Testing the feasibility of intra-operative sentinel lymph node touch imprint cytology. Ann R Coll Surg Engl. 2009;91(4):336–9.

[24] Upender S, Mohan H, Handa U, Attri AK. Intraoperative evaluation of sentinel lymph nodes in breast carcinoma by imprint cytology, frozen section and rapid immunohistochemistry. Diagn Cytopathol. 2009;37(12):871–5.

[25] Tamiolakis D, Papadopoulos N, Venizelos J, Lambropoulou M, Romanidis C, Petrakis G, et al. RETRACTION: intraoperative touch imprint cytological analysis of sentinel lymph nodes for the presence of metastases in breast cancer. Oncol Res Treat. 2006;29(8–9):372–5.

[26] Van Eetvelde E, Vanhoeij M, Verfaillie G, Bourgain C, Lamote J. Role of intra-operative touch imprint cytology in the treatment of breast cancer. Acta Chir Belg. 2011;111(3):130–5.

[27] Motomura K, Nagumo S, Komoike Y, Koyama H, Inaji H. Accuracy of imprint cytology for intraoperative diagnosis of sentinel node metastases in breast cancer. Ann Surg. 2008;247(5):839–42.

[28] Seenu V, Mathur S, Guduru S, Vuthaluru S, Srivastava A, Suhani. Combined frozen section and imprint smear assessment of sentinel node improves accuracy and reduces false negative rates in breast cancer: a prospective study. Indian J Surg. 2021;84(2):335–9.

[29] Lorand S, Lavoué V, Tas P, Foucher F, Mesbah H, Rouquette S, et al. Intraoperative touch imprint cytology of axillary sentinel nodes for breast cancer: a series of 355 procedures. Breast. 2010;20(2):119–23.

[30] Vijayakumar V, Boerner PS, Jani AB, Vijayakumar S. A critical review of variables affecting the accuracy and false-negative rate of

sentinel node biosy procedures in early breast cancer. Nucl Med Commun. 2005;26(5):395–405.

[31] Kim KW, Lee J, Choi SH, Huh J, Park SH. Systematic review and meta-analysis of studies evaluating diagnostic test accuracy: a practical review for clinical researchers-Part I. General guidance and tips. Korean J Radiol. 2015;16(6):1175–87.

[32] Grube BJ, Giuliano AE. Observation of the breast cancer patient with a tumor-positive sentinel node: implications of the ACOSOG Z0011 trial. Semin Surg Oncol. 2001;20(3):230–7.

[33] Wang Y, Li L, Xu W, Zheng Z, Wu J, Yang W, et al. High sensitivity of touch imprint cytology in young patients with invasive lobular carcinoma of the breast. Tumor Biol. 2014;35(6):5741–6.

[34] Reynolds C. Rapid preoperative assessment of axillary lymph node status using imprint cytology. Breast (Edinburgh, Scotland). 2000;9(2):113–4.